plus!

Dear Resolutionary,

Please discover below, in alphabetical order, around 732 solutions to clean up, to repair and to protect our Planet. Half of these were published daily on our website. Having found the solution you are looking for in this alphabetical manuscript (it may be in several places), we suggest you post the solution title on a search motor such as Google and then to find, images, YouTubes and update/or news. These should find websites, such as firms or academic/research organisations have also been publishing news updates. Once researched, while respecting copyrights/patents, you can apply one or more of these solutions to your personal way of life, to your company or government policy. You can also put the word about family, friends and colleagues on your social networks (telephone, facebook, instagram, twitter etc)

We are not alone. A growing number of organizations have been publishing websites full of solutions: SolarImpulse Foundation 1300+ solutions); Sustainability Champions, 1,500 champions); GreenMatch; springwise.; 50WaystoHelp; HealthThePlanet; BBC; National Geographic; ecoplanetrewards.co; easaonline.org; climatree.org;ecomisfits.carrd.co; carbonchoice.co.uk; un.org; unep.org; greenpeace.org; litterati.org! *Not forgetting* Instagram resolutionaries: @environment_advice; @theplanetwillthankyou; @lemon.and.chesnuts; @misssionclimatesustainability; @that_chatuk; @go_green_civic_project; @seachemistry;

@mynetzerohome; @thegreenplanetph; @conserve_the_planet; @earthwise; @saveourplanet.official; and more. After all, we Resolutionaries need all the allies we can muster!

Happy hunting!

Agroforestry

Problem:

Halting deforestation is a global challenge largely due to unsustainable agricultural practices that degrade natural ecosystems. Ninety percent of deforestation is the result of agriculture, with 60% due to the extension of agro-industrial intensive farming (soya, palm oil, …), and the remaining 30% caused by small-scale and subsistence farmers. Close to 20% of all carbon emissions result from deforestation and forest degradation. With slash and burn subsistence agriculture, due to heavy seasonal floods, the exposed soil is washed away, leaving infertile barren soil exposed to the dry season. Farmed hillside sites to be abandoned after a few years.

Solution:

In 1977, a team led by Canadian forester John G. Bene published a seminal work “Trees, food and people : management in the tropics” in which Bene coined the word agroforestry. This led to the setting up of an International Council for Research in Agroforestry, now the World Agroforestry Center headquartered in Nairobi, Kenya.

Agroforestry is a use management system in which smart reforestation goes in with crops or pastureland. This intentional combination of agriculture and forestry increases biodiversity and reduces erosion. Unlike full-sun fields, vulnerable and contributing to ecosystems degradation, agrofrestry is a way to preserve productive ecosystems and adapt to climate .

One example of agroforestry has proved successful at the Quesungual Lempira Department, Honduras. Here, the Food and Agriculture Organization of the United Nations (FAO) helped introduce a system incorporating local

knowledge consisting of the following steps: Hillside secondary forest were thinned and pruned, leaving individual nitrogen-fixing trees to help reduce soil erosion, maintain soil moisture, provide shade and provide an input of nitrogen-rich matter in the form of litter. Maize, a local crop was then planted in rows beside the trees, then harvested, leaving their stalks used for nitrogen-fixing climbing plants. Further intercropping was carried out with pumpkin, its leaves and horizontal growth providing additional shade and moisture retention. Pumpkins do not compete with the for sunlight since the latter grow vertically on the stalks. Another agroforestry application is Taungya, a system originating in Burma. In the initial stages of an orchard or tree plantation, trees are small and widely spaced. The free space between the newly planted trees accommodates a seasonal crop. Instead of weeding, the underutilized area provides an additional output and income. complex taungyas use between-tree space for multiple crops. The crops become shade tolerant as the tree canopies grow and the amount of sunlight reaching the ground declines. Thinning can maintain sunlight levels.

J. G. Bene, H.W. Beall, A. Cöté, “Trees, food and people : management in the tropics,” *International Development Research Centre*, 1977. Daizy Patish, *Ecological of agroforestry*. CRC Press.2008; Langford, "Turning the tide on farm productivity in Africa: an agroforestry solution,". *World Agroforestry Centre,* 8 July 2009.

Ahimsa Silk

Problem: To produce one pound of silk involves killing about 2,500 or silkworms. 30,000-50,000 silkworms are killed to one six-yard (5.5 m) saree. The *Bombyx mori* moths, having fed on mulberry leaves until they grow to 3 in (7 cm) (ten thousand times their original size) are then ready to be harvested. The worms are boiled or blasted with steam by manufacturers to collect the cocoons, and this process kills the pupae.

Solution: In the early 1990s, Kusuma Rajaiah was in Andhra Pradesh’s handloom department when ex-president of India R Venkatarman’s wife, Janaki, who was on a state visit to the silk manufacturing facilities, asked Rajaiah if silk could be without killing the worms. Having studied fibers and filaments at The Indian Institute of Handloom Technology for three years, Rajaiah, a firm believer in Mahatma Gandhi’s principles of non-violence, found a solution enabling the silkworm to emerge out of the cocoon naturally and come out from their metamorphosis and live their fullest life peacefully. From the pierced

cocoons the required yarn is extracted and spun into a fiber for making a fabric which has the luxurious feel of silk, with a slightly ‘raw’ appearance. In contrast, the less humane process takes about 15 minutes. The damaged cocoons yield six times less filament, too, doubling the price of conventional silk. Having created his first sample sarees, Rajaiah commercialised his innovation as Ahimsa Silk or Peace Silk. (Ahiṃsā Sanskrit: अहिंसा is an ancient Indian principle of nonviolence which applies to all living beings) The government of India Rajaiah a 20-year patent in 2002 and marks for Ahimsa silk in 2006. It has since been used in designer collections showcased all over the world. The innovative entrepreneur has also been to jersey out of Ahimsa silk, which they now use to T-shirts and lingerie. Based on Rajaiah’s solution, Prayaag Barooah of FabricPlus, a weaving initiative in Guwahati, Assam, works with about 100,000 rural silk farmers and weavers to manufacturer ahimsa silk. With COVID-19, FabricPlus transitioned to making silk masks. *(fabricplus.in)*

Jasreen Mayal Khanna,”Did you know about Ahimsa silk, the eco-friendly fabric created without killing any silkworms?” *Vogue,* September 13, 2019.

Air-breathing sulfur flow battery

Problem: Li-ion cobalt batteries are difficult to produce and to recycle, hence expensive.

Solution: A research team including Yet- Chiang, the Kyocera Professor at the Massachusetts Institute of Technology has developed a type of battery which uses cheaper, abundant materials, and could be used for both short and -term energy . The researchers estimate that the total chemical cost of the battery could be as little as 1/30 the cost of current technologies, including li-ion. The battery utilizes a sulfur (a by-product of fossil fuel production) dissolved in water of which there is an abundant supply, and an aerated liquid sodium salt solution in the cathode. flowing in and out of the cathode causes the battery to discharge and . This battery literally inhales and exhales air, but it does not exhale carbon dioxide, it exhales .

Although the initial prototype of the air-breathing sulfur flow battery was about the size of a coffee cup, flow batteries are known to be easily scalable and thanks to its low materials cost, the battery could be the first technology to

compete in cost and energy density with pumped hydroelectric . The battery has a slow self discharge , and could therefore be used in seasonal – an increasingly important concept as solar moves into regions further from the equator, where sunlight levels vary greatly between seasons.

Soon after Yet- Chiang and Mateo Jaramillo had founded Form Energy in Somerville to market the battery, they were awarded US$11 million, including US$9 million from Breakthrough Energy Ventures (BEV), launched by a group of billionaires including Bill Gates, Jeff Bezos, Jack Ma, Richard , Soros, Mark Zuckerberg, Masayoshi Son, and Michael Bloomberg. In August 2019, Italian oil and gas major Eni signed on as lead investor, joined by Capricorn Investment Group and most of the existing investors from the original US$9 million, pushing it to US$40 million. *(engine.xyz)*

Yet- Chiang et al., "Air-Breathing Aqueous Sulfur Flow Battery for Ultralow-Cost -Duration Electrical " *Joule.* October 12, 2017.

Air conditioner, sustainable

Problem: Leaking CFC and HCFC-based air conditioners contribute to GHG and depletion.

Solution: In 2018 a team of scientists at the National University of Singapore announced the development of a prototype of a sustainable air conditioning unit which uses water instead of refrigerants, and consumes 40 % less electricity to operate, and can cool a space to as low as 18° Celsius. After four years of government-funded research on Project Drawdown, Dr. M. Kum Ja, Dr. Bui Duc Thuan, Associate Professor Ernest Chua, and Dr. Md Raisul Islam produced two new technologies. The first is a membrane dehumidifier which uses special water-absorbing materials and a difference in air pressure to extract water from ambient air as it is passed through the membrane. The water removed is potable and almost as pure as bottled drinking water. The drier air is then passed through what is called the counter-flow dew-point evaporative cooler, the team's second invention. This device removes heat through evaporative cooling, the process that reduces body temperature through perspiration. Instead of relying on HCFCs, the drawdown air conditioner can cool a room using water. It requires 2 pints **(**one liter) of water to cool a master bedroom unit for 15 to 20

hours. While regular air conditioners expel hot air as a by-product, the prototype releases humid air that is likely to be cooler ambient temperatures. This helps to avoid disrupting the microclimate outside. If a city replaces all its compressor-based coolers with this innovative air-conditioner, then it reduces its electrical demand enormously. Cities may slash their need for new power plants in developing countries, with a resource found wherever humans thrive.

In October 2018, team member Ernest Chua was conferred the Best Paper Award at the IEEE-organised "International Conference on Green Energy for Sustainable Development held in Phuket, Thailand. He also presented a paper in January 2019 at the World Economic Forum Annual Meeting at Davos. But he has emphasised that the 5 ft. (1.6 m) tall prototype was not the finished version, and his team is now looking to create a compact and commercially viable product for the market in three to five years' time. *(nus.edu.sg)*

In 2015, Monish Siripurapu, a student at the Institute for Advanced Architecture of Catalonia in New Delhi came up with a cooling solution hat offers a low tech, eco-friendly and inexpensive alternative to air conditioners, using little energy and no refrigerants. Inspired by biomimicry, the device passes water through a honeycomb of terracotta cones that facilitate evaporative cooling. The system is inspired by the traditional passive design of a beehive, in existence across the world in India, Iran, Egypt and Saudi Arabia. But Monash customized it through advanced computational analysis and modern calibration techniques. It could also help generate employment for potters and support a fading traditional craft. Water runs over the honeycomb of tubes. When it evaporates, it cools the air inside the tube, which comes out 15 degrees cooler than it entered. In 2018, Monash's start-up, CoolAnt, was awarded a United Nations Environment Program Award.

Ernest Chua, "A hybrid air conditioning system employing membrane dehumidification and dew-point cooling" *International Conference on Green Energy for Sustainable Development*, October 2018.

Air-filtering vehicles

Desmond 05 should go here

Problem: Construction, industrial and vehicle-generated PM10 (Particulate Matter) contribute to life-shortening cardiovascular illnesses and respiratory diseases.

Solution: To mount various types of air purifiers circulating vehicles. In September 2018, Bluestar, one of the UK's largest bus operators launched the country's first air filtering bus prototype in an effort to tackle air pollution in the city of Southampton. They chose one of their low-emission Euro VI buses, each of which produces no 0.08g/km of nitrogen oxide. The filter, designed and manufactured in collaboration with PALL Aerospace, headquartered in Port Washington, New York, the world's largest aerospace and defence filtration company, is in an engine barrier-type filter construction and designed to remove up to 99.5% of particles from the air without any impact on the passenger or travel experience. Southampton was chosen as the location for the pilot following a 2018 World Health Organisation (WHO) report, which warned that the city was at the limit of unsafe air pollution.

From September 2018, running for 100 days, covering 9,000 miles (14,500 km), the pilot bus was to clean 113 million cubic ft. (3.2 million cubic m.) of the city's air, the equivalent to the volume of 1,288 Olympic swimming pools. The air filter took in 35 cubic feet (1 m^3) of air per second meaning that in one hour it was filtering the volume of air as 6,000 people breathing. It extracted PM10 weighing a total of 65g - roughly the as a tennis ball - over the course of the trial. Encouraged, Bluestar decided to retro-fit an additional five buses on the number seven serving Lordshill and Sholing via the general hospital, Millbrook, Shirley, City Centre and Woolston. While a single bus has the capacity to clean the air on its route every 215 days, to a height of 33 ft. (10 m), it would just nine days for the newly expanded fleet to achieve the passenger capacity and remove as much as 2.8 lb (1.25kg) of PM10 from the air every year. Further encouraged, from summer 2020 "breathe Bluestar" introduced the technology to Oxford, Plymouth, Newcastle, Manchester, Crawley/Brighton. A further five buses were also brought into service in Southampton. If the air filter were to be deployed on 4,600 buses across the UK, it could remove as much as 2,425 lb (1,100 kg) of PM10 particles every year. In parallel, Bluestar also fitted a total of 19 vehicles with solar panels, one of them fitted with the air filter to see whether solar energy could be used to the filter completely self-sufficient. *(www.bluestarbus.co.uk)*

Shivom Sharma and François Maréchal at the Industrial Process and Energy Systems Engineering group, EPFL in Zurich had patented a concept which involves capturing CO_2 within the exhaust system of a truck, converting it into a liquid and it on the vehicle. The liquid CO_2 would then be delivered to a service station where it will be turned back into fuel using renewable energy. The system could theoretically work with all trucks, buses and even , and with any type of fuel. The advantage of this system is that it can be retrofitted to existing vehicles in to neutralize their impact in terms of carbon emissions. (*epfl.ch/labs*)

In terms of private transport, automobile manufacturer Hyundai has developed the NEXO hydrogen fuel cell automobile with an advanced air purification system capable of filtering 99.9% of very dust. As a test, they

teamed up with University College London (UCL) to on London's dirtiest driving , which includes areas such as Kings Cross, Westminster, Elephant and Castle, and Deptford. Hyundai claims that if just one NEXO is driven for an hour, it has the potential to purify 59 lb (26.9 kg.) of air, which it says is the amount as 42 adults breathe in 60 minutes. The car producer also claims that if there were 10,000 NEXOs on the road it would subsequently a carbon-reducing effect akin to planting 60,000 trees. *(hyundai.com)*

Other schemes in South Korea and China are also on air purifying transport. And in Thailand there is also work on an air purifying bike.

In Rotterdam, the Netherlands, Studio Roosegaarde's Smog Free Project has teamed up with China's largest bike- company Ofo, to develop a *Smog Free Bicycle* with a dual function: not does it offer transport on two wheels and ease traffic congestion, it also cleans smog. Through a device mounted on the handlebars, polluted city air is in through vacuum suction while the bicycle is in motion. As the air passes through a filter, it is cleaned of harmful particles and purified, literally giving the cyclist a breath of fresh air. Dan Roosegaarde often takes his inspiration from biomimicry for his innovative eco-friendly projects. The Smog Free Bicycle was inspired by the manta ray, the flatfish which has a unique filter system of pores that acts as a sieve for the plankton it feeds on, while expelling the purified seawater through its gills. The is to launch an initial 300 bicycles. There is interest in cities such as London, Paris and Luxembourg as part of their bicycle-sharing programs. *(.studioroosegaarde.net)*

Together, fleets of buses, automobiles, electric and pedal bicycles, all fitted with air filtering systems could certainly a contribution to planet protection.

Shivom Sharma and François Maréchal, “Carbon Dioxide Capture From Internal Combustion Engine Exhaust Using Temperature Swing Adsorption” *Frontiers in Energy Research*, 16 December 2019.

Air-ink machine

Problem: Fossil-fuel gasoline automobile exhausts pollute and damage health in crowded cities.

Solution: A machine called Kaalink for recycling their soot to generate ink for printers, has been invented by Anirudh Sharma of India. Between 2013 and 2015 Sharma co-led activities at the Massachusetts Institute of Technology’s Media Lab India Initiative consortium to help shape self-organized, design-led innovation in India. During a visit to his Indian home in 2013, Sharma noticed that his friend’s clothing was stained by air pollution. After experimenting for a year to see whether pollution rejected by vehicles was a resource recycling idea, Sharma realised that his invention would not help India if he set up office in the US. So, in 2013 he returned to India and, with three researcher friends, co-founded Graviky Labs in Bengaluru. Initially when they were experimenting with a new technology, there was no set guidance available in the market. They conducted several experiments to understand the optimum technique for harvesting pollution from fossil fuel combustion sources. By 2016, the team started to retrofit Kaalink machines to car engine exhaust pipes in Bengaluru. They were to capture approximately 95 % or 1.6 kg of the particulate matter pollution without inducing back-pressure. Kaalinks were manually and individually installed by drivers, and after about two weeks of city driving were traded in at a Graviky Labs. The machines could also be fitted to motorboats and to chimneys.

Graviky then set about converting the captured raw material into a ink they called Air-Ink. An of ink (28 gm) is produced by about 45 minutes of

exhaust. Sharma and his team then built a prototype to test their ink's printability. They assembled a Nicolas' ink shield with Arduino interfaced with their soot-catcher pump design. This shield allowed them to connect a HP C6602 inkjet cartridge to their Arduino2015 turning it into a 96dpi print platform. It used 5 pins which could be jumper-selected to avoid other shields. For the project they had to widen the holes of the cartridge to let the ink out, since the size of the particles in Air-Ink is much larger the industrial ink. Conventional ink is one of the most consumed products in the industry. Most of this printing ink is produced in factories with complex chemical procedures. Companies such as HP/Canon 70 % of their profits by selling these cartridges at 400% margin. Air-Ink presented a far economic option.

In August 2016, Graviky Labs, in partnership with Tiger Beer, Heineken Global, next linked up with international artists to spread the message of environment conservation. They collaborated with seven -based artists for this project, providing approximately 42 gallons (150 liters) of Air-Ink in graffiti . These worked well and were used in Kong's Sheung Wan district for street art activation to campaign against air pollution. They captured this moment on a video that went viral and garnered 2.5 million views within 10 days. Sharma next travelled to smog-choked cities around the world and challenged 19 street artists to create billboards and murals in Air-Ink illustrating the effects of carbon waste, starting in London, on to Berlin, Chicago, Sydney, Singapore and Amsterdam. Street artist Buff Monster created a beautiful -and-white on a Manhattan sidewalk titled "This art is painted with air pollution."

Anirudh's innovation also gained recognition from Shah Rukh , an Indian actor, film producer and television personality. Referred to in the media as the " of Bollywood" and " ", he has appeared in 80 Bollywood films. pledged to use Air-Ink for his promotions. This included 4 handmade posters of posted across New Delhi and Mumbai advertising the launch of Sharma's TED-Talks in India "Painted with Pollution." With corporate and government partnerships, Graviky hopes to install 1,000 capture units in every constituency.

In 2019, Graviky Labs proudly this post on their website: " (422 billion gallons (1.6 trillion liters) of air cleaned so far." *(graviky.com)*

Clinton Nguyen,"This company is turning car exhaust into inks and paints," *Business Insider,* August 24, 2016.

Air quality sensor

Problem: Some routes taken by schoolchildren to and from their schools are polluted others.

Solution: In April 2020, Ava Garside, 13-years' old, in Year 9 at the Allerton School, Leeds, England created a graphene-based, wearable air quality pin- sensor which collects data and detects the air quality of wherever you are, helping to detect the cleanest and healthiest routes to work or school. For her "Perfect Sense solution", Ava was named the Junior winner of the Youth Industrial Strategy Competition, a national science, technology, engineering and maths (STEM) initiative. She was also awarded the UK Space Agency #SatelLife competition. She has since been alongside scientists at the University of Manchester to develop the prototype further, but like of the solutions presented on this website, the COVID-19 pandemic has slowed things up...

Airborne Wind Energy Systems (AWES)

Problem: -based generation of electricity is limited.

Solution: Alongside aircraft using electricity, there are also aircraft which will be used to regularly generate electricity.

It was in 1978 that Mi. L. Lloyd at the Lawrence Livermore National Laboratory, Livermore, California applied for Patent US4251040 for -scale wind power production by of aerodynamically efficient kites. Based on aircraft construction, these kites would fly transverse to the wind at high speed. The lift produced at this speed is sufficient to both support the kite and generate power. This would come to be known as crosswind kite power.

28 years later, Australian inventor Saul Griffith and kite designer Don Montague teamed up to build a similar type of generator, calling their company

“Makani” after the Hawaiian word for wind. Funded by DARPA, they built a 20 kW turbine-carrying glider and flew it in 2009; the higher the altitudes where the winds are and reliable, the electrical energy is harvested. By 2011 Makani were testing developed models from the tarmac of the former Alameda Naval Air Station. In 2013 they were bought up by Google. Although facing significant regulatory obstacles including wildlife preservation issues as well as the technological challenges, they were eventually to produce their eighth generation prototype designed by Damon Lind, a 600-kW carbon-fiber energy kite with eight rotors rotors each of 7.5 ft (2m³0) in diameter and with the 85 ft (26 m) wingspan of a small jet airliner. The turbine driven generators would also function as motor-driven propellers in a powered flight mode, which could be used for vertical -off and landing. A perch adapted to facilitate the -off and landing would pivot such that the pivot is oriented towards the tension direction of the tether. On May 18, 2017 the Makani 600-kW kite produced power for the first time. The rotation of the 85 ft. wide kite’s rotors drives magnet motors/ generators on board, producing electricity that transfers down the tether where it can be connected to an energy grid. The electricity comes down in DC (direct current), but is converted to AC (alternating current) at its station. In February 2019, Royal Dutch Shell invested in Makani. *(makanipower.com)*

Similar projects are taking place in the Netherlands with the *Ampyx* tethered glider and in Norway with Kitemill and their *Spark* airplane. *(www.kitemill.com)*And Swiss startup Skypull has developed an autonomous that can fly to almost 2000 ft (600m) - about three times the height of a traditional wind turbine. Its current prototype is a rigid , multi-copter "box-" that can off and by itself, with no need for a launcher or ground wind. The -off is battery-powered, but in the air the battery is recharged every time the kite loops back down towards the ground. *(www.skypull.technology)*

Kevin Desmond, *Electric Aircraft and : A History* Jefferson, NC: McFarland, 2018; Panghal, “Report on AWES,” *Academia*.

Airplane electric

Desmond 02 and 03 should go here

Problem: Commercial flights now account for 2.5 % of global CO_2 emissions. The aircraft industry is expecting a seven-fold increase in air traffic by 2050, and a four-fold increase in GHG emissions, unless fundamental are .

Solution: Fortunately the world of aviation is boldly accelerating into a new, silent and less polluting era of electric propulsion. Described as the 'Third Revolution' in aviation (after heavier air and jet engines) the introduction of hybrid-electric aircraft could be a massive breakthrough for sustainable aviation. From the stratosphere to door-to-door, a “hangar” of differing prototypes now entered into their series-production phase, be they airships, or airplanes carrying up to eight passengers or training would-be pilots, be they vertical -off which can carry a single passenger across a city, or those for delivery, cinema or sport, or merely toys which can be -launched and piloted using virtual reality.

One example, the two-seat Pipistrel *Taurus Electro G2* electric aircraft is manufactured at a plant in Italy, 15 mi. (25 km) away from the current Pipistrel Headquarters in Slovenia. Work is underway to mass-produce 4-seater and 19-seater hybrid Pipistrel airplanes at a plant in China from 2020. *(www.pipistrel-aircraft.com)* In Israel, Eviation’s *Alice* can fly 650 mi. (1,046 km) at around 300mph (480kph), 260 knots with three electric motors, one on the tail and one on each wingtip. The prototype carries a 900 kWh li-ion battery and carries nine passengers. US regional airline Air has already expressed an interest in the all-electric *Alice*, saying it will a “double-digit” number of the aircraft to operate on some of its short routes. The aircraft is expected to to the skies in 2022. *(eviation.co/alice).*

For haul -continental flights, one solution is the hydrogen fuel cell. In Germany, the first short 15-minute demonstration flight of the *HY4* was in September 2016 at Stuttgart Airport above the public and the media; air traffic control had all the other air traffic stopped, so spectators could hear the almost-completely-silent fuel cell airplane, flown by pilots, Johannes Anton and Nejc Faganelj in one cockpit with two dummy passengers in the other. In 2018, Airbus, Siemens and Rolls- unveiled a project to develop a hybrid-electric propulsion system, the *E-Fan X.* Parts manufacturing began in 2019, but the program fell victim to the COVID19 pandemic

In March 2017 Professor Josef Kallo, head of the Institute for Energy Conversion and at Ulm University, describing this flight, announced plans to

test the technological platform over the coming years before the will be upped to six or eight seats. He explained: “Recent studies on commercial aviation show that there are indeed feasible propulsion designs for regional air travel with up to 40 seats and a of 435 mi. (700 km) or below, even though the technical challenges are significant.”

Other solutions are trialled such as electric tugs towing electric airliners out to and back from the runways of international airports whose rooftop solar panels could recharge them, while one day a V-formation of -haul airliners could create a to further reduce fuel consumption.

The above does not include development of half a dozen Vertical Off and Landing (eVTOL) 2-6 seater electric city taxi such as the *Volocopter*, the *,* the *Lilium, CityAirbus, aEro2, Embraer,* etc.

Kevin Desmond, *Electric Airplanes and : A History* (Jefferson, NC: McFarland, 2018); Emission-free, electric flight – DLR presents the HY4 research platform at the 2016 Hannover Fair,” 26 April 26, 2016; Hydrogeit,“Fuel Cell Passenger Aircraft for Medium-Distance Flights,” *H-2 International*, March 1, 2017.

Algae yarn rug

Problem: The chemicals in synthetic them highly flammable. Synthetic are cheaper, but the quality is lower, and they can be harmful to the environment and are very slow to decompose.

Solution: Nienke Hoogvliet in the Netherlands in 1989, grew up in the Oosterschelde, a Dutch coastal area, rich in algae or seaweed. Having graduated from Lifestyle & Design at the Willem de Kooning Academy, Rotterdam, Hoogvliet, concerned about sustainability, took some of these sea algae them into yarn and -knotted it in an old fishing net to a rug. Sea algae grow much faster and need less nutrients then cotton. She presented her SEA ME rug at the Dutch Design Week 2014. With funding from the StimuleringsfondsCreatieveIndustrie, Hoogvliet’s research extended, and she Tomorrow’sed uses for the sustainable yarn beyond the textile industry, with a circular zero waste process (where the waste of one process fuels a second and so on until there is nothing left) leading her to unearth their qualities as a natural dye. She collected over 20 different species of seaweed in her native

Oosterschelde and experimented. She also visited Ireland, where a potential of 110 ton (110,000 kg) of seaweed floats ashore every year. Each species gives a different color, showing a color palette that reflects this nature reserve. In 2015, in collaboration with Xandra van der Eijk, Hoogvliet, based in the , presented “Colors of the Oosterschelde”, comprising a bio-plastic chair, a table and bowls at the Dutch Design Week

With the results of this research charted in a self-published 100- book, *“*Seaweed Research”, Hoogvliet’s experimentation with sustainable materials continued with her Tomorrow’sing that fish skins, a waste product of the fishing industry, can also be into a leather alternative. She went to fish shops to collect their waste and by using an old technique, that requires a lot of manual labour, she created a , sustainable and beautiful material that can be used like regular leather. Finding a chemical-free, labour-intensive method for tanning the skins, Hoogvliet reached into the deep again and developed RE-SEA ME. To show the abilities of her leather, Hoogvliet designed a small stool with fish leather seating. For this project she used salmon skins, but almost any kind of fish can be used to leather. While the tanning process was by the Dutch designer believes it also has potential to be produced at a larger scale. Nienke Hoogvliet collected her research into the sustainability of the fishing- and leather-tanning industry in her book “Fish Leather”, where she explains the natural tanning process and hopes to encourage others to use this technique.

Whilst there is an intrinsic beauty in fish skin and seaweed, how does one arrive at used toilet paper? By invite it would seem: impressed with her work with sustainable materials, the Dutch Water Authorities invited Hoogvliet to design products that would show off their good work in recovering valuable energy and raw materials from wastewater. Setting ‘ sieve’ installations into place, water authorities Aa & Maas and Hoogheemraadschap Hollands NoorderkWartier were to reclaim plenty of the 190,000 tons (180,000 tonnes) (190K US ton.) of toilet paper that is flushed down the toilets of the Netherlands each year. (That is 180,000 trees.) Hoping to create the sort of positive association with this unpleasant material, these authorities invited Hoogvliet to design products that would show off their good work in recovering valuable energy and raw materials from wastewater.

Eight sewage treatment plants already transformed into Energy Factories, with preparations underway for a further nine, green electricity can be garnered from the treatment process – as can phosphate, which can be used to produce

fertilisers. Proving time and time again that she can find a beauty in materials discarded, no matter how disagreeable, Hoogvliet used the cleaned pulp to produce unique, handmade products: a collection of objects, consisting of a table, lighting, and decorative bowls. In May 2019, in New York she exhibited "Kaumera Kimono", which combines dyes extracted from wastewater like Anammox and Vivianite with the cutting-edge material Kaumera, an alginate-like biopolymer that amplifies a textile's ability to absorb dye. The result is that less water is required, and polluted, in the dyeing process.

Nienke Hoogvliet's work, raising awareness of social and environmental problems in the textile, leather and food industry, is exhibited worldwide from the Artipelag in Stockholm to New York's Cooper Hewitt Design Museum. *(nienkehoogvliet.nl)*

Amy DuFault, "Dutch Design Studio Nienke Hoogvliet Explores Seaweed Textiles," BKAccelerator, October 27, 2017; Alyn Griffiths, "Nienke Hoogvliet's Kaumera Kimono is dyed with wastewater," *dezeen*, 28, 2019.

Algerian Green Dam (alsadu al'akhdar aljazayiriu)

Problem: Desertification is a serious threat to arid and semiarid environments which cover 40% of the global surface and are populated by approximately 1 billion humans. Of the 588 million ac (238 million ha) that the total area of Algeria, 200 million are natural deserts, 20 million represent the steppe regions threatened by desertification. During The War of Independence, between 1954 and 1962, Algeria's forest heritage had suffered serious damage as a result of the French occupation army's aerial bombardments.

Solution: In a program launched in 1970 by Saïd Grim and backed by President Houari Boumediene, the past forty years seen a reforestation program of the vast steppe of Algeria to counter desertification. Today "The Green Dam" covers an area of 930 mi (1500 km) by 12 mi (20 km) on the average, or 7.5 million ac (3 million ha). But the combat to drive back the desert continues. A study on its rehabilitation and extension was launched in 2012, an action was proposed in 2016, meetings and workshops held in 2018.

In 2019, Ethiopia, in the of Africa, claimed to planted 4 billion trees in three months. The Green Legacy Initiative was championed by the country's

Nobel peace prize-winning Prime Minister, Abiy Ahmed. The highlight was on 29 July when Ethiopians across the country turned out to help with planting 350 million tree seedlings over a 12-hour period. They a very precise number - 353,633,660 trees planted that day. A further 1.3 billion seedlings were grown, but not planted.

The Gambia, which is one of the poorest countries in western Africa, launched a project to restore 10,000 ha of forests, mangroves, and savannas, using climate-resilient tree and shrub species across an area of at least 25,000 ac (10,000 ha). The six-year project will be implemented in four of The Gambia's seven regions, and aims to over 57,000 people resilient to the negative effects of climate . Of these people 11,550 will benefit directly, and 46,200 indirectly.

Merdas Saifi, "The centre of scientific and technical research on arid regions," *ResearchGate*, April 2010; "Le concepteur du Barrage vert Saïd Grim se confie," *Algeriepatriotique* November 21, 2017.

All-weather energy cell

Problem: At present solar, wind and hydro devices work separately. For example, when there is no sunlight, the PV cell efficiency drops to zero and for the wind.

Solution: Financed by the Beijing Natural Science Foundation, the National Natural Science Foundation of China, External Cooperation Program of BIC, the Chinese Academy of Sciences, the 2015 Annual Beijing Talents Fund and China's Thousand Talents Program, researchers NanoYa , Lin and colleagues integrated two energy-harvesting technologies in one: a silicon solar cell and a nanogenerator that can convert wind energy into electrical output. The solar cell component of the system delivers 8 milliWatts of power output (1 milliWatt can light up 100 small LEDs). The wind-harvesting component delivers up to 26 milliWatts. Together, under simulated sun and wind conditions, four devices on the roof of a model home could turn on the LEDs inside and power a temperature-humidity sensor. Installed in numbers on real rooftops, the hybrid device could help enable smart cities.

Also in China, researchers from the University of China in Qingdao and Yunnan Normal University in Kunming invented a type of solar cell that also works on days, when alternative solar panels yield very little energy. The new kind of solar cell is coated in a layer of graphene, layers of carbon just one atom . Graphene, which is a material known for its conductivity, lets electrons move freely across its surface. water contains ammonium, calcium and sodium, which become ions when in solution. This that when water sits on top of a layer of graphene, it creates spots of unbalanced . The electrons in the graphene bind with positively ions in the water, which is known as the Lewis acid-interaction. The movement of electrons is an electric current. The Chinese team used a cheap, thin-film "dye-sensitized" solar cell and added a layer of graphene to it. It was then put on a visible backing of indium tin oxide and plastic. shows promise as a proof-of-concept, but they were to achieve about a 6.5% efficiency in the , compared to the typical average 15-20% efficiency that most solar panels can get in full sun conditions.

Other scientists led by Professor Baoquan Sun at Soochow University in Suzhou, Jiangsu, China, overcome a design flaw of solar panels by allowing them to collect energy in both the and sun. Now, almost any home can install solar panels. So even if you live in a area, you can use solar panels to produce electricity for your home. This innovation could renewable energy completely. Currently, these hybrid solar designs are not ready for home and business use. Researchers need to find ways to increase the efficiency from and sun. However, the efficiency of the Soochow University design was 13%, which makes it a viable alternative to standard solar panels. Comparatively, current solar designs convert 15 to 20 % of the sun's energy into electricity. Thus, the new design is a viable solar solution. Collecting energy from is something the team would like to develop further. Electricity efficiency from its triboelectric nanogenerators was not reported and again the graphene model had an efficiency from of around 6.5%. There is much work to do.

Megan Ray Nichols, "Scientists design new solarcells to capture energy from ," *EuroScientist,* May 21, 2018;

Aluminum smelting factory, carbon-free

Problem: Nearly all aluminium smelting has for years been with hydroelectric power from generators dedicated to the purpose, with the smelters built next to the dams that store the water. However, smelting is the largest single producer of fluorides worldwide. 'Scrubbers' are usually used to remove the majority of fluorides from factory smoke today, but when those scrubbers are spent they are also dumped in landfills where the soluble fluorides absorbed into them can leak out into the soil.

Solution: In May 2018, Alcoa and Rio Tinto unveiled what they describe as the world's first carbon-free aluminum smelting process, through a partnership called Elysis, which refers to the electrolysis of alumina, a process at the centre of aluminum smelting. Apple, which is planning to use the metal in its iPhone and laptop computers, as part of its own efforts to decarbonize its operations and supply chain, is also investing in Elysis.

On August 16, 2019, construction began on the Elysis R&D centre in Quebec's Saguenay-Lac-Saint region, located within Rio Tinto's Complexe Jonquière, the site of the Arvida smelter, Vaudreuil refinery and Arvida research and development center. The project is expected to be fully operational by the second half of 2020, employing 25 technical experts. By 2024, commercialisation on a world scale could eliminate the equivalent of 7 million tons (6.5 million tonnes) of GHG emissions if fully implemented at existing aluminum smelters in Canada – roughly equal to taking nearly 1.8 million light-duty vehicles off the road. *(alcoa.com)*

Meanwhile, Russian aluminum Rusal En+, which uses hydropower from rivers in Siberia to power most of its smelters, is targeting 2021 to roll out its own of carbon-free aluminum, based on an inert system. Rusal has teamed up with US manufacturer Braidy Industries to build a mill in Kentucky, which will be the world's largest low-carbon rolled aluminum producer, as well as the first new greenfield aluminum mill in 37 years to be constructed in the United States. En+ Group, the holding company for Rusal reckons the for lighter and efficient electric car will demand for "green" aluminum. *(enplusgroup.com/en)*

Amphibious housing

Desmond 01 goes here

Problem: Sea levels could as much as 19 in. (48 cm) by 2050, according to "mid- projections" in a report from the U.S. Geological Survey to map all areas the continental U.S. coastline containing homes that lie within one to 10 ft. (0.3 to 3 m) from the water level at high tide. Globally, eight of the world's ten largest cities are near a coast, according to the U.N. Atlas of the .

Solution: In response to the frequency of flooding from periods of heavy , for a time, poor people converted into homes which hardly even moved from their moorings. In North America they are called float houses or shanty , while in the UK they are known as houseboats, indeed over 15,000 people live afloat on the canals and rivers of that country.

The Netherlands is a country with a history of mitigating flood damage and adapting to flood risk. With 60% of the country below sea level, the development and implementation of flood resilient infrastructure has become an important part of the Dutch culture. The flood threat in the Netherlands is not related to rising sea-levels, rivers also pose a risk of flooding. This risk is increased by climate as it causes frequent and extreme rainfall.

The program "Ruimte voor de Rivier" (room for the river), implemented in 1997, included the development of natural flood areas, where water can be temporarily stored in of rising water levels. development of these areas is no allowed. One of these locations, Maasbommel (on the Maas river), became the site where the first amphibious houses were realized in 2005; specifically 32 real amphibious houses plus 14 floating houses, designed by a team led by Adrianus Gerardus Gregorius van Haastert, Richard Jacob Looij and Josephus Antonius Wilhelmus Hockx, built by the construction firm Dura Vermeer Beton & Waterbouw BV. Maasbommel's amphibious house is an innovative approach that combines the best features of floating house and elevated buildings to create homes that can adapt to in water level. House can withstand in the water level, but cannot safely withstand storms with high winds or floods with fast moving water. Elevated homes, while from flooding and wind if constructed properly, can feel isolated from their neighbors and the surrounding environment due to their high decks and extensive stairs. The amphibious houses in

Massbommel float like house sited on a floating concrete “hull.” However, they are also secured against winds and waves by permanent mooring driven deep into the ground, similar to those used to elevate homes. These guide the building to and lower, in place, according to changing river levels. In non-flood conditions, the houses rest on the river , allowing for convenient water access and creating a flat walkable space between homes. Unlike a house boat, the amphibious houses also basements, decks, and small gardens all supported by their foundations. They feature flexible pipes for electrical, water, and sewer lines that will keep the home “on the grid” even in a flooding event. Dura Vermeer also built floating houses near the Limburg village of Ohé en Laak. These homes, known as the Meuse Villas, consist of a concrete floating , including the shell, and each home weighs approximately 100 tons.

Although the technology of amphibious houses proved itself during a flood in 2011, the concept has been moderately adopted in the Netherlands. In 2012 the total number of “water houses”, which is the definition under which amphibious houses fall, was estimated at several hundred in the Netherlands. In the of Maasbommel, both the adequate technology and an interested developer were available. However, the difficulty proved to be to obtain building permission due to unfamiliarity with the concept in regulation and hesitance to build in areas that were considered dangerous. Another important difficulty is that an unconventional building approach leads to higher construction , combined with a limited market of possible owners. (*en.duravermeer.nl)*

Bungalow (Bunbo) are very popular on the vast northern German waterway network, also on the Lahn river. Hulls are aluminum, superstructure from wood. Typically used for charter (short-term, weekly), they are also good for older people and those with disabilities. Propulsion is electric, power is solarn(100 watt) and cooking/heating by gas.

In the Czech Republic, architect Marek Štěpán of Tachov in the Plzeň Region, has designed and built a series of prefabricated one-bedroom floating homes called *Freedomky*, which can be towed to a selected venue, such as Charles Bridge in the up-and-coming district of Smíchov in . *(freedomky.cz/en)*

factorarchitecten.nl/portfolio/drijvende-en-amfibische-woningen; Elizabeth C English, Carol J. Friedland, Fatemeh Orooji, “Combined Flood and Wind Mitigation for Hurricane Damage Prevention: for Amphibious Construction,” *Journal of Structural Engineering*, February 2017.

Amphibious water bomber

Problem: In recent times, due to anthropogenic global warming (AGW) and drought, major wildfires been spreading all over the Planet, from north to south, from east to west. Fires do not respect borders.

Solution: Various aircraft been used over the years for firefighting.. The yellow and red amphibious water bombers or "super scoopers" Canadair CL-215 and the CL-415 are the most commonly used. They are assembled at the Bombardier Aerospace facility near North Bay/Jack Garland Airport in North Bay, Ontario, and tested on Nipissing. In 2018, there were 165 in-service CL-215 and CL-415s serving 11 countries. The CL-415 can scoop up to 1,620 US gallons (6,140 liters) of water from a nearby water source in ten minutes, mix it with a chemical foam if desired, and drop it on a fire without having to return to to refill its tanks.

In 2019 the European Union set up a RescEU fleet of seven Canadairs and six helicopters from six EU member states: Spain, Italy, , Sweden, Croatia and Greece. They are also available to other European countries and adjoining states, which can request to use the planes in an emergency to fight forest fires across Europe. *(bombardier.com)*

Another solution to fighting fires is the **L**eaf blower for controlled burn (see entry).

Animal as electrical energy

Problem: As all transport transitions to electric propulsion, the increase in the demand for electrical energy will call on a diversity of sources.

Solution: One of these is by converting the coming from horses, cattle, pigs and other livestock to electricity, using an anaerobic digester.

In the Fall of 1998, two ex-Aachen University students from farming families, Hendrik Becker and Meyer zu Strohe built an anaerobic digester or methanizer at a prototype biogas plant feed facility in Münsterland, north-west Westfalen. They started up PlanET to manufacture the green dome-shape units for use in rural areas. Anaerobic digestion is a sequence of processes by which microorganisms break down biodegradable material in the absence of . The process is used for industrial or purposes to manage waste or to generate biomethane or electricity. PlanET's innovative solids injection technology for biogas plants, offers technology solutions for the use of 100 percent or and demanding substrates such as straw and . During the past two decades, PlanET has sold and implemented nearly 480 biogas plants of between 40 kW and several MW to , the UK, the USA and Canada. The total electric power of PlanET installations currently in operation is 142,000 kWel. The plant also processes other waste such as that of cereal farmers (the unusable part of the harvest).

The Germans were not . In 2015, Finland's state energy company, Fortum, led by Anssi Paalanen, began trials at Järvenpää initially sourcing raw materials from four stables from Espoo and Kirkkonummi for raw material for their anaerobic digesters. The and bedding of three horses could provide heat and light for a single-family Finnish home in a colder climate. The wood shavings in the mix are already a waste product of Finland's timber industry. Finland has 70,000 horses, enough to provide heat and electricity for up to 23,000 homes. Fortum began with a small plant, with the just 10% of the wood-shaving mix used for burning. By autumn, with stables taking part, the proportion was raised to 20%. The number of horses in society is increasing. According to Statistics Sweden, there are 360,000 horses in Sweden, of which three-quarters are situated in or near- environments. With a dry matter content of 40%, this equates to a quantity of 1,500 tons (1,360 tonnes) of per annum and corresponds to an annual biogas production of 641 GWh. In 2016, Finland banned the disposal of in landfill sites, with other , biodegradable materials. This that stables risked with a pile of ordure they could not shift. The can be given to farmers for use as fertilizer, but in the EU this is now permitted on flat fields because of the risk that exists on sloping fields that the will leach into water courses. Flat fields are fair for muck-spreaders, but the E.U. the strewing of on any sloping site, as a sensible precaution against equine faeces leaching

into the water system. This that Finland's does not places to go, making the biomass a double win. The Fortum solution, which they called quite simply "HorsePower", seemed the most logical.

From August 2017, Fortum set up a pilot project in Bergslagen, southern Sweden, requesting from the 400-500 horses in the region, the electricity produced to households in the town of Hällefors. Fortum was looking for local suppliers and asked that there are at least 10-20 horses in the stable in to cover transport . By the end of the year 3,000 horses were producing energy. If Fortum could process the mix from 280,000 of Sweden's horses it would be enough to heat all of the houses in Östergötland and Gotland.

Following the 2017 FEI European Equestrian Championships held in the city of Gothenburg in August, Renova, the municipal waste management, created around 360 000 kWh of district heating and 60 000 kWh of electricity, from the estimated 330 tons (300 tonnes) of and straw left by the 600 horses participating in the competition. Two months later, Finland's Show in Helsinki Ice Hall followed suit. During the event, HorsePower delivered wood-based bedding for the 250 or so horses that stayed in temporary stalls, their at Fortum's Järvenpää power plant anaerobically generating 140 kW to meet all of the electricity needs of the event from lighting to scoreboards to support infrastructure. (*fortum.com)*

According to a report compiled in 2006 by the Food and Agriculture Organization of the United Nations (FAOSTAT), there are an estimated 58 million horses in the world. In terms of HorsePower potential, one is therefore talking about gigawatts of electricity. If the of the world's population were put to work, this would provide electricity for 19.5 million homes or two New York cities, not to mention electric vehicles. At the beginning of 2016, the global number of four-wheeled electric vehicles in use to around 13 million units: 6.18 million electrified power trains will be produced by 2020. This does not in the hundreds of millions of two- and three-wheeled vehicles, particularly in China. With such a demand for electrical energy, it is inevitable that – not to mention from cattle, pigs and other livestock - will play its part alongside other sustainable energy sources.

Kevin Desmond, *Electric Trucks, A History*, (Jefferson, NC: McFarland, 2019). Hendrik Dipl.-Ing. Becker (Fh) and Dipl.-Ing. Meyer zu Strohe (FH) "Biogas plant feed facility," European Patent 1201111B1, Published March 2, 2002; Köpke, "Münsterland-Power seit über 20 Jahren," *Energie and*

Management, November 20, 2019, Thauer, R.K.; Jungermann, K.; Decker, K. "Energy conservation in chemotrophic anaerobic bacteria," *Bacteriological Reviews, 1977, 41;* Neil Johnson, "Plant turns into methane powering generator," *Tampa Bay Times,* 10 March 10, 2010; "Parc équestre fédéral : de l'électricité le fumier," *La Nouvelle République,* 30 October 2013 ; P. Doligez, "La méthanisation du fumier de cheval," *Institut Français du Cheval et de l'Equitation Les Haras Nationaux,* March 2015 ; Jay Hennessy and Ola Eriksson, "Energy and nutrients from . Life-cycle data inventory of management systems" *Gävleborg University Press*, 2015; Carolina Liljenstolpe, "Horses in Europe," *Swedish University of Agricultural Sciences*, 2009.

Antibiotics, peptidomimetics and bithionol

Problem:

Growing resistance is rendering colistin antibiotics ineffective, with the threat of catastrophic public health consequences should this continue much .

Solution: There are a number of solutions to reduce our reliance on antibiotics including the ban on antibiotics as growth promoters in animal feed, the education of doctors and patients regarding the over prescription of antibiotics, allowing the body to combat infections etc. In 2011, Professor Felden and a team at Inserm *(inserm.fr)* with Michèle Baudy and another team at the Rennes Institute of Chemical Sciences in Brittany*(iscr.univ-rennes 1.fr)* Tomorrow'sed a new toxin that they then transformed into antibiotics that could fight against bacteria responsible for human infections. This French advance could both fresh impetus and new possibilities for fighting antibiotic resistance worldwide. Named *Floc'h*, this new family of so-called peptidomimetics was inspired by the existing natural bacterial peptides, shortened and modified. Out of the twenty molecules created, two proved effective against resistant *Staphylococcus aureus* and *Pseudomonas aeruginosa* in mouse models of severe sepsis or skin infection.

Felden and his team tested these molecules at doses 10 to 50 times higher the effective dose without seeing toxicity. After several days of direct exposure to the drugs in vivo, the bacteria showed no signs of resistance. To truly ensure this was the , the team created conditions that were particularly favorable to resistance and found a negative result. experimental stages could be helpful, and

the team's next steps are to launch clinical trials on humans. The patent has been licensed and a startup created.

On Monday 18 September, 2017, on the occasion of the General Assembly of the Rennes 1 Foundation, the Bacterial Regulators and Medicine team of the University of Rennes 1, led by Felden, was honored for its breakthrough.

They are not alone. “A selective membrane-targeting repurposed antibiotic with activity against persistent methicillin-resistant *Staphylococcus aureus,”* is a recent study published in July 2019, in “Proceedings of the National Academy of Sciences”. Researchers at Brown, Emory and Harvard universities found that they can repurpose bithionol, a formerly used to treat parasitic infections in horses, to kill antibiotic-resistant bacteria, including MRSA, a common hospital-acquired infection. The 24 scientists’ idea was to find an existing that could the bacteria's membrane, a part of the bacteria that most antibiotics do not attack. The scientists started by looking for existing drugs that could penetrate the membrane of MRSA persisters. They performed a screen of 80,000 known drugs. They infected worms known as *C. elegans* with MRSA and then tried the drugs to see which would kill the MRSA bacteria, but not the worms. They found 185 drugs that passed this screen, but a few of them, including bithionol, could penetrate the membrane of persister bacteria. But the researchers found a potential problem with bithionol. It is destructive. When used in high doses, it makes the bacteria burst and die. Although they demonstrated that, in combination with gentamicin, bithionol effectively reduces bacterial burdens in a mouse model of chronic deep-seated MRSA infection, for bithionol to be a antibiotic treatment in humans, the scientists must now to show that it can penetrate the membranes of bacteria, not those of human cells.

Felden et al. “Functionality and cross-regulation of the four SprG/SprF type I toxin-antitoxin systems in Staphylococcus aureus*,” Nucleic Acids Research 47(4)* December 2018; Luisa Torres, “To Find the Next Antibiotic, Scientists Give Old Drugs A New Purpose,” *WBUR News*, August 12, 2019.

Anti-Poaching Intelligence Devices

Problem:

Rhinoceros and elephant poaching for their horns is widespread.

Solutions:

Some governments have deterred rhinos to deter poachers, though that requires constant monitoring, and it has not always proven effective. Very recently, conservationists begun using drones and microchip implants to enhance surveillance of threatened population.

In 2014, Paul O'Donoghue, a biologist at Protect, a British non-profit focused on conservation and animal welfare developed the Real-time -Poaching Intelligence Device (RAPID). This system uses GPS , heart monitors embedded under the skin of rhinos. If the animal's heart suddenly elevates or plummets, RAPID will send an alert to operators at a control centre, who can then remotely activate a tiny camera implanted into the rhino's . A leather collar around the animal's neck also tracks its GPS coordinates, allowing park authorities to quickly deploy -poaching forces if the live camera footage suggests that it is attacked. By 2015, Protect had moved from proof-of-concept trials to small-scale field testing at secret locations in South Africa with the for a larger scale launching across the continent. Protect also began to explore alternative ways to power the heart monitor battery, including solar and kinetic energy. The organization said that RAPID could also be adapted to other threatened species such as elephants, lions, or even whales. A version for tigers was also in development. *(hsi.org/rhinos)*

According du Toit, director of the Lowveld Rhino Trust in Zimbabwe and Africa Program Coordinator for the International Rhino Foundation, the downside is that the video camera is likely to last hours, maybe days or at best weeks on a rhino before smashed, obscured with dirt, or otherwise rendered useless. Moreover, even if the device was to alert authorities to a potential poaching incident, it is unlikely that on-the-ground forces would be to respond as quickly as required.

Another alternative is dye. In April 2013, (*takepart.com)* reported that 100 rhino from Sabi Sands Reserve, part of Greater Kruger National Park in South Africa, had their drilled and a liquid poison/dye mix injected by the Rhino Rescue Project in an effort to deter poachers and devalue the price of . Since then, it has been reported that rhino from Dinokeng Reserve (Gauteng), Plumari Private Reserve (Gauteng), Ndumo Reserve (KwaZulu-Natal), Tembe Elephant Park (KwaZulu-Natal) and Kapama Private Reserve (Limpopo) all been similarly treated.

Leon Barron from King's College London and Mark Moseley from the Metropolitan Police Service collaborated to develop an ivory fingerprint kit, which has been dispatched to 40 countries. The powder it contains can reveal prints up to 28 days after poachers touched the ivory, compared to two or three days with conventional methods. Barron also recently showed that it is possible to determine the age of a person from the DNA contained in their blood, using artificial intelligence. The hope is that this can be replicated and validated for blood stains at crime scenes, and potentially used to solve future wildlife crimes.

Jamal Firmat Banzi, "A Sensor Based -Poaching System in Tanzania National Parks," *International Journal of Scientific & Technology Research* Volume 4(4), April 2014; *Pachyderm* No. 55 January – July 2014.

Solar Cells: A Photovoltaic Cell That Works at Night

Problem:

Solar cells cannot function at night.

Solution:

Jeremy Munday and Tristan Deppe at the Department of Electrical and Computer Engineering at the University of California Davis developed a thermoradiative cell which generates electrical current as it radiates infrared light (heat) toward the night sky and extreme cold of deep space. Such a cell could generate up to 50 watts of power per square meter under ideal conditions at night, about a quarter of what a conventional solar can generate in daytime.

Jeremy Munday and Tristan Deppe, "Nighttime Photovoltaic Cells: Electrical Power Generation by Optically Coupling with Deep Space," *ACS Photonics* January 7, 2020.

Apps

Problem:

The iPhone was released in 2007 to critical and commercial success. During the last measured period, an average of 6,140 mobile apps were released through the Google Play Store every day. As of the first quarter of 2019, these app users could choose to download between 2.6 million Android, and 2.2 million iOS apps The is that they are used to satisfy insatiable curiosity or for brief and not very significant social networking, while the Planet goes into crisis mode.

Solution:

Harness the widespread use of apps on the world's 5 billion mobile phones. Every environmental pressure group has its own app such as *FridaysForFuture* is a people's movement following the call from Greta Thunberg to school strike and the World Wildlife Fund's *Together* that brings you closer to 16 endangered species. In this book, several apps are described in detail such as *myclimate carbon calculator*, *NatureMapr* and *EC3*

But there are others. There are apps to reduce congestion and carbon emissions such as *GoCarma* which encourages car-pooling and CO_2 *Green Drive* which tracks the emissions that can be saved by walking or cycling. *Dropcountr* helps reduce water waste while *Too Good To Go* reduces food waste by allowing retailers to sell food near its sell by at a discount. There are apps such as *iRecycle* and *Plastic Analyzer* which help reduce landfill and apps encouraging tree planting. This is clearly an area with enormous potential growth and impact.

: AquaBattery

Problem:

The availability of ecological electricity and its storage also for smaller applications is the challenge of the future, as conventional batteries represent an ecological problem

Solution:

The AquaBattery

Chinese-born Jiajun Cen had already obtained his PhD degree from Imperial College, London where he worked on carbon capture and storage in saline

aquifers. Moving to Leidschendam, South Holland, Netherlands, Jianjun leads a team to develop safe, sustainable and scalable energy storage technologies. This has resulted in the AquaBattery, the of which is the use of salt water, whereby acid and base are stored in separate tanks. When electricity is needed, the acid and base are mixed in the same membrane . No toxic or rare chemicals are required. There is no risk of explosion. When the battery is not used, it does not lose any energy. Alongside this BlueBattery, there is the GreenBattery storing electricity in concentration and pH gradients and the TerraBattery using nickel-iron cells with an expected service life of over twenty years. At the end of life, this latter battery is fully recycled.

'Artificial leaf'

Solution:

Researchers led by Yimin A.Wu at the Center for Nanoscale Materials at the National Laboratory (ANL) in Illinois and the Waterloo Institute for Nanotechnology in Ontario, collaborating with California State University (Northridge), and the City University of Hong Kong, been developing an artificial leaf which bio-mimics the carbon-scrubbing abilities of the real thing. But rather turning atmospheric CO_2 into a source of fuel for itself, the artificial leaf converts it into a useful alternative fuel. Making methanol from carbon dioxide, the primary contributor to global warming, would both reduce greenhouse gas emissions and provide a substitute for the fossil fuels that create them. The key to the process is a cheap, optimized red powder called cuprous oxide (Cu_2O) . Engineered to as many as eight-sided particles as possible, the powder is created by a chemical reaction when four substances – glucose, copper acetate, sodium hydroxide and sodium dodecyl sulfate – are added to water that has been heated to a particular temperature. The powder then serves as the catalyst, or trigger, for another chemical reaction when it is mixed with water into which carbon dioxide is blown and a beam of white light is directed with a solar simulator. The reaction produces , as in photosynthesis, while also converting carbon dioxide in the water-powder solution into methanol. The methanol is collected as it evaporates when the solution is heated. Next steps in the research include increasing the methanol yield and commercializing the patented process to convert carbon dioxide collected from major greenhouse gas sources such as power plants, vehicles and oil drilling.*(uwaterloo.ca)*

Yimin A Wu et al., “Facet-dependent active sites of a single Cu_2O particle photocatalyst for CO_2 reduction to methanol,” *Nature Energy* Volume 4, pages957–968 (2019).

Asbestos recycling

Problem:

Although asbestos is a naturally-occurring material that was used in thousands of homes and offices for centuries, it is a carcinogen that can cause serious illness and death if not handled correctly. the asbestos has been safely removed, it is taken to a landfill that is qualified to receive the waste, not the safest answer.

Solution:

Asbestos can be recycled by a shingle or siding recycler through the use of incredibly high heat 1,000–1,250 °C (1,800–2,300 °F) which eventually converts the fibers into an inert silicate glass. The resulting material is completely inert and will no cause . Silicate glass can then be used to create porcelain stoneware tiles, porous single-fired wall tiles, and ceramics .

Gualtieri, A. F.; Tartaglia, A, “Thermal decomposition of asbestos and recycling in traditional ceramics". *Journal of the European Ceramic Society.* **20** (9): 1409–1418. 2000).

(ATLAS) Asteroid Terrestrial-impact Last Alert System

Problem: Asteroid collisions can destroy or seriously damage the Planet.

Solution: Programs to detect asteroids on hazardous orbits were started after there was much public discussion of the fact that the Hollywood film industry had just spent much money on making two fictional films about asteroids that were heading for Earth had ever been spent on attempting to detect such asteroids in time to do anything about them.

One key scientist who has great progress in killer asteroid warning systems is John Tonry. Tonry studied mathematics at Princeton University until 1975 and received his PhD in physics from Harvard University in 1980. In 1986 he became a professor at MIT, a year later, he moved to the Department of Astronomy at the University of Hawaii. There, between 1993 and 1995, with Kenneth Chambers and Nicholas Kaiser, Tonry discovered two asteroids. Between 2002 and 2010 Tonry developed the Panoramic Survey Telescope and Rapid Response System (Pan-STARRS). This was an AFRL (Air Research Laboratory) funded effort to build a telescope and to carry out wide-field (3 deg), deep imagery of the whole sky. What was different about Pan-STARRS was that they were this every night and covering the whole sky times to try to detect any asteroid whose orbit makes it a potential to Earth. The work does not itself reduce the risk of an asteroid strike but might it possible to action to divert the asteroid or evacuate the impact area.

Even efficient is ATLAS (Asteroid Terrestrial-impact Last Alert System), developed at the University of Hawaii with US$ 5 million funding from NASA. Its first telescope at Haleakala observatory (ATLAS-HKO) became fully operational at the end of 2015, and the second one 100 mi. (160 km) away at Mauna Loa observatory (ATLAS-MLO) in March 2017. Replacement of the initially substandard Schmidt corrector plates of both telescopes in 2017, brought their quality closer to its nominal 2 pixels (3.8 in./9.7 cm) width and consequently improved their sensitivity by one magnitude. NASA then confirmed that it will provide US$3.8 million over the next 4 years to support the construction and operation of two asteroid-hunting observatories south of the Equator. Researchers to build one facility in South Africa, but are deciding on a location for the second outpost.

ATLAS comprises four 200 in. (500 cm) telescopes that can see things 10x brighter Pan-STARRS can, so it is easier to work to a third or a half of the distance of Pan-STARRS. What is different is that ATLAS patrols the entire, visible sky twice a night, whereas Pan-STARRS is *much* slower. Pan-STARRS is narrow and deep; ATLAS is wide and shallow. The motivation for ATLAS is to provide warning of an asteroid on its final, impact trajectory: maybe a week's warning for a 2 Mton explosion and three weeks' warning for a 100 Mton explosion. Recently ATLAS found a 10 Mton asteroid (K17Q60) that missed us by 10 Earth radii, and another (A103wzq) on the MPC confirmation whose MOID (minimum orbital intersection distance) could be less an Earth radius (it

might hit us). The *Last Alert* part of the system acknowledges that ATLAS will find smaller asteroids years too for potential deflection but would provide the days or weeks of warning needed to evacuate and otherwise prepare a area. This gives enough time to evacuate the area of people, measures to protect buildings and other infrastructure, and be alert to a tsunami generated by impacts. Tonry explained that if ATLAS had been up and running, astronomers might very well seen the Chelyabinsk meteor that hit Russia in 2013 and could provided one to two days' warning, so enabling most of the injuries it caused to be avoided, because news broadcasts could warned people to keep away from windows. Most of the people injured were looking at the meteor's dust trail through windows that shattered on the arrival a couple of minutes later of the caused by passage of the meteor through the air.
In August 2018, ATLAS obtained US$ 3.8 million of additional NASA funding to install two telescopes in the Southern hemisphere, one of which will be hosted by the South African Astronomical Observatory, while the other most likely installed in Chile. This geographical expansion of ATLAS will provide visibility of the far Southern sky, continuous , better resilience to bad weather, and additional information on the asteroid orbit from the parallax effect. The full ATLAS concept consists of eight telescopes, spread over the globe for full-sky and 24h/24h . So far ATLAS has discovered 33 potentially hazardous asteroids and 304 near-Earth asteroids. For his work on asteroid surveillance, in 2016, asteroid 40919 was named after John Tonry and in 2018 he was elected to the National Academy of Sciences.

Another machine involves the seven-year Double Asteroid Redirection Test (DART)’s kinetic impactor. U.S. agencies, principally the Air , and the European Space Agency will each design and build three NEO (Near Earth Orbiting) shield kinetic impactor spacecraft, for a total of six. Each will be propelled by Fregat, the upper of the Soyuz launcher. The hope is that at least two of them will hit the asteroid with enough to slightly deflect it. The effort billions of dollars, but this is a crash program, with the highest international priority. In 2022, DART is scheduled to reach an asteroid renamed *Dimorphos* (ex binary pair *DidymosB*) which 'two forms,' so reflecting the status of this object as the first celestial body to have the 'form' of its orbit significantly by humanity, in this case, by the DART impact. The European Space Agency (ESA) compares the size of Dimorphos with the Great Pyramid of Egypt. DART's exploits will be witnessed by a small CubeSat companion from the Italian Space

Agency. Two years later, ESA will launch its own Hera spacecraft to visit Didymos and examine the results of the DART mission.

Nonetheless, in March 2019, scientists reported that asteroids may be much difficult to destroy thought earlier. In addition, an asteroid may reassemble itself due to gravity after disrupted.

A team of researchers at Leiden University in the Netherlands developed a neural network called "Hazardous Object Identifier" that they say can predict if an asteroid is on a collision course with Earth. Using a supercomputer, the researchers fast-forwarded through a simulation of 10,000 years of orbital movements of the Solar System's planets. The team then reversed the simulation, simulating future Earth-impacting asteroids by flinging them away from Earth and tracking their exact locations and orbits. Their new AI identified 11 asteroids that were not previously classified by NASA as hazardous, and which were larger 100 meters in diameter. They also focused on space rocks that could come within 4.7 million miles of Earth. The team is now on making its neural network even accurate.

John Tonry "Description of ATLAS"*Publications of the Astronomical Society of the Pacific* volume 123, 58-73, 2011; Traci Watson,"Project that spots city-killing asteroids expands to Southern Hemisphere" *nature*, 14 August 2018; John D. Hefele, Francesco Bortolussi and Simon Zwart, "Identifying Earth-impacting asteroids using an artificial neural network," *Astronomy & Astrophysics,* Volume 634, February 2020.

: Atmospheric Water Generator (AWG)

Problem:

The sufficient availability of drinking water is becoming a question of survival for human beings. Already today, 3 out of 10 people have no regulated access to drinking water. No society, from rural African areas to metropolises like New York, London, and Beijing, is immune to the scarcity of clean drinking water. And as terrible as the crisis currently is, it will continue to aggravate over time —WHO warns that at this rate, half of the world's population will face water stress by 2025 unless drastic changes are made.

Solution:

Atmospheric Water Generator

Founded in 2009 by Israeli entrepreneur and former combat commander Arye Kohavi and a team of engineers, Watergen, based in Petah Tikva, was originally a startup conceived to provide easily accessible water to militaries worldwide.

Its patented GENius plug-and-play atmospheric generators have been used around the world by armies as well as the public and private sectors in the United States, Latin America, India, Vietnam, Uzbekistan and the African continent. One litre of water 7-15 cents, which depends on local electricity .

Watergen's largest machines can provide 6,000 litres of water in a day. It has already been used to support entire hospitals in the Gaza Strip and rural villages in central Africa, where people would otherwise have to walk hours to find water. It also helped Australia's government battle devastating bush fires in 2020 that killed 34 people and destroyed 3,500 homes.

A similar machine has been developed by Walter Kreisel and his team at the Imhotep Group in Freistadt, Upper Austria, with the mobile water giant PHANTOR to produce drinking water anywhere in the world, by using a special process to exploit the surrounding humidity. In this way, around 10,000 litres of drinking water can be produced per day.

Primary power comes from a photovoltaic system on the roof. In combination with a power storage unit, power outages are no problem. This makes it particularly interesting for semi-stationary use. The drinking water produced meets Austrian standards.

This is enough to permanently supply a hospital or residential building with drinking water. But it also guarantees a reliable water supply in the event of a disaster. Because the mobile water giant PHANTOR is suitable for both stationary and semi-stationary use, it sets new standards. It is designed for standardized container transport and built for plug-and-play.

Automobile, electric

Problem:

Overall, diesel and petrol automobiles emit hydrocarbons, carbon monoxide and lead pollution contributing towards the GHG thread.

Solution:

The electric automobile is far less polluting.

From 1997, the Toyota *Prius* hybrid-electric automobile was the ambassador for the revival of the solution of the electric automobile. Since its launch, Toyota has sold 4.3 million units Currently, over thirty manufacturers are making battery-electric automobiles with a range of 250 to 700 miles (400 to 1,000km). According to the "Global EV Outlook 2020", the sales of electric cars reached 2.1 million globally in 2019, surpassing 2018 – already a record year – to the to 7.2 million EVs. Annual sales of EVs is predicted to exceed 3.5 million vehicles in 2030, reaching 20 percent of annual vehicle sales in 2030. BloombergNEF expects one in 10 vehicles purchased in 2025 will be battery-powered and although COVID-19 has temporarily put the brakes on, by 2022 there will be over 500 different EV models available globally.

Three of the world's best-selling electric automobiles are the Nissan *Leaf* (500,000 units), the Tesla *Model 3* (500,000 units) and the Renault *Zoë* (218,000 units). The two-seat Renault *Twizy* quadricycle has sold over 30,000 units.

Bloomberg adds that by 2040, the world will need about 12 million public charging points. As of July 2019, there were over 170,000 public charging stations for electric vehicles in Europe, over 400 charging stations are by Ionity with an average of six charging points per station. As of July 2020 The Tesla-fast-charging is now at 2,035 public stations with 18,100 individual chargers in North America, compared to about 1,400 charging points for ChargePoint, a company that operates an independent network of EV chargers and 1,660 points for Volkswagen's Electrify America network. General Motors is teaming up with the EVgo charging network to add 2,700 fast-charging connectors in cities across the U.S. By August 2020 EV charging stations passed the million mark globally.

There are almost one dozen Apps which inform drivers there whereabouts of the nearest and most available charging points. As the leading app for EV drivers, *PlugShare* provides near-global of charging stations and over 800,000 downloads.

"Global EV Outlook 2020", *iea Technology report* , 2020; "The Electric Vehicle Outlook 2020", BloombergNEF

Bacterial protection by skin dentasols

Problem: Hospital-acquired or nosocomial infections are deadly, resulting in 99,000 deaths each year

Solution: Dr. Anthony B. Brennan, materials science and engineering professor at University of Florida, had been asked by the U.S. Office of Naval Research to identify new antifouling strategies to reduce use of antifouling paints and trim associated with dry dock and . Brennan was convinced that using an engineered topography could be a key to new antifouling technologies. This became clear upon watching an algae-coated nuclear submarine return to port while visiting the U.S. naval base at Pearl Harbor in Oahu in 2002. The submarine was strikingly similar in appearance to a whale moving slowly into the harbor. This observation resulted in a discussion on the of slow moving mammals that do not readily collect microorganisms on their skin. The animal identified with that met these criteria was the shark. Following identification, became expert in understanding what properties of sharkskin contribute to the difference in adhesion.

An actual impression of sharkskin, or specifically, its dermal denticles was taken in an effort to understand these properties. Examining the impression with scanning electron microscopy Brennan discovered that sharkskin denticles are in a distinct diamond pattern with tiny riblets. The presence of millions of tiny diamond-shaped dermal denticles is unique to sharks in comparison to other slow moving animals and is key to the micro- resistant properties of sharkskin. He called them Sharklets. The first test performed showed an 85% reduction in green algae settlement compared to smooth surfaces.

Taking a biomimicry approach Anthony Brennan has adapted the Sharklets to develop a textured adhesive film which can stop bacterial growth on a number of different surfaces, including medical devices such as hospital surfaces, public restrooms, childcare facilities, commercial venues, laboratories

and animal research facilities. The film may also be manufactured into the top layer of workspace mats to create immediate and moveable surface protection.

For manufacturing, Brennan set up Sharklet™ Technologies Inc., a biotechnology company is based at the Bioscience Park Center, an incubator in the Fitzsimons Life Science District adjacent to the renowned Anschutz Medical Campus in Aurora, Colorado. To test Sharklet, trials were conducted in Sharklet Inc. laboratories, independent facilities and United States' government agency facilities, on bacteria incuding Staphylococcus aureus, Staphylococcus epidermidis, MRSA, Pseudomonas aeruginosa, Escherichia coli and VRE. LG International in Portland, a manufacturer of bacteria inhibition products, designed to protect environmental surfaces and decrease bacterial attachment, survival, and touch transference, was the first company to sell a bacteria-inhibiting film-based product under the Tactivex . Tactivex has been deployed into healthcare facilities, research laboratories and other settings where bacterial inhibition is desired. Tactivex with Sharklet products are semi-durable covers for the surfaces that leading microbiologists at the U.S. Centers for Disease Control identified as critical for keeping clean. These surfaces include: patient bed rails, overbed tables, bedside tables, staff call handsets, patient room light switches and door levers. The Tactivex will also feature a product for nurse stations and areas that serve as pivot points of activity between patient room visits. Sharklet will also be applied to children's backpacks, suitcases and yoga mats.

Kenneth K. Chung, James F Schumacher, Edith M Sampson, Robert A , Patrick J Antonelli, Anthony B Brennan, "Impact of engineered surface microtopography on biofilm formation of Staphylococcus aureus*," Biointerphase,* 1» 2007 sharklet.com

Baler twine, compostable

Problem: Baling twine or baler twine is a small diameter synthetic twine used to bind a quantity of fibrous material (notably hay or straw) into a compact and easily stacked form. At the very beginning, natural fibres such as sisal (sisalana), abacá (Manila hemp), henequén, cotton were used for making baler twine. But because of their features were not suitable for baler machines, so artificial fibres such as polypropylene became popular for its strength and -life, But recycling for baling twines are low. They usually end up in a landfill. Furthermore, other farmers resort to toxin-emitting burning or burying them in their private landfills

Solution: Rebtex (Pty) Ltd of Polokwane, South Africa manufacture sisal baling twine that is a , non- plant fibre product that is totally biodegradable.

Rebtex twine is available countrywide from farmers supply stores and co-ops in three types differing in thickness, tensile strength and length per 5kg spool for round balers, round balers and square balers. Sisal fibers are of 65% cellulose, 12% Hemicellulose, 9.9% Lignin, and 2% Waxes. Cordex "Envirocord" biodegradable baler twine is engineered to be a high-performing, yet cost-saving alternative to sisal baler twine. It is water proof and odorless, and is solar degradable starting at 3 months of sun exposure. When comparing the spool length and tensile strength, savings of 33% to 50% are realized.

Ballpoint pen, biodegradable

Problem: According to the Writing Instrument Manufacturers Association (WIMA), over three billion ball point pens and over 500 million mechanical pencils were shipped in the US in 2007. since been lost – some behind the back of a sofa – while countless others will probably find their way into landfill.

Solution: From 2003 Société BIC of Clichy, Hauts-de-Seine, set up a team of 25 researchers to transform their commitment to sustainable development into ecological solutions that must constitute competitive advantages for the Group.

After five years of extensive research and development the BIC team in learned to develop PLA (Poly-Lactic-Acid) from , with which by 2008 they were to produce a precision shaver handle. From this BIC built up a new of stationery products, including pens which they -marked as "Ecolutions". BIC became the first manufacturer of writing instruments to earn NF Environment certification. A full of nineteen BIC products has been this ecolabel, including historical products such as the BIC Cristal® and the BIC 4-Colors™ ballpoint pen, as well as the pens in the BIC Ecolutions , manufactured using recycled materials (at least 50%) in compliance with the standard ISO 14021. For example, the BIC® Matic Ecolutions® mechanical pencil contains 65% recycled materials. All stationery lines now include at least one product with alternative (e.g. recycled) materials. In 2019, BIC added the Kids Evolution *Ecolutions* colouring pencils to this . (*bicgraphic.eu)*

On the other , from 2010, Paper Mate of Oak Brook, Illinois used Mirel, a bioplastic whose primary raw material is sugar (dextrose) derived from a wet milling process, to launch a range of biodegradable pens, and pencils, including the Gel 0.7, that feature components that break down in soil or home compost in the space of a year. Five years later, Pilot Corporation of Tokyo, Japan developed the Bottle to Pen (B2P) of writing instruments, which are the world's first pens from recycled plastic water bottles. The plastic from one bottle can be used to create approximately two B2P pens. PET plastic from bottles are used for much of it, so it is sometimes nicknamed the 'PetPen' or 'PetBall'. *(jetpens.com)*

In 1998, a team led by Yasumichi Iwasi at the Mitsubishi Pencil Co Ltd in Tokyo had obtained Japanese patent JP2000043470A for "a Composting decomposable writing instrument to decompose and return it to soil by adopting biodegradable fiber for obtaining biodegradable performance even in inner members (nib, inner cotton)." Their solution was a nib and inner cotton formed of lactic lactone of polylactic acid (PLA).

In 2009, Leon Ransmeier and Erik Wysocan of DBA, New York, obtained a patent for a pen from potato-based plastic which could be composted within 180 days. The catch was the stainless steel nib - which up 2% of the pen and was left behind. The ink reservoir stored a non- ink. The plug, cap, ink reservoir and main housing were all formed from biodegradable, non- materials. The pens would be in a wind-powered factory and packaged in 100% recycled and recyclable FSC-certified paper printed with vegetable-based inks. Although, the *DBA98* (98% biodegradable) was launched as the "green pen" with a publicity event at the Standard Hotel in New York, the company was unable to overcome some of the obstacles inherent in the pursuit of challenging conventional, outdated practices and the pen, as well as DBA's endless notebook of 100% recycled paper, were never manufactured.

bicgraphic.com; Yigal Azrouel, "Hollywood And Fashion Stars Turn Out To Celebrate A New Eco-Pen," *Styelcaster*, 2010.

Bamboo silk

Problem: Sericulture is not considered an eco-friendly practice. Living cocoons are collected and kept under the sun, or boiled, or exposed to steam to kill the silkworms and make the cocoons easier to unravel. The boiling of cocoons leads to the formation of vapours that can pollute the environment and also cause respiratory problems for the workers.

Solution: Artificial silk, also referred to as viscose is from regenerated wood fibre while bamboo silk is extracted specifically from bamboo stalks. Bamboo silk, a popular fibre because it is breathable like cotton and cool to the touch, is used for luxury towels, bedding and linen.

Bamboo can be a very sustainable crop; a fast growing , it requires no fertiliser and self-regenerates from its own roots, so it does not need to be replanted. When compared to cotton cultivation, which requires amounts of water, pesticides and labour, the advantages are pretty clear.

The first process involves combing out the bamboo fibres and spinning these into thread. This results in a slightly coarse fabric that is usually called “bamboo linen”. Creating this “linen” is labour intensive and expensive and the result not suitable for the soft, intimate products for which bamboo is most in demand. The second and much popular method is the process used to the silky soft bamboo fabric you find in sheets, underwear and . This “bamboo ” is produced through a highly intensive chemical process, similar to the process used to turn wood chips into . This is where the sustainability of bamboo gets a little prickly.

The majority of bamboo is grown in China, and there is no information regarding how intensively bamboo is harvested, or what sort of clearing might be underway in to way for the bamboo. Also, although bamboo doesn’t require pesticides, there is no guarantee that they are not used to maximise outputs.

A similar fabric called Lyocell (also known by the brand name TENCEL) uses a closed-loop process to recapture and reuse 99% of the chemical solution. It was developed beginning in 1972 by a team at the American Enka fibers facility at Enka, Western North Carolina and called Newcell. The fibre was developed further as Tencel in the 1980s by Courtaulds Fibres in Coventry, UK. Tencel is often from sustainably farmed oak, birch and eucalyptus trees with respect for the indigenous forest, and the fabric was awarded the “European

Award for the Environment" by the European Union. Bamboo Lyocell is with pure bamboo pulp; it is crushed, washed and spun into yarns. Traditional lyocell is from wood, but bamboo lyocell is a renewable plant source. Bamboo lyocell is silky, smooth and very soft. Companies using bamboo Lyocell include Ettitude in Los Angeles for their sustainable bedding . The process of making Lyocell consists of cellulose fibre from dissolving pulp using dry jet-wet spinning. The oxide used to dissolve the cellulose and set the fibre after spinning is recycled. 98% of the oxide is typically recovered. Since there is little waste product, this process is relatively eco-friendly. In 2000, CVC (Citicorp Venture Capital) sold the Tencel division to Lenzing AG, who combined it with their "Lenzing Lyocell" business but maintained the Tencel. In 2004 Weyerhaeuser Company introduced a modified kraft pulp fiber that is used to generate Lyocell fibers for textiles and non-woven products. Four years later Lenzing and Weyerhaeuser teamed up to develop lyocell-based nonwoven fabrics. In 2016, Lenzing's Tencel Denim Team, Tricia Carey, Ozturk and Michael Kininmo, launched "Carved in Blue", a blog covering the inner and innovations of the denim industry and be part of a community that has a growing environmental consciousness and creativity: stories on sustainability, trends, mills, and brands including social media channels on Instagram, Facebook, Linked In, Twitter and You Tube. Result: as of 2017, Lenzing's Tencel is perhaps the most widely known lyocell fiber producer throughout the world and is building the world's biggest Lyocell plant in Thailand. Dr Richard Blackburn, a sustainable materials expert from Leeds School of Design, believes this extraction method could be extended to other high cellulose plant by-products such as stalks, stems and leaves, to create different types of sustainable fiber. In August 2020 Tencel, the textile specialty fibre under Lenzing, has partnered with India-based textile and garment major Arvind Ltd to launch a collection of trendy, stylish sustainable workwear shirts and suiting for men. *(lenzing.com)*

Patent N° US6210801B1: 2001 "Lyocell fibers, and compositions for making ." Inventors: Mengkui Luo et al.

:Barefoot social architecture

Problem:

In 2005, an earthquake of 7.8 magnitude on the Richter scale hit the Northern Areas of Pakistan killing 80,000 people and leaving 400,000 families displaced,

Solution: earthquake-resistant shelters using locally-sourced earth, lime and bamboo

For Yasmeen Lari, the first-ever female architect in Pakistan, and co-founder of the Heritage Foundation of Pakistan, a return to traditional materials and construction techniques could help eliminate carbon emissions.

With that in mind, she has built more than 50,000 eco-friendly homes from mud, lime, stone and bamboo that aims to help victims of such natural disasters. With a team of volunteers she taught people to use indigenous materials to build better and safer, encouraging the victims to work on a self-help rather than depending on government assistance.

When in 2010 floods hit the Khyber Pakhtunkhwa and Sindh provinces, Lari diverted her attention to this area, using her knowledge of working with bamboo to make shelters with mud, lime and bamboo – all sustainable materials with a zero carbon footprint – and community centres on stilts, allowing the flood waters to flow through without any damage or harm to those sheltered within.

By 2014, 40,000 zero-carbon shelters had been constructed. Similarly, when earthquakes hit Pakistan – in the Balochistan province in 2013 and then in Shangla in the north in 2015 – Lari designed earthquake-resistant shelters using earth, lime and bamboo, tested to resist movements many times greater than the Kobe earthquake, which measured 7.5 on the Richter scale.

According to Lari, her designs also help to keep the operational carbon footprint of the building low, due to the natural insulation provided by the earth and the ventilation via the thatched roof.

:Battery

Solution:

Julio M D'Arcy and a team at Washington University in St Louis, Missouri, have managed to create a material that can be used with regular house to turn them into energy storing devices. Smart

They purchased plain from a local hardware store and converted them into energy storage devices capable of powering an LED light, by pumping them full of gases that react with iron oxide, the pigment that gives their reddish color, to create a specialized plastic that conducts electricity. In laboratory tests, a few pieces of polymer-coated lit up an LED, and based on the Washington Uni team's calculations, 60 regular sized would provide enough energy to run emergency lighting for 50 minutes, taking just 13 minutes to recharge. can be recharged 10,000 times, on par with more traditional supercapacitors, and could provide other benefits such as the ability to detect temperature or the presence of CO_2 or pH levels, which might indicate exposure to chemicals. Combine these dark blue "smart " with solar panels and a house can potentially store and distribute energy in many useful ways. Walls can act as huge batteries

Plans are under way to improve 'energy density' in the material by mixing certain transition metals into the , like manganese, and also to scale up chemical synthesis to reduce and speed up production. Other semiconductor materials will be introduced into the nanofibres to the amount of energy they can store, also forming 3D patterns to further increase the surface area.

:Battery from nuclear waste

Problem: The disposal of waste from a nuclear fission power plant should be turned into something useful.

Solution: A team of physicists and chemists led jointly by Professor Tom Scott and Dr Neil Fox at the University of Bristol grown a man- diamond that, when placed in a radioactive field, is to generate a small electrical current in a nuclear-powered battery. Unlike the majority of electricity-generation technologies, which use mechanical energy to move a magnet through a coil of wire to generate a current, the man- diamond is to produce a simply by placed in close proximity to a radioactive source. The Bristol team demonstrated a prototype ‘diamond battery’ using Nickel-63 as the radiation source. However, they are now to significantly improve micropower battery efficiency by utilising carbon-14 incorporated within the diamond battery. One available source of this radioactive version of carbon, is found in decommissioned nuclear reactors where it is generated in graphite blocks used to moderate the reaction in nuclear power plants. Extracted from waste at the Berkeley power station in Gloucestershire, Carbon-14 was chosen as a source material because it is a pure beta emitter, which is quickly absorbed by any solid material. Carbon 14 is naturally present in the ecosystem at a background level as it is easily taken up by living matter. This would only make it dangerous to ingest or touch with your naked skin if present in unnaturally large quantities, but safely held within a diamond, no short- radiation can escape. Neutron irradiated (Magnox) reactor graphite blocks form the bulk of the existing legacy feedstock. Each block contains machined ‘through-hole’ channels for accommodating fuel rods and gas cooling. The wall surfaces of these channels contain the bulk of the carbon 14 carbon which can be harvested by robots and converted into gas such as carbon dioxide and into methane. Gas centrifuges will be used to purify C14 methane and there are techniques to efficiently separate light isotopes. The UK currently holds almost 105,000 tons (95,000 tonnes) of graphite blocks and by extracting carbon-14 from them, their radioactivity decreases, reducing the cost and challenge of safely storing this nuclear waste. Radioactive material from a nuclear power plant being decommissioned in the U.K. could soon be used to create "ultra--lasting" power sources. Using carbon-14 the battery would 5,730 years to reach 50% power, which is about as long as human civilization has existed.

Neil A. Fox et al., “A theoretical study of substitutional boron-nitrogen clusters in diamond,” *Journal of Physics Condensed Matter* 30(42) · August 2018

:Battery, seawater mineral-sourced

Problem: battery materials, including metals such as nickel and cobalt, pose tremendous environmental and humanitarian risks. Cobalt in particular, which is largely available in central Africa, has come under fire for careless and exploitative extraction practices.

Solution: In December 2019, a team led by -Hye Na at IBM Research Center in Almaden in San José, California, USA announced the development of a new battery built from minerals and compounds found in seawater (magnesium, potassium, boron, strontium, fluoride etc.). It uses a cobalt and nickel-free cathode material, as well as a liquid electrolyte with a high flash point, thereby reducing flammability, which is widely considered a significant drawback for the use of lithium metal as an material. When optimized for this factor, this new battery design will exceed 10,000 W/L, outperforming the most powerful li-ion batteries available. Additionally, tests shown this battery can be designed for a cycle-life, making it an option for smart power grid applications and new energy infrastructures where longevity and stability are key.

To move this new battery from early stage exploratory research into commercial development, IBM Research has joined with Mercedes-Benz Research and Development North America; Central Glass, one of the top battery electrolyte suppliers in the world, and Sidus, a Silicon Valley battery startup to create a new next-generation battery development ecosystem. Moving forward, the team has also implemented an AI technique called semantic enrichment to further improve battery performance by identifying safer and higher performance materials. Using machine learning techniques to give human researchers access to insights from millions of data points to inform their hypothesis and next steps, researchers can speed up the rate of innovation in this important field of study. *(research.ibm.com)*

:Beach-cleaning machines

Problem: On beaches in Hong Kong, Indonesia, Saint Helena in the South Atlantic, plastics and debris piled up on their beaches. In a 2012 study, the cost to local governments to clean beaches from the 90 towns in Washington, , and California was estimated at US$500 million.

Solutions: Although plastic beachcombing and plogging is predominantly a human activity, there are also machines a good job. In the early 1960s, Harold S. Barber of Naugatuck, Connecticut explored the idea of building a prototype to clean beaches of unwanted seaweed, cigarettes, glass, shells, , stones, rocks, , and man- debris including plastic from wet and dry with ease. He named the unit the SURF Model 500. Mr. Barber's novel invention quickly proved to be the most effective tool for the emerging beach cleaning industry in the United States. Since then, Barber has sold beach cleaners around the world any other , used on six continents and in over 90 countries. The tractor-towed 600HD, weighing almost 4,000 lb (1,800 kg.) can clean up to 9 ac (3.1 has) an hour, and with a 7 ft (2 m) wide cleaning path. In the 1990s, Rockland of Bedford, Pennsylvania, developed their Beach featuring a 2.2 cubic yard hopper to debris. *(h.barber.com)*

Over in Europe, Unicorn of Torredembarra, Spain, manufacture a of six beach cleaners from the *Musketeer*, a medium-sized, self-drive sifting-type machine with a vibrating mesh for surface cleaning of small areas for cleaning small beaches to the *Magnum* with its capacity rear hopper that can unload at a height of 8 ft (2.50 m) and its operating width of 7.5ft (2.30 m.) Metaljonica in the Teramo Area of Italy EcoBeach, a *macchina puliscispiaggia*, powered by an 8.4 hp Honda GX270 unleaded petrol engine.

Until now, tractors towing beach cleaners been diesel or gasoline-engined, but with the latest developments of the battery-electric tractor, they may soon become cleaner and silent.

Totally electrically driven, the *Solarino* developed by DronyX in 2013 a remote-controlled beach-cleaning machine, developed in Montemesola in the province of Taranto, Apulia, south eastern Italy by three mechatronics engineers – Alessandro Deodati, Emiliano Petrachi and Giuseppe Vendramin. The *Solarino* includes a removable that scoops and discards debris. It can also be used to tow up to 2,200 lb (1039 kg) when the system is not attached. The *Solarino* is powered by 3 full isolated gel batteries and also by solar energy. The wide matched tread helps to optimize the traction system performance both on wet and dry sandy terrains. *(dronyx.com)*

Edwin Bos and Martijn Lukaart TechTics in the Hague, Holland, working with students from Delft University, have developed the BeachBot, a beach cleaning robot that employs an artificial intelligence algorithm to learn how to recognise scattered cigarette filters and pick up, even if they are half-buried in

the sand. This uses Microsoft's "trove" an app that connects AI developers with photo-takers worldwide to feed the robot with millions of cigarette pictures for it to recognize them.

The BeachBot had its first outing in October 2020 at the World Cleanup Day at Scheveningen Beach where it managed to clean up ten butts in half an hour of work. If in doubt, the robot made a picture of the object found and mailed it to the trove app. According to TechTics, BB will learn faster as the database grows. The company is looking to amass upwards of 2,000 images and will pay contributors for their entries.

Bee Stops

Problem:

Of the 358 bee species in the Netherlands, 56 per cent of them are currently in danger of extinction.

Solution:

The city of Utrecht in the Netherlands has launched an agenda to create a more sustainable city by 2040

Part of this has been to install green roofs on its 316 bus stops. Green roofs capture particulates, store rainwater, provide cooling when it's hot and promote urban biodiversity. All of these are beneficial for insects like bees, bumblebees and butterflies. The roofs are mainly decorated with sedum plants, as they require low maintenance. The bus stops feature LED lighting and 96 of them are outfitted with solar panels. They all have a bamboo bench. The base of the bus shelters is made of recycled concrete. The maintenance will be carried out with electric vehicles.

The city is also offering incentives to residents to transform their own rooftops into green-roofs, offering compensation to anyone with a roof over 20 square metres. Utrecht2040 also involves replacing buses with electric buses and installing solar panels along cycle paths

Beer from recycled bread

Problem: 44% of bread is never eaten and thrown away by bakeries, delicatessens and supermarkets.

Solution: Tristam Stuart, the founder of Feedback based in London, England campaigns against food waste. In December 2009, he launched a food waste campaign by organising "Feeding the 5000" in London's Trafalgar Square in which 5,000 people were served free curry, smoothies and fresh groceries from cast off vegetables and other food that otherwise would have been wasted. Stuart heard about a brewery in Belgium which uses discarded bread to brew craft ale. There is nothing new about this process. Kvass (from rye bread) although typically not strongly alcoholic has been around in Russia, etc. for at least 5 centuries. After refining the recipe with Hackney Brewery in London, Stuart then contracted with Hambleton Ales in North Yorkshire to produce it in quantities. In 2016, Tristam began selling Toast Ale at London restaurants, online and through a growing number of distributors. Using roughly one per ½ UK pint (284 ml) bottle, his team of three recycled 3.6 tons (3.3 tonnes) of bread in the first 15 months. The beer is created when surplus bread is sliced and mashed to breadcrumbs, then toasted and brewed with malted barley, hops and yeast to a quality ale with a distinctive taste of caramel notes that balance the bitter hops, giving a malty taste similar to amber ales. All profits go straight to Feedback. Toast Ale subsequently expanded nationally in the UK, and internationally to New York, with Chelsea Craft Brewing Company, in the Claremont section of the , but also in South Africa, Brazil, Iceland and Sweden. It also -sources a recipe for homebrewers. The company has received global press and won 11 industry awards, while Tristam Stuart was named at the World Economic Forum in Davos as one of 30 leaders to inspire ambition and mobilise action to reduce food loss and waste globally. Cans of Toast Ale bear the slogan “Here's to Change” and describes the contents as among other terms “tropical” and “zesty”, “planet-saving.

Bicycle, recycled plastic

Problem: Humans riding on bicycles are more energy-efficient than any other animal and any other form of transportation. Currently, two billion bicycles are in use around the world, almost 20,000,000 of which are sold annually across Europe. The most traditional material, steel, has been used for over a century, with aluminium close behind which is after all energy consumptive to smelt.

Solution: In 1998, Carlos Calabrese Muzzi, a Uruguayan artist and mechanical engineer living in Sao Paulo, Brazil began research into PET and nylon materials including plastic bottles, shampoo containers, car dashboards and kitchen trash as a source of raw material, to a plastic bicycle. It would not rust, be sturdier, flexible and cheaper. By 2008, Muzzi had found a way to integrate his molded frames with wheels, mudguards, pedals and seats, but it took four further years of testing to market the product to secure the seal of quality from INMETRO (Brazil's National Institute of Metrology, Standardization and Industrial Quality). By then a plant had been built which could in 17,000 tons (15,400 tonnes) of recycled plastic every year using it to produce 10,000 *Muzzicycles* per month in every color of the rainbow. With 200 plastic bottles into each , the process uses far less energy is required for making traditional metal frames, saving well over 5 tons (4.5 tonnes) of CO_2 emissions, although a steel bicycle will last a lifetime.

In 2020, Do Bem, manufacturer of fruit juice a promise to remove from the environment 100% of the amount of -life cartons that it produces per year, approximately 44 million. This has included the donation of 20 Muzzicycles to four ngos in Rio de Janeiro: "Champion Hug", " Development Network", "Irmãos Kennedy Community Center" and "Yes, I am from the Middle". Additonal, while with Teto and Ecolar, the polyaluminium used to Do Bem's fruit juice cartons would be recycled into glasses, tiles and floors - the last two items will be used in the construction of sustainable housing organizations. The production of a tile, for example, takes 500 boxes. Each house has 20 square meters and is with 63 sheets and 16 recycled tiles, which requires about 40,000 cartons

In 2012 after discovering the *Muzzicycle*, Carlos Seguro of Medellin, Colombia set up Eco Muévete Seguro making and marketing his bikes as *Re-ciclas*, or *Re-cycles*. Seguro then partnered with a local recycling firm, Kaptar, which operates a network of bottle collecting machines that link to smartphone applications. Bottle collectors, by depositing bottles in the machine, earn points that can be spent on benefits such as subway tokens and movie passes. Kaptar's machines in 2,000 polyethylene terephthalate (PET) bottles every day.

Now there is a waiting list of at least 2,500 people to buy a recycled bike that is custom in Sao Paulo. Muzzi is now planning to manufacture recycled child's bikes and plastic wheelchairs. *(muzzicycles.com.br)*

A. Tucker, R Catlett, “Energetic cost of locomotion in animals,” *Readings in Animal Energetics*, 1973; Carlos Calabrese Muzzi, “Recyclable polymer bicycle mold and process” BRPI1100578A2. Published 2013.

Bicycle wheel, air-purifying

Problem:

Although billions of pedal bicycles circulated around the streets of cities, towns and villages, although they do not pollute, perhaps they could capture the pollution themselves

Solution:

Kristen Tapping, a design student at London South Bank University, has designed GoRolloe, a bicycle wheel with pollution filters that uses movement to actively purify the air.

The solution consists of three parts: a tri-wheel and two circles that hold together washable and circular air filters. As the bicycle wheel rotates, GoRolloe recreates a centrifugal fan that sucks polluted air into the center of the taurus, passes it through a set of filters, and expels out cleaner air into the environment. In total, there are three filters: glass wool, capable of preventing the largest particulates and rain from reaching finer filters; a HEPA filter that helps remove particulate matter (<PM1) small enough to pass through the throat and nose and enter the lungs; an activated carbon filter can trap noxious gases and CO2.

One of the key features of GoRolloe is the low maintenance it requires. Just install it and start traveling miles.

Tapping’s concept goes beyond the wheel itself. Her idea includes an App-based reward system to entice citizens to cycle. In London, where the bike is currently in development to be on the market by 2022, the idea is to have Transport for London pay commuter cyclists to use a Rolloe wheel by giving them a free wheel or or an ongoing payment per km cycled. TFL could cover the cost of maintenance in relation to the wheel, tire and filters by connecting with local bicycle shops.

While GoRolloe is currently under development and aims to be commercially available in 2022, Tapping is researching sustainable plant-based filtering media solutions for GoRolloe such as algae.

Billion Tree Tsunami

Problem: Pakistan has lost swaths of forest to decades of felling, which makes it vulnerable to deadly flooding and landslides.

Solution: In 2014, Muhammad Tehmasip and a team from the Government of Khyber Pakhtunkhwa launched Plant for Pakistan (Plant4Pakistan) and set about planting of 1 billon trees over five years. The Billion Tree Tsunami, as it is now known, reached its goal in August 2017. On September 3, 2018, after becoming Prime Minister of Pakistan, launched a 5-year, country-wide 10 billion tree plantation drive from Makhniyal, KPK to combat the effects of AGW. This is part of the even greater initiative launched by the IUCN to restore 370 million ac (150 million ha) of degraded and deforested worldwide by 2020, and 865 million ac (350 million ha) by 2030.

Bio digital curtain

Problem: The high levels of CO_2 in cities need to be captured and stored

Solution: Dr Marco Poletto and Claudia Pasquero of EcoLogicStudio in East London collaborated with University College London, UK and the University of Innsbruck to create a digitally designed and custom- bioplastic flat photobioreactor that uses daylight to feed living micro-algal cultures and releases faint bio-luminescent shades at night. Unfiltered city air enters the curtain from the bottom, and as it travels up through the liquid in the tubes, the micro-algae within capture the carbon dioxide molecules. This process of photosynthesis also produces , which is released from the top of the unit. One curtain's ability is equivalent to a mature tree. The main material of the hardware is ETFE, a hi-tech polymer with exceptional transparency, durability, fire retardant properties and recyclability. Another beneficial by-product of the process is biomass, which the algae grow from the sequestered carbon, and which can be burnt for energy or turned into bioplastic material, such as that used to the curtain.

EcoLogicStudio's first -scale design for the Milan EXPO 2015, was an interactive pavilion containing living microalgal cultures that oxygenated air and provided shade from the sun. In 2018 an installation of bio-curtains, composed of 53 x 22 ft (16.2 x 7 m) modules and dubbed "Photo.Synth.", was installed at

the Customs and Revenue House in Dublin, during the Irish capital's Climate Innovation Summit, created in collaboration with climate-KIC, EU's most prominent climate innovation initiative. Another installation was set up outside the House of Nobility Palace in Helsinki as part of that city's Fashion Week. Here they absorbed approximately 2 lb (1 kg) of CO_2 per day, equivalent to that of 20 trees. In 2020, London will see its first Photo.Synth. on display, as part of an exhibition at The Building Centre in . Bio-curtains would to be adopted on a very scale to start making any meaningful effect. *(ecologicstudio.com)*

Marco Poletto, " Microbiology as the Key to Building the Future of our Cities" *Linkedin,* May 4, 2018.

Bio polypropylene

Problem: Because of their short lifespan as packaging, petroleum-based polypropylene (PP) and polyethylene (PE) thermoplastics end up in landfills as waste and around 20-30 years to completely decompose.

Solution: In October 2008, at BioJapan in Yokohama, Braskem of Brazil announced that after five years' research they had succeeded in producing the first green polypropylene sample using 100% sugar as a feedstock resource, which was verified in accordance with ASTM D6866. They had used fermentative ethanol production, followed by chemical conversion into ethene, dimerization and metathesis. The following year, Braskem entered into partnership with Novozymes as well as with UNICAMP and LNBio. With access to sugarcane crops in Brazil, reaching 30 million ac (12,2 million ha) in 2015. Braskem became the leading manufacturer of non fully biodegradable bio-polymers in the world.

In 2019, after considerable R&D, Neste Oyj of Finland, the world's largest producer of renewable diesel from waste and residues, and LyondellBasell of Rotterdam, Netherlands, one of the largest plastics, chemicals and refining companies in the world, announced the first parallel production of bio-based polypropylene and bio-based low-density polyethylene on a commercial scale. The joint project used Neste's renewable hydrocarbons derived from sustainable bio-based raw materials, such as waste and residue oils. The project successfully produced several thousand tons of bio-based

plastics which are approved for the production of food packaging and marketed under the names Circulen and Circulen Plus, the new family of LyondellBasell circular economy product brands.

LyondellBasell sold some of the renewable products produced in the trial to multiple customers, one of which is Cofresco, a company of the Melitta Group and with brands such as Toppits and Albal, Europe's leading supplier of products in the field of household film. Cofresco plans to use the Circulen Plus bio-based polyethylene to create sustainable food packaging materials. Other uses include textiles, bottles, Rubik's cube stickers, and even polymer banknotes. *(lyondellbasell.com)*

One of Neste's first clients was home furniture company IKEA initially for plastic boxes. As capacities improve, products will follow. IKEA is to all of the plastic used in IKEA products to plastic based on recycled and/or renewable materials by 2030.

In 2019, during the G20 Ministerial Meeting on Energy Transitions and Global Environment for Sustainable Growth in Karuizawa in Nagano, Japanese materials company Mitsui Chemicals introduced a new cost-effective production concept for bio-PP. This involves the fermentation of various biomass types, mainly non-edible plants, to produce isopropanol (IPA), which is then dehydrated to obtain propylene in a first-of-its-kind IPA method.

During the next few years, bioPP breaking down readily in sunlight is expected to generate profits in terms of revenue but also contribute to planet protection.

Pedro G. Machado et al., "Bio-based propylene production in a sugarcane biorefinery: A techno-economic evaluation for Brazilian conditions *Biofuels Bioproducts and Biorefining*, August 2016.
Eric Markl, "PHB - Bio Based and Biodegradable Replacement for PP: A Review" *Researchgate*, September 2018.

Biochar, carbon sequestering fertile soil

Problem: Ordinary soil has during the past 150 years required chemical fertilisers which are harmful to the Planet.

Solution: Pre-Columbian Amazonians are believed to used biochar to enhance soil productivity. They seem to produced it by smouldering agricultural waste in pits or trenches. European settlers called it *terra preta de Indio*. Following observations and experiments during 2006, a research team in French Guiana hypothesized that the Amazonian earthworm *Pontoscolex corethrurus* was the main agent of powdering and incorporation of charcoal debris in the mineral soil to produce tropical soil fertility. As high yield biochar can be produced through torrefaction or slow pyrolysis, unlike the conventional burning of wood or plant matter, the carbon stored up through photosynthesis is not released back into the atmosphere which has a significant effect on reducing AGW (Anthropogenic Global Warming) through the reduction of GHG (Greenhouse Gases). Livestock , with waste-feed residues and bedding materials, is a potential source of biochar.

Pro-Natura International has developed a continuous process of pyrolysis of vegetable waste (agricultural residues, renewable wild-grown biomass) transforming them into green charcoal. This fuel performs the same as charcoal made from wood, at half the cost. It represents a freeing up from the constraints of scarcity, distance and cost of available fuels in Africa. The first pilot program operated at Pro-Natura's plant in Ross Bethio, Senegal.

Research worldwide into biochar has seriously increased over the past decade, and in India specifically, the number of studies on biochar has up in the past five years. A lab at the University of Zurich is bent on understanding how biochar can be effectively used and has conducted field trials in Germany, Spain, Italy, Norway, Nepal, North America, Indonesia, Madagascar, Zambia, and importantly in India where, for over 12 years, Zurich has been collaborating with GKVK College of Agriculture and the Indian Institute of Science (IISc) in Bengaluru.

On a farm near Manjimup in south-west Australia, since 2012 beetles been with cowpats to develop biochar which is then added to the cattle's feed and reduces their methane emissions and also enriches the soil.

Genesis Industries LLC, Vega Biofuels, Inc., Phoenix Energy, Full Circle Biochar, Pacific Biochar, Diacarbon Energy Inc., Earth Systems Bioenergy, Pacific Pyrolysis Pty Ltd, Agri-Tech Producers, LLC, Biochar Supreme LLC, CharGrow, LLC, and Cool Planet Energy Systems are some of the prominent companies currently functional in the global biochar market which is expected to reach around US$ 3.82 billion by 2025.

“Putting the carbon back: is the new green,” *Nature* 442, 624-626, 2006; -François ; Stéphanie Topoliantz; Sylvain Ballof; -Pierre ; Patrick Lavelle; - ; Philippe Gaucher, "Ingestion of charcoal by the Amazonian earthworm Pontoscolex corethrurus: a potential for tropical soil fertility" *Soil Biology and Biochemistry*. 38 (7), 2008–2009*;* S.D.Joseph et al, “Feeding Biochar to Cows: An Innovative Solution for Improving Soil Fertility and Farm Productivity,” *Pedosphere* 25(5):666-679, August 2015.

:Bio-enzymatic Fuel Cells

Problem:

Digital pregnancy/ovulation tests and continuous glucose monitors for the management of diabetes are typically powered by lithium coin- or button-cell batteries, with an average of 97% of all miniature battery chemistries ending up in landfills.

Solution:

The biodegradable paper-based battery.

Jules Hammond, Rodolphe Durand-Maniclas, Jean-Francis Bloch and a highly experienced team of engineers and doctors of mechanical engineering, electronics and electrochemistry at BeFC (Bio-enzymatic Fuel Cells) in Grenoble, France have developed a paper-based, ultra-thin, and portable biofuel cell system that uses biological catalysts instead of chemical or expensive metal catalysts to convert natural substrates (such as glucose and oxygen) into electricity.

BeFC founded in 2020 sees their biodegradable compostable button battery being used to power small single-use electronic devices such as watches, TV remotes and low-power disposable medical devices. medical monitors.

BeFC is in the process of closing a VC seed round, required to scale up production toward 50,000 units per day and instate quality assurance processes. By the end of 2021, the team expects to complete the design of the production facility ready for pilot production trials in France.

Biodegradable bottles

Problem: In 1908, Dr Leo Hendrik Baekeland, Belgian- inventor experimenting in Yonkers, New York produced a synthetic shellac from

formaldehyde and phenolic which he called Bakelite. This was the world's first thermo-setting synthetic plastic. In 1912 Baekeland became President of the Bakelite Corporation with the slogan "the material of a thousand uses". While wooden and glass objects, back thousands of years, were biodegradable, *no thought had been given to how Bakelite might be recycled*. The applied to polystyrene (1930), Perspex (1934) nylon (1938), polyester resin (1948), polypropylene (1954) etc.

Solution: In 1989, Pat Gruber was tasked by his new employer, the commodity processor Cargill Inc., to find new uses for sugars. He set out to turn into plastic. Although this had been accomplished before, the plastic produced had no commercial value. Gruber ascertained that if he fermented sugar with the right lactic bacteria and distilled it, this might be a to a commercially viable biodegradable plastic. In 1990, he trialed the first ten batches with yoghurt bacteria on his kitchen stove, and produced a high-quality biodegradable plastic. By 1994, supported by Cargill Inc, Gruber had progressed to a test factory to learn how to adjust the process to the performance of the polymer for different applications. That was enough to persuade Dow Chemical Co. to collaborate as a partner. In December 1997, two years and one month after Cargill Dow was officially established, work began on building a US$3 million plant in Blair, Nebraska to produce NatureWorks PLA (poly lactic acid) polymer. The plant was up and running by early 2002, with the capacity to produce an annual 154,000 tons (140,000 tonnes) of NatureWorks PLA from 40,000 bushels of locally grown per day. Gruber's polymer was soon used for making items such as bottles. In 2002, a manufacturing facility in Blair, Nebraska began operations. It is the world's first and largest PLA facility and it supplies NatureWorks' biopolymer. The Blair facility increased its nameplate capacity and in 2013 NatureWorks sold 1 billion lb (454,000 kg) of .

In 2009 Coca-Cola invested millions of dollars in creating its PlantBottle™, which uses PET plastic that is combined with up to 30 % of plant-based material from sugar juice and/or molasses. The company sought verification from third-parties such as Imperial College, London, where a biologist performed a life-cycle analysis of the bottle and reported that the packaging reduced the CO_2 impact by 12% to 19%. A Michigan State University professor also confirmed PlantBottle's green benefits. Coca-Cola has since distributed 15 billion of the breakthrough bottles in 25 countries,

including parts of the U.S., Canada, Japan, Brazil, Mexico, Norway, Sweden Denmark and Chile. This saved 347,000 tons (315,000 tonnes) of CO_2 between 2009 and 2015.

In 2011, Coca-Cola took the first step in this collaborative innovation approach by licensing PlantBottle technology to H.J. Heinz for use in its ketchup bottles. 200 million 20 oz (500 gm) packages, which feature "talking labels" asking "Guess what my bottle is made of?" reached store shelves and foodservice counters in the U.S. and Canada.

The next generation of plant-based PET packaging – or PlantBottle 2.0 – began in December 2011, when Coca-Cola invested in three leading companies, Virent, Gevo and Avantium, to speed the commercialization of a PET plastic bottle entirely from plants. That year the company did launch a 100% plant-based bottle using a different drop-in plastic. It introduced a single-use bottle from 100% bio-based high-density polyethylene for its Odwalla juice. The material was sourced from Brazil-based chemicals and plastics company Braskem.

In 2012, Coca-Cola also teamed up with Ford, Heinz, Nike and Procter & Gamble to form the Plant PET Technology Collaborative. Together, these brands been together to pursue a 100% renewable polyester plastic solution entirely from plants for use in everything from clothing and footwear, to automotive fabric and packaging. Coke is partnering with The World Wildlife Fund (WWF) to create guiding principles for sourcing agricultural feedstocks used in PlantBottle packaging. In 2015, at the Expo Milano World's Fair, Coca-Cola showcased the world's first demonstration-scale PET plastic bottle entirely from plant-based materials. The bottles used BioFormPX paraxylene produced by Coca-Cola partner Virent.

By 2018 PlantBottle technology had been used in 60 billion packages worldwide, although Coca-Cola was accused of "greenwashing" by a Danish local environmental group called Forests of the World who claimed that the company's marketing of PlantBottle was exaggerated and misleading.

In July 2019 the Company committed to reducing the carbon footprint of "the drink in your " by 25% by 2020, compared to 2010 levels. This includes the first-ever goal targeting for the entire Coca-Cola end-to-end value chain, cutting CO_2 across its manufacturing processes, packaging formats, delivery fleet, refrigeration equipment and ingredient sourcing. Coca-Cola has calculated

that this will directly and indirectly prevent the release of 220 million tons (20 million tonnes) of CO_2 into the atmosphere.

The Plant PET Technology Collaborative is not . In Indonesia, Kevin Kumala has taken a local and cheap root vegetable called the Cassava, combining its starch with vegetable oil and resins to a compostable plastic which breaks down over a period of months on or at sea. It dissolves instantly in hot water. The inventor claims it leaves no residue, which he demonstrates by drinking the dissolved plastic. In 2014 Kumala founded Avani Eco, further innovating a material from soy and sunflower seeds with which he has ponchos. The strength of Avani Eco's bioplastic is comparable to that of normal plastic.

Javier Gomez Fernandez, assistant professor and a team at the Singapore University of Technology and Design (SUTD), researching into biodegradable building options investigated a fungus-like class of eukaryotes known as oomycetes. Their structures combine cellulose with the second-most abundant polymer on the planet: chitin, an artificial polymer from chitin, a fibrous substance which is extracted from shells of crustaceans such as shrimps. Chitin is biodegradable polymer that is antimicrobial, antibacterial, and biocompatible.

Inspired by this newly studied species of oomycetes, the SUTD team mixed small amounts of chitin with cellulose in an industrial dough mixer to create an , biodegradable composite they call Fungus-Like Additive Material (FLAM). FLAM can be 3D-printed or cast, as well as manufactured using common woodworking techniques (e.g. sawing, drilling, polishing…) and also combinations of them. *(epd.sutd.edu.sg)*

Researchers at Harvard University's Wyss Institute developed a material called Shrilk, an artificial insect cuticle from chitin (a polysaccharide) and fibroin (a protein from silk). Simply mixed together, the materials mechanical properties that reflect the average of each material and are two times the component. Shrilk could one day be used to suture wounds, and serve as scaffolding for tissue regeneration. *(wyss.harvard.edu)*

Although shrimp shells are part of the waste problem in Egypt, in collaboration with the Nile University in Egypt, bioengineers at the University of Nottingham engineered chitin into biodegradable shopping , as well as new food packaging material to extend product shelf life.

Other materials are developed. Scientists from the Centre for Sustainable Chemical Technologies at the University of Bath developed a renewable plastic from a chemical called pinene found in pine needles. In the Netherlands, Jalila Essaïdi and her team have found a way to turn manure into a bioplastic they called Mestic, which derives from the Dutch word for (‘mest’). Essaïdi was approached by the agricultural sector of the Dutch province Noord-Brabant to help find a way to deal with the surplus of the . An annual report in 2016 showed that a total of 190,600 tons (172,900 tonnes) of phosphate was produced in the Netherlands, of which 99.7 million kg. originates from cow dung.

coca-colacompany.com/sustainable-business; Kevin Desmond, *The Harwin chronology of Inventions, Innovations, Discoveries* (London, UK: Constable 1986). ; Kevin Desmond, *Planet Savers, 301 Extraordinary Environmentalists* (Sheffield, UK: Greenleaf, 2008), 242.

Biogenic material, fruit-based

Problem: Single-use plastic cups, thrown away, can over a century to biodegrade.

Solution: To biomimic fruit as a replacement, Jun Aizaki of Williamsburg, Brooklyn, founder of the firm Crème, initially tested paper, but then settled on the gourd, a fast-growing plant of the family *Cucurbitaceae*, which for centuries has been used as receptacles including pots, and bowls, and gourds, used to this day in Asia and South America. For water vessels, they are preferred over earthenware jars because they are lighter and they cool the water by evaporation. In Chinese culture, gourds were grown to hold alcohol.

In Japan watermelons are grown in little boxes so that they become square. It looks quirky and weird, but it makes them easy to pack and totransport. The idea is giving nature a little bit of a modification to form it into shapes that would be more functional. The Crème team created 3D-printed molds in several shapes to experiment with, while Aizaki planted gourds in the backyard of his home in Brooklyn so they would grow into the shape of a cup. After three summers of growing gourds, the team settled on two main shapes: a stackable cup that has geometric facets and a flask style with a smaller opening, which go by the of HyO-Cup. The finished cups are translucent, unique objects

that are 100% and biodegradable. But it takes a month for the plant to fruit, two to three weeks for the fruit to develop, and then it is finally grown enough, it takes another two to three months of sitting in the sun for the gourd to dry enough that it can be used to drink out of. Aizaki is determined to find a way of making the production process more efficient and thus more scalable. When in 2019, Crème opened their natural timber, white-painted brick and gingham fabric RedFarm eatery in West Village, New York, following with a second eatery in Covent Garden, London, Hyo-Cups were one of the features. *(cremedesign.com)*

In Mexico, Scott Munguia's Biofase Company has been making single-use cutlery and straws out of bioplastics from discarded avocado pits. This is largely due to a phenomenon called "bonus of biogenic carbon", which explains that the avocado tree, when growing, absorbs CO_2 of the atmosphere to form its tissues. This phenomenon does not occur in the production of any plastic derived of oil. It takes 240 days for Biofase's avocado seed-based bioplastic items to biodegrade in natural conditions, whether they are simply buried underground or placed in a compost pile. The avocado pits Biofase uses are byproducts of a company called Simplot's Avocado Farms, which are located in Mexico, keeping the manufacturing process . 80% of the items Biofase produces are exported to other countries (the U.S., Canada, Rica, Colombia, and Perú. Biofase also supplies straws to a few major restaurant chains, including P. F. Chang's and Chili's. *(biofase.com.mx)*

A team of scientists led by Vikramaditya Yadav, at the University of British Columbia's Department of Chemical and Biological Engineering, in a town which often has cloudy days, built a cheap, sustainable solar cell from E. coli, creating a "biogenic" solar cell. Theirs is not the first experimental biogenic solar cell, but it is reportedly different from the others and it produces a powerful current. Also, it works as well in dim light as in bright light. Previous attempts to build biogenic solar cells focused on extracting the natural dye that bacteria use for photosynthesis. This is an expensive and complicated process that uses materials and actually can harm the dye. The Canadian researchers decided to try something a little different. They left the dye in the bacteria, and tinkered with the , inducing it to produce amounts of lycopene, the dye found in tomatoes and other red fruits. They then coated the bacteria with a mineral that acts as a semiconductor, and applied the mixture to a glass surface. With the coated glass on one end of the cell acting as an , an electrode through which conventional current flows, they generated a current density much greater than

that achieved by other non-crystalline silicon prototypes in the field: 0.686 milliamps per square centimeter compared with 0.362. *(chbe.ubc.ca)*

Katharine Schwab, "Is this the disposable cup of the future? *Fast Company,* July 25, 2018.

Biomass pellets, coffee-derived

Problem: The world population drinks over 2.25 billion cups of coffee every day. With an estimated average of 11 grams of fresh ground coffee going into each cup, around 381,000 tonnes of ground coffee are brewed every year, resulting in an estimated 500,000 tonnes of spent coffee grounds, dumped into general waste and sent to landfill where they emit the greenhouse gas methane

Solution: While low volumes of spent coffee grounds are good for fertilising gardens, until the past few years, spent coffee grounds been largely overlooked as a valid, sustainable resource on an industrial scale. Founded in 2012, Bio- Ltd. in Huntingdon, UK has developed a solution to collect thousands of tons of spent coffee grounds from businesses at every scale, from leading coffee chains and transport hubs to office buildings, instant coffee manufacturers, restaurants and small independent cafés. It then converts them into sustainable biomass pellets. In 2016 Bio- launched their first consumer retail product, Coffee Logs, and are now poised to launch their first natural flavouring ingredient into the food and beverage industry.

Arthur Kay and Allan Smith, "Agricultural waste, e.g. crops, clippings, nut shells or oil pressing residues," *Bio- Ltd*, WO2017093757A1 July 8, 2017; Dr Padmapriya Rangarajan, Coffee waste management-An overview International Journal of Current Research 33(1):9-16 February 2019.

Biomaterial, sargassum-based

Problem: *Sargassum* is a genus of brown (class Phaeophyceae) macroalgae (seaweed) in the Fucales. These brown algae are potentially dangerous to health because they can accumulate on beaches to a depth of 3ft (1 m) or and then decompose, releasing poisonous gases such as hydrogen sulphide and ammonia. Since 2011, the Caribbean islands, Guadeloupe, Martinique, Saint-Martin, Saint-Barthélemy, the Dominican Republic, Barbados, and Trinidad and Tobago faced an invasion of *Sargassum* algae, which returned in 2015 and massively in 2017-2018. One method of cleaning is by spade and barrow onshore. Another is by offshore. Barrages of shallow nets floated by buoys can be used to ward off algae drifts, depending on height and current.

Solution: Several companies have found solutions to convert *Sargassum* into compostable biomaterial. Having worked in plastics manufacturing for 15 years where he specialised in the development of biomaterials, in 2010, Rémy Lucas of Saint Malo (Ille-et-Vilaine), founded Algopack to commercialise his formula for sourcing *Sargassum* powder to produce a biomaterial from which office supplies, packaging, slabs, glasses frames, mugs, caddies chips etc. are . This included finding a system to capture *Sargassum*, stabilize it and sure it does not rot during shipping from the Caribbean. With two other Breton companies, Olmix (Morbihan) and Codif (Saint-Malo), Algopack founded an acceleration company called BioAlg. Its objective is to create a worldwide chain and to structure the collection of *Sargassum*, on an industrial scale. In 2015, the company was bought by Lyreco, the European leader in the distribution of office supplies and personal protective equipment. Based in Valenciennes, the group employs 2,500 people in . *(algopak.com)*

In Quintana Roo, a Mexican state on the Yucatán Peninsula, after five years of research and development, Castro of Guanajuato founded Renovare to clothing- textile fibers and environmentally friendly footprint objects using recycled plastic and *sargassum*.

Traditionally, *Sargassum* was used as a natural fertilizer or a herbicide to improve the harvest of products like , squash, chili and . Recently, this fertilizer process has been commercialised by SUEZ, through its subsidiary SITA Verde. Supported by ADEME, in Guadeloupe, SUEZ has introduced *Sargassum* from the territory of the riverbank deposits of the Riviera du Levant in its recovery processes. *(sita-verde-suez-rv-guadeloupe.business)*

Hossein Rabhari et al. “Bio-Oil Production from Sargassum Macroalgae: A Green and Healthy Source of Energy,” *Researchgate*, January 2019.

Leaf fertilizer

Problem: Plants been transforming sunlight into things that we can use for fuel for 1.6 billion years. However, with a few exceptions, they are about 1% efficient. Solar cells do much better, but the energy produced must either be used immediately or stored in ways that can be problematic.

Solutions: In 2009, Daniel D. Nocera, the Henry Dreyfus Professor of Energy at the Massachusetts Institute of Technology (MIT) founded a startup called Sun Catalytix to develop a prototype design for a system to convert

sunlight into hydrogen which could be used to produce electricity. During the next two years, Nocera developed what he called the “artificial leaf,” a silicon strip coated with catalysts on each side. When placed in water and exposed to sunlight, the leaf splits the H_2O to release on one side and hydrogen on the other. In August 2014, Lockheed Martin purchased the assets of Sun Catalytix, and now Sun Catalytix technology is commercialized under the venture, Lockheed Martin GridStar Flow.

Soon after, Nocera was appointed Patterson Rockwood Professor of Energy in the Department of Chemistry and Chemical Biology at Harvard University, teaming up with Pamela Silver of Harvard Medical School to create the “ Leaf”. This merged the artificial leaf with genetically engineered bacteria *Ralstonia eutropha* that feed on the hydrogen and convert CO_2 in the air into alcohol fuels or chemicals. The first model that used the nickel-molybdenum-zinc alloy created a reactive species that destroyed the bacteria's DNA. Abnormally high voltages were used to prevent the microbes from dying, but they also resulted in reduced efficiency. An improved model removed the nickel-molybdenum-zinc alloy catalyst and allowed the team to reduce the . The new catalyst improved the efficiency of producing alcohol fuels by nearly 10%. The Leaf operates at solar-to-biomass and solar-to-liquid fuels efficiencies that greatly exceed the highest solar-to-biomass efficiencies of natural photosynthesis.

With this system, *Xanthobacter* bacteria which pull nitrogen from the air and use the bioplastic, which is basically stored hydrogen, to drive the fixation cycle to a bacteria-laden yellowish liquid that can be sprayed fields. In greenhouse experiments at the Arnold Arboretum, radishes grown with this *X. autotrophicus* fertilizer ended up double the size of control radishes grown without added fertilizer. But the real proof is in the radishes. The researchers used their approach to grow five crop cycles. The vegetables receiving the -leaf-derived fertilizer weigh 150% the control crops. In 2018, Nocera founded a second company called Kula Bio, to focus on the development of renewable and distributed crop fertilization and restoration. When mass-produced, these tiny solar “carbon-negative” fuel factories could be inexpensive enough for everyday people to use to power their vehicles and run their lights and appliances. Farmers with a small on-site array of leaves could create enough fertilizer for their own needs instead of buying container-loads of synthetic fertilizer produced at sprawling CO_2-spewing factories and shipped for thousands of miles.

Daniel D Nocera and Dilek K Dogutan,"Artificial Photosynthesis at Efficiencies Greatly Exceeding That of Natural Photosynthesis," *Accounts of Chemical Research* 52(11) · October 2019.

Bioplastic for building automobiles

Problem: Vehicles in steel and aluminum which are to extract, must be taken to a scrapyard for an energy-expensive process involving crushing, then shipping off to a recycling center where they are shredded and separated into small pieces, which are then sorted into various metals.

Solutions: In the early 1940s, Henry Ford experimented with making plastic parts for automobiles. These experiments resulted in what was described as a "plastic car from soybeans." Based on the work of Afro-American scientist/ botanist Washington Carver, the "Soybean Car" was unveiled by Henry Ford on August 13, 1941 at Dearborn Days, an annual community festival. The exact ingredients of the plastic panels are unknown because no record of the formula exists today. On the other , the Trabant automobile of which several million were between the 1950s and about 1990, had most of its body panels from phenol-formaldehyde reinforced with cotton. The average life of these cars was 30 years.

Sixty years later, in 2001, Deborah Mielewski, the Senior Technical Leader of Materials Sustainability at Ford Motor Company's Research and Innovation Center in Dearborn, Michigan, initiated the biomaterials program. Her team was the first to demonstrate soy-based foam that met all the requirements for automotive seating, enabling Ford to include the product first on the 2008 Mustang, then in every Ford North American-built vehicle. Ford Research's next step was to look at the fruit. The blue cactus *tequilana* has spiked leaves and a round, fleshy (the piña) and grows in the hot and arid regions of Mexico and the Southwestern United States. The leaves are chopped off and the is cooked and crushed to create juice, which is fermented and distilled to tequila. Jose Cuervo the best-selling tequila in the world. As of 2012, Jose Cuervo sells 3.5 million cases of tequila in the US annually, and a fifth of the world's tequila by volume. Ford teamed up with Jose Cuervo to bioplastics from fibre waste that otherwise must be burned or sent to the landfill, for use in vehicle interior and exterior components such as wiring

harnesses, bins and HVAC units. This could cars lighter and improve fuel economy.

Debbie Mielewski at Ford has also teamed up with fast food chain McDonald's to incorporate coffee chaff — coffee skin that comes off during the roasting process — into the plastic headlamp housing used in some cars. The coffee version is sustainable because it is lighter and does not use the talc which, as a mineral, is not renewable. Coffee chaff, on the other , is widely available. McDonald's also achieved its goal of sourcing all of its US coffee sustainably, one year ahead of schedule, and is also with competitors to develop environmentally friendly coffee cups. *(corporate.ford.com)*

In Poland, at the Gdańsk University of Technology in Wroclaw County Selena, a research group led by Wojciech Komala, is turning to plants that are not used in the human food chain as a potential source of eco-friendly plastics.

One environmental benefit of 3D printing is the ability to print items anywhere, even in a store or at home. This theoretically could significantly reduce the need to transport items and therefore lower the emissions associated with that transportation. Unlike subtractive manufacturing, 3D printing uses the material it needs when layer by layer is added so reducing waste, while it is also capable of reusing plastic waste.

Using 3D printing, automobile dashboards and other interior components could soon be from Tytan which has been protected by patents in Poland, Germany, and Great Britain. In Japan, a research team led by Professor Hiroyuki at Kyoto University is working on nanocellulose, a wood pulp material for automobile door panels, fenders and car hoods, a material as as steel, but 80% lighter. The team chemically treats wood pulp, which consists of millions of cellulose nanofibres (CNFs), and disperses these CNFs into plastic. *(rish.kyoto-u.ac.jp)*

Researchers at Oak National Laboratory () in Tennessee spent a lot of time with unique 3D printing materials, such as polyester, lignin and nanocellulose. In 2019, a new research collaboration between and the University of Maine's Advanced Structures and Composites Center aims to increase efforts to use nanocellulose as 3D printing materials. Together, the team will work with the forest products industry to create new bio-based 3D printing materials that can be used to products for building components including automobiles. One of their partners is American Process Inc. with its

nanocellulose product BioPlus, at the company's plant in Thomaston, Georgia. already used their "Big Area Additive Manufacturing" (BAAM) a fused deposition modeling (FDM) 3D-printer, in collaboration with Cincinnati Incorporated to print the full-sized, National Harbor Strati electric car in conjunction with Local Motors in Phoenix, Knoxville, and National Harbor. The car took just 44 hours to print during the 2014 International Manufacturing Technology Show in Chicago, Illinois. The printing was followed by three days of milling and assembling. After the car was printed, the mechanical and electrical parts such as battery, motors, and suspension were manually assembled, with the completed car first test-driven on September 13, 2014. Local Motors also located to Tempe, Arizona where they teamed up with IBM's Watson IoT's AutoLAB to release the self-driving Olli shuttle bus. Local Motors has also set up localized micro-factories in Phoenix, Las Vegas, National Harbor, and Berlin, which design and manufacture automobiles in the regions they serve. This has helped the company achieve a small-, on-demand business model, so they can keep a small footprint while on big ideas such as the Olli bus, that the potential to redefine existing industries. *(.gov)*

In 2014, Mitsubishi Chemical Corporation announced the development of a new of high-performance, high-transparency bio-based engineering plastic called DURABIO™, for use in touch panels on automobiles, using plant-derived isosorbide as its raw material. *(m-chemical.co.jp)*

Filament; Axel Barrett, "First Car Completely From Bioplastics"

Bioplastic for building

In 2018, Eindhoven University of Technology researchers created the first car completely out of bioplastics. The Bioplastic car was named *Noah* and weighs 794 pounds (360 kg) without batteries, approximately half the weight of a regular car. The batteries weigh 132 lb (60 kg). The chassis is from sugars, the body is from polylactic acid (PLA) and the car is weather-proof. *(tue.nl)*

Over in Friesland and Omrin, the Netherlands, in August 2019, 10XL of Dordrecht teamed up with Frisian waste management company Morssinkhof in the creation of a 3D printed sloop out of recycled polypropylene. The 20ft (6m) boat was printed by a robotic arm with six axes, taking around 24 hours to

create. It belongs to the municipality of Súdwest-Fryslân. Now that the company has or less perfected the design, they are planning to a ship building factory in Friesland. Two months later, the University of Maine's Advanced Structures and Composites Center used the world's largest prototype polymer 3D printer to create the 25 ft (7.6 m), 5,000 lb (2,268 kg) ship, dubbed *3Dirigo*. At the end of the event, the team tested the seaworthiness of its boat in UMaine's Alfond W2 Ocean Engineering Laboratory, which features a multidirectional and a high-performance wind machine. If pushed to its limits, the 3D printer can create objects up to 100 ft. , 22 ft. wide, and 10 ft. high.(30m x 6.7m x 3 m) *(composites.umaine.edu)*

Bioplastics News, July 9, 2018 ; "Frisian companies helping create 3D printed boat from recycled plastic," *The Northern Times*, August 12, 2019.

Bioplastic, cellulose-based

Problem: Much bioplastic uses sugar and molasses. But some reason that with a burgeoning global population, such vast plantations should be precision-farmed to provide food and that other sources should be used.

Solutions: In 2008 a team lead by John A. Bissell and Makoto N. Masuno started up Micromidas in West Sacramento, California to develop 95% plant-based polyethylene terephthalate (PET) plastic, from waste biomass feedstocks, such as old corrugated cardboard (OCC), sawdust, and wood chips, that do not divert resources or from food production for human or animal consumption. Since non-food ("gen-2") plant-based feedstocks do not compete with food production, Micromidas's proprietary chemistry turned C-6 cellulose into four isolated building- chemicals in one chemo-catalytic step, with almost zero carbon loss. In March 2017, changing its name to Origin Materials, the Sacramento startup joined with Danone and Nestlé Waters to form the NaturALL Bottle Alliance. The consortium released a report claiming that they had successfully produced samples of 80% bio-based PET at pilot-scale. The partners selected a site in Sarnia, Ontario, and commenced construction of a demonstration-scale plant, which was expected to be fully operational by 2020. Officials in Sarnia-Lambton had already been working in recent years to promote the community as a site for bio-chemistry companies. Montreal-based BioAmber opened a plant in Sarnia in 2015 where it makes the building-chemical succinic acid from corn syrup. Comet Biorefining, a company

originally based in London, Canada, was planning to build a plant in Sarnia to turn and wheat waste stalks into sugar for industrial customers. Materials prepared to pay sawmills in the area US$20 a ton for the scraps left over in the process of turning logs into lumber. In September 2018 beverage firm PepsiCo joined the NaturALL Bottle Alliance. construction is complete, the partners expect to produce 95% bio-based PET and subsequently achieve full commercial-scale.*(originmaterials.com)*

Another firm using tree cellulose is VPZ (Verpackung Zentrum) in , Austria. Since the 1990s the family enterprise of Helmut and Susanne Reininger has specialised in biogenic packaging from alginsulate foam, biopolymers from agricultural waste materials and net packaging from cellulose natural fibres. Packnatur®, their tear-resistant and wet-proof tubular netting first appeared on supermarket shelves in December 2012, when REWE first used it for their Ja! Natürlich products, such as fruit and vegetables. The packaging has also been used by HOFER (the Austrian ALDI) for their "Zurück zum Ursprung" (Back to the Roots) and "Natur aktiv" since 2013. Since November 2017, the Packnatur cellulose netbag has been on the shelves of the Swiss Coop supermarket chain. The main raw material is FSC-certified beech wood, which is a by-product of forest thinning in central Europe, and which is converted to cellulose fibres by Lenzing AG, using a CO_2-neutral process in with the strictest environmental standards. In addition, the feature a wooden drawstring stopper, which is also from beech wood and turned in a local workshop. *(vpz.at)*

VPZ also developed labels in association with IM Polymer GmbH, Lenzing Plastics GmbH & Co. KG and the Vegetable Growers Association, Marchfeldgemüse. They avoided the use of the thermal paper, due to the controversy around bisphenol A. and even thought about the print on the labels. The Packnatur® wineglass labels are printed for EAN-Code and identification using thermal (carbon ribbon) printing.

Patent N°: 10414742 "Methods of producing alkylfurans" John A. Bissell, Makoto N. Masuno et al.

Bioplastic material by carbon capture

Problem: Carbon capture should be turned to something useful.

Solution: Markus D. Herrema, founder of NewLight Technologies of Huntington Beach, California has found a way to use a specially developed micro--based biocatalyst (similar to an enzyme) to turn waste gas captured from air into a bioplastic called AirCarbon, a naturally-occurring biopolymer that can match the performance of oil-based plastics and out-compete on price. The biocatalyst pulls carbon out of methane or carbon dioxide from farms, water treatment plants, landfills, or energy facilities, then combines it with hydrogen and to synthesize a biopolymer material. AirCarbon can be used in extrusion, blown film, cast film, thermoforming, and injection molding applications to products, including cases and furniture.

Herrema, who graduated magna cum laude High Honors from Princeton University with a Bachelor of Arts degree in Politics and Political Theory, with additional work in Physics, Mathematics, and Chemistry, founded NewLight in 2003. He was assisted by Kenton Kimmel in the design, scale-up, and optimization of the company's gas-to-plastic technology, including the engineering, construction, commissioning, and optimization of the Company's production lines, as well as the detailed engineering of Newlight's commercial production facility.

Since commercial scale-up in 2013, Newlight has developed commercialization relationships with Dell, Sprint, Virgin, KI, HP, and The Body Shop. In 2015, Newlight executed a 19 billion pound off- agreement with Vinmar International as well as 10 billion pounds in licensed production. The following year, Paques Holdings in Balk, the Netherlands entered into a 15-year technology license agreement that would allow Paques to manufacture, process, and sell bioplastics based on Newlight's proprietary GHG to AirCarbon™ conversion technology, at a of up to 1.4 million tons (1.3 million tonnes) per year.

recently, Newlight launched Covalent, the very first fashion accessories from greenhouse gases. There are thus handbags, wallets and sunglasses.

The company is also developing a tool to let customers know exactly how much carbon is in the products they buy. Mark and Kenton's current plant can capture the equivalent of the emissions of 6,000 cars. A number that Mark would like to multiply by 200!

In recognition of Newlight's technological and commercialization achievements, Newlight was awarded "Innovation of the Year" by "Popular

Science” in 2014, "Technology Pioneer" by the World Economic Forum in 2015, "Technology Excellence Award" by “PC Magazine” in 2014, "Company of the Year" by CleanTech OC in 2014, "Biomaterial of the Year" by the Nova-Institute in 2013, and an R&D 100 Award as “one of the 100 most significant innovations of the year" in 2013.

newlight.com; "Newlight Produces AirCarbon at Commercial Scale," *Environmental Leader*, 30 January 2014; Bogo, Jennifer; Gertz, Emily, "Plastic from Thin Air," *Popular Science,* 285 (6): 024, December 2014.

Bioremediation

Problem: Since the iconic 1969 oil well blowout in Santa Barbara, California, there been at least 44 oil spills, each over 10,000 barrels (420,000 gallons), affecting U.S. waters. On March 24, 1989, the oil *Exxon Valdez* hit Prince William Sound's Bligh Reef in Alaska, spilling 40.9 million litres (11 million gallons) of crude oil over 1,000 miles (km of shoreline. It is thought to be one of the worst man environmental disasters ever. But three years later the worst oil spill in history, the Gulf War oil spill spewed an estimated 8 million barrels of oil into the Persian Gulf after Iraqi forces opened valves of oil wells and pipelines as they retreated from Kuwait in 1991. The oil reached a maximum size of 101 miles by 42 miles and was five inches .

Solution: Bioremediation is the use of mainly microorganisms, plants, or microbial or plant enzymes to detoxify pollutants into non- substances is a process used to treat contaminated media, including water, soil and subsurface material, by altering environmental conditions to stimulate growth of microorganisms and degrade the pollutants.

The breakthrough in 1972 when M Robinson, assistant county petroleum engineer for Santa Maria, California successfully used microbes to clean out the fuel tanks on the *RMS Queen Mary*, the start of implementing bioremediation towards contamination sites. This was improved by Ananda Chakrabarty, an Indian American microbiologist, who carried out performed bacterial genetics to the pollutant-eating bacteria into a single “super-bug” *Alcanivorax borkumensis*, that would eat multiple components of oil. Following the *Exxon Valdez* spill, cleanup by physical methods such as skimming the water and spraying the rocky shore with detergents was used first, and the result dispersed about two-thirds of the oil. Then the genetically engineered bacteria and other bacterial strains were added to consume the remaining oil. Because bioremediation became a

prototype in the almost never-ending oil spill cleanup sites since, it has involved interactions within scientific researchers all over the world Provided that proper nutrients are present, an oil spill that was estimated to be cleaned by natural conditions in 5-10 years could be cleaned in 2-5 years with the use of bioremediation.

Daniel J. Kevles, "Ananda Chakrabarty Wins a Patent: Biotechnology, law, and Society, 1972-1980", *Historical Studies in the Physical and Biological Sciences,* Vol. 25, No. 1 (1994), pp. 111-135

Biotransformation

Problem: Biodegradable solutions faltered in the past, largely due to the creation of microplastics, lack of compatibility with recycling systems, and confusion from consumers around the recycling of packaging.

Solution: Led by Niall Dunne, Polymateria Ltd, currently based at Imperial College London's I-HUB, has come up with a solution designed to trigger a chemical conversion which attacks the structure of commonly used plastics. As developed by Graham Chapman, Christopher Wallis and Gavin Hill, Polymateria's biotransformation technology (or additive) converts the hydrocarbon backbone of a plastic product which has escaped a recycling facility, into an oligomeric material in two ways: It breaks up / cuts the links in the polymer chain to produce smaller wax-like oligomeric and discrete chemical compounds, i.e. reduces the molecular weight. Then it chemically transforms the super-hydrophobic hydrocarbon polymer backbone into a hydrophilic bacteria and fungi material capable of interaction with the natural environment, fully biodegrade within two years, leaving behind no microplastics.

In October 2019, Polymateria announced a partnership with Clariant, one of the world's leading speciality chemical companies. The ambition of the partnership is to Biotransformation technology to market in South East Asia, the main global source of "fugitive" plastic, which is plastic that escapes. into the natural environment. In July 2020, Polymateria received £18.9 m (£15 million) in funding from impact investing platform Planet First Partners (PFP) to fund the roll-out its 'biotransformation' technology. Sportswear group Puma will be using Polymateria's additive in the production of 160 million plastic it uses each year which will be on in Southeast Asia in 2021. *(polymateria.com)*

Graham Chapman, Christopher Wallis, Gavin Hill, “Degradable polymer and method of production,” *Patent N° 20190309147* October 10, 2019.

Biowaste composter, accelerated

Problem: The conventional composting of biowaste is slow.

Solution: In the early 1990s, John Webb of Macclesfield, Cheshire, England, wanting to speed up the composting process on his smallholding, developed a machine that could treat his garden waste and and turn it into highly nutritious compost in just 14 days. closely with DEFRA (The Department for Environment, Food and Rural Affairs) after the 2001 foot and mouth crisis, Webb and his son Simon continued to develop the machine to ensure it was fully compliant with the Animal By-Products Regulations to safely treat other wastes, including food waste. They founded Tidy Planet to build and commercialise a machine they called the *Rocket.* It comprises a continual flow system with waste being mixed with dry woodchip for compost production. The capacity of the electrically-powered Rocket of machines goes from 154 gallons (700 liters) up to 3.9 tons (3.5 tonnes) per day. Tidy Planet expanded its globally-acclaimed of Rocket composters, with the creation of the B1400, a machine specially-commissioned for its French distributor: Alexandre Guilluy and Fabien Kenzo of Les Alchimistes needed equipment that would process up to two tonnes of a mix of food and shredded wood wastes every day – in with the site’s waste processing threshold. Les Alchimistes a fleet of trailer bicycles and small which go around Paris collecting food waste from supermarkets, restaurants, and hotels across the French capital. This is assembled at Lil’O known locally as L'Île-Saint-Denis an island in the River Seine, 6 mi (10km) north of The Eiffel Tower where it is turned into compost, to be sold to agriculture and gardening. Due to the project’s resounding success, Les Alchimistes has received support from the French Government and EU funding to set up similar food waste collection centers in Lyon, Toulouse, Toulon, and Marseille, each of them using Tidy Planet’s B1400 Rocket.

In China, another solution dealing with food waste is to feed it to cockroaches *(Blattodea)* which then become either feed for livestock or for curing and peptic ulcers, skin wounds and even stomach . At one farm, run by Li Yanrong in the Zhangqiu District, over 1 billion cockroaches are consuming some 55 tons (50 tonnes) of kitchen waste every day. Elsewhere in Sichuan, a

company called Gooddoctor is rearing 6 billion cockroaches, while Shandong Qiaobin Agricultural Technology Co., in Jinan plans to set up three such plants, aiming to process a third of the kitchen waste produced by Jinan, home to about seven million people.

tidyplanet.co.uk. Food Wastes as a Potential New Source for Edible Insect Mass Production for Food and Feed: A review *Fermentation* 5(3):81 · September 2019.

Birdsafe Glass Ornilux

Problem: Billions of birds are killed annually following collision with the of glass used in modern buildings.

Solution: One company, German-based Arnold Glas, patterns its Ornilux bird protection glass with an ultraviolet-reflective coating. Birds can see the coating, but it is virtually invisible to humans. In the 1990s Dr. Alfred Meyerhuber, a German attorney with a personal interest in birds and science read an article in a magazine about orb weaver spiders and their use of *stabilimenta*. Orb weaver spiders, common worldwide, build their distinctive webs using strands of silk with UV reflective properties. Meyerhuber was good friends with -Joachim Arnold, the President of Arnold Glas, a manufacturer of insulated glass products headquartered in Remshalden, Germany. As a business , Arnold was motivated by technical and environmental challenges and looked for ways to set Arnold Glas apart from its competition. When Meyerhuber brought the orb weaver spider's strategy to his attention, Arnold was intrigued. Despite initial resistance by the board of directors, he convinced the company to undertake the necessary research and put his company to work developing a product that would the UV-reflecting qualities as spider silk.

Arnold Glas's Head of Research and Development, Christian Irmscher, led the technical product development of ORNiLUX. The coating was developed together with technicians at Arnold Glas's sister company, Arcon, located in Feuchtwangen, Germany, which specializes in thin low-e and solar coatings for architectural glass. The companies tested different coating types and patterns. The researchers found that a patterned coating (versus a solid coating) the contrast of the glazing intense: the coated parts reflected UV light while the interlayer sandwiched between two layers of glass absorbed the UV light. The two functions together enhanced the reflective effect. Although the

specific pattern of a spider's web inspired the solution, Irmscher and his team had to design a unique pattern for the window coating in to the application process practical. After patenting the transparent UV coating in 2001, Arnold Glas introduced ORNiLUX SB1 Bird Protection Glass, its first commercial product using the technology, in 2006. The vertical lines of UV-reflective coating used in this product were sometimes perceptible but very subtle and not visually distracting.

Three years later, the company introduced an improved second-generation product, ORNiLUX *Mikado*. The name refers to the crisscrossed UV pattern of the design and comes from the German name for the game of pick-up sticks . The new pattern and improved coating of *Mikado* is nearly invisible to the human eye. Independent pre-market testing by the Max Planck Institute for Ornithology in Radolfzell, Germany, demonstrated that ORNiLUX windows are highly effective at protecting against bird strikes.

The first project in the USA to use ORNiLUX was at the Center for Global Conservation at the Bronx Zoo and was completed in 2009. The architects specified ORNiLUX SB1 for the entire building, but in the end it was used in a corner conference room that had the biggest risk of bird strikes. An ongoing monitoring program has noted a dramatic difference between the portions of the building with and without the bird- glass. A year later, Munich's Hellebrunn Zoo used ORNiLUX Mikado in the design for a new outdoor polar bear exhibit. Due to the zoo's location near the Isarauen Nature Reserve, which harbors wild kingfishers, bird collisions were a significant concern. The zoo had other outdoor glass enclosures with a history of bird strikes, and previous attempts to use hawk silhouettes and bamboo plantings to protect the birds had failed. ORNiLUX Mikado was used for the polar bear enclosure and pelican house. Zoo officials were pleased to find a solution that did not visitors' views of the animals and noted in the first months after it was installed that no birds had collided with the glass. Ongoing testing of existing and new configurations continues with American Bird Conservancy's Flight Tunnel Test Facility located at the Carnegie Museum Powdermill Nature Reserve in Rector, PA. Additional tests are conducted with a flight tunnel facility in Rybachy, Russia.

At the American Institute of Architects Expo in June 2019, Arnold Glas debuted new oversize production capabilities for its bird-safety glass, ORNILUX. It is now offered in a maximum size of 126 x 472 in (320 x 1200 cm).

arnold-glas.de. Arnold Glas, “A Biomimcry Study”, *Synapse by Biomimcry 3.8*, 2017; Centre Luxembourgeois De Recherches Pour Le Verre Et La Ceramique (C.R.V.C.) Sarl patent 2014 “Ig window unit for preventing bird collisions” WO2015183681A1; Daniel Klem Jr and Peter G , “Evaluating the Effectiveness of Select Visual Signals to Prevent Bird-window Collisions” *The Wilson Journal of Ornithology* 125(2):406-411, June, 2013.

Birdwatcher AI

Problem: Solar facilities kill tens of thousands of birds every year, and no one is quite sure why. In 2016, a first-of-its-kind study estimated that the hundreds of utility-scale solar farms around the US may kill nearly 140,000 birds annually. That is less one-tenth of one percent of the estimated number of birds killed by fossil-fuel power plants (through collisions, electrocution, and poisoning), but the researchers

Solution: In 2020, the US Department of Energy awarded a team of researchers at National Laboratory in Illinois a $1.3 million contract to develop an artificial intelligence platform dedicated to studying avian behaviour at -scale solar facilities around the US. Using and adapting a camera system designed to monitor pedestrians and cars, the team is planning to mount the AI bird watcher on top of a solar . In this way they are able to gather data to help help ornithologists unravel the mystery of why our feathered friends are dying in droves at solar farms. (*anl.gov*)

Victor Tangermann,“Scientists Are Using an “AI Bird Watcher” to Solve a Solar Farm Bird Massacre Mystery,” *futurism*, August 10, 2020.

Board games Planet-oriented

Problem: The manufacturing of a board is not environmentally friendly. It uses power, raw materials and chemicals just such as most manufactured products and it may concentrate on abstract concepts such as “Sorry” or “Snakes and Ladders”.

Solutions: In 1996, following the success of his first board Bioviva, - Thierry Winstel of Montpellier, decided to create a of question-and-answer-themed educational games for family and children that would awareness of respect for nature in an eco-design approach. They must be exclusively in , so reducing CO_2 emissions related to their shipment and linked to an eco-design approach i.e. paper, cardboard and FSC-labelled wood and plant-based inks, respectful of people and the environment. This approach, unique in the

publishing sector, allowed Bioviva to constantly improve its production methods and to reduce its ecological footprint ever . The games are offered at attractive prices, in to them accessible to the greatest number. One popular product is a board called “Nature Challenges” where children Tomorrow’s the incredible diversity of animals and try to protect them on 5 continents. Added to their board and card games, Bioviva launched “Nature Challenges” books. Bioviva has produced 2.5 million copies of "Nature Challenges", translated into various languages and sold in 13 countries. In February 2018, on the occasion of the 10th anniversary of the Nature Challenges card Bioviva announced the launch of the Défis Nature club, a 12- promotional magazine including gifts (cards, posters) andcontests.

Alongside Bioviva, other games encourage players to focus on our Planet. “Earthopoly” is inspired by the “Monopoly” board which since 1935 has been translated into 47 languages, played in 114 countries and has sold 275 million copies. To play Earthopoly, a player chooses their token (an object from nature) and starts at "Go Green." Players increase their property value by collecting Carbon Credits and them in for Clean Air. But try to avoid getting sent to the Dump! Such as Bioviva’s “Nature Challenges”, not is Earthopoly a about the earth it is entirely eco-friendly itself as the pieces are either by nature or completely recyclable, the ink is vegetable oil-based, with the box from 100 % recycled Chip board. All the paper is recyclable and is with 10 % recycled pulp that comes from a mill that purchases pulp that is monitored by a responsible third party forest management group. Green Power was purchased for the electricity used to manufacture the paper for the box (renewable energy in the form of wind, hydro, and biogas).

While TDC Games produces “The Green ” for 2 to 6 players, with its coasters growing actual wildflowers, Global Horizons Ltd. produces “Envirochallenge - The Ultimate Challenge for the last Endangered Species MAN.” “Ethica”, based on the principles behind the collaborative ethical investment group Reseau Financement Alternatif, lets up to 27 players assume the of an investment or venture capitalist and see how well their green intentions stand up in the world of international finance. “Wildlife Web”, inspired by Pokémon card games, created by Montana-based author and educator Thomas J. Elpel, is a dynamic ecology strategy that engages players to experience what life is such as for a red-tailed hawk or yellow-bellied marmot for food, raising and defending against predators. It gets players' animals to cooperate or compete with one another.

(bioviva.com)

“Borgs”

Problem:

Since 2007, methane gas concentrations began to rise due to greater wetland production in a warming world, although this remains a of debate.

Solution:

Australian-born Jillian F Banfield FRS and researchers at the Microbial Research initiative within the Innovative Genomics Institute, of University of California, Berkeley have discovered a never-before-identified DNA structure that encourages soil bugs to eat methane, a potent greenhouse gas. These structures – which have been named “Borgs”, after the aliens from the TV show *Star Trek* – are thought to live inside a bacterial host, because they appear to be unable to fend for themselves. They are comparatively large – about one-third the size of the host's own DNA, which is stored in a single chromosome.

The scientists took samples of muds in California wetlands. and sequenced all the DNA to see what they could find, then they had to fit the sequenced DNA together like a puzzle. In addition to its own chromosome, a bacterial microbe often has short sections of DNA, known as plasmids, floating around its cell. But these are a lot shorter than the newly discovered Borgs.

The discovery could help scientists to better understand how methane is created in waterways and rice paddies. Ultimately, the knowledge could be used to ensure agricultural fields favour cells with Borgs, to minimise methane production.

Bottle-recycling machines

Problem: Bottles thrown away can end up in landfills or in Nature.

Solution: From May 1999, Norsk Resirk launched a deposit return scheme for plastic bottles and aluminum beverage which has led to 97% of all

plastic drinks bottles in Norway recycled, 92% to such a high standard that they are turned back into drinks bottles. Norway's model is based on a scheme, which when a consumer buys a plastic bottle, they are a small additional fee equivalent to about 13 to 30 US cents. The scheme is to all consumers who can either a bottle or can to a reverse vending machine which returns the money after scanning the verifiable barcode of the deposited bottle, or they can return it to various small shops and gas stations for cash or store credit. These shop owners also receive a small fee for each bottle they recycle, and some it has even increased their business. Three processing plants were opened to receive the bottles, one in Fetsund outside Oslo to handle approximately 80% of what is collected in Norway. First step in the process is out the aluminum and steel . Next step is separate out clear and light blue bottles. Then follow the coloured bottles. Some of the material has been recycled 50 times. The company is now called Infinitum. All the materials are then structured into ballots and sent further for recycling: metals go to the company Norsk Hydro in Holmestrand, Norway; PET bottles are sent to Cleanaway AB in Sweden. Nevertheless, even in Norway, there is room for improvement. During the year, Infinitum estimates that 150,000 bottles will not be returned, and if they had, it would saved enough energy to power 5,600 households for the year. The system is now used in neighbouring Sweden, Denmark, and Germany and a number of US and Canadian states. There are ten states in the United States with container deposit legislation, popularly called "bottle bills" after the Bottle Bill (established since 1971), the first such legislation that was passed. Container deposit legislation (CDL) also known as a Container Deposit Scheme (CDS) was first implemented in South Australia in 1977 and has since been extended all over that contient.

In 2017, DB Breweries in New Zealand built a machine which pulverizes glass bottles then turns them into fine-grain substitute building sand in just 5 seconds. Two thirds of the world’s beaches are retreating as people across the world use non-renewable beach for construction, roading and other uses. There were even some beaches in New Zealand where they were taking the off one beach and putting it on another beach, which seemed crazy to DB. All a drinker needs to do is deposit his or her bottle in the machine, a laser triggers a wheel of small steel hammers spinning at 2,800 rpm to crush it into 7 oz. (200 gm.) of in five seconds. After extracting the plastic labels and silica with two vacuum systems, the is then processed through a screener which sorts it into a between 1.1 – 0.4mm particle sizes. In several months, a fleet of these machines recycled 100 tons of , which is the equivalent of 500,000 DB Export Bottles. Until

recently about 11,000 ton (10,000 tonnes)of glass at Visy Recycling in Auckland could not be recycled, so, rather have it diverted to landfill, it now goes into the industrial beer bottle machine.

The resulting substitute was then given to their construction and retail partners to use in place of beach . Finding partners for the program was a critical step in achieving scale for the project. The brewer has finalized a two-year deal to supply DB Export Beer Bottle to DryMix, which is New Zealand's biggest producer of bagged concrete, leading to a new solution of eco-concrete, sold to consumers through the country's biggest home improvement chain. Beer Bottle is now used by Downer in road-making projects, commercial and residential construction, and even golf bunkers and resurfacing projects, and Drymix, which has created a ''super easy eco concrete'', available through Mitre10. In 2018, DB Export's beer bottle was combined with recycled ink toner cartridges to an aggregate for resurfacing the 430,000 ft² (40,000m²) Queenstown Airport apron, the first project of its kind. Requests for machines arrived from as far away as Dubai, with scoping to supply 500 machines currently underway. DB's trucks carry the slogan "Drink DB Export. Our Beaches." *(db.co.nz)*

Eik and Andreas Brekke, "Interactive product development in recycling systems – A study of the Norwegian deposit system for PET bottles," Conference Paper, January 2003.

:Bowls from coconut shells

Problem: 99% of harvested coconut shells are discarded and burned. In the process, the shells release harmful carbon dioxide and methane gasses, and they're burning in the millions.

Solution:

In 2019, when Maria Kuriakose quit her job at a social enterprise in Mumbai, India, a on visit a old coconut oil mill in Thrissur, Kerala, she noticed that the shells or copras were being discarded as waste. Investigating further, she learned that a few businesses use them to make activated charcoal, otherwise they are burned as fuel. Several artisans around Kerala had once used the shells to make ladles for serving food but this was a dying-out craft.

This gave Maria an idea for a business she named Thenga. Its aim was to bring natural coconut shell products from Kerala to consumers such as Mumbai or New Delhi keen to move towards a sustainable living. These could range from designer smoothie bowls and other products such as hanging planters, candle holders, teacups and even cutlery.

She spent a few months understanding how the shells were sorted and how the final product is made, using machinery to scrub the outer and inner parts of the shell to give it a smooth finish. As she did not want to put in a large investment on purchasing machinery just for doing a trial run, her 65-year-old father, Kuriakose Varoo, a retired mechanical engineer, was able make a low-cost version of the machine. Once the artisans had the machinery, they only needed to be briefed on what kind of shells to use to maintain the size of the bowls and rather than use any chemical-based product, they would use coconut oil instead of varnish for the final coat of polish.

By the end of 2020, Thenga had four sizes of bowl, the smallest one being 150ml priced at Rs 250 and the largest being 900 ml used for serving salads priced at Rs 950. Engraved on the outside “For Earth’s Sake”.

Brigantine for plastic fishing

Problem: Plastic waste needs to be fished out of the before it breaks down into irretrievable microplastic.

Solution: In 1979 Mary T. Crowley founded Inc., an international yacht chartering business that offers a full of services, including educational sailing program., sailing vessels, expedition ships, motor yachts and scuba and snorkeling program all over the world. At the time Crowley started , Inc. she started Institute, a nonprofit institute that has a mission of preserving the maritime arts and sciences, the environment and island culture.

In 2008, Crowley founded Project Kaisei, bringing together a team of innovators, scientists, environmentalists, lovers, sailors, and sports enthusiasts with a common purpose: to study the North Pacific Gyre and the debris that has collected in this region, to determine how to capture the debris and to study the

possible retrieval and processing techniques that could potentially be employed to detoxify and recycle these materials into diesel fuel. Their first research expedition in the summer of 2009, on board a 140ft (43m) sailing brigantine S/V *Kaisei,* was critical to understanding the logistics that would be needed to launch future clean-up operations and testing existing technologies that had never been utilized under conditions. From 2011, sometimes twice a year, Mary Crowley and volunteers from the Ocean Voyages Institute set out on S/V *Kaisei* from Hawaii to clean up trash floating in the . During 2019, the brigantine's pulled out 40 tons (36 metric tons) of abandoned fishing nets as part of an effort to rid the waters of the nets that entangle whales, turtles and fish and damage reefs. The ship returned to Honolulu, where 2 tons (1.8 tonnes) of plastic trash were separated from the haul of fishing nets and donated to local artists to transform into artwork to educate people about plastic pollution. The rest of the refuse was turned over to a zero emissions energy plant to incinerate it and turn it into energy,

oceanvoyagfesinstitute.org. -François Tremblay, "Mining The Sea Of Plastic," *Chemical & Engineering News,* August 17, 2009 Volume 87, Number 33; Mary T. Crowley, "Project Kaisei & Institute," *Bayarea Science*, May 23, 2017.

Building, algae-nourished

Problem: Founded by Sir Ove Arup in 1946, Arup of London has over 14,000 staff based in 92 offices across 35 countries and is well known for iconic buildings such as the City of Manchester Eti Stadium (2002), the Allianz (2005), Beijing National Stadium (2008), Donbass (2009) and the Singapore Sports Hub (2014). These buildings were constructed in conventional single-use concrete and steel.

Solution: In 2012, Arup teamed up with Splitterwerk Architects of , Austria, Colt, and Strategic Science Consult to design and build a five-storey 15-apartment residential building in Hamburg, covered by panels filled with algae, a fast-growing form of biomass. The panels are 98 in. x 28 in.x 0.78 in. , (2m50 x 0.9m x 1.8 cm) and cover about 2,150 ft² (200 m²) on two south-facing sides, also providing internal shading. The micro-algae growing in the glass louvres provide a clean source of renewable energy. Called *Solar Leaf*, the building pumps water, nutrients, and compressed CO_2 between 129 "bioreactors." These bioreactors four glass layers. The two inner ones have a 6 gall (24-li) capacity

cavity for circulating the growing medium. Either side of these, insulating argon-filled cavities help to minimise heat loss. The glass consists of white - reflective glass, while the glass on the back can integrate decorative glass treatments. Compressed air is introduced to the bottom of each bioreactor at intervals. The gas emerges as air bubbles and generates an upstream water flow and turbulence to stimulate the algae to in CO_2 light. At the time, a mixture of water, air and small plastic scrubbers washes the inner surfaces of the panels. *SolarLeaf* integrates all servicing pipes for the inflow and outflow of the culture medium and the air into the frames of its elements. When the sun shines, the algae multiply as a result of photosynthesis. The system collects the residue, then converts it to biogas, which is burned in a boiler. Together with a heat recovery system and solar panels on the roof, the building is completely energy independent. The system can be operated all year round. The efficiency of the conversion of light to biomass is currently 10% and light to heat is 38%. For comparison, PV systems an efficiency of 12-15% and solar thermal systems 60-65%. The flat photo-bioreactors are highly efficient for algal growth and need minimal maintenance. The building, also called BIK, completed in 2013, was part of Hamburg's International Building Exhibition. *(arup.com)*

In 2015, Guglielmo Carra of Arup Berlin with Kasper Jørgensen of GXN Innovation in Copenhagen, developed *BioBuild*, the first self-supporting façade out of bio-composite materials. Developed as part of the €7.7 million EU-funded BioBuild program, the design reduces the embodied energy of facade systems by 50% compared to traditional systems with no extra cost in construction. The 13 ft x 7.5 ft (4m x 2.3 m) is from natural flax fabric and bio-derived resin from agricultural processing of , sugar and other crops. Intended primarily for commercial offices, the glazing unit features a parametrically-derived faceted design, and comes prefabricated ready for installation. The is also designed to be easy to disassemble, making it simple to recycle at the end of its life. The won the JEC Award 2015 for the best composites innovation in the construction field. *(gxn.3xn.com)*

In 2017, Arup published a report entitled "The Bio-Loop: Growing, Making and Regenerating" in which it demonstrates that a different paradigm for materials in construction is possible. The report highlights the following matter products already available: peanut, , banana and potato.

The use of fruit and vegetable for making recyclable products is highlighted in other entries in this book.

Vicente , “SolarLeaf. Algae bio-reactive façade,” *morethangreen.es;* Kasper Guldager Jørgensen, “GXN: Building Networks for Collaborative Research on Materials in Architecture,” *Architectural Design* 81(6) November 2011; Arup *The Bio-Loop: Growing, Making and Regenerating*, Milan: Arup. (2017),

Bus electric (production models)

Desmond 06 should go here

Problem: The three million diesel-engined buses circulating in the world, account for for nearly half of all nitrogen oxides (NOx) and two-thirds of all particulate matter (PM) emissions from US transportation sources. Its composition often includes hundreds of chemicals, including sulfates, ammonium, nitrates, elemental carbon, condensed compounds, and even carcinogenic compounds and heavy metals such as arsenic, selenium, cadmium and zinc.

Solution: In 2018, there were about 425,000 electric buses in service in the world's cities. Almost all—99 % of them—were in China. Arguably the first commercial li-ion electric bus was developed by Mr Lu Guanqiu at the Wanxiang Electric Vehicle Company (WXEV). The company traces its origins to the creation of a repair shop for agricultural machinery in 1969 in the people's commune Ningwei. In 1979, a factory for agricultural machinery was created. Then in 2000, WXEV bought a li-ion battery company and three years later they were running a prototype li-ion bus on Y9 around West , Hangzhou City. By 2009, a fleet of these had clocked up 350,000 mi. (560,000 km) on this and WXEV had delivered buses to major cities in China, including Shanghai, Hangzhou, Guangzhou, Zhengzhou, Nanchang, etc. They also supplied 100% electric buses to the 16th Asian Games, held in Guangzhou in 2010 while at the Shanghai Expo 2010, Wanxiang deployed 160 buses, each with 65 seats and 300 batteries, on two 8.6 mi (14km) lines, each capable of a of 50 mi. (80km). The additional batteries were in a hall and by robots in 6 minutes.

There will be 1.5 million electric buses in use worldwide by 2030, according to the International Energy Agency Europe. Every five weeks, 9,500 new electric buses take to the roads in China: that is the equivalent of the entire London bus fleet. A number of cities in the Europe’s Nordic region such as Oslo,

Trondheim and Gothenburg also electric buses in operation. 1.6% of all city buses in Europe are electric. In the US, it is about 0.5%.

Alongside the biggest manufacturer, BYD, other electric bus manufacturers include Proterra, Alexander Dennis Ltd., New Flyer, VDL, Heuliez, Solaris, Irizar, Mercedes-Benz, etc.

(byd.com). Anna Hirtenstein, "Electric Vehicles on the Road Are Set to Triple in Two Years," *Hyperdrive Bloomberg*, 30 May 2018.

Cactus as biofuel

Problem: Crops such as , sugar , soybean and palm oil, which up 97% of biofuels worldwide, are often grown in monocultures. This takes up that could otherwise be used to produce food, destroys habitats and leads to less balanced ecosystems. It also leads to intense pressure on water resources, and has been linked to drought.

Solution: Wayland , head of Elqui Global Energy in Santiago, Chile argues that 'an of cactus produces 43,200 m3 of biogas or the equivalent in energy terms to 25,000 liters of diesel. In the year 2000, Elqui Global built the first biogas plant using nopal cactus (prickly pear) as the biomass. Nine years later, in the Naucalpan de Juárez Area of Mexico, Rogelio Sosa Lopez who had already succeeded in the - tortilla industry, teamed up with Miguel Ake who had been experimenting with Nopal cactus as biofuel to found Nopalimex. Nopal crops produce between 330 and 440 tons (300 and 400 tonnes) of biomass per hectare in less fertile lands, and up to 880 – 1,100 tons (800-1,000 tonnes) in richer soils. Nopal also requires minimum water consumption and its waste, if properly processed, can be turned into biofuel. First, the cacti are cut and processed to extract flour, which is used to make tortilla chips. The remaining inedible scraps of the plant are mixed with cow dung in a bio-processor, a fermentation that heats the wasted cactus pulp. Then the fuel is distilled from the remaining liquid and collected via tubes and into a . While Nopal biofuel produces enough fuel for the buildings that process all parts of the nopal plant in a sustainable way, a commitment has been signed with the local government of Zitácuaro, in the state of Michoacan, to provide official vehicles, from police cars to ambulances, with cactus-based fuel with world's first cactus-based biogas refueling station selling at 2 pesos (US$ 0.61) per liter since March 2018. With the amount of Nopal growing in Mexico, this biofuel could eventually

replace the traditional use of gas and fuel of non-renewable sources. *(nopalimexgasyenergia.com)*

Taciana do Nascimento Santos et al. “Potential for biofuels from the biomass of prickly pear cladodes: Challenges for bioethanol and biogas production in dry areas,” *Biomass and Bioenergy* 85:215-222 · February 2016; Gerardo Espinosa Garza et al., “Production of nopal-based biogas,” *Proceedings of the 2018 IISE Annual Conference.*

Canal-top solar power

Problem: India is a -scarce country – there is so much for an economy of 1.3bn people. Then there is the high population density – an average of 464 people per square kilometre. In Gujarat, India, some 9,000,000 litres (2,000,000 imperial gallons; 2,400,000 US gallons) of water would evaporate annually from the Narmada canal network while of the villages alongside did not access to electricity.

Solution: To use the State’s 19,000 km (12,000 mi) network of Narmada canals across the state for setting up solar panels to generate electricity. In April 2012, Narendra Modi, then Chief Minister of Gujarat, inaugurated a 1 Megawatt (MW) pilot project to be built on the Narmada branch canal near Chandrasan village of Kadi taluka in Mehsana district by SunEdison India. The project virtually eliminated the requirement to acquire vast tracts of , limited evaporation of water from the 750 metres (2,460 ft) canal and providing electricity to a small village of 40 homes with thatched walls and tin roofs. The system was called canal-top solar. Its success led to the first -scale canal-top solar power plant in the Vadodara district of Gujarat in 2015, at a cost of $18.3 million. Since the first solar canal project, a number of others been commissioned in India, including a 100MW canal-top solar power project atop the branch canals off the Narmada River, stretching for a distance of 40km, at an estimated cost of 1bn Indian rupees. Overall, Gujarat has 80,000km of canals meandering through the state. According to Gujarat State Electricity Corporation, if 30% of this were converted to canal top solar, 18,000MW of power could be produced, saving 90,000 acres of .

Asha Sajimon and Chacko, “Design of reflectors for a canal top solar power plant,” *Conference: 2017 IEEE International Conference on Intelligent Techniques in Control, Optimization and Signal Processing (INCOS);* "NGujarat's canal-top solar power plant: 10 must-know facts". *The Economic Times of India*. 10 April 2013; Kalpana Sunder, “The ‘solar canals’ making smart use of India’s space,” *bbc.com*, August 4, 2020.

CO2 calculators

Problem: A method was needed to measure the total greenhouse gas (GHG) emissions caused by an individual, event, organization, service, or product, expressed as carbon dioxide equivalent so people would become of the damage their were .

Solution: In 1996, William E. Rees and his PhD student Swiss- Mathis Wackernagel at the University of British Columbia, Canada published their solution for calculating this in a book "Our Ecological Footprint", now available in English, Chinese, French, German, Hungarian, Italian, Japanese, Latvian, and Spanish. Wackernagel went on to set up a Global Footprint Network, an international sustainability think tank with offices in Oakland, California; Brussels, Belgium, and Geneva, Switzerland. The think- is a non-profit that focuses on developing and promoting metrics for sustainability.

For calculating personal carbon footprints, several online carbon footprint calculators are now available. These websites ask you to answer or less detailed questions about your diet, transportation choices, home size, shopping and recreational activities, of electricity, heating, and heavy appliances such as dryers and refrigerators, and so on. The website then estimates your carbon footprint based on your answers to these questions. Here are just some:

carbonfootprint.com); *carbonstory.org;* *coolclimate.berkeley.com*

footprintnetwork.org; *footprint.wwf.com*, *resurgence.org*

CO_2 capture

Problem: When humans first started burning fossil fuels on an industrial scale in the 19th century, Earth's atmosphere contained about 280ppm of CO_2. The intervening years have seen that concentration above 410ppm, alongside a corresponding global average temperature increase of 1°C. There is virtually blanket scientific consensus that atmospheric CO_2 is the root cause of this rapid AGW, and that humanity must stop burning fossil fuels to halt it. Recently, however, there has also been growing consensus that decarbonisation on its own will not be enough. Removing CO_2 from the atmosphere is a crucial condition to achieve climate goals: to hit the 2C , we would need to remove 11 billion tons (10 billion tonnes) of CO_2 every year from 2050 onwards. If the goals set out in the 2016 Paris Agreement are to be met, scientists – including those at the Intergovernmental Panel on Climate (IPCC) – believe that CO_2 must be actively removed from the atmosphere.

Solutions: Less natural, but no less interesting, is the method of direct air capture (DAC), whereby CO_2 is extracted from the atmosphere using man-technology. Several DAC systems are in operation, in Iceland, in Switzerland, In Canada and in the USA.

In 2006, CarbFix was initiated jointly by the Icelandic President, Dr Ólafur Ragnar Grímsson, Einar Gunnlaugsson at Reykjavík Energy, Wallace S. Broecker at Columbia University, Eric H. Oelkers at CNRS Toulouse (), and Sigurður Reynir Gíslason at University of Iceland to limit GHG emissions in Iceland. Before the injection into subsurface basalt started in CarbFix, the consensus within the scientific community was that it would decades to thousands of years for the injected CO_2 to mineralise.

During the first 6 years of the project, the main focus was to optimize the method through lab experiments, studies of natural analogues, and characterization of the CarbFix pilot injection site, often referred to as the CarbFix1, located 0.6 mi (3 km) SW of the Hellisheidi power plant in south-west Iceland. Design and construction of gas capture, injection and monitoring equipment was carried out simultaneously. From January to March 2012, 193 tons (175 tonnes) of pure CO_2 were dissolved and injected into subsurface basalt at about 1600 ft (500 m) depth at about 35°C, and from to August, 73 tonnes of 75% CO_2-25% H_2S gas mixture from the Hellisheidi geothermal plant were injected under the right conditions. Research results published in 2016 would indicate that 95% of the injected CO_2 had been solidified into calcite within 2 years, using 25 tonnes of water per of CO_2.

Following the success of the pilot injections, the process was scaled up to industrial scale at Hellisheidi geothermal power plant, with injection of 65% CO_2-35%H_2S gas mixture at about half a mile (800 m) depth and about 230°C at the Husmuli injection site, located 1 mi (1,5 km) northeast of the power plant. The injection has been an integral part of the operation of the Hellisheidi Power Plant since 2014. In 2016, the injection operations at the Hellisheidi Plant were scaled up again, doubling the amount of gases injected. In 2017, 10,000 tonnes of CO_2 were "digested" by CarbFix The injection is ongoing today and at the end of 2018, approximately 37,500 tons (34,000 tonnes) of CO_2 had been captured and injected at Hellisheidi. At current capturing capacity, approximately 1/3 of the CO_2 and about 3/4 of the H_2S emissions from the plant

are re-injected, or approximately (11,ooo tons (10,000 tonnes) of CO_2 and about 6,000 tonnes of H_2S annually

Reykjavik Energy had supplied the initial funding for CarbFix. Further funding has been supplied by the European Commission and the Department of Energy of the United States. In addition to finding a new method for permanent carbon dioxide , another objective of the project was to occupy scientists for years of work to come. Several universities and research institutes participated in the project under the scope of EU funded sub-projects, including Amphos 21, Climeworks and the University of Copenhagen. Recently carbon capture and approach has been upscaled at Hellisheiði and ongoing research is implementing this approach at other sites across Europe, thanks to the ubiquity of basalt which covers most of the floors and around 10% of the continents. areas are to be found in Siberia, Western India, Saudi Arabia and the Pacific Northwest.

In 2019, A Letter of Intent was signed between the Prime Minister of Iceland, Reykjavík Energy, the Aluminium and Silicon Industry in Iceland (Elkem, Fjarðarál, PCC and Rio Tinto), the Ministry for the Environment and Natural Resources, the Ministry of Industries and Innovation and the Ministry of Education, Science and Culture for exploring further exploitation of the CarbFix method for emitters in Iceland was signed in Reykjavík. The companies will each look for ways to realize carbon neutrality in 2040, as stated in the announcement from the Government Offices. *(carbfix.com)*

Gunnarson, I., Aradottir, E. S., Oelkers, E., et al, "The rapid and cost-effective capture and subsurface mineral of carbon and sulfur at the CarbFix2 site" *International Journal of GHG Control*, Volume 79, pp. 117-126(2018); Gislasson, S.R., Sigurdardottir, H., Aradottir, E.S., Oelkers, E.H. A brief history of CarbFix: Challenges and victories of the project's pilot phase. *Energy procedia*, (2018) Volume 146, pp. 103-114.;

CO2 Capture: Solution 2

In Switzerland, Christoph Gebald and Jan Wurzbacher, engineering students at ETH Zürich, developed a concept of a modular CO_2 collector as well as a prototype for their Masters degree in Renewable Energy. It involved that would in the air and bind carbon molecules into filters. In Hinwil, Zurich, with funding

from the European Union to partner with Reykjavik energy Climeworks' plant with its 18 units was capable of capturing 900 tonnes of CO_2 in a year directly from the air, enough to grow vegetables in a nearby greenhouse. Its technology is based on a cyclic capture-regeneration process using a filter of porous granulates modified with amines. suck in atmospheric CO_2 that chemically binds to the filter's surface. saturated, the filter is then heated to around 100°C, releasing high-purity gaseous CO_2. According to Climeworks, the filters can operate for several thousand cycles before needing to be replaced. In 2016, Climeworks,having announced participation in four leading European CO_2 conversion projects (Kopernikus Power-to-X, STORE&GO, and Celbicon), was chosen as one of 20 companies to present its technology as a potential solution to meeting climate targets at the COP22 UN Climate Conference 2016 in Marrakech. In 2017, having built the production infrastructure with a capacity of hundred CO_2 collectors per year, Climeworks commissioned the world's first commercial-scale direct air capture plant. In 2020, Climeworks attracted US$30.8 million in a private funding round to up its production to hit its ambitious plans of capturing 1 % of annual CO_2 emissions by 2025. In August 2020, Climeworks, Carbfix and ON Power agreed to build a new plant at the Hellisheidi Geothermal Park in Iceland to significantly scale-up carbon removal and . The plant will on a reliable supply of renewable geothermal energy to power Climeworks' DAC technology. Their is to remove ,000 tons of carbon dioxide directly from the air every year and store it deep beneath the ground in Icelandic basalt. *(climeworks.com)*

Carbon Engineering (CE) in Calgary, British Columbia, Canada takes a different approach of converting a 1 ton concentrated CO_2 (Direct Air Capture) into 1 barrel of clean liquid fuel per day. CE grew from academic work conducted on carbon management technologies by Professor David Keith's research groups at the University of Calgary and Carnegie Mellon University. Founded in 2009, a scalable pilot plant in Squamish, B.C was built and developed. CE is privately and is funded by investment or commitments from private investors and government agencies. CE's investors include Bill Gates, Murray Edwards, Oxy Low Carbon Ventures, LLC, Chevron Technology Ventures, and BHP. CE has been well supported within the clean-tech innovation system and has led projects funded by top-tier government agencies in both Canada and the USA. *(carbonengineering.com)*

Global Thermostat, a privately funded carbon capture company located in Manhattan, New York was founded in 2010 to developed a DAC system where based sorbents are bonded to porous, honeycomb ceramic “monoliths” which act together as carbon . These carbon efficiently adsorb CO_2 directly from the atmosphere, smokestacks, or a combination of both. The captured CO_2 is then stripped off and collected using low-temperature steam (85-100° C), ideally sourced from residual/process heat at little or no-cost. The output results in 98% pure CO_2 at standard temperature and pressure. During the process steam and electricity are consumed, without the creation of emissions or other effluents. This entire process is mild, safe, and carbon negative. GT plants would be completely modular – from a single 50,000 /yr. Module to a 40-Module, 2MM / yr. Plant, and larger – a GT plant grows by adding modules. In 2019, ExxonMobil Research and Engineering Company and GT signed a joint development agreement to examine the scalability of GT’s DAC system. If technical readiness and scalability is established, pilot projects at ExxonMobil facilities could follow. *(globalthermostat.com)*

The Texas Clean Energy Project (TCEP) near Odessa, USA, is developed by Karl E. Mattes and a team at Summit Power Group in Seattle to build of the world’s first Integrated Gasification Combined Cycle (IGCC) green-field natural gas-fired clean-coal power plant. TCEP is designed for 90% carbon capture, which is projected to be 2.7 million tons of CO_2 per year. The potential carbon captured by the plant will be used for enhanced oil recovery in the West Texas Permian . *(summitpower.com)*

In July 2019, a team at the RFF-CMCC European Institute on Economics and the Environment (EIEE) explored the use of DAC in multiple computer models. It showed that a “massive” and energy-intensive rollout of the technology could cut the cost of limiting AGW to 1.5° or 2°C above pre-industrial levels. But the study also highlighted the “clear risks” of assuming that DAC will be available at scale, with global temperature goals breached by up to 0.8C if the technology then fails to deliver. DAC should be seen as a “backstop for challenging abate ment” where cutting emissions is too complex or too . *(eiee.org)*

The $20 million NRG Carbon XPRIZE is a global competition to develop breakthrough technologies that will convert CO_2 emissions from power plants and industrial facilities into valuable products like building materials, alternative fuels and other items that we use every day. This four-and-a-half-year global

competition challenges teams to transform the way the world addresses carbon dioxide (CO2) emissions through breakthrough circular carbon technologies that convert carbon dioxide emissions from power plants into valuable products. In April 2018, at Bloomberg New Energy Finance's *Future of Energy Summit* in New York City, ten finalists were chosen from a field of 27 semi-finalists by an independent judging of eight international energy, sustainability and CO2 experts. Each took home an equal of a $5 million milestone prize. One of these the University of California, Los Angeles, developed their Carbon Upcycling UCLA system to siphon half a ton of CO_2 per day from the Dry Fork power plant's flue gas and produce 10 tons of concrete daily. Together with four other finalists, including CarbonCure, a Canadian startup making greener concrete, and Carbon Capture Machine, a Scottish venture focused on building materials, UCLA competed in Wyoming, while another five teams competed at a natural gas plant in Alberta, Canada. After Wyoming, the teams must dismantle their systems and haul them to Wilsonville, Alabama where they must repeat a three-month pilot at the National Carbon Capture Center, a research facility sponsored by the U.S. Department of Energy.

Jan Wurzbacher et al. "Heat and mass of temperature-vacuum swing desorption for CO_2 capture from air" *Environmental Science & Technology* January 2016; Giulia Realmonte et al. "An inter-model assessment of the of direct air capture in deep mitigation pathways" *nature communications*, July 22, 2019. Jeffrey Ball, "Inside 'Project Odessa,' an experiment in greener fossil-fuel power," , March 16, 2020.

CO_2 by carbonation of recycled concrete

Problem: Cement production is a major source of CO_2 in the world (5 - 7% of total emissions). On the other , a amount of recycled concrete from the deconstruction of buildings and structures is available while natural resources need to be preserved. Although recycled concrete aggregates (GBR) can already be used in concrete by adjusting the mixes, they exhibit greater porosity, higher water absorption and slightly degraded mechanical properties.

Solution: For almost a decade, Ifsttar (French Institute for Science and Technology in Transportation, Planning and Networks) has been searching for a method to store CO_2 by the carbonation of recycled concrete. the Accelerated Carbonation of Recycled Concrete Aggregates (ACRAC) project ended in 2013, five years later a new project was launched called FastCarb. In this, Ifsttar has been with IREX (Institute for Applied Research and Experimentation in Civil Engineering) and MTES (Ministry of Ecological and Solidarity Transition). The

aim of FastCarb is to store CO_2 in GBR in an accelerated , to improve the quality of these aggregates by blocking porosity and ultimately to reduce the CO_2 impact of concrete in the structures. This would recover about 20% of the CO_2 initially released during the manufacture of a given concrete, i.e. 88-132 lb per cubic ft (40 to 60 kg per m^3).

ifsttar.fr. R.V. Silva et al. "Carbonation behaviour of recycled aggregate concrete," *Cement and Concrete Composites,* 62 · June 2015.

CO_2 capture by seaweed

Solution: Much of the world's seaweed is produced in sea-based farms off the coasts of China, Indonesia, the Philippines, South Korea and Japan. With a global production of 19 million (17.3 million tonnes), seaweed aquaculture is second in volume to the farming of freshwater fish. A new study conducted by scientists at UC Santa Barbara found that if 9% of the world's surface were used for seaweed farming, this would sequester 58 billion tons (53 billion tonnes) **of CO_2** from the atmosphere. This is just from the absorption of carbon during the growing process. What makes seaweed a particularly appealing carbon sink is its growth : about 30 to 60 times the of -based plants. Grown in these quanities, seaweed may be used for the reduction of methan in cows, edible water bubbles, drinking straws and other non SUP materials.

Antoine de N'Yeurt et al., "Negative Carbon Via Afforestation" *Process Safety and Environmental Protection* 90:467-474 · November 2012 University of the South Pacific.

CO_2 Capture & (CCS), sub seabed

Problem: CO_2 is captured, it needs to be stored.

Solution: In January 2019, the Norwegian authorities the Northern Lights CCS Project, a full-scale pilot CCS, carried out by Equinor (former Statoil), Shell and Total, a permit to exploit an area in the North Sea for CO_2 injections. The partners aim to capture CO_2 at three plants in Southern Norway, liquefy it, and transport it over 430 mi (700 km) by ship to a hub near Kollsnes. From there, the CO_2 will be sent offshore via a pipeline for injection

into a depleted well in the Johansen formation, about 20 miv(30 km) offshore from mainland Norway. The three plants selected for CO_2 capture are Yara's Ammonia plant in Porsgrunn, Norcem's cement factory in Brevik, and the Fortum recycling plant in Oslo. After completing feasibility studies for CO_2 capture in 2018, the plants are presently compiling FEED studies for the final investment decision, to be taken by the Norwegian Parliament in 2020/21. The Northern Lights CCS Project is supported by CLIMIT, Norway's national research programme for accelerating the commercialisation of CCS. CLIMIT aims to reach an annual CO_2 capture capacity of 1.4 million tons (1.3 million tonnes) by 2022. In May 2020 Equinor, Shell and Total an initial investment of $680m (NOK 6.9bn) between them into the Northern Lights (CCS) project. The project will capture industrial and imported carbon dioxide (CO_2) emissions to be injected into reserves from a terminal in Øygarden, on Norway's west coast. *(northernlightsccs.com)*

Tip Meckel at the Bureau of Economic Geology, The University of Texas at Austin and Philip Ringrose, an adjunct professor at the Norwegian University of Science and Technology and geoscientist at the Equinor Research Centre in Trondheim, calculated that the geological injection of CO_2 into 10,000 to 14,000 injection wells worldwide in the next 30 years, would meet the IPCC's goal of using CCS to provide 13 % of worldwide emissions cuts (6 to 7 gigatons of CO_2) so achieving emissions cuts under the 2°C scenario by 2050. *(beg.utexas.edu)*

Another first-time licence, allowing offshore exploration to select a site for storing CO_2 underground, has been by the UK Oil and Gas Authority (OGA), in December 2018. The holder of the licence is the Acorn CCS project, led by Pale Blue Dot Energy Ltd. and centred on the St Fergus Gas Plant in northeast Scotland. The project aims to capture220,000 tons (0.2 million tonnes) of CO_2 from flue gases annually, for in depleted gas fields, beneath the North Sea. Instead of creating new infrastructure, existing offshore gas pipelines shall be repurposed to transport CO_2 in the opposite direction. In January 2019, the project estimated the available offshore capacity at 700 million tons (650 million tonnes) of CO_2 and suggested that the neighbouring port at Peterhead could be used to import 16 million tonnes of CO_2 for per year by ship, from the UK and Europe. Before starting CO_2 injections, the Acorn project needs to apply for a permit from OGA, as soon a site has been selected. In December 2018, the British government

announced financial support for the project (£0.17 million). Earlier British CCS projects such as the Scottish Peterhead Project did not obtain public funds, after completion of the FEED studies. *(-blu.com)*

At the end of April 2019, a research vessel left the Scottish coast to reach the Goldeneye Gas Platform, an abandoned offshore platform in the North Sea, about 60 mi (100 km) northeast of Peterhead. A central part of the STEMM-CCS (Strategies for Environmental Monitoring of Carbon Capture &) project is a sub-seabed CO_2 release experiment. 3.3 tons (3 tonnes) of CO_2, augmented with inert chemical tracers, will be injected below the seafloor at the Goldeneye experimental site. The experiment aims to test CO_2 leak detection and leak quantification with help of chemical sensors. The project receives funding from the European Union's Horizon 2020 research and innovation programme.

This initiative is supported by an analaysis by a team of scientists led by Jonathan Scafidi and a team of scientists at the School of GeoSciences, University of Edinburgh of the Beatrice oilfield, 15 mi. (24 km) off the north-east coast of Scotland. Using a computer model, the team calculated that over a 30-year period, the scheme would be around 10 times cheaper decommissioning the Beatrice oil field, which is such likely to cost US$ 340 million. The study, published in the International Journal of Greenhouse Gas Control, was completed as part of the University of Edinburgh's GeoEnergy MSc. programme. *(ed.ac.uk)*

"Geoengineering Developments: Carbon Capture, Venture Capital and Would-be Megaprojects," *geoengineeringmonitor.org,* May 15, 2019; P. S. Ringrose & T. A. Meckel, "Maturing global CO_2 resources on offshore continental margins to achieve 2DS emissions reductions." *Scientific Reports* volume 9, Article number: 17944 (2019).

CO^2 recycler for craft breweries

Solution: Josh , founder and president, Hops and Brewing in Austin, Texas, has set up Earthly Labs with Amy to commercialise CiCi, a plug-and-play carbon capture technology for craft brewers. The craft brewing industry represents one small scale opportunity with nearly 20,000 emissions sources representing 500 million metric tons or annually. CO2 is one of the five key ingredients in beer making, with hops, malt, yeast and water. Brewers also use CO2 to carbonate and package their beer, commonly purchasing it from a third-party provider, which creates a closed loop recycling opportunity. CiCi is

uniquely designed to capture carbon dioxide waste from smaller sources such as businesses, homes, and transportation that up half of all carbon dioxide emissions. The beer-making process emits carbon dioxide (CO_2), and yet small breweries need to purchase commercial CO_2 to carbonate and package their beer. Earthly Labs' goal is to capture one billion tonnes of CO_2 as fast as possible. *(craftbrewingbusiness.com)*

Carpooling

Problem: Four to six-seater privately automobiles are seldom full, creating massive traffic holdups and emitting amounts of GHG.

Solution: Carpooling or ridesharing, (French covoiturage) consists of two or persons driving together in a privately vehicle. It first became prominent in the United States as a rationing tactic during World War II. It returned in the mid-1970s due to the 1973 oil crisis and the 1979 energy crisis. At that time the first employee vanpools were organized at Chrysler and 3M. Recently, however, The Commuter Benefit system linked to the Internet has facilitated growth for carpooling and the commute mode has grown to 10.7% in 2005. In 2007 with the advent of smart phones and commercially available GPS, computer programmers John Zimmer and Logan Green, from Cornell University and the University of California, Santa Barbara respectively, rediscovered and created carpooling system called Zimride. This was a precursor to Lyft launched in the summer of 2012 which operates in 640 cities in the United States and 9 cities in Canada. It develops, markets, and operates the Lyft mobile app, offering car rides, scooters, and a bicycle-sharing system. In China, since Didi Chuxing set up a carpooling service called Hitch in Beijing, Harbin, Taiyuan, Shijiazhuang, Changzhou, Shenyang and Nantong, it has clocked a billion rides of trips less 31 mi. (50 km.) in metro areas between 5am and 8pm for female users. users can enjoy the service till 11pm.

Due to the COVID19 pandemic, provided social distancing and mask wearing are observed, carpooling, -in- with public transport systems, will be most effective when all the vehicles involved are zero emission electric.

Katie Warren, "Zimmer, went from organizing carpools on college campuses to running a -hailing company worth $29 billion," *businessinsider.com,* March 29, 2019; Manish Singh, "China's Didi to relaunch Hitch carpooling service this month," techcrunch, November 6, 2019.

Cell components, biodegradable Part 1

Problem: Approximately 150 million mobile phones are discarded each year in the USA. Although cell phones the highest recycling market of any electronic material 10 % of these are recycled while the rest may end up in a landfill, but likely to end up in desk drawers or garages.

Solutions: Jeremy Lang of Pela of Saskatoon, Saskatchewan Canada, using Flaxstic, a bioplastic from flax straw has developed a cell comprised of 35 - 45% biobased content (plant-based plastic and flax straw) and 55% non-renewable, biodegradable materials. As a boy, discovered that flax farmers were in the practice of burning their fields after a harvest, in to prevent the flax straw from getting caught up in and ruining their farming equipment. He realized that if that flax straw was so , it could certainly be used for something.

Elsewhere Sprint and Samsung each launched the *Reclaim,* a biodegradable handset that is 80% recyclable and comes with a 40% -based plastic cover. The *Reclaim* ditches a paper manual for a virtual one and comes with a charger that is energy-efficient standard chargers. Sprint's is nearly free of commonly used materials such as polyvinyl chloride (PVC) and brominated flame retardant. And the company is donating US$2 from each to the Nature Conservancy's Adopt an Program. Ideally the would be completely free of all materials and a solar charging option. But these are improvements that Sprint

and Samsung will probably in the future. Samsung has already developed a separate solar-powered . *(support.sprint.com)*

Alongside the , there is the screen. The Australian National University's (ANU) Research School of Engineering created a semiconductor with both and inorganic materials that can convert electricity into light with a very high efficiency. Engineers developed an ultra-thin semiconductor featuring one-atom- material with two-atom- inorganic materials to a new type of electronic screen. The compound is incredibly thin and is just one atom . The carbon and hydrogen makes up part of the semiconductor developed by the Australian team. The inorganic compound is just two atoms. The super-thin biodegradable semiconductor would be ideal for screens and other displays on cell phones. The thin, flexible surface could also be used in an entirely new series of high-performance electronics. *(eng.anu.edu.au)*

But then there are the thousands of transistors inside a cell . The tiniest transistors are now less 30 nanometers . You could fit 16,000 of them, side-by-side, in the period at the end of this sentence.

For the internal components, Simon Vecchioni, who recently defended his Ph.D. in biomedical engineering at Columbia University, is using synthetic biology to produce DNA nanowires and networks as an alternative to silicon device technology. Vecchioni ordered synthesized DNA from a company, used it to create his own custom BioBrick, a circular piece of DNA, and inserted it into the bacterium *E.coli*, which created copies of the DNA. He then cut out a part of the DNA and inserted a silver ion into it, turning the DNA into a conductor of electricity. His next challenge is to turn the DNA nanowires into a network. The DNA nanowires may one day replace wires of valuable metals such as gold, silver (which Vecchioni uses at the atomic scale), platinum and iridium, and their ability to "self-assemble" could eliminate the use of the processing chemicals used to etch silicon.

As silicon transistors (the devices that carry the 1s and 0s of computers) start to bump up against the limits of physics in terms of size and density, the evidence so far points to carbon nanotubes a faster and energy efficient option. Processors (lots of transistors packed together) from carbon nanotubes could help computing the next leap forward. This would be by far the most advanced chip from any emerging nanotechnology that is promising for high-performance and energy-efficient computing. After the first carbon nanotube (CNT) transistor was created in 1998, researchers progress by building other circuit elements

such as gates. In 2010, Desire´e L. Plata, a civil and environmental engineering professor at Duke University, designed a research experiment to determine how chemical bonds are built during nanotube synthesis, with the goal of improving the manufacturability of CNTs and minimizing the environmental impacts of this technology. Her study was published in 2010 in the American Chemical Society's online journal *ACSNano.* But a computer with an all-nanotube central processor remained elusive. Researchers from Stanford University said that they had successfully built a carbon nanotube computer and their research paper published on September 25, 2013 in the journal *Nature.* They named their prototype *Cedric.*

Six years later at the Massachusetts Institute of Technology, computer scientist Max Shulaker and a team built a 16-bit processor (the bits, the complexity), functional enough to run a program, producing the words "Hello, World! I am RV16XNano, from CNTs". In this new study, researchers used rolled up sheets of carbon, each a single atom , to form 14,000 carbon nanotube field-effect transistors (CNFETs) – up from a previous attempt in 2013 that managed 178 transistors. The researchers reckon these chips could be viable within five years. *(eecs.mit.ud)*

Cell components, nanocellulose Part 2

Problem: Approximately 150 million mobile phones are discarded each year in the USA. Although cell phones have the highest recycling market of any electronic material 10 % of these are recycled while the rest may end up in a landfill, but likely to end up in desk drawers or garages.

Solution: In recent years, researchers demonstrated that nanocellulose, which is by breaking wood fibres down to the nanoscale, can be a viable support material for a variety of electronic devices, including solar cells. John Rogers, a professor of materials science at the University of Illinois at Urbana-Champaign, developed the method for transfering small amounts of semiconducting material from a wafer to the nanocellulose surface. In 2015,

researchers at the University of Wisconsin-Madison, led by Zhenqiang (Jack) Ma, a professor of electrical and computer engineering, collaborated with researchers in the Madison-based U.S. Department of Agriculture Forest Products Laboratory (FPL), to innovate wood-based semi-conductor chips, by making the gallium arsenide electronic components in a similar way but then using a rubber stamp to lift them from the wafer and them to a new surface of nanocellulose. The challenge was to produce a smooth-enough surface that also had the capacity for thermal expansion. The final product evolved from the concept of breaking wood down further from individual fibre, at the micron , to the nanoscale. The result is a material which is very , transparent, flexible, and, most-importantly, biodegradable, cellulose nanofibril (CNF). An epoxy coating is added to the surface to ensure a smooth layer and eliminate the hydroscopic nature, both of which were previously barriers for using wood-derived materials. This reduced the amount of semiconducting material used by a factor of up to 5,000, without sacrificing performance. Their results also show that a transparent, wood-derived material called nanocellulose paper is an attractive alternative to plastic as a surface for flexible electronics. In conventional chip manufacturing, electronic components such as transistors are on the surface of a rigid wafer of a semiconducting material such as silicon. In two recent demonstrations, Ma and his colleagues showed they can use nanocellulose as the support layer for radio frequency circuits that perform comparably to those commonly used in smartphones and tablets. They also showed that these chips can be broken down by a common fungus. *(fpl.fs.fed.uk)*

In 2019, researchers at the Institute of Materials Science of Barcelona (ICMAB-CSIC) created a new concept of thermoelectric material, published in the journal *Energy & Environmental Science* ("Farming thermoelectric paper"). It is a device composed of cellulose, produced *in situ* in the laboratory by bacteria, dispersed in an aqueous culture medium containing sugar and carbon nanotubes, producing the nanocellulose fibers that end up the device, in which the carbon nanotubes are embedded. The intention is to approach the concept of circular economy, using sustainable materials that are not for the environment, which are used in small amounts, and which can be recycled and reused. *(icmab.es)*

Mike Orcutt, “A Biodegradable Computer Chip That Performs Surprisingly Well, *MIT Technology Review* July 14, 2015; Larry Lu et al.“Efficient and Layer−Dependent Exciton Pumping across

Atomically Thin –Inorganic Type−I Heterostructures," *Advanced Materials*, 30 August 2018; Rob Matheson MIT engineers build advanced microprocessor out of carbon nanotubes | *MIT News Office* August 28, 2019.

Central-heating system, baseboard

Problem: Traditional heating systems, burning fossil fuels, using heat pumps and/or solar energy are using the most inefficient heat distribution systems in the real consumption place, the room. By creating an unbalanced distribution of hot and cold air, this in turn is detrimental to human health and is giving the highest energy consumption in the room and hereby the highest loss in the transportation of the heat to the room.

Solution: In 1974, Erik Christian Vilhelm Keldmann, a mechanical engineer from Odense, Denmark improved the efficiency and energy consumption of central heating and air conditioning systems. His ''heat embracement'' skirting board systems he called Elpan for an electrical system and Wanpan for a hot water-heated system. Both systems involve interconnecting module elements in such a way that the apparatus can extend all the walls of the room. The key in his invention is the balance in each module between heat delivered by radiation and convection. The created even comfort temperature, all over the living of the room, is created by the all embracing system by about 65 – 75 % radiation and approximately 25 – 35 % convection (circulating air). This created the experienced comfort temperature constant from floor to ceiling, which is the condition for having the highest thermal comfort for the lowest energy consumption.

Keldmann's Elpan/Wanpan system which he patented in 1978, could be easily mounted by persons without special education. It is today, after 45 years, an elegant timeless designed product, the world's smallest heating system giving freedom in furnishing even small rooms. Keldmann also innovated an eco-friendly silent cooling system he called Norpan, where panels from the ceiling, over the office desks, with chilled water circulating in and out of the . The human body radiates heat up to the and the sends back chilled air to cool the body. This is cooling for human beings at the lowest energy consumption.

Keldmann's innovations threatened to disrupt the steel-based traditional radiator industry. The Elpan – Wanpan systems proved the for disruption in a

two year comparable test in four homes by the biggest Danish newspaper "Berlingske Tidende – Boligen", proving energy savings of 20 – 37 %., the system was then accepted. But despite the world's need for heat-saving systems, Elpan-Wanpan has not yet disrupted old fashioned traditional heating systems.

Erik Keldmann is the president and of Keldmann Innovation A/S. With his son and partner Troels, they are now on new inventions to add value to Elpan/Wanpan all embracing heating systems. *(keldmanninnovation.dk)*

Erik Christian Vilhelm Keldmann, "Baseboard electric heating apparatus." U.S Patent No.4,086,468. April 25, 1978; Communication from Erik Keldmann December 9, 2019.

Cirrus Cloud Thinning

Problem:

The warming caused by anthropogenic greenhouse gas emissions musdt be offset

Solution:

Increasing the Earth albedo by cirrus cloud thinning

The wispy, elongated "cirrus" clouds are found at high altitudes, 20,000 ft and often absorb more sunlight than they reflect, because they form in cold temperatures and consist of ice crystals. If these ice crystals are numerous and small, cirrus clouds prevent long-wave terrestrial radiation from escaping into space, and have a climate impact similar to greenhouse gases. In the presence of natural ice nuclei such as dust, the ice crystals that form are fewer and larger, with a shorter lifespan and fewer climatic effects.

Cirrus cloud seeding would involve injecting ice nuclei – such as bismuth triiodide or aerosol particles as sulfuric or nitric acid – into regions where cirrus clouds form. This could be performed by squadrons of drones.

However, unlike cloud seeding to produce rain, cirrus cloud thinning is a very new idea, and it is uncertain whether the technique is even feasible. Researchers admit that the injection of "too many" ice-nucleating particles into cirrus clouds may produce the opposite effect – more and thicker clouds may be produced, so that even more heat is trapped, which could lead to increased anthropogenic global warming

Citizen Convention for Climate (CCC)

Problem: Mobilising action for the Planet on a national, people's level.

Solution: In November, 150 French citizens, and female, were by lot and given eight months to discuss and forms their solutions for the Planet. On Sunday 21, 2020, La Convention Citoyenne pour le Climat (CCC) presented French President Emmanuel Macron with nearly one hundred proposals around five axes relating to the fight against global warming: produce and work, shelter, feed, move, consume. Objective: a reduction of "at least 40% of greenhouse gas emissions by 2030". These include making energy renovation of 20 million buildings compulsory by 2040, quadrupling the amount of the bicycle fund to 200 million euros per year, which would finance bicycle paths, increasing the bonus for hybrid and electric cars by 25%, the deployment of short food circuits, and the curbing of overconsumption. In response, the President pledged an additional €15 billion ($16.9 billion) to help address the issue.

On a European Union level, the month before, Pascal Canfin, chairman of the Environment Committee in the European Parliament, proposed an alliance for a green recovery. This movement, which brings together together 80 ministers, MEPs, CEOs, NGOs & Unions joined by around thirty CEOs (Ikea, Unilever, Danone, Saint-Gobain, H & M, etc.) In her Green Deal, the President of the European Commission Ursula von der Leyen promised a "green, digital and resilient future".

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Closed-loop circular sandblaster

Problem: Paint protects steel structures from corrosion. When performing maintenance on these structures, old paint and rust is removed, and new paint is applied. With the use of traditional methods for maintenance, the removed paint is normally emitted to the . Paint is plastic. The removed, tiny paint particles are microplastics. Taking just the 184 oil in the North Sea, -blasting and water-jetting on those causes microplastic emissions that are equivalent to dumping 14 millions plastic bottles into the North Sea every year!

Solution: Harald Aadland at Pinovo AS of Bergen, Norway, has developed technology which eliminates all emissions from surface treatment of

rust and old paint (=microplastics) into the . Their yellow and grey *PiBlast* is an automated, fully pneumatic, closed loop vacuum blasting tool intended for dust free abrasive blasting of straight pipes. The for or , tool comes in different sizes depending on the size of the pipe.

Harald Aadland, Geir Veglo, "Abrasive blasting" *PINOVO AS* World Patent N° 20120301643 November 29, 2012.

Clothes-washing machine, detergentless

Problem: When in 1924 firms such as the Savage Arms Corporation of New York presented the electrically-powered wash/spin-dry clothes washing machine to the world, neither its energy and water consumption, nor the harmful effects of chemical detergents on the ecosystem, were taken into account. Today, the eco-efficient bio washing machine has become of primary importance.

Solution: Although, Japan Ace, based on research at Nihon University produced a detergentless, ultrasonic bubble-cleansing washing machine in 1985, the main breakthrough was by Stephen Burkinshaw at the University of Leeds focusing on the structure of nylon polymer beads. He discovered that nylon was the best material for absorbing tiny particles, and together with his team of researchers up with the concept of using nylon polymer beads to remove stains from clothes. When the wash cycle is completed, the beads automatically return to a holding area inside the machine and are ready to be used again for the next wash. These beads can be used for up to a thousand washes and are then collected to be recycled and exchanged for new one.

From 2009, Burkinshaw and his team collaborated with Stephen Jenkins and William Westwater at Xeros Ltd. in Catcliffe, South Yorkshire, England to commercially produce the beads which they called *XOr*b and a 55 lb (25 kg) capacity waterless washing machine by the end of 2011. According to Xeros Ltd., its technology uses 90% less water than the conventional washing machine. While a conventional -loading washer uses about 20-25 gallons (75-95 liters) of water, the Xeros Washing Machine is estimated to use as little as one gallon of water. The machine is also projected to consumers up to 30% for operating in electricity and water. Xeros then presented their XDrum technology to other washing machine manufacturers. Hotel groups such Hilton, Hyatt, or Hampton Inn acquired Xeros to wash their laundry. In March 2018,

Xeros acquired Gloves Inc., providing personal protection equipment cleaning, inspection and repair services in the Miami metro areas.

At CES 2018, Xeros unveiled XFiltra to go with XOrb and XDrum technologies XFiltra is designed to help capture the synthetic fibers from fleece and other clothing that are making their way from the wash into . Appliance makers would to design around the pump and filter. *(xerostech.com)*

The biggest commercial washing manufacturers in China and India both signed up, while Dongguan Crystal Knitting and Garment, a subsidiary of Crystal International Group, the world's largest apparel maker by volume, are trialling the technology. In 2019 Xeros signed up with Indian home appliance manufacturer IFB Industries Ltd. in Kolkata to and sell X technology in India by from 2020-2021. Xeros, a platform technology company that works on reinventing water intensive industrial and commercial processes, believes the reason the Indian market is important for its water-saving technology is that the country is under extreme water stress. According to the NITI Aayog, 600 million Indians acute water shortages. The Xeros tech can also water in the tanning industry and, having entered the market itself, Xeros signed a deal which will see at least one Mexican producer convert its re-tanning operations.

S.M. Burkinshaw, "Attempts to reduce water and chemical in the removal of reactive dyes: Part 1 bis(aminochlorotriazine) dyes," *Dyes and Pigments*, December 2009.

Clothing from recycled plastic bottles

Problem: In January 12, 2010 Haiti suffered a catastrophic magnitude 7.0 Mw earthquake, with an epicenter near the town of and approximately 15 mi (25 km) west of Port-au-Prince, Haiti's capital. Over almost 300,000 people lost their lives, while 250,000 residences and 30,000 commercial buildings collapsed or were severely damaged. Ian Rosenberger travelled to Haiti looking to help people after the earthquake.

Solution: Having observed the intense levels of pollution and poverty, he found a way to support the locals by starting up a business that recycles plastic bottles into fabric thread for clothing.

The company, Thread International produces both yarn and fabric, depending on the need. Its manufacturing process is simple. It heats up plastic waste collected by the Haitians, which is then extruded through a shower head-type machine, which then cuts up the result. The method reduces energy consumption by 80% compared to making virgin polyester, but the cost to clients is roughly 10% higher. The impact in Haiti has been dramatic. Thread International supports about 300 recycling jobs on the island and, in 2015, sent 440,000 lb (200,000 kg) of plastic fiber to the U.S., where it is blended with cotton to produce canvas, jersey and denim products.

With a US$1.5 million from the Richard Mellon Foundation, Thread International was able to move from their East Liberty office in Pittsburgh, Pennsylvania into a larger workspace in Homewood. While the company has found success partnering with brands such as Nike and Timberland since its initial founding. In February 2019, Timberland launched a Thread-infused collection (, duffel bag, backpack) and Thread signed up Kenneth Cole, another major brand. The move to Homewood, provides the company with space to and employ staff from the local community to stitch and assemble the bags, creating jobs to help battle unemployment in Homewood while also growing their eco-friendly business. Thread has several full-time employees on the ground in Haiti and Honduras to coordinate with local partners. The company is also looking to expand its operations to Guatemala and Southeast Asia. According to Thread's website, they shipped 200,000 lb (100,000 kg) of recycled plastic out of Haiti since 2010. *(threadinternational.com)*

In , Thomas Huriez of -sur-Isère () is making denim using sea litter collected by the French fishermen of the Mediterranean, during fishing trips on the coast. They are encouraged to continue to clean up the beaches and their surroundings, which are full of polyethylene-type plastics, which then serve to create the fabric for the pants in a mono-material. Huriez had already launched Modetic, a shop specializing in the sale of ecological, equitable, ethical, and local products, when in 2013 with his brother Huriez switched to trousers and shoes. They called their *Infini 1083*, 1083 km. the longest distance that can be traveled in by road number between Menton and Porspoder, north of Brest. Not

are the trousers from 100% recycled plastic, they are 100% recyclable and returnable. The life cycle of *Infini* begins at the company , which manufactures Seaqual ™ yarn in Spain (80 km from the French border). Infini then dye this 100% recycled yarn, in Pont-de-Labeaume, they weave it in Coublanc, then they the in Marseille. bought, when the client's reach the end of their life, they will return it to Infini for free and get back their 20 € deposit. Their old will then be crushed to be re-transformed into yarn and *1083* again and so on ad infinitum. *(1083.fr)*

Another much bigger manufacturer, , by Kontoor, has introduced denims dyed with foam, a revolutionary technique that uses 100 % less water conventionally-dyed denim and also reduces energy use and waste by 60 % compared to the conventional denim dyeing process. Wrangler's *Indigood* technology reflects in the brand's global sustainability goals, which include: conserving 1.5 billion gallons (5.5 billion liters) of water at and operated facilities by 2020; using 100% preferred chemistry throughout their supply chain by 2020; powering all and operated facilities with 100% renewable electricity by 2025; and sourcing 100% sustainable cotton by 2025. *(kontoorbrands.com)*

Gest, "Thread International makes a business for good," *SmartBusiness*, July 1, 2017; "1083 le infini, indéfiniment recyclable, " *maddyness*, July 14, 2019 ; *1083.com* website.

Cloud of Sea

Problem:

How to recuperate the millions of microplastic particles from the ocean.

Solution:

Matteo Brasilini, op Porto Sant'Elpidio, Marche Region, Italy, was a student at the Nuova Accademia di Belle Arti in Milan (Naba) when he built Cloud of Sea, a fender to enable sailboats to easily capture microplastics while they are cruising. Hooked onto the boat using ropes, it contions a rotting helix-shaped filter, made of a semi-rigid membrane with holes that taper inwards, allowing micro-particles to enter, but not leave the filter. It has also been to be easily emptied when the boat reaches the harbor, where it functions as a fender. Its unusual shape should attract other yacht owners to acquire a Cloud of Sea for themselves.

In 2020, Matteo Brasili won the Italian edition of the James Dyson Award.

:Cloud-seeding by drones

Problem:

Given its location on the Tropic of Cancer in the Persian Gulf, the UAE was never going to be anything but hot; between the dry, desert-heated winds blowing in from neighboring Saudi Arabia and Oman and the humidity from the sea, winters tend to be toasty, and summers unbearable. But the region has seen record high temperatures of 125 degrees Fahrenheit (51.8 degrees Celsius) this summer, coupled with characteristic low rainfall; Dubai gets a total of about 2.7 inches of precipitation per year.

Solution:

Cloud seeding is a method of inducing a cloud to produce rain. This pioneer technology was introduced in the UAE in the late 1990s.

In 2000, the UAE's National Center for Meteorology funded a collaboration with Dr. Keri Nicoll who led a cloud-seeding project at both the University of Reading, England who had discovered that when cloud droplets have a positive or negative electrical charge, the smaller droplets will combine and form raindrops.

A fleet of five drones or UAVs designed by scientists at Reading, were built and tested at the University of Bath. Custom-built with a six-foot wingspan to fly at low altitudes, they were equipped with sensors measuring temperature, charge, and humidity. Charge emitters on the drones would deliver electric charges to the molecules in clouds.

They were then shipped out to the UAE. Trials involved flights whereby once experts had identified clouds that can hold rain, drones release an electric charge inside the clouds to create rain. Trials were made in Abu Dhabi, Al Ain and Dubai. During 2021 altogether 126 flights were executed.

Videos from the last few weeks show it not only raining in Dubai and surrounding areas, but raining so much that some streets started to flood, a rare if not unheard of occurrence there.

Nicoll, K., Harrison, G., Marlton, G. J. and Airey, M. W. (2020) *Consistent dust electrification from Arabian Gulf sea breezes.* Environmental Research Letters, 15 (8).

Cloud-seeding rain-making chain

Problem: China has to feed nearly 1.4 billion people, despite 40 % of its arable suffering from degradation.

Solution: The largest-ever weather modification program worldwide is named Tianhe and located across the Tibetan Plateau in China. The Tianhe originates from the ancient Chinese for the Milky Way, which was the sky river that separated Niulang and Zhinyu in the folk "The Cowherd and the Weaver Girl". The project, developed by researchers in 2016 at Beijing's Tsinghua University, is covering an area larger than Alaska and three times the size of Spain with tens of thousands of fuel-burning chambers for cloud seeding to channel amounts of additional artificial rainfall into China's arid northern regions. In 2018, the installation of hundreds of burning chambers on alpine slopes in Tibet, Xinjiang and neighbouring areas started, with a deadline of 2022. Throughout the past months the program has been increasingly questioned and criticized, internationally and nationally: the Tibetan plateau feeds most of Asia's major rivers, including Yellow, , Mekong, Salween and Brahmaputra. These streams serve as lifelines for a considerable proportion of the world population. The local and transnational implications of the Tianhe project, not in terms of water supply, are as yet unknown.

Peter Dockrill, "China's 'Sky River' Will Be The Biggest Artificial Experiment Ever," *Science alert*, April 28, 2018.

Cocoon, tree-planting device

Problem: Reforestation must also place in arid and degraded and saplings must be protected during the first months of their life.

Solution: In 2013 Arnout Asjes, Harrie Lövensteain, an arid agronomist, and Jurriaan Ruys at the Land Life Company in Amsterdam had an innovative idea: to develop a system that enables trees to grow in arid and degraded . This is a 100% biodegradable cardboard donut they call the cocoon which can hold 6.6 gallons (25 liters) of water underground to aid a seedling's first critical year.

Plantation is mapped using an AI database on conditions. In Matamorisca, Land Life intervened in 42 acres (17 ha) of barren terrain by the regional government and peppered them with Cocoons. Around 16,000 , ashes, walnuts, , and whitebeams were planted in May 2018, and the company reports that 96% of them survived that year's scorching summer without extra irrigation, a critical mi. for a tree. The three-year-old startup recently raised US$2.6 million to expand its mission to reforest the world's 865 million acres (2 billion ha) of degraded . By 2030, the goal is to reach 350 million, a promising 20%.

Colour pigmentation, bacterial

Problem: It is estimated that a single mill can use 200 tons (181 tonnes) of fresh water per ton of dyed fabric. Not does this consume water, but the chemicals pollute the water causing both environmental damage and diseases throughout developing communities.

Solution: Following eight years of research at the Department of Biochemical Engineering at University College London, synthetic biologists John Ward and Natsai Audrey Chieza developed a microbe *Streptomyces coelicolor* can produce a particular pigment that might be used to dye textiles a blue hue, using 500 times less water and not requiring chemicals to fix the dye. The microbe naturally color based on the pH of the medium it grows inside, so by tweaking that environment, it becomes possible to create navy blue, for example, or bright pink. With synthetic biology, it will be possible to program the to sustainably produce an even fuller of colors *(ucl.ac.uk)*

Bacterial pigment is biodegradable, but designers to avoid dumping it into water. Laura Luchtman and Ilfa Siebenhaar, who run a Netherlands-based lab, called Living Colour are looking to create a closed-loop process where there is no effluent that ends up in waterways. Living Colour focuses on strains of bacteria that naturally produce pigment. Rather than genetic engineering, the designers are interested in how with living organisms can create a new aesthetic of color. Leftover pigment could also be used for products that require less saturated pigments textiles. *(livingcolour.eu)*

To promote the innovation, Natsai Audrey Chieza's London startup Faber Futures has exhibited at prestigious institutions including at the Pompidou Centre, Vitra Design Museum and the Science Gallery, Dublin, and sits in permanent collections including at the Forbes Pigment Collection at Harvard Art Museums, Cambridge, Massachusetts. *(faberfutures.com)*

"Natsai Audrey Chieza on with nature to help solve fashion's waste problem," *Design Indaba,* July 6, 2018; Liz Stinson, "Stylish Silk Scarves, Dyed With Bacteria," *Wired.*

CO^2 inhaler

Problem:

More than 1.5 million deaths are caused annually by respiratory conditions made worse by pollution

Solution:

CO^2-recycled plastic to make inhalers to help those suffering from pollution-related respiratory illnesses.

The inhalers are a collaboration between AstraZeneca Brazil, McCann Health New York and Sao Paulo and Cornell chemist Geoffrey Coates, who leads research and development of CO2-based plastic. The colours of the inhaler, and white are symbolic for how pollution can be used for good: the carbon dioxide removed from the air can help patients breathe better

Compost, human-based

Problem: When people die, usually one of two things happens to their : either they are buried below ground in caskets, or they are cremated, reduced to fragments by intense heat. Cemeteries up space and crematoria emit carbon dioxide. According to figures published on PBS in 2013, there is an average of

2.4 million funerals each year in the United States. Their add up to an estimated US$20.7 billion. Both cremation and conventional burial leave just over a metric ton of carbon per body.

Solutions: Zoroastrians had a different approach: to preclude the pollution of earth or fire, the of the dead were placed atop a tower and so exposed to the sun and to birds of prey. The roof was divided into three concentric : The of men are around the outer , women in the second circle, and children in the innermost . the bones had been bleached by the sun and wind, which can as as a year, they were collected in an ossuary pit at the center of the tower, where they gradually disintegrate and the remaining material, with run-off rainwater, ran through multiple coal and filters before being eventually washed out to sea.

White Eagle Memorial Preserve (WEMP) in Klickitat County, Washington was founded in 2008 so people could be buried in natural surroundings without embalming, caskets or headstones. It is certified as a Conservation Burial Ground by the Green Burial Council, a national non-profit certifying body. WEMP spans 20 acres (8 ha) set within 1138 acres (461 ha) of permanently protected oak and ponderosa forest, meadow and steppe on the edge of spectacular Rock Creek Canyon near the Columbia River National Scenic Area. Deer, coyote, cougar, eagles, wild turkeys, steelhead in the canyon creek, western grey squirrels, rattlesnakes, the occasional bear or lynx live and die freely.

Paris has opened its first green cemetery at Ivry-sur-Seine. Part of the already-existing cemetery has been dedicated to eco-friendly burials, meaning that Parisians concerned about the lasting ecological impact of their funerals can now rest in peace. The cemetery will do away with gravestones, replacing them with wooden markers that the city of Paris has said it will replace every ten years. Coffins and fittings must be made out of biodegradable materials, either cardboard or unvarnished local wood, and corpses must be clothed in natural biodegradable fibers. They cannot, of course, be embalmed with formaldehyde.

Katrina Spade was studying architecture when she learned about livestock composting and wondered if the some practice could be applied for humans. She earned a BA in anthropology from Haverford College in Pennsylvania, then turned her focus to sustainable design while attending Yestermorrow Design/

Build School in Vermont. At Yestermorrow, Spade helped to build a Pain Mound - a compost-based bioenergy system invented by Pain that can produce heat for up to 18 months. She first drafted her plans for a ‘human composting’ facility in 2012 while earning her Master’s degree in architecture and design, which she completed in 2013. In 2014, she was awarded a climate fellowship from the Echoing Green Foundation. This enabled her to start a 501c3 nonprofit called the Death Project involving an crematorium (go in, remains come out), but using the slower, less carbon-intensive of “ reduction,” or composting. Spade alternately describes this process as "cremation by carbon."

To research the process of cadaver decomposition into soil, Spade collaborated with Lynne Carpenter-Boggs, a Professor of Sustainable and Agriculture at Washington State University. They developed a carbon-and nitrogen-heavy mixture of wood chips, alfalfa and straw. They found that natural reduction turns into two wheelbarrows full of soil within 30 days. In 2017, Spade closed the nonprofit and started Recompose in Seattle, Washington, as a public-benefit corporation. In 2018 she was awarded the Ashoka Fellowship

In November 2018, Washington State Senator Jamie Pedersen pre-filed a bill to legalize this human composting, also known as "recomposition." This law, passed on Tuesday May 21, 2019, Washington the first state in the United States to allow the practice. The Act also legalized alkaline hydrolysis, the dissolving of in a pressurized vessel with water and potassium hydroxide, or lye, a process which is already legal in 16 states.

Recompose estimates that one metric ton of CO_2 is saved for every person who opts to compost a body instead of burning it. This is equivalent to taking a gas-powered car off the road for about three months. Spade should start composting by 2020 hosting 750 annually, 20 to 25 at a time. Spiritually and emotionally, there are those who are against this system. They are happy to their ashes scattered, but do not wish to use the compost of a loved one to improve plant growth. *(recompose.life)*

Katrina M. Spade, “Of Dirt and Decomposition: Proposing a Place for the Dead,” *University of Massachusetts, Amherst* 2013.

Concrete

Problem: The traditional baking of and mixing concrete creates CO_2. Until the 1980s, kilns in Stewartby, Bedfordshire, UK manufactured 20% of the nation's . Prior to closure, production totalled 135 million a year but there was a problem with emission of fluorine compounds in quantities hazardous to the health of people downwind.

Solutions: J. Gilliam, Seeker and a team at Calera Inc. in based in Los Gatos, California, achieved an eco-friendly concrete by novel, metastable calcium and magnesium carbonate and bicarbonate minerals, similar to those found in the skeletons of animals and plants. They refer to this as Mineralization via Aqueous Precipitation, or MAP for short. In its simplest form, MAP involves contacting gas from the power plant with natural waters found in abundance on Earth. of the crystallographic forms Calera synthesizes are previously undescribed, or poorly known. These novel 'polymorphs' it possible to produce high reactive cements and aggregate precursors, with bulk chemistries that would usually be relatively inert. Calera estimates that for every ton of cement produced using their method instead of the traditional one, half a ton of CO_2 is sequestered. Led by Ivrin Chen, Calera, operates a pilot and demonstration plant next to BluePlanet a 1000 MW power plant in nearby Moss Landing. The Calera process bubbles the plant's waste gases through seawater. This removes about 90% of the carbon dioxide and combines it with minerals in the water, resulting in the creation of limestone that is composed of about 50% waste carbon dioxide. Given that the Moss Landing plant produces 2 million tons (1.8 million tonnes) of carbon dioxide per year, the production of or carbon neutral – or even carbon negative – concrete is very promising.

Mehrdad Mahoutian, Chris Stern and a team in Montreal, Quebec, Canada developed Carbicrete, a cement-free construction material; the concrete employs steel and CO_2 as raw materials. Steel is a byproduct of the steelmaking process that is often placed into landfills. A traditional cinder , known in the construction industry as a concrete masonry unit (CMU), weighs about 14 lb (6 kg). Within that, there is normally 4 lb (1.8 kg) of cement and in that there are 4 lb (1.8 kg) of CO_2 that is emitted. Carbicretre sequester one kilogram of CO_2, so the total emitted or avoided is 6 lb per 14 lb (3 kg per 18kg) CMU. Mahoutian across the material as he was researching alternatives to cement while his PhD at McGill University. In 2018, Carbicrete won a CU$2.1m (US$1.57m) from Sustainable Development Technology Canada to build a production facility at an

existing concrete plant and reach commercial production by mid-2021. In April 2019, Carbicrete was awarded the Best CO_2 Utilisation prize by Germany's Nova-Institute. Carbicrete has assembled a consortium of project partners that includes a concrete maker, an industrial gas company and steel handler. *(carbicrete.com)*

Bio Bricks

Problem Traditional -making requires blasting clay in kilns at 2,000 degrees for several days, thereby releasing massive amounts of carbon into the atmosphere About 8 % of all global carbon emissions come from manufacturing, according to estimates from the EPA.

Solution: In Durham, North Carolina, since 2012, a team led by Ginger K. Dosier and her husband Michael of bioMason developed a building whereby placed in molds is injected with bacteria, which are then fed calcium ions in water. The ions create a calcium carbonate shell with the bacteria's cell walls, causing the particles to together. A grows in three to five days. Dosier studied architecture at Auburn University and as a graduate student at the Cranbrook Academy of Art in Michigan. While for an architectural firm in 2005, she was tasked with looking into green alternatives for building materials. She later moved to North Carolina's Research Park to teach architecture at North Carolina State University. In 2009, Dosier, whose mother was an engineer and father worked for NASA's shuttle program, started to investigate potential ways to masonry eco-friendly. She looked at how was to these incredible structural formations that could withstand water and erosion and began really researching how it was to grow. She took her research to scientists in Research Park and beyond to see if the process could be replicated to create . Their opinions were nearly unanimous: it could be , it just had not been attempted before, at least not scale. bioMASON's can be customized to glow in the dark, absorb pollution, or color when wet.

In 2016 bioMason collaborated with Ecovative Design of Green Island, New York to produce all-grown furniture. While the table top was a bioMason ,

the legs had been grown using mushroom technology. After left to grow in a former in a dark place for about five days during which time the fungal mycelial network binds the mixture, the resulting light robust compostable material can be used within products, including building materials, thermal insulation panels and protective packaging.

In 2017, bioMason moved into a new facility in Research Park giving it a capacity to grow 5,000 every two days. Dosier has signed licensing agreements with two U.S.-based manufacturers of construction materials.

bioMason also developed kits, compositions, tools and methods for biologically cemented structures, used in the farming of bivalves, such as oysters and clams, and also other and fresh water invertebrates such as , and other commercially worthwhile sessile organisms. These kits can also be used for erosion control of beaches and underwater surfaces, for the formation of foundations such as footings for pier supports, walls and other desirable structures.

bioMason also developed cyclic industrial process to form biocement. This involves decomposing calcium carbonate into calcium oxide and carbon dioxide at an elevated temperature, reacting calcium oxide with ammonium chloride to form calcium chloride, water, and ammonia gas; and reacting ammonia gas and carbon dioxide at high pressure to form urea and water, which are then utilized to form biocement.

In 2019, the USAF's think Blue Horizons collaborated with bioMason on Project Medusa to grow military- runways. Project Medusa has undergone several tests, including a 2,500 ft² (232 m²) structural prototype in Durham, North Carolina. A follow-on effort began between bioMason, AFRL, and DARPA to mature the technology and build up different soil samples to see how well the technology functions across different areas of responsibility. *(biomason.com)*

In India, Himanshu Verma of the Navrattan Group, Mumbai, has developed a concrete called Navrattan Crete that uses a proprietary binder derived from a species of algae and a guarded extraction process which ultimately transforms an enzyme of the algae into a highly concentrated elastic polymeric powder. Individual polymer chains are linked together by covalent bonding to form one single molecule with all of the aggregates. In addition, a thin plastic film cross links and permeates the entire mixture adding flexibility.

The cement has a higher tensile strength Portland cement. Its low coefficient of expansion enables it to work efficiently in all weather conditions. The mixture prepared is hydrophobic, and is therefore resistant to water, acids, corrosion etc. Navrattan Crete also reduces CO_2 emission as its manufacturing process does not require breaking down of limestone or the use of energy intensive kilns, which is a major issue with the conventional cement industry. In 2016, Navrattan built two manufacturing units in the Punjabi cities of Rajpura and Bathinda with the total production capacity of over 44,000 tons (0.4 million tonnes) per annum each. *(navrattancement.com)*

Production of masonry with bacteria Patent N° 9796626. Inventor: Ginger K. Dosier (2017); Kevin J. , "How This Startup Is Using Bacteria to Grow From Scratch," *Inc.com* 2016.

Container , autonomous electric

Problem: Emissions from diesel vehicles been reported to be significantly harmful those from petrol vehicles. Diesel combustion exhaust is a source of atmospheric soot and particles, which is a component of the air pollution implicated in human , heart and damage, and mental functioning. There are thousands of diesel-engined container ships and plying the canals and rivers of Europe.

Solution: Ton van Meegen, inland waterways entrepreneur in the Nijmegen Area, Netherlands has started up Port-Liner Holdings CV to develop a fleet of fully-electric crewless container to transport freight initially from the ports of Antwerp, Amsterdam, and Rotterdam. Called "Tesla ships", One Kempenaar-sized vessel called the *Tempsnip* is 170 ft (52 m) and 19ft (6.7m) wide, and to carry twenty-four 20ft (6 m) containers weighing up to 468 tons (425 tonnes). Its electric motors will be driven by 20-ft (6 m) Vanadium Redox Flow Batteries (VRFB), giving it 15 hours of power, on shore by the carbon-free energy provider Eneco. Although designed to operate without any crew, EC52 will be manned initially. Adjustable wheelhouses enable them to go under 5m60 (16 ft) bridges, while by flooding its ballast tanks, it can further reduce its height. The *EC 110* version has a length of 328 ft (100 m) and a width of 38 ft (11m45), to load 14 containers of 20 ft (6 m). or 7 containers of 40 ft.(12 m) or any combination of the two sizes.with four E-Powerboxes would an action radius of about 30 hours (143 mi or 230km). This allows the vessel to easily cover the Rotterdam/Antwerp/Duisburg corridors, at competitive cost compared to

conventional diesel propulsion. The ship can be customized (dimensions, type) up to 7700 tons (7,000 tonnes) . Port-Liner submitted a project under which it will build five hybrid that will ply between De Kempen intermodal terminal in the Netherlands and Antwerp. Thanks to these hybrid there will be 23 000 fewer diesel trucks on the roads annually and a reduction of about 18,000 tonnes per year of CO_2. According to a report from transportation news site Elektrek, the 100 million-euro (US$122 million) project has been supported by a €7 million (US$8.6 million) subsidy from the European Union, with *Loadstar* also having reported that the Port of Antwerp had added a €200,000 (US$245,000) subsidy as part of a wider initiative to improve its port's efficiency. Port-Liner can build 500 of these ships per year. The battery pack could also be used to retro-fit existing river . During summer 2020, the 443 ft (135 m) *Portliner Anna* went on trials from Werkendam, southern Netherlands. *(portliner.nl)*

Dag Pike, "Port-Liner building Electric Container ", *Maritime Journal*, February 9, 2018.

Container ship management system

Problem: The problem in the Less--Container-Load (LCL) sea freight industry is lack of space utilization. 100 million of these shipping containers go 25 to 40% empty from one port to the other. These are wasted emissions.

Solution: In 2016, Sheikh Ahsan Tariq, Hood Al Hoqani, Hamza Al Kharusi, and Wajiha Khalid Paracha of Muscat, the capital and largest city of , founded Cubex Global, created an online digital marketplace, built on a secure blocktrain, for sea freight where freight forwarders can buy, sell and bid on empty container space in real-time, thus enabling them to recover as much as $25 Billion in lost revenues on an annual on top of sustainably decarbonising as much as 20% on emissions. Very soon, Cubex Global had 2,000 active shippers and carriers on its platform with its services used in the Emirates, Asia Pacific, and some parts of Europe. With further funds raised by Technology Fund as part of its Wadi Accelerator, Cubex has been to expand across six continents by opening new branch offices in China, Singapore, and Taiwan. The startup had recently also won Challenge by World Economics Forum where it competed with 50 startups from the world.*(cubex.global)*

Contraceptive, biodegradable

Problem: Despite a century of horrific wars and some significant international plagues, human populations managed to grow 400 % during the 20th century. Today's world population is 7.6 billion, and the United Nations projects that another billion will be added by 2030, another by 2050, and that by 2100, the world population will be 11.2 billion. Can the Earth's resources feed this people?

Solutions: Alongside sterilisation and vasectomy, the contraceptive should be regarded as a planet-protecting measure. One solution is the condom, a sheath-shaped barrier device, used during sexual intercourse to reduce the probability of pregnancy or a sexually transmitted infection. Early contraceptives were biodegradable. The Egyptian Ebers Papyrus (1500 BC) describes a vaginal plug of lint, ground acacia and honey. Condoms, of silk, were not always effective. The ancient condom was found in Lund, Sweden, and is believed to been and used around 1640 A.D. It is from pig intestine, although before latex, condoms of sheepskin or intestine were not uncommon. Condoms of dried sheep intestines were used by soldiers to protect themselves during campaigns away from home. Neither rubber condoms which became available in 1855, nor latex condoms since the 1920s are biodegradable. About six to nine billion are sold a year. New innovations continued to occur in the condom market, with the first polyurethane condom, Avanti and produced by the manufacturer of Durex, introduced in the 1990s.

With the advent of AIDS (Acquired Immune Defiency Syndrome), the protective condom as mass-produced by Durex became even popular. Worldwide condom use is expected to continue to grow: one study predicts that developing nations would need 18.6 billion condoms by 2015. Biodegradable, latex condoms damage the environment when disposed of improperly and they also contain preservatives and hardening agents to sure the rubber can withstand a fair amount of friction, making it harder for the condoms to break down in the landfill According to the Conservancy, condoms, with certain other types of trash, cover the reefs and smother sea and other bottom dwellers. The United States Environmental Protection Agency also has expressed concerns that animals might mistake the litter for food.

The biodegradable condom is of a biological material, lambskin, from the intestinal membrane of a lamb as used by the , hence non-Vegan. One such is the "Trojan", a of condoms and sexual lubricants manufactured by the Church & Dwight Company of Township, New Jersey. Although biodegradable it does

not protect against sexually transmitted infections (STIs) and HIV. *(churchdwight.com)*

There are other methods. In 1951, the contraceptive pill was invented by Gregory G. Pincus and Min Chuch , biologists at the Worcester Foundation for Experimental Research, Shrewsbury, Massachusetts, in collaboration with Dr John Rock, obstetrician-gynaecologist of the Brookline Reproductive Clinic, and again in collaboration with Dr Carl Djerassi of the Syntax Corporation, Mexico, who discovered the progestogenic agent, 19-Norsteroids. The US Food and Administration approved “the pill” for public use in 1961, after extensive trials in Puerto Rico and Haiti. The downside are the hormones in the pill, either progestin or a combination of progestin and synthetic estrogen, known as endocrine disruptors: women who the pill end up passing some of them through their . If they it through the wastewater systems, the hormones can flush into rivers and streams altering fish reproductive systems and damaging ecosystem dynamics. The minipill is with progestin, a man- form of the hormone progesterone by the body.

Then there is the intrauterine device (IUD). During the 1950s these were of plastic with a nylon string. U.S. physician Howard Tatum’s innovation of the copper IUD in the 1960s brought with it the capital 'T' shaped design used by most modern IUDs. Together, Tatum and Chilean physician Jaime Zipper discovered that copper could be an effective spermicide and developed the first copper IUD, TCu200. Not does this contraceptive an incredible 99-plus % effectiveness, but it also requires just one small plastic T—either wrapped in copper or holding synthetic progesterone hormone—to prevent pregnancies for 3 to 12 years. Physical waste is nearly nonexistent. Copper IUDs use up less one tenth of an (0.3 gm) of copper. Hormonal IUDs release small quantities of synthetic progesterone directly into the uterus, meaning that most of the hormone stays exactly where it is needed. In short, for the Planet, IUDs are the lesser of the three evils.

Bernard Asbell, *The Pill*, New York: House (1995); Howard J. Tatum, *Milestones in intrauterine device development*, March 1983.

Cooling

Problem: Bleached reefs are dying around the world due to AGW.

Solutions: Mo Ehsani, the Centennial Professor Emeritus of Civil Engineering at the University of Arizona, who has developed innovative solutions for infrastructure renewal and repair for over 30 years. Having pioneered the field of repair and strengthening of structures using fiber reinforced polymer (FRP) products Ehsani left the full time academic world in 2010 to devote his time to the management of QuakeWrap, Inc., a company he founded in 1994. His products been used in the construction industry to repair high pressure pipelines, freeway underpasses, piles, historical structures and . One of these products, called StifPipe®, received the 2016 Innovation Award from the American Society of Civil Engineers as the world's first green and sustainable pipe. His -changing technology for onsite-manufactured continuous pipe, called *InfinitPipe*, plays a significant part in the proposed reef bleaching answer through piping that is enough to continually feed cooler water from nearby greater depths to the heat-stressed in the shallows. *(infinitpipe.com)*

The Seychelles is a 115-island archipelago in the western Indian . In 2010 Nirmal Shah and a team of Reef Rescuers of Nature Seychelles ngo, funded by United States Agency for International Development (USAID) set about restoring the bleaching within Cousin Island Special Reserve. Utilising the ‘ gardening’ concept, fragments of healthy coral were collected, raised in underwater nurseries and then transplanted onto a degraded reef. In eight years, 50,000 corals been raised in underwater nurseries, of which over 24,000 were successfully transplanted, covering the area of a football field 5,600 ft² (5,225 m2). Based on this experience, in December 2019, Nature Sechelles presented their toolkit to provide guidelines on how to complete a successful restoration project at the Reef Futures Symposium held in Key , Florida. Six participating countries in the India , Kenya, Tanzania, Mozambique, Madagascar, Mauritius and Rodrigues benefitted from the solution. *(natureseychelles.org)*

Coral Regrowth

Elsewhere in August 2015, Sam Teicher and Gator Halpern, formerly at University, set up a reef restoration company in Washington, DC called Coral Vita. Using a process called micro-fragmentation pioneered by the Mote

Laboratory, Vita uses a terrestrial farm in Palmas, USA, to grow. The system accelerates growth up to 50 times the natural or from decades to 6-18 months. This is perfect for species such as Brain or Great Star that serve as critical building blocks for reefs, but grow too slowly to be feasible for restoration projects using -based nurseries. Vita can grow these corals in months rather decades. In 2019, Vita created the world's first regrowth farm in the Bahamas, including electrical installation, plumbing and aquaculture tanks. The farm aims to restore the island's corals reefs, featured in the Netflix film "Chasing ," and provide restoration projects with hardier corals by together with scientists, communities, farmers, businesses, investors and governments. Although the initial is to grow about 10,000 corals per year and serve as an education and visitation center, the -term goal is to be growing millions of corals every year, restoring reefs worldwide. *(coralvita.com)*

From 2017, a team led by H. Malleshappa, head of the Tamil Nadu State Climate Cell deployed a semi-circle of concrete artificial reef modules 820 ft (250 m). from the vulnerable Island in the Gulf of Munnar. Each module is 8 ft (2.5 m) in width, 6.6 ft (2 m) in height and 3ft (1 m) in longitudinal length, and weighs 2 tons (1.8 tonnes) In the first two phases, 4,600 modules been deployed in eight months. Following signs of regeneration, with the funding from Adaptation Fund, the total number of artificial reefs has increased to 10,000 in two layers. *(environment.tn.gov.in)*

In 2019, scientists on Project at The Florida Aquarium's Center for Conservation in Apollo Beach in Tampa have spawned an Atlantic pillar in a lab setting. This is a world-first reef restoration and research advancement in which Atlantic , living for several years at the Center as part of a genetic archive, has been reproduced through induced spawning, setting a new for saving reefs in Florida and the Caribbean. Project works in partnership with London's Horniman Museum and Gardens to create spawn, or egg deposits, in a lab. Jamie Craggs, aquarist at the Horniman Aquarium started Project and in 2013 became the first organization globally to develop protocols that replicate natural reef conditions, and the triggers for mass spawning events, in the lab, to predict and induce -based spawning in a fully closed aquarium lab setting in to investigate, counter and repair the impact of climate on reef health and reproduction. The team started on the research in 2014 with the Staghorn , but then the focus shifted to pillar coral because of a disease that has been devastating to the Florida Reef Tract. Pillar corals are now classified as almost extinct since the remaining and female clusters are too far apart to reproduce.

This conservation effort enables sexual reproduction to occur entirely outside of the using innovative technology. It also up the potential for de-extinction. *(flaquarium.org)*

In Korea, (Steel Company) in conjunction with the Research Institute of Science and Technology (RIST) and the government developed Triton, an artificial reef produced by steel , to create a healthy environment for life. has supplied 1,418 units of Triton for forest projects such as artificial fish reefs executed by the government and municipalities. Triton is naturally with high % of and calcium, which work to create the ideal conditions for seaweed and algae spore growth, and purifies contaminated sediment. These reefs can also help reef populations migrate to cooler waters. *(poscoenc.com)*

Siddharth Pillai, a teenage Class XI student from BD Somani School, Mumbai, India has found a way to modular artificial reefs using 3D printing. He has named them after the Linkin Park vocalist Chester Bennington. In early 2019, several porous Linkin Park blocks, a combination of dolomite and cement in a 10-90 per cent , weighing 24 lb (11 kg) each, were dropped near Puducherry in the Laccadive Sea. This design is replicable as well as stackable, enabling reefs as high as 3ft (1 m) and as wide as 66 ft (20 m) on the bed. *(bdsomaniinternationalschool.com)*

Another solution has been developed during 2019 by David Branthôme, director of the Limousin Aquarium, and the I.Ceram company in Limoges, : cuttings are installed on a piece of alumina (a special ceramic). Since ceramic is neutral, it does not the disadvantages of plastic or concrete supports. *(aquariumdulimousion.com)*

Maoz and a team at Bar- University, together with the research lab at the Interuniversity Institute for Sciences on the Gulf of Aqaba in Eilat, Israel Israel having analysed why Red Sea corals are resilient are investigating how their lessons could be used to influence coral reef health and resilience in the central Pacific Islands. *(life-sciences.biu.ac.il)*

The Australian Institute of Marine Sciences (AIMS), researchers led by Patrick Buerger, successfully developed a coral more resistant to increased seawater temperatures in a laboratory. The team isolated the microalgae from and cultured them in the specialist symbiont lab. They then exposed the cultured microalgae, using a technique called "directed evolution," to increasingly warmer temperatures over a period of four years, which assisted the corals to

adapt and survive hotter conditions. the microalgae were reintroduced into larvae, the newly established -algal symbiosis was heat tolerant compared to the original one. *(aims.gov.au)*

In 2013, Alex Goad and a team at the Reef Design Lab, Melbourne, Australia began to develop the Modular Artificial Reef Structure (MARS), by 3D-printing irregularly-shaped cement tiles for coral farming and reef restoration. These mimic the root structure of mangrove trees, which are a favourite habitat for sea life but are disappearing at an alarming rate. Oysters, molluscs and other marine life use the artificial crevices in the gaps between the tiles to create new habitats. The tiles are marine-grade concrete reinforced with recycled plastic fibres.

MARS reimagines these farming structures as a three dimensional lattice that can be deployed from small and implemented by divers similar to an underwater lego set. This completely eliminates the need for heavy-duty machinery (which many communities do not have access to) but allows for a strong structure using minimal material. The system is then built depending on the needs of the coral farm or the restoration goal. Each unit has specially designed surface geometry to encourage natural recruitment of juvenile coral and to make it easier for transplanted coral to take hold.

The designs were developed by Sydney Institute of Marine Science, with support from Volvo. Fifty tiles have been installed along a seawall in Sydney Harbour, Australia. Called the "Living Sea Wall", the tiles will be in place for 20 years, according to the Sydney Institute of Marine Science. Scientists plan to study how wildlife responds.

Researchers led by Prof Jörg Wiedenmann at The Coral Reef Laboratory of the University of Southhampton, England discovered that in warming when some corals, instead of bleaching white, suddenly display fluorescent colouring they are fighting to survive.*(Southampton.ac.uk)*

Georgina Gurney et al, "Modelling Reef Futures to Inform Management: Can Reducing Local-Scale Stressors Conserve Reefs under Climate ?" *PLoS ONE* 8(11):e80137 , November 2013; Elena Bollati, Cecilia , Rachel Alderdice, Pratchett, Maren Ziegler, Wiedenmann, "Optical Feedback Loop Involving Dinoflagellate Symbiont and Scleractinian Host Drives Colorful Bleaching," *Current Biology*, 2020; DOI: 10.1016/j.cub.2020.04.055.

Cork e-friendly building material

Solution: The cork oak tree (*Quercus suber*) has a much impressive layer of cork bark. It's this tree that cork is sourced from. The cork oak tree is native

to the countries in the Mediterranean region, as this area of the world has the perfect growing conditions for cork oak: not too much rainfall, high humidity levels, and plenty of sunshine. The forests of the Mediterranean region evolved to thrive despite the low rainfall and frequent brush fires: hence Morocco, Algeria, , Italy, and Tunisia all grow cork oak trees, but Portugal and Spain are the world's biggest suppliers. Cork does not absorb water or rot. Likewise, if left uncoated – it is naturally fire resistant.

Ancient Egyptians, Greeks and referenced cork as a preferred material for stoppers used with and olive oil. The also recommended making beehives out of cork, because of its low heat conduction; they employed corkwood planks in the construction of their homes, proved ideal for flooring and insulation sheets due to its noise as well as adsorption attributes.

Cork harvesting takes place for the first time when a tree reaches maturity, which is usually at about 15 to 25 years of age. The specially trained harvesters will first measure the tree's circumference to ensure it's at least 70 cm when measured from 1.3 meters above ground level. The harvesting itself takes place from about the middle of May to the end of August. This is when the cork oak trees enter their active growing phase.

Although the primary market for the material today remains bottle stoppers—which comprise some 60% of leading Portuguese cork producer Corticeira Amorim's exports—architectural applications are on the . Panels and strips are not the formats for cork façades. *(amorim.com)*. Cork is used to for the outer walls of houses, as in Portugal's pavilion at Expo 2000. Albacete, Spain–based coating company DecoProyec makes Projected Cork, a spray-finish material composed of cork and vegetable resin in a water . When applied to building envelopes, the resulting stucco-like finish is waterproof and well-insulating, yet also breathable and resilient. Projected Cork resists cracking and splitting, and is capable of extending up to 33 percent beyond its original surface area.

Sofia Knapic, "Cork as a building material: a review", *Holz als Roh- und Werkstof* , July 2016.

Coronal mass ejections (CME), early warning system

Problem: Serious coronal mass ejections could cause global chaos disrupting electronic systems including satellites, navigation systems, GPS

systems, communication systems, aircraft, power grids, radios, televisions and . For perspective, the fastest ejections would just 15 to 18 hours to hit Earth.

Solution: To set up an early warning system, NASA's Goddard Space Flight Center and the U.K. Space Agency (UKSA) teamed up to develop a forecast system designed to provide an extra day for shutting down vital electronic systems. The project, which also involves the European Space Agency and the U.S National and Atmospheric Administration, aims to develop a plasma analyzer. The creation of the instrument will be spearheaded by the Mullard Space Science Laboratory of University College London. Their research demonstrates how the new warning system can both measure and model coronal mass ejections (CMEs) and how this can help predict how CMEs will affect the Earth. The new detection system would use cameras on satellites in multiple locations to estimate where the approaching solar storm is located and in what direction it is traveling. This data is then combined with coronographs from the sun itself, provided by the ESA/NASA Solar and Heliospheric Observatory (SOHO), which show how the CME moves towards Earth. The scientists already successfully tested a model of the system on eight mass ejections and NASA plans to continue testing. The research group's next step is to create an interface that makes the warning system easy to use. NASA hopes the system will be to assist in monitoring space weather in the future. *(nasa.gov)*

In the next 5 years NOAA and ESA with support from the UK are planning to launch two complementary solar monitoring satellites. On March 30, 2020, NASA decided to fund the Sun Interferometer Space Experiment (SunRISE) mission for its heliophysics program, developed by a team lead by Justin Kasper at the University of Michigan. Launched by July 2023, six cubesats In July 2023, SunRISE will get to orbit flying on a commercial satellite built by Maxar. A system called the Payload Orbital Delivery System, attached to the satellite, will release six SunRISE cubesats in orbit. They will fly in a formation about (10 km) across, so creating a virtual telescope to detect and pinpoint emissions from the sun associated with solar storms. The UK's 'plasma analyser' will fly on ESA's Lagrangian 5 space weather monitoring mission to observe solar wind. L5 is about one astronomical unit from Earth (the distance of the sun, or 93 million mi (150 million km), but off to the side of the Planet. The UK Space Agency is cooperatively with ESA and the United States' NOAA

on their complementary Lagrangian 1 space weather monitoring spacecraft. RAL Space in the UK is also on optical instruments for space weather missions under the current ESA programme.

"UK and USA join forces to launch 'space weather' service," *UK Space Agency* 4 2019; Inigo Monzon "NASA, UK Team Up To Protect Earth From Deadly Solar Storms", *International Business Times*, 6, 2019; Jeff Foust, "NASA selects space science cubesat mission," *Spacenews*, March 30, 2020.

Credit card as personal CO_2 calculator

Problem: Since its invention in 1946 by John Biggins of the Flatbush National of Brooklyn in New York, the credit card has paying from cash to online. The number of credit cards from the four primary credit card networks (VISA, Mastercard, American Express) is 679 million in 2018. There were a total of 1.06 billion credit cards in 2017 and the projection for 2022 is close to 1.2 billion. Cards are of several layers of plastic laminated together. The is commonly from a plastic resin known as polyvinyl chloride acetate (PVCA). This resin is mixed with opacifying materials, dyes, and plasticizers to give it the proper appearance and consistency. This bodes badly for landfills.

Solution: In 2008, Discoverers launched a "green" credit card of biodegradable PVC, 99 % of which can be absorbed back into the environment given the right conditions. They contended that, with exposure to soil, water, compost, and other microorganisms, the card will degrade completely within nine months to 5 years.

But can a biodegradable card do more than facilitate purchases? Having worked for nearly ten years in Sweden's banking and insurance section, when Nathalie Green was faced with the inertia of institutions to respond to the climate emergency, she decided to leave her post and dedicate all her energy to the creation of products to accelerate the ecological transition. Founding a company called Doconomy, she conceived "Do", a mobile application that measures CO_2 emissions from our purchases. From there on, Doconomy has progressed to the Do-Card, incorporating technology from the Ålands Index, a Finnish financial tool that uses big data to match every purchase with the most accurate estimation of CO_2 emissions related to its production and consumption.

Specifically, each time the card is used, its receives an alert that indicates the carbon footprint of the purchase. For example, at a checkout, he will know that the purchase of jeans is 70 lb (32 kg) of CO_2. Those who sign up to DO will receive access to a free savings account that helps them understand their carbon footprint, learn about UN-certified climate compensation projects, and Discover's investment funds that a positive impact on people and the planet. The card itself is of bio-sourced material and is printed with Air-Ink (see entry), and with no magnetic strip is the first of its kind in the world. For this solution, Doconomy is with Mastercard via their global network, reaching and levering the power of consumers all over the world and direct capital towards sustainable initiatives.

doconomy.com ; "DO – the world's first credit card with a carbon limit", *mastercard.com* April 30, 2019.

Crop fertilizer from recycled batteries

Problem: According to Lithium Australia some 6,600 tons (6,000 tonnes) of alkaline batteries are sold annually around Australia and the Battery Stewardship Council estimates that at the end of their useful life, 97% of these spent products are thrown away and end up in landfill sites where they leak into the soil, causing pollution.

Solution: Lithium Australia's 74%- Envirostream has been producing its mixed metal dust (MMD) containing cobalt, nickel, lithium and carbon from a 3,300 ton (3,000) per annum lithium-ion battery recycling plant, with the dust to shipped immediately to SungEel in South Korea for refining into chemicals that will be incorporated in new batteries In recycling spent lithium-ion batteries. one step further, during 2019, Envirostream began to assess the use of zinc and manganese, obtained from recycled alkaline batteries, as micro-nutrient supplements in fertilisers. It conducted an initial round of "glasshouse pot trials", growing wheat in a variety of controlled scenarios including using the recycled zinc and manganese separately as fertiliser sulphates and a combination of the two metals as fertiliser sulphates. Testing was also conducted on growing the wheat using no fertiliser micro-nutrients. From this, field trials are carried out in near the rural town of Kojonup around 160 mi (260 km) from Perth in the wheat belt of Western Australia, a region that produces about 15.4 million tons (14 million tonnes) of annually and serves as a major contributor to Australia's

exports. The Kojonup site was selected for its low pH, as well as accompanying zinc, manganese and phosphate deficiencies. Adding zinc would assist in making chlorophyll. In addition to Australian field trials, Envirostream intends to conduct further trials overseas in jurisdictions outside Australia which seeking out partners willing to explore. *(lithium-au.com)*

Prior to this in 2018, in Kärsämäki, central Finland, a team led by Mikko Joensuu and Joni Rahunen created a cleantech company called Tracegow to recycle batteries in Finland and also use the zinc and manganese to enrich soils for growing food crops. Batteries are first crushed, then filtration and purification processes remove elements such as mercury and nickel. It is important that these do not end up in the fertiliser as they could their way into the food we eat so testing of the final product is rigorous. removed, they are sent on to be safely disposed of by hazardous waste treatment plants. Initially, Tracegrow's *ZM-Grow* fertiliser was used on tomatoes, cotton and avocados with promising results. On March 30th 2020 Tracegrow was an international patent and signed up a distribution partnership for Australia and New Zealand with ReNutrients PTY Ltd. *(tracegrow.com)*

"Finnish company turns used batteries into fertilizer," *yle.fi/Uutiset*, October 18, 2018; Matt Birney, "Lithium Australia to produce fertiliser supplements from spent batteries," *The West Australian*, May 12, 2020

Cross-laminated timber

Problem:

The dependency on concrete and steel to build everything from homes to sports stadiums comes at a severe environmental cost. Concrete is responsible for 4-8% of the world's CO_2 emissions.

Solution:

Some architects are therefore arguing for – and pressing ahead with – a return to wood as our primary building material. Wood from managed forestry actually

stores carbon as opposed to emitting it: as trees grow, they absorb CO_2 from the atmosphere. As a rule of thumb, 35 cubic ft. (1 cubic meter) of wood contain around a of CO_2 or less, depending on the species of tree.

Cross-laminated timber, or CLT, has become the primary material on the construction site. It is an “engineered wood”, the planks of which are by gluing them in layers of three, with each layer perpendicular to the other. This that the CLT does not bow or bend, it has integral strength in two directions allowing the manufacture of plates or surfaces – or walls. It is a plywood of boards that can reach enormous dimensions: between 7.8 ft. (2.40 m) and 13 ft. (4.00 m) high, and up to 40 ft. (12 m) . CLT is a renewable, green and sustainable material, since it is out of wood and does not require the burning of fossil fuels during production. CLT, however, is below 1% adhesive, and typically uses a bio-based polyurethane. The planks are bonded together under heat and pressure to fuse that small amount of adhesive using the moisture of the wood.

CLT was first developed and used in Germany and Austria in 1994 after Austrian- researcher Gerhard Schickhofer at University of Technology presented his PhD thesis research on CLT, “Starrer und nachgiebiger Verbund bei geschichteten, flächenhaften Holzstrukturen” ("Rigid and resilient composite in layered, flat wood structures"). This was partly in response to the death of the furniture and paper industries. 60 % of Austria is forest and they needed to find a new sales outlet. Indeed it was Austria which published "Holzmassivbauweise", the first national CLT guidelines in 2002, based on Schickhofer's extensive research. These national guidelines are credited with paving a path for the acceptance of engineered elements in multi-story buildings. CLT factories in Austria are even powered by renewable biomass using the offcuts, and twigs. Some factories produce enough electricity to power the surrounding communities. *(tugraz.at)*

Nail-Laminated Timber (NLT) and Dowel-Laminated Timber (DLT) been revived, while - started looking good again because it is so efficient in its use of wood.

An increasing number of architects now build tall with CLT, allowing the construction of buildings with up to 30 floors for the 180 ft. (53m) Commons Tallwood House, in Vancouver, in Canada, up to 18 floors in Finland and in Sshickhofer’s native country, the 276 ft (84m), 24-storey 'HoHo Tower' nearing completion in the Seestadt Aspern area of Vienna, Austria. 76 % of the latter

structure will be constructed from CLT, which will save a 2,800 tonnes of CO_2 emissions over similar structures built out of steel and concrete. Moreover, 1 m³ of concrete weighs approximately 2.7 tons (2.5 tonnes), while 35 cubic ft. (1 m³) of CLT weighs 882 lbs (400 kg) and has the resistance. The goes for steel. Completed in March 2019 after two years of construction, the 280 ft (85.4 m) "Mjøstårnet" 18-storey skyscraper, located in Brumunddal, some 60 mi (100 km) north of Oslo is built in CLT. It takes its name from Lake Mjøsa, on the edge of which it was built. Designed by Voll Arkitekter its timber was located and prepared within a radius of 10 mi (15 km) around the tower. Containing apartments, hotel, a 10,760 ft² (4,700 m²) swimming hall. office space and a restaurant, it has been declared "The Tallest Timber Building in the World." by the Council on Tall Buildings and Habitat.

In 2019, Gerhard Schickhofer, Head of the Institute of Timber Engineering and Wood Technology at University of Technology, was awarded the Marcus Wallenberg of SEK 2 million (US$ 209,000).

Alexandra Thiel and Gerhard Schickhofer, "CLTdesigner - A software tool for designing cross laminated timber elements: 1D-plate-design" January 2010; Gerhard Schickhofer et al.,"Cross laminated timber (CLT): overview and development," *Holz als Roh- und Werkstoff* 74(3) · January 2015.

Crowdfunding

Problem: Solutions created by start-ups need funding to kick-start them.

Solution: Online crowdfunding, created by entrepreneur Michael Sullivan in 2006, is one of the fastest growing sources of funds for any new venture. It is a method of funding a venture or project through the collective efforts of family, friends, customers and individual investors. There are crowdfunding platforms or websites that investors can use. Crowdfunding is a particularly well-suited idea for any green business. In 2008, Danae Ringelmann, Slava Rubin, and Eric Schell of San Francisco, California launched an "all or nothing" crowdfunding website they called "Indiegogo." Powered by curiosity, the Indiegogo community has helped 800,000 innovative ideas to life since 2008. Today, our

group of backers is 9 million , representing 235 countries and territories While it covers every industry, it has a section called Environment. With the right idea, entrepreneurs reason to be optimistic. Among successful Indiegogo campaigns for green businesses: Crowdcube electric carpooling club; Powervault for its its electricity device project; Sondors Electric Bike; etc. (*support .indiegogo.com)*

Crowdsource cleaning

Solution:

Find a discarded coffee cup, crushed soda can, candy wrapper, or any other piece of litter & take a picture. Discard Properly & Tag the Photo. The app automatically geo-tags the image & our LitterAI tool recommends tags for what kind of litter it is. Confirm the tags to help the LitterAI keep learning.

In 2014, Jeff Kirschner found that when he posted photos to Instagram of random litter he would come across and picked up, the litter became “artistic” on Instagram. Because it was now artistic, it became more approachable. After one week, Kirschner of California had 50 photos on his phone. He realised that in the way way that people are measuring the steps they walk or the miles they ride or even the calories they consume, he was measuring the positive impact I was having on the Planet.

What started as a hashtag on Instagram grew into a full app platform on iOS and Android and a community in 165 countries that has picked up almost 5.3 million pieces of litter. Litterati has translated these photographs into data on litter worldwide, which it has licensed to schools, brands and nonprofit organizations to help develop behavioral insight, map problem areas, and mitigate future risk.shape policy.

Litterati’s app has 4,000 local challenges that have been created around the world, and the startup has raised over $1 million in funding from the likes of Twitter CEO Jack Dorsey and The National Science Foundation. Litterati has been featured by National Geographic, Rolling Stone, and Forbes, and they are backed by leading Silicon Valley investors, the National Science Foundation

In the Netherlands, for example, the Litterati community picked up 50,000 plastic fireworks called Knetterbals, leading a major retailer—the largest Dutch supermarket chain, Albert Heijn—to ban the sale of these firecrackers.

While the startup began in California, Kirschner has moved with his family to Chapel Hill, home to a campus of the University of North Carolina and is now a

part of the Triangle tech scene. In 2016, he took his Litterati story to a Ted Talk as part of a Ted residency.

Ultimately, Litterati's mission is to use crowdsource cleaning to create a litter-free world and inspire people to be a part of the solution.

Cryodistillation, airborne

Solution:

Eran Oren, chief scientist and found of German-Israeli startup High Hopes, based in Stuttgart, Baden-Württemberg, Germany and Tel Aviv, Israel is planning to put low-energy carbon capture rigs in high-altitude hydrogen balloons, send them up to heights where they can work most efficiently (just below the inversion layer, where atmospheric temperatures start to rise), fill up pressure tanks with dry ice, then bring them down to Earth. As the temperature rises, the dry ice will turn back into CO2 gas, pressurizing itself thanks to the restricted volume of the tanks, and it can be sent straight out for geosequestration.

The balloons are already commercially available from Aerostar Technical Solutions, Inc.They are the same Google was using for its now-defunct Project Loon stratospheric broadband project. The Google balloons can carry 150-200 kilos (330-400 lb) up to 20, 20-something kilometers (65,000-plus ft). So where High Hopes is concerned, one balloon can carry something like 300 kg (660 lb).

A balloon would need to stay aloft for between 12-24 hours in order to collect a full metric ton of CO^2, at which point it would come down, land, top up its hydrogen, swap its full CO^2 tank for an empty one, and go back up. High Hopes has flown and tested prototype balloons in the range of several kilograms, and is satisfied that the technology works and all underlying assumptions are correct

Oren is aiming to get a system that will have the ability to pull one metric ton of CO2, per balloon, daily, for a cost that makes it feasible to sell carbon credits. Given that the world currently emits over 117 million tons of CO2 each day, High Hopes will require a large fleet of balloons.

Cryogenic energy (CES)

Problem: What to do with excess energy from thermal generation plants, steel mills and LNG terminals.

Solution: Peter Dearman, a garage inventor in Hertfordshire, UK who had initially developed a liquid air powered car, then put the technology to use as clean grid energy. A CRYOBattery makes use of excess energy, such as that generated by renewable sources, which cannot be sent immediately to the grid to liquefy air and store the liquid until the electricity is needed and can be distributed. At this point, the liquid air is allowed to evaporate and expand through a turbine, where its latent energy of vaporisation is converted into electric current. Connecting to thermal generation plants, steel mills and LNG terminals can further the system's efficiency and diversify its offering. In 2011, a 300 kW, 2.5 MWh capacity pilot cryogenic energy system was developed by researchers at the University of Leeds and Highview Power that used liquid air (with the CO_2 and water removed as they would turn solid at the temperature) as the energy store, and low- waste heat to the thermal re-expansion of the air. In April 2014 the UK government announced it had given £8 million to Viridor and Highview Power to fund the next stage of the demonstration. The resulting grid-scale demonstrator plant at Pilsworth Landfill facility in Bury, Greater Manchester, UK, started operation in April 2018 This was based on research by the Birmingham Centre for Cryogenic Energy (BCCES) associated with the University of Birmingham, and had for up to 15 MWh, with a peak supply of 5 MW (so when fully lasts for three hours at maximum output) and is designed for an operational life of 40 years. With Highveiw Power's Potentially CRYOBattery is to deliver anywhere from 20 MW/80 MWh to 200 MW/1.2 GWh of energy to power up to 200,000 homes for a whole day. In 2020, Highview, teamed up with Carlton Power and announced construction of the world's biggest liquid air battery with a capacity of 50 MW/250 MWh at a the Trafford Energy Park, a decommissioned thermal power station site in the North of England. With the first system scheduled to go into operation by 2022, another four will be set up in the UK, to deliver a total of over 1GWh. *(highviewpower.com)*

David Strahan; *Liquid air in the energy and transport systems : opportunities for industry and innovation in the UK : summary report and recommendations*, The Centre for Low Carbon Futures, White Brussels, 2013. Stuart Nathan, "Highview Power to build Europe's largest energy plant," *The Engineer*, October 22, 2019; Highview Enterprises Ltd, "Heat recovery," Patent N°: 10662821. Filed: September 29, 2016 of Patent: May 26, 2020

: "1 déchet par jour "

Problem:

The battle against rusting or rotting rubbish in ditches, on sidewalks or on the seashore is far from won. The more of us will behave as eco-citizens, the more the environment will thank us for it.

Solution:

In 2016, during a visit to his home town of Leeds Edmund Platt, a British citizen living in Marseilles, was surprised to see the state of his childhood park. Garbage had replaced the green of the lawn and for him it was impossible not to react. He then imposed on himself the challenge of collecting at least one garbage per day. At the time, we were in the middle of a selfie-mania and he took a picture of himself with his trash before throwing it in the trash and posted the snapshot on social media.

This caused an avalanche of likes and comments. Among these, there was that of Georges-Édouard Legré. The latter challenged him to get their waste collected by the citizens of Marseilles. On his return to the French city-port, they met and formalized a solution that could hopefully affect the whole planet. *1 Déchet Par Jour* was founded on January 16, 2016, by Edmund Platt, George-Édouard Legré, and Romain Jouannaud.

To spread the message everywhere, 1 Déchet par Jour also offers users to pick up garbage in the street, in front of their homes or in front of their office, and to take a selfie and then post it on Facebook, Instagram or Twitter with the hashtag # 1 waste per day.

Since the launch of its activities in 2015, 1 Déchet par Jour is at the origin of events such as “Love ta Bonne Mer!”, Of waste collections in the Félix Pyat city, on the Canebière, at the Saint-Charles station and even made an appearance in one of the episodes from the series “Plus Belle la Vie.”

According to the 2019 activity report, the association organized 54 collections (for example every year a waste collection is organized in Notre-Dame-de-la-Garde, on July 12, 2017 in the city of Felix Pyat, and more besides…). It has around 2,500 participants and collected 10,000 kg of waste in 2019

To spread the word nationally, Edmund Platt and Frédéric Munsch, an independent videographer made an 880 km trek across France, picking up one piece of rubbish per day, filming it and posting it on social media

To fight against pollution and educate citizens about the protection of nature, the Marseille association 1 Déchet par Jour is launching a vast waste collection operation from May 15 to 19, 2021 Citizens, associations or companies can create their own action or join an already existing collection. 55 events are already scheduled in the region

De-extinction

Problem: According to the IUCN Red List of Threatened Species, there are now 41,415 species on the IUCN Red List, and 16,306 of them are endangered species threatened with extinction. An estimated 50,000-70,000 plant species are used in traditional and modern medicine worldwide. About 110 million tons (100 tonnes) tons of aquatic organisms, including fish, molluscs and crustaceans are taken from the wild every year and represent a vital contribution to world food security. It is called the Sixth Extinction.

Solutions: A paper published in the journal *Proceedings of the National Academy of Science* reported the Earth BioGenome project where the DNA of all known eukaryotic life on Earth is recorded. It is estimated to 10 years, cost US$4.7 billion, and require 200 petabytes of digital space (a petabyte is one quadrillion, or 10^{15} bytes). “Eukaryotes” refers to all plants, animals, and single-celled organisms, all living things except bacteria and archaea (those will be taken of by the Earth Microbiome Project). It is estimated there are somewhere between 10–15 million eukaryotic species, from a rhinoceros to a chinchilla down to a flea (and there are far smaller). Of the 2.3 million of these documented so far, scientists sequenced fewer 15,000 of their genomes (most of which been microbes). One of the biggest questions is how, exactly, scientists will go about the gargantuan task of collecting intact DNA samples from every known species on Earth. Some museum specimens will be used, but not been preserved in such a way that the DNA could produce a high-quali ty genome. One important source of samples will be the Global Genome Biodiversity Network. *(ggbn.org)*

There is significant controversy over de-extinction or resurrection biology, or species revivalism. Critics assert that efforts would be better spent conserving existing species, that the habitat necessary for formerly extinct species to survive is too limited to warrant de-extinction, and that the evolutionary conservation benefits of these operations are questionable. In 2017, a report published in the

journal *Nature Ecology & Evolution*, found that de-extinction of extinct animals for the species in New Zealand and New South Wales, Australia would be harmful to biodiversity. The lead author of research is the professor of biology at the Carleton University, Canada, Joseph R. Bennett, who used the extant analog to predict the result of the de-extinction of extinct animals with his six colleagues from Australia and New Zealand. Indeed Michael Crichton's best-selling dystopian novel "Jurassic Park" (1990) and Steven Spielberg's blockbuster film of the (grossing USUS$1 billion) led people to believe that cloning dinosaurs back to life could go terribly . But there are an increasing number of cases where species might be "brought back to life". *(carleton.ca)*

Cloning involves extracting the nucleus from a preserved cell from the extinct species and swapping it into an egg of the nearest living relative. This egg can then be inserted into a relative host. It is important to note that this method can be used when a preserved cell is available. This that it is most feasible for recently extinct species. For example, the banteng is an endangered species that was successfully cloned, and the first to survive for over a week (the first was a gaur that died two days after). Scientists at Advanced Cell Technology in Worcester, Massachusetts, United States extracted DNA from banteng cells kept in the San Diego Zoo's "Frozen Zoo" facility, and transferred it into eggs from cattle, a process called cell nuclear . Thirty hybrid embryos were created and sent to Ova Genetics, which implanted the fertilized eggs in cattle. Two were carried to term and delivered by Caesarian section. The first hybrid was on April 1, 2003, and the second two days later. The second was euthanized, but the first survived and, as of September 2006, remained in good health at the San Diego Zoo. *(embryo.asu.edu)*

De-extinction via DNA

One of the most powerful tools to fight biological obliteration is CRISPR, *(*Clustered Regularly Interspaced Short Palindromic Repeats*)* involving slicing DNA apart then adding and subtracting genes at will. In 1987, researchers at

Osaka University studying the function of *Escherichia coli* genes first noticed a set of short, repeated DNA sequences, but they did not understand the significance. Six years later, another microbiologist, Francisco Mojica at the University of Alicante in Spain, noted the sequences in a different single-celled , *Haloferax mediterranei*. The sequences kept appearing in other microbes and in 2002, the unusual DNA structures were given a : CRISPR. In 2012, Jennifer Doudna, from UC Berkeley, and Emmanuelle Charpentier, at Umea University, Sweden, showed CRISPR could be hijacked and modified. Essentially, they had turned CRISPR from a bacterial defence mechanism into a DNA-seeking missile strapped to a pair of molecular scissors. Their modified CRISPR system worked extremely well, finding and cutting any they chose. The floodgates opened, and CRISPR research, which had been the domain of molecular microbiologists, skyrocketed. The number of articles referencing CRISPR in preeminent research journal *Nature* has increased by over 6,000 % between 2012 and 2018.

One scientist who is using CRISPR for a particular de-extinction is Ben Novak, a lead scientist with conservation nonprofit Revive & Restore in Sausalito, California. Novak is to back the passenger pigeon, North America's most abundant bird. The last passenger pigeon, a female named Martha, died in the Cincinnati Zoo in 1914, rendering the species extinct. Novak spends most of his time in a facility southwest of Melbourne, Australia, with the Commonwealth Scientific and Industrial Research Organisation (CSIRO) breeding -tailed. To completely resurrect the passenger pigeon, Novak and his team are to create a hybrid pigeon with parts of the CRISPR system embedded within its genes. The hybrids will be bred for several generations until the offspring DNA matches that of the extinct species. The first generation of ‘revived’ pigeons is expected to hatch in 2022. *(reviverestore.org)*

In 2019, scientists at the North-Eastern Federal University in Yakutsk and the South Sooam Research Foundation succeed in extracting liquid blood from heart vessels of a 42,000-year-old Lenskaya breed foal excavated in the Batagai depression. The autopsy showed beautifully preserved internal . Scientists already indicated that they were confident of success in extracting cells from this foal to de-extinct its species. Elsewhere, in a study pubished in *Scientific Reports*, a team of scientists from Japan and Russia at Kindai University, in central Japan announced that they managed to recover cells from the left hind leg of a 28,000-year-old juvenile mammoth that was discovered in the Siberian permafrost in 2011. Cell nuclei from the mammoth were successfully implanted

in mouse cells were to react and that there is biological activity. De-extincted mammoths could be introduced to Pleistocene Park

In 2019, David Liu, a chemist at the Broad Institute in Cambridge, Massachusetts invented “prime editing” which further improves on the CRISP-Cas-9 solution by offering targeting flexibility and greater editing precision.

Although CRISPR should useful in de-extincting ancient species, perhaps importantly in its ability to help living species that are in of becoming extinct, it is certainly a Planet-protecting solution.

This of course includes plants. American chestnut trees dominated the East Coast of the U.S. until 1876, when a fungus carried on imported chestnut seeds devastated them, leaving less 1 % by 1950. To blight-resistant trees, scientists inserted a wheat into chestnut embryos, enabling them to an enzyme that detoxifies the fungus. This chestnut tree is likely to become the first genetically modified to be released into the wild it is approved by the Department of Agriculture, the Food and Administration (FDA) and the Environmental Protection Agency (EPA). Genomic research on crops, for example, has already yielded plants that grow faster, produce food, and are resistant to pests or severe weather. Researchers may find new medicines or discover better ways to engineer organisms for use in manufacturing or energy.

“Crispr and editing the human genome. Four years after its discovery, scientists worldwide are honing Crispr for a torrent of applications, pushing it from science to the field,” *Researchate*, February 2, 2016; Ben Jacob Novak,” De-Extinction” *genes*, November 13, 2018.

Delivery vehicle, door-to-door

Problem: Continuing to use cars to individually travel to and from supermarkets to buy weekly provisions is not eco-efficient.

Solution: As long ago as August 1967, the UK Electric Vehicle Association put out a press release stating that Britain had battery-electric vehicles on its roads, the rest of the world put together. All manufacturers of battery electric vehicles were, at one time, members of the Electric Vehicle Association of Great Britain, and they received returns from the manufacturers on a regular , so they were to give accurate numbers of BERVs in use in the UK

for a certain year. The EVA also had industrial truck manufacturers, battery manufacturers and component suppliers as members of the Association. Closer inspection disclosed that almost all of the 30,000 battery driven vehicles licensed for UK road use were milk floats or door-to-door delivery vehicles, the final link from electric milking machines at the dairy farm.

This link continues today with the addition that instead of the milkman taking orders and paid at each doorstep, the client can command pay for their groceries on-. In 2012, a startup calling itself Picnic bv. was formed by a team of IT specialists, led by Joris Beckers, Frederik Nieuwenhuys, Bas Verheijen and Michiel Muller in Amersfoort, the Netherlands. Backed by these four investors, it planned to come up with a new business that would be to gain a position in a market dominated by companies in the grocery market. The idea was simple. Clients ordered their dairy products and groceries using an on- App- which would then be delivered for free within a one-hour timeslot of their choice, using an electric truck with a 68 mi (l10 km) called the E-Worker, built by the French company Goupil. Starting off with 150 customers in Amersfoort, by 2016 Picnic was serving over 30,000 households in several cities in the middle of the Netherlands. In March 2017, having received US$110 million (€100 million) in funding, Picnic announced an aggressive expansion in the years ahead, including 5 new warehouses,70 distribution hubs, and the procurement of a staggering 2,000 electric delivery vehicles. In 2018 Picnic entered the German market, selecting Kaars, Neuss, Meerbusch and Oberkassel (part of Düsseldorf's district 4) with further expansion, starting in North -Westphalia which has a population of about 18 million people. Picnic is also expanding its delivery service in the Netherlands, to Noord Brabant, starting with Breda and Tilburg. Launching in May, 185,000 families will be to use the grocery delivery service. The next move is Belgium. There is no reason why Picnic should not eventually serve the 27 counties in the European Union. By mid-2019, around 700 of these electric carts were making deliveries around in the Netherlands and around 80 in Germany, particularly in North -Westphalia. *(picnic.app)*

Tomorrow's electric trucks will most surely be -in- with electric in the business of doorstep delivery. It has already begun. In 2017, Workhorse of Loveland, Ohio, already makers of an electric W-15 pick-up truck, unveiled their 100 mi. (160 km) *N-Gen* delivery van as part of their concept towards delivery with their integrated *HorseFly* . The latter takes off from the parked *N-Gen* lifting packages weighing up to 10 lbs (4.5 kg) and delivering them to a

destination within the driver's of sight. Production of the *N-Gen-1000* began in 2019. Thus the definition of a milk float enters the future… *(workhorse.com)*

In September 2019, Amazon CEO Jeff Bezos placed an for 100,000 electric delivery from Michigan-based startup Rivian. The announcement during an event in Washington, DC where Bezos unveiled Amazon's sweeping to tackle climate .

Kevin Desmond, *Electric Trucks: A History of Delivery Vehicles, Semis, Forklifts and Others* (Jefferson, NC: McFarland, 2019); Picnic.app.

Deodorant, zero-waste

Problem:

Deodorant bombs and high-does chemical applicators pollute. Household aerosols such as air fresheners, deodorants and furniture polish have overtaken cars as a source of smog polluting chemicals

Solution:

Maxime Debalt working for the Bleuvert family, based in Caumont-sur-Durance in the Vaucluse region of southeast France has produced : a solid, natural, zero waste deodorant. The eight active ingredients of this deodorant are 100% natural and 72% of them are certified organic: organic coconut oil, organic shea butter, organic sunflower oil, organic Carnauba wax and natural perfumes that come from Grasse, these are the ingredients to which must be added diatomaceous earth which has an absorbing power.

For the applicator, Maxime wanted a practical and beautiful object. He drew several of them himself and then submitted them to Patrice, a woodturner who helped him improve the first prototypes. The applicator is therefore made of wood from sustainably managed French forests. is therefore composed of a beech applicator, a cork pusher and a refill.

Desalination via aquaporin water channel protein

Problem: Worldwide water purification remains a major challenge.

Solution: In the 1980s, Peter , a physician-scientist at the Johns Hopkins University Medical Center, found an unknown protein that contaminated his every attempt to isolate the Rh protein from red blood cells. Intrigued by this mysterious interloper, persevered until he revealed its function and structure. The protein, which he named "aquaporin," turned out to be an essential piece of the cell's apparatus for maintaining the right balance of water inside and outside of the cell. Its structure is superbly adapted to let water molecules, and water molecules, pass through in number with remarkable efficiency and speed. Aquaporins are crucial for life in all organisms, from bacteria via plants to man. They facilitate rapid, highly selective water transport across the cell membrane, thus allowing the cell to regulate its volume and internal osmotic pressure according to hydrostatic and/or osmotic pressure differences. The importance of the aquaporin in human is perhaps most conspicuous in the kidney, where 40 to 50 gallons (150-200 litres) of water need to be reabsorbed from the primary each day, that is, aquaporin facilitated water transport is invoked when water must be rapidly retrieved from a body fluid. Aquaporin water channels are also important to life on Earth, also transforming our ability to purify drinking water at a scale, that in 2003 the Nobel Prize in chemistry was awarded to Professor for his discovery.

The need for clean water is an equally compelling problem tackled by bio-engineers. Biophysicist Morten Østergaard Jensen speculated that aquaporin could form the of a biological water filter. Together with entrepreneur Peter Holme Jensen, he formed a company in 2005 that aimed to scale up aquaporin-based water filtration. Aquaporin A/S in Kongens Lyngby, Denmark, has developed Aquaporin Inside technology devices to be employed in industrial and household water filtration and purification. Aquaporin InsideTap Water

Reverse Osmosis elements are sold globally and in standard configuration from 1812 up to 8040 elements, making it easy for original equipment manufacturers (OEMs) to use in their systems for a sustainable production of healthy drinking water. *(aquaporin.com)*

In September 2015, Danish astronaut Andreas Mogensen used Aquaporin A/S membranes to filter the water he in space. Making sure that astronauts enough to drink is one of the toughest parts to figuring out -term space travel. Water is heavy, quickly used and expensive to get into orbit. To put it into perspective, it costs US$10,000 per pound to launch a spaceship, a gallon of water weighs 8.33 lb (3.8 kg). Since 2011, Aquaporin A/S had been with NASA and Danish Aerospace Company, testing prototypes in a lab so that four years later Mogensen and crew members were to drink filtered on the International Space Station.

In 2018, Berghof Membrane Technology GmbH, a manufacturer of tubular membranes for the filtration and separation of industrial process streams and wastewater, signed a joint development agreement with Aquaporin A/S, wherein both companies would leverage their respective expertise in forward osmosis (FO) and tubular membrane technologies to launch products targeted for high-strength industrial wastewater and food and beverage process streams. Aquaporin also teamed up with the Massachusetts Institute of Technology to form a student program to further develop research into the applications of aquaporin. Two Chinese companies are also involved. *(berghofmembranes.com)*

According to a report issued in August 2019 by Bridge Market Research, The global tubular membrane market is projected to be US$ 137.33 billion by 2026. This increase in market value stems from a growing interest and concern for the environment and a lack of freshwater sources, leading to increased interest in water treatment and purification systems. Alongside Aquaporin A/S, a host of companies are now involved: MICRODYN-NADIR; Filtration Group Corporation; Dynatec Systems; Spintek; Pentair plc; Berghof Membranes; Duraflow LLC; Hyflux Ltd.; Athersys Inc.; BASF SE; Lenntech B.V.; Markel Corporation; Synder Filtration, Inc.; Koninklijke DSM N.V.; Koch Membrane Systems, Inc.; ASTOM Corporation; KATMAJ Filtration; CleaNsep Systems; Advent Envirocare Technology Pvt. Ltd.; SEPRA S.r.l.; M.W. Watermark, L.L.C.; Christian Bürkert GmbH & Co. KG and SUEZ.

Peter , “Aquaporin Water Channels” (Nobel Lecture), ResearchGate, *Angewandte Chemie International Edition,* August 2004; Vogel and Claus Helix-Nielsen, “Versatility of Aquaporin Based Membranes for Water Treatment,” *ResearchGate*, January 2017.

Diapers, biodegradable

Problem: An estimated three billion diapers are thrown away every year in the UK, accounting for 2-3% of all household waste, according to recycling charity . The vast majority of diapers are not recyclable and must be thrown away with general waste, meaning they will probably end up in landfill or burnt. Energy can be harnessed from burning waste and used for fuel but this also produces GHG, as do landfills. says by the time they are potty , a baby could used 4,000 to 6,000 disposable diapers, or 20 to 30 reusable diapers.

Solution : In 1991, Moltex in Germany launched the world’s first unbleached panty diaper. Its components were wood (cellulose, absorbent material) harvested from sustainable forestry operations bearing the seal of the FSC® (Forest Stewardship Council), a 100% chlorine-free absorbent (TCF) and a tea-leaf extract to bind odours. They were designed to biodegrade within 50 years,

ECO diapers developed by Marlene Sandberg of Stockholm, Sweden use wood pulp responsibly harvested from Scandinavian forests as the main absorbent and are fully biodegradable. The conventional plastic outer sheet has been replaced with a biodegradable material from maize starch and cellulose fiber, both natural materials. ECO is the first eco *nappy* to receive OK Biobased Certification by Vincotte, one of the world's most demanding independent certifications. *(naty.com)* Another solution is diapers from breathable bamboo fibres and chlorine-free wood pulp, making them 60% decomposed in less 3 months and can achieve ~80% decomposition over tim. Bambo Nature eco diapers are manufactured in a production facility where 95% of the production waste is recycled, making Bambo Nature one of the most eco-friendly diapers on the market. (*bambnaturusa.com)*

Since September 2019, a French composting company called Les Alchimistes has been experimenting with the composting of 11 million diapers coming from ten nurseries around Paris. The truckloads of compost produced will be sold to horticulturists. Co-founder Alexandre Guilluy realising that the element for which they have not reached a bio-sourced solution is the attachment scratches. However they are soon to launch the manufacture of 100% compostable diapers. *(alchimistes.co)*

"ECO by Naty," *mygreengoodiebag*, January 9, 2018;

Digital nose forest fire alarm

Problem: Raging wildfires continue to wipe out not only homes but also swathes of natural , from Australia to California and dozens of other countries in between. In a wildfire, each minute matters; a fire might move as quickly as 14 mph , so early detection might saving a few miles of forest and potentially stopping the blaze before it reaches homes

Solution: Entel of Santiago, Chile's largest telecommunications company teamed up with the AI start-up DataRobot to produce a sensor which can literally "sniff" the air in forests to alert firefighters in of fire. Using an IOT sensor, these "digital noses", (vigilante *digital*) small, very sturdy white boxes that are installed high up on a tree, are not to identify particles, but also the humidity and temperature of forest air. collected, this data is fed into a system that uses artificial intelligence to determine with great precision the type of smoke and the posed to the forest. When a threat is identified, a message is sent to the nearest firefighting teams to intervene as quickly as possible. This is much less expensive installing cameras. For its pilot phase, DataRobot and Entel installed 300 sensors in the Chilean forests reporting that they saved up to 12 minutes between the time of detecting a fire and responding to firefighters. *(daterobot.com)*

Dishwashing balls

Problem: In 1889, when after ten years of prototypes Mrs W.A. Cockran of Shelbyville, Indiana, USA, produced an electrically operated dish-washing machine, neither its energy and water consumption, nor the harmful effects of chemical detergents on the ecosystem, were taken into account.

Solution: The eco-efficient bio dish washing machine has become of primary importance and one key solution is the natural ceramic Eco Hi-Ball as invented in 2013 by Kyung-Sub Shin, of DaeEun Global Solution Co., Ltd in Inchon, South Korea. The Eco Hi-Ball for dishwashers uses oxygenation of the water to effectively clean and shine, without the harmful effects of a chemical

detergent. Its body is formed by thermally bonding a top plate and a bottom plate and has through holes formed in an outer side portion to completely the washing water at the time of washing dishes. In this way the washing balls can be maintained in a dried state and their efficiency. *(eco-hiball.com)*

Kyung-Sub Shin, " for dishwasher-use washing balls," *EP303138OA8*, Application January 25, 2017.

District Level Licensing

Problem:

The Great crested newt (*Triurus cristatus)* is widely distributed throughout lowland Great Britain, and absent from Ireland. In the last century great crested newts have seen dramatic declines in their populations over the last 60 years despite being legally protected.

Solution:

The District Level Licensing scheme (DLL) better protects this orange-bellied amphibian by using conservation payments from housing developers to create a network of ponds providing vital habitats helping to join up sometimes isolated populations and helping them to thrive.

The scheme also benefits local people and authorities by avoiding delays for developers, helping to ensure homes are built and local authorities can deliver their plans.

Natural England, in partnership with Lancashire Wildlife Trust, has invested developer payments not only into creating or restoring new ponds but also taking care of and monitoring the ponds too, for 25 years. By the end of March 2021, Lancashire Wildlife Trust had already created or restored nearly 60 ponds across the county for the scheme. The DLL solution is now being adopted in Kent, Cheshire and Suffolk with the objective of gradually becoming available for use in all counties throughout England.

Documentary films

Problem: Poor communication can lead to ignorance of the dangerous situations which the Planet has deterioted.

Solution: Well- and promoted documentary films urging solutions to protect the Planet can a mass effect. From 1903, with British cinematographer F. Martin Duncan's Unseen *World* series about microscopic creatures, the big screen has served that purpose. Between 1968 and 1975, the television series *The Undersea World of Jacques Cousteau* focussed on biodiversity and warned that life in the had diminished 40 % in just 20 years. Following former United States Vice President Al Gore's bestseller book *Earth in the Balance,* and his slide show *An Inconvenient Truth* given to over one thousand audiences worldwide, from 2006 a namesake film version became the eleventh highest grossing documentary film to in the United States. In 2007, billionaire actor Leonardo DiCaprio co- and narrated *11th Hour.* Through interviews with experts in scientific fields, as well as prominent activists and politicians, the film seeks to convince viewers, beyond any reasonable doubt, that the planet is in and that action needed to be taken immediately if we are to any chance of reversing the negative consequences. In the UK, the BBC Natural History Unit (NHU) is best known for its highly regarded nature documentaries presented by David Attenborough. *Life on Earth: A Natural History* sold to 100 territories and was watched by an estimated audience of 500 million people worldwide. In *Blue Planet II* (2017) and *Climate – The Facts,* Sir David, 93, discusses the science of climate and possible solutions to counteract it, including plastic recuperation.

In 2019 Australian actor-turned-filmmaker Damon Gameau took a different approach in his film *2040, Join the Regeneration.* In this he structures the film as a one-way conversation with his four-year-old daughter, who will be 25 when the titular year arrives and, he hopes, part of a brighter and better world. Gameau's documentary bills itself as a "journey to explore what the future could look such as by the year 2040 if we simply embraced the best solutions already available to us."

In collaboration with the Royal Canadian Geographical Society (), The *Anthropocene Project*, created by renowned photographer Edward Burtynsky and award-winning filmmakers Nicholas de Pencier and Jennifer Baichwal is a multidisciplinary body of work combining art photography, film, virtual reality, augmented reality, and scientific research to investigate human influence on the state, dynamic, and future of the Earth. Through evocative photography, a documentary, 360° cinematography, and captivating augmented-reality installations, this multimedia project explains the emergence of the Anthropocene epoch, distinguished by human-caused to our planet. As part of this the offered #OnlineClassroom, its free, bilingual learning tools to all

Canadians to support teachers, parents and students isolating at home during the COVID-19 pandemic.

Dopper bottle

Problem: Single-use plastic bottles end up in landfills.

Solution: Merijn Everaarts lived near BloomendahlSee beach in Haarlem, North Holland Province, the Netherlands, where he daily saw plastic and bottles either left by holidaymakers or washed in by the tide. In October 2009, after watching a documentary about 'plastic soup' Merijn joined in the search for a solution for plastic waste and a better plastic use lifestyle. Merijn, an entrepreneur in the event and marketing business, joined the local Haarlem Legacy, a group of 25 creative people who were pitching ideas every few weeks to the perfect disposable plastic bottle for tap water. In 2010, Merijn launched a design competition. van Remorte, at VDL Hapro having graduated at TU Delft, won that competition. Remorte beat nearly a 100 other contestants because he provided a sleek and clean design while also making it durable (lasting up to five years).

The chosen was Dopper. From the 16th Century, a *dop* as a kind of hat inspired by the Middle Dutch *dop* or *dopper* meaning shell, or goblet or pot. The first real Dopper bottles (certified B-Corp), were released on October 10, 2010, also known as Durability Day which created a lot of media attention. A Dopper bottle prevents 40 single-use water bottles from entering our .

In 2017, 1,687,598 Doppers were sold. M/s Dopper Foundation conducts an annual maker Challenge where students Masters in any Dutch university can apply and participate. The participants should select a for thesis either on water management or plastic waste. With 5% of the net proceeds, since the very first water bottle was sold, Dopper has been donating to the Simavi water projects in Nepal. They are part of the WASH programme. By installing water points and toilets, tens of thousands of Nepalese people now better access to drinking

water and sanitary facilities. Dopper Foundation started in the southern district of Ruphendi, and in the Gorkha and Baglung districts for 20.000 people. When they teamed up with local partner Sebac, they extended their projects to the Sindhupalchowk and Dolakha districts.

In 2018, Dopper has introduced an insulated water bottle. Designed to keep drinks hot or cold, this is the first insulated bottle the company has added to its . According to the company, the bottle will keep drinks hot for 9 hours and cold for up to 24 hours and holds 17 oz. (0.5 liter) of liquid. That Dopper Foundation and National Geographic Encounter unveiled a replica of the Brooklyn Bridge in Times Square with 5,000 single-use plastic water bottles to turn the tide on plastic pollution through Art and education. The plastic bridge replica represents the scale of bottles sold in a split second – 5,000. *(dopper.com)*

DropTop

Problem:

Due to the COVID-19 pandemic, the forced trend of working from home had considerably lowered greenhouse gas emissions and single-use plastic as fewer people were travelling to work. Many people hated it though. Working from home simply wasn't as effective as being in the office. They wanted to get back to the pre-pandemic normal.

Solution:

In 2011, Romanian-born Stefan Husanu of Hoddesdon, Hertforshire, southern England, founded Pith & Stem Ltd. to produce sustainable future. His workforce uses a variety of woods and timbers, sourced from waste management centres, recycling centres, refurbishment projects and condemned scaffold boards from local scaffolding companies. All new timber is sourced from suppliers signed up to the Forest Stewardship Council, the world's most trusted sustainable, non-profit forest management solution. Recycled plastic is sourced from less than 50 miles away. The majority of the steel is surplus sections from metalwork fabrication companies, stockholders, metal recycling centres, refurbishment projects and collected from the public.

With these materials, Pith & Stem team created DropTop, the world's first fully-integrated, plug-and-play, wall-mounted twin-monitor workstation, that can be customized with various wood and art options such as transforming into wall art, a framed picture when not in use, like a folding bed. Out of sight, out of mind.

It’s an ergonomic workstation that has been designed to maximise multitasking and productivity and was built for professional daily use. Its unique design gives the user ample workspace and plenty of screen real estate so that they can perform their work comfortably and use their time very efficiently minimizing the need to work long hours.

Socks for plastic waste recuperation

Problem: For years, towns all over Australia been battling with waste such as plastic containers, bottles, paper and vegetation discharged into the city's waterways by stormwater drains.

Solution: In Kwinana, a town of 40,000 inhabitants, just south of Perth in Western Australia, they considered a sock as developed in the early 1990s by a fisherman based in New South Wales, then acquired by the South Australian-based Asset Solutions. The 35 in. (90 cm) wide polyethylene sock has of a stainless-steel sleeve extension and is cleverly designed to pull shut like a drawstring bag when full. In March 2018, Mayor Carol Adams and Kwinana Council installed two Ecosol Net Tech socks over stormwater drains in the local Henley Reserve. Later, by removing them full of plastic waste and pollutants, they effectively eliminated the risk of flooding during peak-flow storms, particularly in areas where road is discharged into public spaces and wetland reserves. During the trial, 815 lbs (370 kg) of debris consisting of food wrappers, plastic bottles, and tree leaves was cleaned out of the nets, the plastic sent off for recycling. While three locations were identified as suitable points for further nets to be installed following the trial’s success, images posted by the Kwinana Council on social media went viral worldwide, over 25 million views and obtaining enquiries from New Zealand, the USA, Chile, Brazil, European

countries, the Philippines, Saudi Arabia, Zambia and China. *(kwinana.wa.gov.au)*

Meanwhile, the neighbouring City of Cockburn has become the first West Australian council to build a new road out of recycled plastic. About 40,000 single use plastic collected by supermarkets across Australia were melted into an asphalt mix used to a laneway in Port Coogee. *(cockburn.wa.gov.au)*

Ashwini Saseedaran, "City of Kwinana initiative nets impressive results," Sound Telegraph, August 7, 2018.

Drones for agriculture

Problem: Invasion by alien species is a worldwide phenomenon with negative consequences at both natural and production areas. Pest damage is one of the most significant problems facing farmers. It is estimated that as much as 35% of yield loss is due to pre-harvest pest activity. Globally, farmers spend over $40 billion per year on pesticides and herbicides (weed killers) - and the number in the US is almost 25% of that number at $9.2 billion. Why are farmers buying so much pesticide? They are trying to avoid an estimated total of $200 billion in crop loss annually caused by pests. About 200,000 suicides each year are attributed to pesticide poisoning, almost all in developing countries.

Solutions: Farmers are using infra-red camera carrying to pinpoint problem spots with insects and aphids in vast fields and ranchlands. This is based on the mapping, another then drops a 'cocktail' of predatory insects, transported in a sock attached the underbelly of the and containing a mixture of vermiculite and insects vines and citrus trees to combat pests. By focalizing pest control, they prevent spread and money.

After a successful joint venture, in January of 2018 SkySquirrel Technologies and VineView Scientific Aerial Imaging Inc. merged to form VineView. VineView can check 50 acres of vineyards in 24 minutes for telltale signs of mold, bacteria or other diseases. The system is used in two of the world's top two regions - California and France.

For herbicide-free weedkilling, in 2010 Gaëtan Séverac, PhD student in teamed up with Aymeric Barthès, one of his classmates at the Institut Méditerranéen d'Etude et Recherche en Informatique et Robotique (IMERIR) to develop an all-terrain weeding robot. OZ, their prototype used a satellite

positioning algorithm with a precision of 4 cm called PPP-CNES, (PPP meaning Punctual Positioning Specific). In 2011 Séverac and Barthès founded their startup, Naïo Technologies in Toulouse. Soon after, field trials were carried out on two vegetable farms and a vineyard in the Occitania region. From 2015, Naïo Technologies organised a « Move Your Robot » national contest opened to engineering colleges and universities, with the objective of improving the OZ guidance programs For example, in 2016, participants proposed a power supply solution with a solar adaptable to the robot, a touch-screen human-machine interface, a soil analysis laboratory embedded on the robot, a guidance system and a gun noise to birds. By 2016, a growing number of OZ weedkillers were used by customers anxious to get away from products like Monsanto's Roundup (glyphosate). Naïo next produced TED, a -straddling robot weedkiller, trialled by Bernard Magrez up and down the vines of his Château Fombrauge (Saint-Emilion Cru Classé), then by Philippe de Rothschild on his vineyard. Measuring 1m80 wide by 2m high, equipped with a GPS, the electric 4WD TED is to leaves the warehouse to go directly to the plot, programmable to work according to the weather, and to several passes. Naïo Technologies' next machine was *Dino*, a straddle robot for the mechanical weeding of vegetable plantations. It is particularly suitable for salad crops, which it weeds mechanically and autonomously thanks to its and guiding tools. *Bob*, the fourth option on caterpillar tracks. In December 2018 the fourth FIRA International Forum of Agricultural was held over two days at the Diagora center in Labège. Organized by Naïo-Technologies, it hosted 800 delegates from around the world. This sector is evolving, with projects of all shapes and sizes.

Kevin Desmond, *Electric Agricultural Machinery*, NIPA, New Delhi, India 2019

Dual chemical energy system (containerised)

Problem: How to electrochemically store sustainable energy?

Solution: GS Yuasa Battery Europe Ltd has helped to develop and build the world's first container-based energy platform where lead acid and lithium-ion batteries are combined to feed a power conversion system. The ground-breaking unit will store and control the release of locally generated renewable energy back into the grid. GS Yuasa partnered with Infinite Group, the University of Sheffield and Innovate UK to develop the platform, called ADEPT

(Advanced multi-Energy management and oPTtimisation time shifting platform) which has been constructed at their battery manufacturing facility on the Rassau Industrial Estate in Ebbw Vale. ADEPT is unique and completely self-contained within a 20 ft weatherproof shipping container, allowing it to be integrated rapidly into any renewable energy micro-grid configuration and avoiding the need for internal space. The platform features two GS Yuasa battery systems; a 75Kw hour lithium-ion battery system of 36 GS Yuasa LIM50 modules alongside a 250 Kw hour Valve Regulated Lead Acid battery system of 240 Yuasa SLR500 cells. The two systems are connected to a 100Kw bi-direction power conversion unit as well as full monitoring and battery management systems. ADEPT uses the GS Yuasa dual chemistry battery system, which stores the energy generated by wind turbines on the industrial estate and solar panels on the roof of the container. An ADEPT container can thus re- four mid- electric cars simultaneously.

Peter R. Stevenson “Battery monitoring,” Yuasa Battery (UK) Limited Patent number: 5093624 March 3, 1992

Dye-Sensitized Solar Cell

Problem: Since the 1980s, solar cell percentage efficiency has continued to progress. In 2014 two teams succeeded in pushing the envelope beyond 40%. The first team a four-junction “smart cell” design capable of 44.7%/ Soitec’s III-V multi-junction solar cells” were originally developed for use in space. The second team, led by Professor Martin Green at the University of New South Wales, Australia achieved 40.4%, using commercially available triple-junction solar cells readily accessible to the solar industry. Researchers at the High-Efficiency Crystalline Photovoltaics Group of the National Renewable Energy Laboratory (NREL) built a six-junction solar cell with an efficient of 47.1%, which was measured under concentrated illumination. A variation of the cell also set the efficiency record under one-sun illumination at 39.2%.Each of the cell’s six junctions (the photoactive layers) is specially designed to capture light from a specific part of the solar spectrum. The device contains about 140 total layers of various III-V materials to support the performance of these junctions, and yet is three times narrower than a human hair. The is now to achieve 50% efficiency solar panels that did not need sunlight to function

Solution: Alongside this progress, dye-sensitized solar cells (DSSC) mimic the ability of plants to capture photons of light and turn them into electricity. This is achieved by using special dyes to capture the energy in light at different wavelengths, just like chlorophyll pigments in plants. As compared to conventional silicon solar cells, DSSCs the ability to capture ambient diffuse daylight and weaker sunlight. They can also be integrated into liquids and gels, hence allowing solar cells to be tinted and installed on window panels. Over the past two decades, conversion efficiencies reached 16 % and excellent stability has been attained, rendering the DSSC a credible alternative to conventional p-n junction PV converters.

When they were developed in the early 1990s by Michael Grâtzel of Switzerland and Brian O'Regan of the University of California at Berkeley, DSSCs had an efficiency of 7 %, since increased to 16 % by using new pigments as light harvesters in particular metal perovskites.

In 2008 G24 Power a company in Newport, Wales went into mass production of DSSCs, -named GCells. One machine creates rolls of cells up to 1,640 ft. (500 m) and 6 in. 15 cm) wide. A secondary DSSC manufacturing process customizes and finishes the GCell into a module to suit the size requirements of the customer. An interconnect between the GCell module and the product mating printed circuit board (PCB) is added, and finally the GCell module is encapsulated to provide environmental protection. A 106,000 sq. yard (89,000 m²) factory can produce 550,000 yards (503,000 m) of lightweight flexible GCell modules per year.

They are employed in back packs to provide power for electronics (computers, cell phones, tablets etc.) Using DSSC, Pro12 rugby league installed iBeacon technology in their home stadium, BT Sport Cardiff Arms Park, Wales. Manufacturer G24, a beacon and energy innovation company, installed all of the parts in the stadium, crafting a low-power and sustainable option for the rugby team. G24 is supported by its R&D laboratory at the EPFL (École Polytechnique Fédérale de Lausanne), Switzerland plus a product development and integration team in Dongguan, China *(gcell.com)*

Various approaches been used to prevent electrolytic leaking with DSCCs by using H_2-reduced carbon, ionic liquid or wet-laid PET membrane electrolytes. Sony has developed DSSC panels for car battery charging. The production is presently scaled up at SICCAS, a research-based enterprise wholly financed by the Shanghai Institute of Ceramics, in China. Eunkyoung Kim and

colleagues paired a DSSC with polymer films to produce an even more efficient hybrid which, although it is a great deal more expensive than others, has an increased solar energy production that far outweighs the higher cost. The conductive polymer known as PEDOT is layered with a DSSC, then placed atop a pyroelectric thin film and a thermoelectric device, both of which can convert heat into electricity. The result is a contraption that harnesses solar energy at a of 20 % higher the solar cell on its own. This is possible because the hybrid cell can generate electricity from the sun's heat as well as light. *(sic.cas.cn)*

Sources: Communication from Michael to the author November 8, 2014; O'Regan and Michael , "A low-cost, high efficiency solar cell based on dye-sensitized colloidal TiO^2 films." *Nature* 1991 353 (6346):737; Kevin Desmond, *Innovators in Battery Technology: Profiles of 95 Influential Electrochemists.* Jefferson, NC: McFarland, 2016; Communication from G24, February 2017; John F. Geisz et al. "Six-junction III-V solar cells with 47.1% conversion efficiency under 143 suns concentration," *Nature Energy.*April 2020.

e-cigarette

Problem: Cigarette butts are the most abundant types of human-produced garbage in the world's . Most of the roughly 5.5 trillion cigarettes manufactured globally every year contain a plastic-based filter, of cellulose acetate, according to the Cigarette Butt Pollution Project. An estimated 1.69 billion pounds of butts wind up as trash each year. A cigarette does not readily biodegrade. The decomposition of the butt can take anywhere from 18 months to 10 years to decompose. Sunlight will degrade it and break it into very small particles, which wind up in the soil or swept in water, contributing to water pollution. recently, when testing the effects of soaked used cigarette butts on two fish species (saltwater topsmelt and freshwater fathead minnow), researchers found that the nicotine from one cigarette butt per litre of water was enough to kill half of the exposed fish. It is not clear which toxin was responsible for the death of the fish.

Solution: Electronic cigarettes or e-cigarettes are eco friendly a tobacco cigarette in ways. The first electronic cigarette was developed in America. In 1963 Herbert A. Gilbert applied for a patent for his “smokeless non-tobacco cigarette”, and the patent was in 1965. Gilbert’s invention was nicotine-free, but it produced a flavoured vapour that was supposed to replace tobacco smoke. Gilbert actually got as far as making prototypes of the gadget, but there was not any real commercial interest. There were some technical challenges, too. Gilbert’s design relied on battery power, but battery technology in the early 1960s was a long way behind where it is now. Rechargeable batteries were expensive and usually heavy; conventional batteries were expensive and had limited energy . The first electronic cigarette was ahead of its time both socially and technologically, but after Gilbert’s patent was granted the concept fell into obscurity for almost 40 years: the stored energy could not be withdrawn fast enough.

In 2001, Hon Lik of Beijing, China, a 52-year-old research pharmacist, who worked as a research pharmacist for a company producing ginseng products reportedly created an electronic cigarette after his father, also a heavy smoker, died of . Lik thought of using a high frequency, piezoelectric ultrasound-emitting element to vaporize a pressurized jet of liquid containing nicotine. This design created a smoke-like vapor. Lik found that using resistance heating obtained better results and the difficulty was to scale down the device to a small enough size. In 2003, he registered a patent and the e-cigarette was first introduced to the Chinese market the following year. E-cigarettes entered the European market and the US market in 2006 and 2007. The company that Lik worked for, Golden Holdings, registered an international patent in November 2007 changing its to Ruyan (如烟, literally "like smoke") later the month.

The number of e-cigarette brands sold on the internet is and the variety of flavours staggering: 460 brands and 7700 flavours. Roughly 10.8 million American adults are currently using e-cigarettes, and half of them are under 35 years old, a U.S. study suggests.

From their very roots, what they do, to where they end up, vapor cigarettes a far lighter carbon footprint their combustible counterparts. Designed to be reusable, they last a very time, and e-cigarette cartridges get out according to the smoker’s . They are not a landfill burden but they do pose an environmental threat of considerable proportions. Instead of merely thrown away, these complex devices present simultaneously a biohazard risk with

potential high quantities of leftover or residual nicotine and an environmental health threat as littered electronic waste. While most batteries are recyclable, unfortunately, vapers tend to throw their old in the trash. Whether it is pens or mods, all vaporizers operate on li-ion batteries. Some may last longer than others, but the result is that sooner or later, these will be disposed of and replaced. According to their manufacturers, disposal of li-ion batteries requires ensuring that they are fully discharged and cooled, then submerging them in cold saltwater for two weeks—covered securely with a lid—before wrapping them in newspaper and placing them in the trash. In addition, the zinc and manganese recycled from such batteries can be used as fertilizer (see entry)

bit.ly/2wkECfL Annals of Internal Medicine, *online* August 27, 2018.; Lisa Rapaport, "Almost one in 20 U.S. adults now use e-cigarettes," *reuters*, August 28, 2018

Earth Overshoot Day

Problem: Since 1961, the first year consistent United Nations statistics were available, humanity's demand on resources has from within the of what nature could support to significantly over budget. Our planet went into global overshoot in the early 1970s. A symbolic indicator had to be created which would show the world the urgency to find and apply solutions.

Solution: In themed 1980s, Andrew Simms of the UK thinktank New Economics Foundation came up with a smart solution which he called Earth Overshoot Day (EOD) or Ecological Debt Day which marks the when humanity has exhausted nature's budget for the year. For the rest of the year, by maintaining our ecological deficit by down local resource and accumulating carbon dioxide in the atmosphere, we are operating in overshoot. In 1990, EOD was October 11, by 2000, it was September 23, by 2019 it was July 29. By 2020, EOD had moved back by three weeks to August 22. but due to the global coronavirus lockdown. By 2021, alarmingly, it had returned to July 22.

Solutions for making it move further back can be found on *overshootday.org* but also here on *366Solutions.com*

Earthquake warning system

Problem: On May 22, 1960 the earthquake in Valdivia, Chile was the most powerful earthquake ever recorded. It occurred on a fault that is almost 1,000 mi. (1600 km) and 150 mi.(24o km) wide, dipping into the earth at a shallow .. Various studies placed it at 9.4–9.6 on the moment magnitude scale. It lasted approximately 10 minutes. Various estimates of the total number of fatalities from the earthquake and tsunamis been published, between 1,000 and 7,000 killed. Fifty years later, on 11 March 2011 a magnitude-9.1 earthquake struck 44 mi. (70 km) off Japan, the country's warning system was little help for people in the path of the torrential tsunami that swamped the coast; nearly 16,000 died.

Solution: At a 2-day emergency summit at UC Berkeley a month later, an early warning system called *ShakeAlert* won a US$6.5 million commitment from the Gordon and Betty Moore Foundation in Palo Alto, California, to build a prototype. It had been developed over the years by two seismologists Thomas H. Heaton at the California Institute of Technology (Caltech) in Pasadena, and Richard Allen, at the University of California (UC), Berkeley.

In 1985, Heaton had laid out his idea for a "seismic computerized alert network" in a 1985 paper in *Science.* But though automated systems could act immediately to prevent chemical spills, electrical fires, and other catastrophes, they would do little to protect San Francisco from an earthquake such as the one in 1906, which was centered near the city. Over the years, inspired by warning systems in Mexico, Japan, Taiwan, and Chile, others, which emphasize detecting earthquakes at the source and warning distant cities before the seismic waves arrive, Heaton and Allen collaborated with Japanese seismologists to develop a system they called *ShakeAlert*. people thought such a system would be useless in fault-riddled California, where earthquakes seem to erupt underfoot anywhere, but Heaton and Allen persevered, deploying a pilot system in 2012.

From 2019, with important funding, *ShakeAlert* covering every corner of Los Angeles, in schools, at businesses, even on smartphone applications is in place. If all goes as planned, this dense network of 1,650 seismometers in California, , and Washington will detect the first, weak waves of an earthquake and relay a 10-second warning of ground shaking to come. To start, those warnings will go to first responders, power companies, and transit agencies. But in the next couple of years, alerts could roll out to the public to provide at least a few seconds of warning. Not much time, but enough to provide cover. New

technologies will sharpen the warnings, too. GPS sensors, though slower seismometers, can capture shaking enough to outdo conventional instruments, enabling the system to cope better with the biggest earthquakes. Heaton expects artificial intelligence, especially neural networks, will in the next few years be to discern P waves, an earthquake's first whisper, from seismic noise earlier the existing algorithms. *(shakealert.org)*

Paul Voosen, "Moments to . California's new earthquake warnings deliver critical seconds of ," *Science*, November 1, 2018; Lucy Yin, Thomas Heaton, Jennifer Andrews,"Reducing process delays for real-time earthquake parameter estimation – An application of KD tree to databases for Earthquake Early Warning" *Computers & Geosciences* 114, January 2018.

The Earthshot Prize

Problem: Repairing and protecting our Planet will need major incentives to encourage hundreds of solutions described in this book.

Solution: On Thursday 8th October 2020 Prince William, the Duke of Cambridge joined forces with Sir David Attenborough to launch a multi-million pound prize which will be awarded to five winners a year over 10 years, comprising at least 50 innovative solutions to the world's greatest problems by 2030.

The prestigious prize, inspired by US President John F. Kennedy's ambitious "Moonshot" lunar program is appropriarely called the Earthshot Prize

Between 2021 and 2030, five one million-pound prizes will be awarded each year. The five Earthshots are: Protect and restore nature, clean our air revive our , uild a waste-free world and fix our climate of these solutions can be found on our 366solutions.com website.

the Earthshot Council, Her Majesty Queen Al Abdullah (); Blanchett – actor, producer and humanitarian (Australia); Christiana Figueres – Former UN climate chief, responsible for the landmark Paris Agreement on Climate (Rica); Sir David Attenborough – broadcaster and natural historian (UK); Hindou Oumarou Ibrahim – environmental activist (Chad); Shakira – and philanthropist

(Colombia); Yao Ming – Naismith Basketball Hall of Famer and environmentalist (China) and others.

Earthshot joins the Goldman Environmental Prize (aka The Green Nobel), Volvo Environment Prize, the UNEP Sasakawa Prize, the Energy Globe Award as an incentive to find solutions. *(earthshotprize.org)*

Michelle Lewis, "UK royals William and launch the Earthshot Prize 'to repair the Earth,"' *eletrek*, January 1, 2020.

Eat-Lancet commission

Problem: There is a need to feed a growing global population a healthy diet while also defining sustainable food systems that will minimise damage to our Planet.

Solution: The EAT-Lancet Commission consists of 37 world-leading scientists from 16 countries from various scientific disciplines, them Dr Walter Willett of the Harvard Medical School. The goal of the Commission was to reach a scientific consensus by defining targets for healthy diets and sustainable food production. It proposes an approach to eating that balances the appetites of a growing global population with the increasing fragility of the earth itself The EAT-Lancet Commission diet consists of a reasonable amount of vegetables, fruits, whole , legumes, nuts and unsaturated oils, some seafood and poultry, and little to no red meat, processed meat, added sugar, refined , and starchy vegetables

Walter Willett, MD et al., "Food in the Anthropocene: the EAT–*Lancet* Commission on healthy diets from sustainable food systems," *The Lancet*, January 16, 2019.

Tomorrow's solution: the Ecocapsule producing energy it consumes

Ecocapsule

Problem: Most homes are dependent on an external supply of electricity, even most caravans and mobile homes which are limited to a campsite. Tents also their limitations.

Solution: Soňa Pohlová obtained a Master of Architecture (M.Arch.) focused in architecture and urbanism from Slovak Technical University, Bratislava, Slovakia and Arquitectura La Salle, Barcelona. With Tomáš Zácek, Soňa co-founded Nice Architects in Bratislava. In 2009 they submitted a bid for a competition to design a luxurious mobile home that could operate off-grid and leave no . During the next five years, Nice Architects were on the technological and product design of the Ecocapsule ® in to the best possible product.

By 2014, the development of technology for the Ecocapsule was ready. It is designed to produce energy it consumes, as as the external temperature remains between 4 °F (−16 °C) and 104 °F (40 °C). Energy for the pod is renewable, sourced through an 880-watt (1.18 hp) solar cell array and a silent 750-watt wind turbine, which is then stored in a 9,744-watt-hour (35,080 kJ) battery that can hold four days worth of electrical batteries for later use. With this energy, the pod can be off-grid all-year-round, and can even an electric car. Other energy-conservation features of the dwelling are its high-efficiency climate control system and a heat exchanger that uses exhaust air to warm fresh incoming air. The Ecocapsule also harnesses rainwater with its 25.3-US-gallon (96 liter) reservoir, which is located beneath the dwelling's floor. The water is cleaned via a pre-filtration system and two UV LED lamps. Drinking water is also provided by filters installed on the faucets. The Ecocapsule also features a waterless separating toilet. The Ecocapsule has a central computer that monitors its electricity and water levels, and can be controlled via a mobile app. The Ecocapsule should allow its occupants to live off the grid for several weeks to several months

On May 28, 2015, nice&wise (ex-Nice Architects) publically unveiled their Ecocapsule at Vienna's Pioneers Festival after six years of development. Limited to 50 customers from the USA, Japan, Australia and EU, at a price of US$98,000, the patented Ecocapsule is a luxury item for one to two people, but other potential applications include a disaster-relief shelter or a scientific research station. By July 2015, thousands of pre-orders had already been and interest generated celebrities such as Susan Sarandon. In January 2018, the company launched production of the First Series Ecocapsules, limited to 50 pieces. The first micro-home is available for to the general public in Bratislava, positioned on a footbridge in the Zuckermandel district, with a beautiful view overlooking the Danube river. A second Ecocapsule was set up in the Netherlands. The company is now preparing the more affordable Second Series Ecocapsule. *(ecocapsule.sk)*

Sona Pohlova, “Turning vision into reality is a beautiful challenge,” *The Hundert, Vol. 8 – Female Startup Founders Europe’*, May 2016.

Eco-City

Problem: The history of the Planet is one of unending conflict between creeds, politicians and nations where the world’s resources are plundered indiscriminately.

Solution: In the 1960s, Mirra Alfassa, a 90-year-old a spiritual guru, known as "the Mother", dreamed of a place where humanity can live united, in peace and in harmony with nature, beyond of all beliefs, political opinions and nationalities. She asked French architect Roger Anger to design an experimental eco-city in Viluppuram district mostly in the state of Tamil Nadu, India with some parts in the Union Territory of Puducherry. She called it Auroville (“City of Dawn”). The inauguration ceremony of Auroville in 1968 was attended by delegates of 124 nations, who brought soils from all parts of the world. In the mixing of these soils, known as a Yagna began the journey of one-ness.

Endorsed by UNESCO and the Government of India, Auroville is now famous for known as the most environment friendly and pollution free city of India. Construction materials used are mainly and natural including wood, mud, , stabilised earth and fired . In the early 1960s and 70s, a small group of pioneering residents took up extensive tree planting to rejuvenate the barren and harvest rainwater. There is now a forest of over two million trees and some of them . Since then, Aurovilians (residents of Auroville) been constantly experimenting with new ideas and solutions in areas of forestation, farming, renewable energy, water management, waste treatment, building technologies and environmental awareness programs others. Auroville's EcoService collects waste from 2/3rd's of the Aurovilians while the remaining 1/3rd prefer to dispose waste in their own way. 60% of the waste collected is recycled while the rest 40% is filled. Auroville is towards a zero waste policy.

In the middle of the town is the Matrimandir, which was conceived by Alfassa as "a symbol of the Divine's answer to man's aspiration for perfection". Silence is maintained inside the Matrimandir to ensure the tranquility of the space and the entire area surrounding the Matrimandir is called the Peace area. Inside the Matrimandir, a spiraling leads upwards to an air-conditioned chamber of polished white marble referred to as "a place to find one's consciousness".

Matrimandir is equipped with a solar power plant and is surrounded by manicured gardens. When there is no sun or after the sunset, the sunray on the globe is replaced by a beam from a solar-powered light.

There is a solar kitchen equipped to cook for over 1,000 people everyday primarily uses the energy generated from the largest solar collector in Asia developed and build indigenously at Auroville. Windmills, mainly used to pump water, are a common sight in Auroville with solar power panels that provide energy to almost everything in Auroville, from the street lights to the big town hall. Bicycles or motorised 2-wheelers (and some electric 2-wheelers) can be rented

As of January 2018 Auroville had 2,814 residents (2,127 adults and 687 children) from 54 countries with two-thirds from India, and Germany

(auroville.org)

Rakesh Kapoor, "Auroville: A spiritual-social experiment in human unity and evolution," *Futures* 39(5):632–643, 2007; Ian Parker, "Auroville: city of the dawn, city of the future, now," *University of Manchester*, December 2018.

Ecological moorings, permanently positioned

Problem: The activity of diving in the Mediterranean is very intensive: 40 to 50.000 dives a year on the coast of the Natura 2000 Estérel site. But for every dive, it an anchor that's thrown can damage a delicate habitat. As the traditional method of mooring continues to fail, rust, and destroy such habitats, people begun to look for better methods of addressing these issues.

Solution: One solution is in permanent ecological moorings which eliminate the impact of anchors without restricting activity. Moorings generally comprise three main parts, the anchor (helical), the link (or) and the float. For example, the Hazelett Elastic Mooring System, connected to a or Helix screw anchor, floats above the sea bed with a minimal environmental footprint. *(hazelettmarine.com)*

In October 2018, the ngo "Planet Cavem" with the theme "Our mother ... Mediterranean in all its states!" set about equipping dive sites with ecological

anchors built by Parlier Environnement SAS. They positioned 13 scattered units between Île d'Or and Cap Roux. Four moorings reserved for diving frequenting the Cap d'Antibes were also installed and in regular use. They were set up thanks to the partnership between the Alpes-Maritimes Departmental Council, the French Federation of Underwater Sports and Studies and the Antibes -les-Pins Commune.

Elizabeth A. Dinsdale, " reef health indicators: integrating ecological and perceptual assessments of anchor damage," December 2004; *hazelettmarine.com.*

ECOSTRESS

Problem: With the increasing number of heatwaves, droughts, forest fires and flooding, it is vital to precise observations of the damage and how to repair it.

Solution: A precision instrument is in place to survey the temperature of plants growing in specific locations on the Planet over the course of a solar year. These measurements give scientists insight into the effects of events such as heat waves and droughts on crops which can be used for vital precision farming. It is called ECOSTRESS (Ecosystem Spaceborne Thermal Radiometer Experiment on Space Station). This is a multispectral thermal infrared radiometer developed by Joshua B. Fisher and a team at NASA's Jet Propulsion Laboratory (JPL) in Pasadena, Calif., at a cost of under US$30 million.

ECOSTRESS was selected in July 2014 as part of the "Earth Venture" program of small, targeted science investigations, The first 1,200 lb. (550 kg) payload would monitor the mechanism of "transpiration", whereby water is lost from plants through tiny pores in their leaves, as well as evaporation from the surrounding soil. When examined together, this analysis is known as "evapotranspiration". It was delivered to the ISS by the SpaceX on July 3, 2018. Astronauts performed a six-hour spacewalk to prepare for ECOSTRESS to arrive. A Canadian arm took ECOSTRESS off its spacecraft and passed it to Kibo, the Japanese arm for installation. ECOSTRESS then began to use the space station's power and communications to collect data and send it down to Fisher and his team. The program is managed by NASA's Earth System Science

Pathfinder program at NASA's Research Center in Hampton, Virginia. Its data was published via the -access TERN Data Disovery Portal in Australia.

In January 2019, Joshua Fisher presenting his research at the Soil Science Society of America International Soils Meeting, Jan. 6-9, 2019 in San Diego, commented,

The instrument measures variations of ground temperatures to within a few tenths of a degree, and it does so with unprecedented detail: It's to detect temperature at various times of day over areas the size of a football field. These measurements help scientists assess plant health and response to water shortages, which can be an indicator of future drought. They can also be used in observing heat trends, spotting wildfires and detecting volcanic activity.

When in July and August, Europe was hit by two massive heatwaves, their extremes of temperature, +110° Fahrenheit (+44.1° Celsius) were carefully measured by ECOSTRESS which mapped the surface, or ground temperature, of four European cities Rome, Paris, Madrid and Milan. In the images, hotter temperatures appeared in red and cooler temperatures appeared in blue. They showed how the central of each city was much hotter the surrounding natural landscape due to the heat island effect,a result of surfaces and re-radiating heat throughout the day. Soon after, ECOSTRESS captured imagery of fires in the Amazon regions of Brazil and Bolivia. It was also used to estimate terrestrial latent heat flux in the Heihe River of Northwest China. *(ecostress.jpl.nasa.gov)*

Joshua B. Fisher, “ECOSTRESS, A NASA Earth-Ventures Instrument for studying links between the water cycle and plant health over the diurnal cycle” *Conference Paper* · July 2017.

ecovelopes

Solution; In 1997 Emmanuel Druon and a small team set up a factory they called Pocheco in Forest-sur-Marque close to Lille, northern . Their goal was to manufacture *ecovelopes,* recyclable and biodegradable automatic insertion envelopes, while creating zero waste during the operation. Druon based his organisation on “Ecolonomie”, where instead of a hierarchy, there is a four-steering committee. Paper is sourced from sustainable managed forests, unbleached and lighter weight, with solvent free ink and glue. The amount of paper waste from envelope cutting is sold and then recycled. The vegetal roof of the plant several beehives and also recuperates rainwater, which is then used

both to dilute ink, clean chines and to supply water for the toilets. This water, polluted by the ink is then sent to a station where it is cleaned by 80 bamboos, then sent back to the building, ready to be used again. Energy from the machines is used to heat the factory, while solar power contributes to electricity. Before , Pocheco were manufacturing some 2 billion *ecovelopes* per year. Also part of his Ecolonomie aproach, Druon collaborated with a Finnish paper manufacturers (UPM) so that every time one tree is cut down to wood pulp , another four are planted in return, out at 300,000 trees per year. Pocheco's Canopée Reforestation: Association for reforestation of the Northern Region of has seen some 7,000 trees planted since 2009. In 2019, La Poste, producers of 115 million envelopes with transparent windows, partnered with Pocheco to produce windows of pulp instead of plastic film. This these business *ecovelopes* 100% recyclable and biodegradable, saving some 30 tonnes of plastic landfill waste every year. In the of Internet emails and text messages, Pocheco has also diversified to producing for use by pharmacies. *(pocheco.com)*

Emmanuel Druon, "*ECOloNOMY: Doing Business and Manufacturing Differently*", *published by* Charmouth, Dorset: *Triarchy Press.* October 2015; Emmanuel Druon and Franck De Snoeck, "Envelope for sending e.g. letter, has detachable strip such that that, when closure tab is glued to outer of rear wall, detachable strip is located between lower edge of closure tab and lower edge of envelope," *French Patent 2988700A1*, Published 2013.

e-crude

Problem: Regular hydrocarbon diesel pollutes.

Solution : e-crude or e-diesel is created from recycled carbon dioxide, water, and electricity with a process powered by renewable energy sources. E-diesel is considered to be a carbon-neutral fuel as it does not extract new carbon and the energy sources to drive the process are from carbon-neutral sources

From the early 2000s, Nils Aldag, Carl Berninghausen and Christian von Olshausen began to research into sustainable diesel. Electrolysers are energy converters that turn clean electrons into hydrogen. They founded Sunfire GmbH in Dresden in 2009. Inspired by photosynthesis, Sunfire's proprietary technology can be used to turn hydrogen efficiently into liquid hydrocarbons such as gasoline, diesel, jet fuel or waxes for the chemical industry (power-to-products). Alternatively, hydrogen can be used in the industry or H2-mobility.

Sunfire achieved the technological breakthrough within the framework of the Kopernikus project Power-to-X, funded by the German Federal Ministry of

Education and Research (BMBF), in conjunction with the Karlsruhe Institute of Technology (KIT). A co-electrolysis plant (10 kilowatts DC, up to 4 Nm^3/h synthesis gas) was delivered to Karlsruhe, where it was combined with technologies from Climeworks (Direct Air Capture), INERATEC (Fischer-Tropsch Synthesis) and KIT (Hydrocracking) in a container to produce a self-sufficient facility. The was to demonstrate the integrated production of e-Crude by the end of August 2019. Already by 2017 Sunfire had produced 3 tons (2.7 tonnes) of Blue Crude. Concept proved, Sunfire began the process of scaling-up the high-temperature co-electrolysis process to an industrial scale—initially with an input power of 150 kW (DC)—as part of the "SynLink" project funded by the Federal Ministry of Economics and Energy. The plant was built in Norway for use by Nordic Blue Crude, the Norwegian project partner. By 2020, using 20 MW of input power, it will be producing 2.6 million gallons (10 million liters) or 8,800 tons (8,000 tonnes) of the synthetic crude oil substitute e-Crude annually on the of 20 MWs of input power. The Bavarian car firm Audi and the world's largest aircraft manufacturer, , are both project partners. Prominent investors include the French oil company Total, the Czech energy company ČEZ and the investment funds Electranova Capital and Bilfinger Venture Capital; insurance Allianz and automobile maker PSA are also sponsors.

The plant would avoid emissions of around 21,000 t/y of CO_2 by using waste industrial heat and renewable energy. Sunfire has been to attract prominent investors such as Total Energy Ventures, Electranova Capital, IdInvest and KfW . *(sunfire.de)*

Nils Aldag, "Wundersprit fürs Klima," *Handelsblatt* October 27, 2017.

the Eden Project

Problem: What to do with the giant holes and craters left once a resource has been mined and exhausted.

Solution:

The Eden Project

In 1995 Dutch-born businessman Tim Smit and some friends bought an exhausted china clay pit near St Austell in Cornwall, south-west England with the solution of recycling its crater into a centre that would build relationships

between people and the natural world to demonstrate the power of working together for the benefit of all living things. Funded by the Millennium Commission and intended as a way of re-energising the Southwest, the Eden Project (Cornish: Edenva) opened in March of 2001. With no building of this scale in the world, at the time a global audience referred to it as the eighth wonder of the world. It attracted over 1 million visitors in its first four months. Since then it has welcomed more than 19 million people.

What visitors discover are several massive hexagonal Biomes, inspired by soap bubbles. Designed by Grimshaw Architects, these are made from inflatable plastic cells that are supported by steel frames used for their ability to adapt to the uneven shape of the clay pit that they were built in. Each Biome is made up of three layers of ethylene tetrafluoroethylene copolymer (ETFE) that is inflated to create a pillow. Similar to clingfilm, ETFE is lighter than glass but also strong enough to withstand the weight of a car. It also lets in UV light for the plants inside.

Two Biomes emulate Tropical and Mediterranean climates respectively and house a vast selection of stunning plants. Temperatures in the Tropical biome reach between 18 and 35°C to create a humid environment that replicates climates of Southeast Asia, West Africa and South America. The massive amounts of water required to create the humid conditions of the Tropical Biome, and to serve the toilet facilities, are all sanitised rain water that would otherwise collect at the bottom of the quarry. The Eden Project hosts exhibitions and conferences, visitors to the restaurant being sourced from local farmers

In May 2021,The Eden Project charity has announced its plans for its first ecological attraction in Scotland, which in the spirit of recycling, will transform the city of Dundee’s former gasworks on the banks of the River into a large verdant park

Other Edens could soon sprout up in an English motorway service station, a Tasmanian warehouse (themed on the Antarctic). In China, construction is scheduled to start this year on Eden Qingdao, in the port city on the east coast, on the theme of water and its importance for life. A feasibility report is complete for the city of Yan’an – the place Mao Zedong’s Long March came to an end. The plan is to transform a blighted valley just outside the city into a showcase for agriculture, craft and education. The third proposal is for the Sheng Lu vineyard in Beijing, a city regularly cloaked in an opaque fog of pollution.

Edible cutlery

Problem: Plastic cutlery is a major contributor to the growing plastic waste crisis. An estimated 40 billion plastic utensils are used and thrown away each year in the United States . 122 millions tons (111 million tonnes) of plastic waste will nowhere to go by 2030 due to Chinese import ban.

Solution: In 2005, Narayaana Peespaty, an agricultural scientist specialising in groundwater research, was on a field visit to Mahabubnagar, a drought- district in Telangana, India. Peesapaty had ordered a *jowar roti* millet bread for lunch. He arrived . The roti had become cold and hard. Forced to break the roti and scoop the dal and curry with its pieces, crunching into them, Peeseapaty realised if a two-dimensional spatula can work, then why not a three-dimensional spoon? Plastics should not be used for handling food, since they contain chemicals with properties that leach into what we eat. Peesapaty founded a company called Bakeys to produce edible cutlery, primarily from jowar, a millet flour, and and wheat flour in three flavours - savoury, sweet and plain. Tasting like crackers, even if they are not eaten, they are to dispose into the environment, as they are biodegradable. The company has expanded to smaller spoons for soups and desserts as well as small bowls and pots. By 2011, Bakeys had manufactured over 1.5 million edible spoons from , wheat, and millet in eight different flavors: sugar, ginger-cinnamon, ginger-garlic, celery, pepper, cumin, mint-ginger, and carrot-beetroot. *(bakeys.com)*

Several materials such as wheat bran, rice ban, sorghum, corn , etc. are used for manufacturing of edible cutlery and edible tableware. It is baked at high temperature and is non-polluting from production to disposal. Over 10,000 edible knives, spoons and forks are per day by a growing number of companies. For example, Mede Cutlery Company in Zhejiang, China manufactures edible cutlery in attractive colors with new flavors of purple potato, sesame, and . Biotrem's wheat tableware production process was invented by Jerzy Wysocki in Poland After two years commercialising it, Biotrem already produces 15 million pieces a year and they are currently under expansion. *(biotrem.pl).* Since 2017, Eclery Foods in Hyderabad, Telangana, India has a fully automated process enabling a capacity of 200,000 spoons per day, which expected to double by November 2018.

In , former student at the AgroParisTech, Nicolas Richardot, has started up Tassiopée in Normandy in the Cotentin to manufacture an edible coffee cup, of biscuit with an inside chocolate coating. As an alternative to plastic cups, the coffee has been drunk, the cup can be eaten. *(tassiopee.com)* Tiphaine Gueroud has set up Koovee, in the Nouvelle-Aquitaine, to edible cutlery. The spoon, measuring 12 cm is composed of wheat flour and rapseed oil. When dipped in sauce or soup, it does not fold. And at the end of the meal, it is edible.

In Auckland, New Zealand, the burger chain Better Burger teamed up with Innocent Packaging to create plant-based and compostable packaging for their burgers. The wafer paper packaging from potato starch and water encouraged their customers to eat everything on their plate, rubbish included. The wrappers are of potato starch with a taste reported to be similar to a "potato version of a cracker". On International Earth Day (April 22, 2018), 500 burgers sold at the chain's Mount Eden restaurant were wrapped in the material. They even went the distance and used edible ink to the packaging, adding their logo and a fun design. Although pitched as a one off activity to awareness for the challenges of the environment, since October 2017, Better Burger saved 366,000 plastic items from ending up in the landfill from its outlets. *(innocentpackaging.co.nz)*

Vaibhav Khurana, "How to prepare edible cutlery that is biodegradable?" *Indian Institute of Technology Bombay,* August 2018*;* bakeys.com.

Edible packaging

Problem: Seafaring turtles and gulls die, ensnared and poisoned in the net like plastic that yoke six-packs of canned beverages together.

Solutions: In 2012, Chris Gove and Justin Jeffers founded of SaltWater Brewery in Delray Beach, Florida, USA with a mission to not brew good beer, but to give back to our . As part of this initiative, in 2017, they developed six-pack E6PR™ which are 100 % biodegradable and edible, constructed of barley and wheat ribbons from the brewing process. E6PR is said to provide the strength necessary to hold through distribution. The carrier is also designed to be

compostable, both on and if left in a water system where the materials are said not to harm wildlife upon ingestion. Packaging is on-site with the brewery's in-house canning , as well as their new in- labeler for seasonal and special releases. It took about 18 months for the sustainable packaging to be fully adopted throughout all of SaltWater's distribution network. The developed by E6PR are now used by 35 brewers across the globe, including in Africa, Europe, and Australia. *(saltwaterbrewery.com)*

The industry has yet to settle on a single supplier or format that could fully replace plastic six-pack . In 2018, Corona became the first major global beer to pilot E6PR's technology, they are also considering interlocking that can screw into each other. Molson Coors has vowed it would aim for all its packaging to be reusable, recyclable, compostable, or biodegradable by 2025. The Coors Light and Miller Lite brewer says an increased focus on finding sustainable packaging solutions is coming from all sides: consumers, retailers, and investors. They commissioned manufacturer Footprint to compostable, biodegradable for a small test run of the craft AC Golden in Colorado. Carlsberg is with German supplier NMP Systems GmbH in using glue to adhere in a production method that the Danish brewer says would avoid using 1,200 tons of plastic annually, or the equivalent of 60 million plastic , fully adopted. Carlsberg is also tinkering with the inks on labels to improve recyclability, using recycled materials in wrapping where plastic is needed and ending coal use at nine breweries in China as it aims for zero carbon dioxide emissions. *(nmp.khs.com)*

John Kell, "Beermakers Are Experimenting With New—and Sustainable—Six-Pack Designs," , September 2, 2019.

Edible water bubbles

Problem: About 50 billion single-use plastic water bottles of polyethylene terephthalate (PET) are produced in the United States each year, and most are discarded. The properties that PET useful as a packaging material (stability and durability) also it resistant to breaking down after its useful life is over.

Solution: The idea of an edible biodegradable capsule for artificial edible cherries, soft sheets, and the like, called spherification, was first patented in London by Unilever engineer William Peschardt in 1942. recently the method was introduced into modernist cooking by Spanish chef Ferran Adrià. The most recent adaptation has been made by Pierre-Yves Paslier of Skipping Rocks Lab. Paslier started his career as a packaging engineer for L'Oréal in the daytime and hacking 3D-printers in his living room at night. He then decided to study design at the RCA and in 2013, he co-designed one of the first consumer delta 3D-printers. Paslier left L'Oréal in 2012 to start a Masters degree in innovation, design and engineering at Imperial College London and the Royal College of Art, where he set about brainstorming non-plastic container designs. He and classmate Rodrigo García González studied the properties of watermelons, tomatoes, coconuts and tapioca to understand how natural foods hold liquids. They finally settled on seaweed as their material of choice. They called their edible water ball, by dropping ice into separate solutions of calcium salt and "Notpla" a brown sodium alginate, the *Ooho*. You can drink them by tearing a hole into the skin and the water into your mouth, or they can be consumed whole. Containing 100 ml of liquid, the balls can be produced by a compact machine at their point of , eliminating the need for cups.

In 2014 Paslier and Gonzales founded Gravity Sketch, a VR 3D design platform and Skipping Rocks Lab, a sustainable packaging company, in London's East End. A crowd sourcing campaign as well as its accompanying YouTube went viral enabling Skipping Rocks to US$ 1 M from 1,000 investors in a mere three days. The manufacturing processes are covered under a Creative Commons license, making the recipe freely distributed and readily available for anyone to use. In July 2018, they launched sauce sachets from the seaweed material, which were on a six-week trial at 10 London takeaways with the delivery service Just Eat. Following the success of the trial, 10 London restaurants further trialled this product for 8 weeks, which is expected to prevent approximately 40,000 plastic sauce packets from entering homes. Ginger and fruit juice shots were delivered to Selfridges department store, and the product was sold at UK festivals as edible alcohol shots, including espresso martini and tequila sunrise.

In April 2019, when 41,000 people running in the London Marathon reached reach mile 23, thanks to Lucozade Ribena Suntory, they were handed *Oohos* instead of bottles. However, a video surfaced that showed streets strewn with plastic waste after the was over. That September, the Harrow half

marathon in London replaced single use bottles and cups with *Oohos*. Paslier and Gonzalez are now experimenting with on green alternatives to cling film and the plastic liners used in throwaway coffee cups and ways to replace plastic toiletries bottles in hotel rooms. *(notpla.com)*

"The ooho! edible water bubble gets set to replace plastic bottles," *designboom*, April 12, 2017; Pierre-Yves Paslier and Garcia Gonzales, "Method of encapsulating liquid products," Patent WO2018172781, September 27, 2018.

e-faunalert

Problem: The disappearance of raptors is an increasingly alarming problem in the Mediterranean. Collisions and electrocutions on power lines are the biggest threats affecting populations in the region.

Solution: To tackle this issue, IUCN's Center for Mediterranean Cooperation (IUCN-Med) has developed the free mobile application *e-faunalert*, which helps both to identify and map dangerous areas posing an electrocution or collision risk for these species on such infrastructures. Conceived for all types of users, from scientists, to the conservation community, governments, energy sector stakeholders to general global audiences, *e-faunalert* helps to collect data to quickly identify areas of intervention and thus facilitate decision-making in the planning of future power lines. Moreover, the app contains information on the technical characteristics of pylons and different types of electrocution or collision incidents. It also allows to download georeferenced images, create and join workgroups to maximize fieldwork, as well as sharing data with other colleagues.The programme has it possible for specialists from Spain and North Africa to exchange information, cross-border expeditions with Moroccan and Spanish ornithologists to monitor and create a census of raptors in Morocco. This tool has been developed in collaboration with Fundación Amigos del Águila Imperial Ibérica, el Lince Ibérico y Espacios Naturales Privados and is part of the project Flyways - reducing infrastructure-related bird mortality in the Mediterranean", funded by the MAVA Foundation. *(iucn.org)*

Effective altruism

Solution: In 2009, Toby Ord and William MacAskill, philosophy professors at Oxford University launched a community around Ord's "Giving What We Can", and MacAskill's "80,000 Hours" (You have 80,000 hours in your career. How can you best use them to help solve the world's most pressing problems?). Ord's earlier work had explored the ethics of global health and global poverty, demonstrating that aid has been highly successful on average and has the potential to be even successful if we were to improve our priority setting This led him to create an international society called Giving What We Can, whose members pledged over $600 million to the most effective charities helping to improve the world. Giving What We Can (GWWC) members pledged to give at least 10% of their income for the remainder of their lives to the causes that they believe are the most effective.

Ord and MacAskill founded the wider effective altruism movement, encouraging thousands of people to use reason and evidence to help others as much as possible. Effective altruism inspires critical thinking by applying evidence and reasoning to determine the most effective ways to improve the world. ... Effective altruism can add meaning to our lives and can help us in finding fulfilment in what we do. effective altruists say that in good, they feel good. Ord has advised the World Health Organization, the World , the World Economic Forum, the US National Intelligence Council, the UK Prime Minister's Office, Cabinet Office, and Government Office for Science. His work has been featured a hundred times in the national and international media. Factoring in these aspects, EA activists usually come to the conclusion that the three most-pressing issues for humanity are: extreme poverty, animal suffering, and what they call "-term future." This is basically the minimization of global catastrophic risks, also known as existential risks. *(eafoundation.org)*

Toby Ord, *The Precipice: Existential Risk and the Future of Humanity,* Bloomsbury Publishing, Hachette Book Group, 2020;

Electric boat as microgrid

Problem: After a hurricane of Category 4-5, the entire population of a devastated island has no electricity.

Solution: When the first 12 pax solar boats were built in 1995 by MW- in Yverdon-les-Bains, Switzerland. 75ft (23 m) *Solifleur* and *Chlorophylle* they were operated by Pro Natura for nature excursions on the of Neuchâtel. Suggested and implemented by Theodor Schmidt, these were the first solar to be fitted with a mains connection in order to feed extra solar energy into the 230V grid when the are not used.

Twenty-four years later, researchers at the University of New South Wales in Sydney, Australia created an algorithm that can theoretically turn electric into small renewable power plants. They tested the algorithm with a microgrid in their lab, using four 6-volt gel batteries connected in a 24-V series as a stand-in for a boat. To implement this approach, they would need an electric boat with its own PV system, which would the batteries when the boat was moored. Then when the boat is docked, it could act as a small power plant, providing electricity to homes on an island. If Indonesia, for example, were hit with a natural disaster, those microgrids could be destroyed. Even Indonesia's widely electrified islands may be impacted. With the new approach, the Indonesian government could use the it sent with food and supplies to also provide power. In their experiment, they found that the algorithm could manage power flows reliably enough to allow electric energy to provide peak load support to a grid directly after a trip.

With the algorithm in place, boat owners could decide when to sell electricity, and how much they wanted to sell. They might, for example, set their system to automatically sell 10 % of its stored energy, and even if the batteries are at least halfway . Boats are uniquely positioned to provide this kind of service, the researchers point out. Electric cars do not generally their own PV system. So instead of adding power to the grid such as a boat could, electric cars from it. The proposed technology works pretty similarly to the microgrids that are gradually rolling out in Indonesia/ Those microgrids also contain PVs to collect energy and li-ion batteries to store it, but there is . one key difference: portability.

Dr-Ing. Philipp Sinn and a team at SINN Power in Gauting, Bavaria, Germany have designed and built a floating platform to harness waves, small wind and solar photovoltaics. Designed to harvest energy from waves between 2 m (6.5 ft) up to 6 m (19.6 ft) in height, the platform itself doesn't move much at

all, thanks to a series of floats that move up and down in response to wave activity. Six kWp wind turbines are placed at each junction point and the entire top surface can be covered with solar panels, adding up to 20 kW to the final. In December 2015, the Sinn platform was trialed in Iraklio, off the Greek island of Crete but it could also be used for island resorts in the Caribbean.

When some natural disaster occurs in dispersed islands, the electricity networks or generation systems are heavily damaged, and residents live without electricity for weeks. In this , consumers having this technology can immediately get their power.

The concept is still in its infancy, but the University of New South Wales team expects to get its algorithm out of the lab and into the by testing it with an actual electric boat in the near future. *(unsw.edu.au)*

Khizir Mahmud et al, "Real-Time Load and Ancillary Support for a Remote Island Power System Using Electric ," *IEEE Transactions on Industrial Informatics,* July 3, 2019.

Electricity from bacterial wires

Solution: Jim Yao and a team at the University of the University of Massachusetts Amherst succeeded in producing electricity using a bacterial nanowire, measuring seven micrometers film positioned between two electrodes and exposed to the air. This nanowire film, produced by a microbe called *G. sulfurreducens,* absorbs water vapor present in the atmosphere, thus creating a small electrical through the diffusion of protons in the material. Called Air-gen, the system produces a sustained of 0.5 volts at 17 micro amperes per square centimetre, generating clean energy 24/7. The system produces no waste and could (theoretically at least) work in places like the Sahara Desert which is why the team are looking to scale up to industrial-sized systems as soon as possible. issue is the limited amount of protein nanowire that can currently be produced by G. sulfurreducens, however, they may already be a novel solution: get genetically engineered *E. coli* to mass produce the nanowire. *(ece.umass.edu)*

"Not magic, science! Researchers develop system to produce electricity out of thin air," *RT.com*, February 18, 2020.

Electroculture

Problem: Chemical fertilisers and weedkillers such as Monsanto's glyphosate been legally proved to be lethally harmful to both Nature and to human beings.

Solution: Since the beginnings of electricity in the 1780s, experiments have been made to use electro-magnetic energy to increase the crop yield of fruits and vegetables.

In 1923 independent researcher Justin Etienne Christofleau of La Queue-les-Yvelines, published “Augmentation des récoltes et sauvetage des arbres malades per l'électroculture” obtained patents concerning his Electro-Magnétique Terro Celeste. His system involved the use of "lightning rod" antenna, but with a buried antenna connected to buried north-south wires. Christofleau explained that it is not electricity as we know it but a breath of energy between heaven and earth, which stimulates and increases the fertility of the place. For the next twenty years, the Frenchman was persecuted for his inventions by lobbyists from the agrochemical industry who even attempted to the word electroculture deleted from national dictionaries and encyclopaedias. In spite of this, Christofleau’s system was adopted by farmers all over, in Australia, New Zealand, Africa, and even China. He was not . In the August 1935 issue of *Popular Science*, an article entitled “Electricity Controls Tree Growth” reported on the experiments of reputed French nurseryman Georges Truffaut at his Laboratories in Versailles. He planned to invent the orchard of the future where it would be possible to control (advance or delay) the growth of trees and fruits.

Seventy years later, electroculture has finally been validated. Since the 1990s, Chinese scientists been developing electroculture. In 2019, The Chinese Academy of Agricultural Sciences and other government research institutes released the findings of nearly three decades of study in areas with different climate, soil conditions and plantation habits. They hailed the results as a breakthrough. Across the country, from Xinjiang’s remote Gobi Desert to the developed coastal areas facing the Pacific , vegetable greenhouse farms with a combined area of 3,600 ha (8,895 ac) been taking part in an electroculture

programme. The technique has boosted vegetable output by 20 to 30 %. Pesticide use has decreased 70 to 100 %. while fertiliser consumption has dropped 20 %. In a series of greenhouses, with a combined area of 3,600 has (8,895 ac), the vegetables grow under copper wires, set about 10 ft (3 m) above ground level and stretching end to end under the greenhouse roof. The wires are capable of generating rapid, positive as high as 50,000 volts, or 400 times the standard residential in the US. The cables run the full length of the greenhouses and carry rapid pulses of positive , up to 50,000 volts. These high- bursts kill bacteria and viral plant diseases both in the air and the soil. They also affect the surface tension of any water droplets on the leaves of plants, accelerating vaporization. *(caas.cn)*

Kevin Desmond, *Electric Machines in Agriculture: Origins, Developments and Applications* (New Delhi, India, New India Publishing Company, 2020).

Electrolysis, nickel-based

Problem: Currently the most popular system used for water splitting, or water electrolysis, relies on precious hence very expensive metals as catalysts. Most water splitting today is conducted using a piece of equipment called a proton exchange membrane water electrolyzer, which generates hydrogen at a high production . It's expensive, and works under very acidic conditions, requiring precious metal catalysts such as platinum and iridium as well as corrosion-resistant metal plates of titanium.

Solution: Yu Kim, a research scientist at Los Alamos National Laboratory and Yuehe Lin of Washington State University's School of Mechanical and Materials Engineering, developed a system that uses less expensive and abundant materials. They worked to solve this problem by splitting water under alkaline, or , conditions with an anion exchange membrane electrolyzer based on nickel and , elements that are less expensive and abundant in the environment. By 2023, the global hydrogen generation market is anticipated to reach $199.1 billion. Promising markets for hydrogen energy comprise everything from power grid management and mass-energy conversion to fuel cells for cars. According to the duo, around 600 wind farms in the United States are prepared for direct connections to water electrolysis systems. (*.gov* and *wsu.edu*)

Dongguo Li et al.,“Highly quaternized polystyrene ionomers for high performance anion exchange membrane water electrolysers,” *Nature Energy*, March 9, 2020

Elevated villages

Problem: AGW causing the in global sea levels has been flooding the Pacific atoll nations such as Kiribati, Tuvalu, the Maldives, and the Marshall Islands. This also includes Vanua Levu, the second largest of Fiji’s 106 habitable islands in the South Pacific and villages such as Vunidogoloa in Korolao District.

Solution: In 2006, the Fijian Government decided to abandon the flooded village and build a new Vunidogoloa for its 130 inhabitants, a couple of miles (2 km) inland. Eight years and half a million dollars later, on the January 16, 2014, Commodore Josaia Voreqe Bainimarama, Prime Minister of Fiji inaugurated the new village of thirty timbered homes on stilts on a hillside. Further Fijian villages been completely relocated and two are in the initial stages of moving: Denimanu (Yadua Island) and Vunisavisavi, both of which been provided with cyclone-proof houses donated by USAID. This leaves about 40 villages earmarked for relocation in the short to medium term as sea levels continue to . In 2015, a Fijian official said the government was looking at possibly relocating as as 676 villages. *(fiji.gov.fj)*

Other alternative solutions for flooding villages will include dredging and reclaiming . (See also Flood Barriers and).

Karen E. McNamara and Helene Jacot des Combes, “Planning for Community Relocations Due to Climate in Fiji,” September 2015.

Elevating house

Problem: IPCC scientists expect a warming world to lead to extreme rainfall, exposing an additional 250,000 to 400,000 people in Europe to river flooding, and potentially up to 5.5 million per year to coastal flooding. The UK is likely to be one of the worst affected locations, the report suggests. For example, in February 2020, following two storms Ciara and Dennis, there was massive flooding across the West Midlans of England.

Solution; Since 2016, Tom Kelly and Graham Hicks of the UK-based Larkfleet Group, been on an experimental house that could on jacks above floodwaters. The 72 tons (65) house could be raised 4.5 ft. (1.5 m.) in less five minutes. In October 2017, South Holland District Council Planners permission for Larkfleet Homes in Lincolnshire, to build a test house in a paddock in Weston Hills near Spalding. Oddly, the developers, who believe it is the world's first such home, not been allowed to place it on a flood plain. If tests are successful the house could provide a model that would enable housebuilding on thousands of sites across the UK which at present cannot be developed because of the risk of flooding. built, experiments with raising and lowering the house, including testing -term maintenance and operation of the jacking system, will run for up to five years. Because the house will be of modular steel- design it can then be disassembled and re-erected on another site on conventional foundations as a family residence.

It is anticipated that houses of this design would be jacked up well ahead of the arrival of flood waters, based on advance warnings from organisations such as the Environment Agency. Rooftop solar panels and a battery would provide the house with some continuing electricity supply when raised above the ground and the water and sewage would remain connected through flexible hoses. However, it is not envisaged that residents would remain in occupation during floods. Instead, the householders would pack up, lock up and jack up the home before taking refuge in temporary accommodation on higher ground elsewhere. *(larkfleet.com)*

Tom Kelly, Graham Hicks "Elevatable building for preventing flood damage," Patent number: 10208474 (2019).

Embodied Carbon in Construction Calculator ("EC3")

Problem: According to the independent non-profit Architecture 2030, two trillion ft². of buildings will be built or undergo a significant renovation between 2015 and 2050 worldwide. Over the average 30-year lifecycle of a new building completed in 2019, roughly half if its carbon will come from embodied carbon i.e. the emissions associated with building construction, including extracting,

transporting and manufacturing materials. Considering that materials used for construction are estimated to consume 75 % of all new materials annually by volume, the reason for reducing the carbon emissions embodied in building materials is clear.

Solution: For Skanska of New Jersey, the USA's investment in addressing the embodied carbon challenge began in 2016, through its ongoing internal Innovation program. Smedley, regional director of sustainability for Skanska's building operations based in Seattle, Washington, received funding to research and establish embodied carbon benchmarks in partnership with the University of Washington's Carbon Leadership Forum. with with Phil Northcott of C Labs in Coquitlam, British Columbia, the program called was jointly seed-funded by Skanska and Microsoft. They determined that a collaborative, -source solution, backed by a comprehensive database of digitized Environmental Product Declarations (EPDs) was the best way to maximize the impact of this groundbreaking tool in reducing global carbon emissions. There are over 16,000 materials in the database, including concrete, steel and gypsum. Professionals, contractors, and owners needing actionable data to informed decisions about climate impact and performance will benefit. In the fall of 2019, Skanska launched the Embodied Carbon in Construction Calculator ("EC3") web tool for a non-profit alliance of AEC firms, manufacturers, foundations, and building owners including the Carbon Leadership Forum, American Institute of Architects, American Institute of Steel Construction, Skanska, Autodesk, Arup, Interface, the MKA Foundation, Charles Pankow Foundation, ACI Foundation, Microsoft and 30 other industry leaders. *(usa.skanska.com)*

Sara Maassarani et al., " Developing a Calculation Tool for Embodied Energy in the Conceptual Design Phase," *International Journal of Computer Applications* 157(6):41-49,January 2017.

Energy paths

Problem: With the transition from fossil fuel to electrical energy, the exponential demand will need the widest variety of sources.

Solution: Another clean system for generating electricity makes use of piezo materials (usually in the form of the mineral quartz, topaz, or lead zirconate titanate), where the simple act of walking or jumping or driving a

vehicle over a surface can generate electricity. Floors composed of piezoelectric tiles are designed to capture the wasted energy and store or redistribute it where it is needed. They were patented in 2007 by teams at the technical universities of Delft and Eindhoven in the Netherlands. Power is generated when a footprint compresses the board from a depth of 0.2 in. to 0.4 in (5 mm to 10 mm. The triangular design maximizes power output and data capture, and its high durability and ease of installation allow it to be seamlessly integrated into any location. Through electromagnetic induction by copper coils and magnets, each step produces from 2 to 4 joules, which generates an average of 5 watts of energy: enough to operate an LED bulb for 30 seconds. This energy is stored in batteries that can power lights or other devices, such as speakers. The first applications were on the floors of nightclubs and gymnasiums. In 2008 the East Japanese Railway Company installed the system while updating Tokyo Station where pedestrians walking on piezoelectric mats power the ticket barrier and the displays. *(jreast.co.jp)*

The challenge was also taken on by Laurence Kemball-Cook, an undergraduate studying Industrial Design and Technology at Loughborough University, England. Following the publicity generated by a short demonstration film of his PaveGen tiles posted on his website Kemball-Cook, was awarded US$ 13,000 prize and a US$ 250,000 deal with one of the largest shopping centers in Europe, Westfield in London. PaveGen received orders from at Heathrow Airport's Terminal Three and entered into collaboration with the US government. In Lagos, Nigeria, the tiles been installed under a soccer field, enabling players to light up the entire field during a match. A second generation of PaveGen tiles is triangular in shape, with a generator in each corner to maximize energy output. In addition to power generation, PaveGen can use Bluetooth to connect to smartphone applications and the system can also communicate with building management systems.

A study of a central building at Macquarie University in Sydney, Australia, suggested that if pavers covered the 3.1 % of the floor that sees the most foot traffic, it would generate an estimated 1.1 MW-hour per year, about 0.5 % of the building's energy needs.

The downside to this system is that when the PaveGen is not walked on it does not generate energy, this problem occurs if the tile is placed somewhere that is crowded but at times does not receive any people on it which causes it to not generate energy. But this problem can be largely avoided by just placing the

tiles in places that always receive people such as the subway stations of New York or other similarly crowded cities. *(pavegen.com)*

At the NASA Kennedy Space Center's Visitor Complex at Canaveral, Florida, in 2017, Stern, a senior research scientist with the Georgia Tech Research Institute, and colleagues, collaborated on a project supported by NASA contractor Delaware North Corporation to build a 40,000 ft² (3,700 m²) lighted outdoor piezoelectric footpath. *(delawarenorth.com)*

Energy roads

Problem: Highways and roads use up energy to build and to maintain

Solution: Engineers from Lancaster University, UK, are on 'piezolectric' ceramics that when embedded in road surfaces would be to harvest and convert vehicle vibration into electrical energy. The research project, led by Professor Mohamed Saafi, will design and optimise energy recovery of around one to two kWs per kilometre under 'normal' traffic volumes—which is around 2,000 to 3,000 cars an hour. The system developed will then convert this mechanical energy into electric energy to power things such as street lamps, traffic lights and electric car charging points. *(lancaster.ac.uk)*

In Portugal, an energy road system called ESPHERA has been financed by the Centre for the Innovation of Smart Infrastructures, founded by Ferrovial, the Castile-La Mancha regional government and the University of Alcalá. Ferrovial is also in of technical coordination for ESPHERA, which has benefitted from the collaboration of Cintra (the motorway subsidiary company of Ferrovial) and the Aravía Company, who hold the concession for the maintenance of the section of the A-2 motorway between Zaragoza and Calatayud. *(ferrovial.com)*

In 2016 the California Energy Commission (CEC) approved a pilot program in which piezoelectric crystals were installed on several freeways. Scientists estimate the energy generated from piezoelectric crystals on a 10 mi (16 km) stretch of freeway could provide power for the entire city of Burbank (population: 105,000). Italy signed a contract to install this technology in a portion of the Venice-to-Trieste Autostrada. Also that year, unveiled the world's

first solar road through the tiny town of Tourouvre-au-Perche in Normandy. French Environment Minister Segolene Royal said the road could generate enough electricity to safely power the street lamps. Some of the biggest concern stemmed from the weight of cars travelling over the panels. An estimated 2,000 motorists would traverse the road each day. Unfortunately by 2018 there were reports that the yield of the roadway had fallen way below expectations. Each vehicle was shadowing the solar panels while mud, leaves, and litter did not help things either

China's first solar highway was built by Pavenergy and Qilu Transportation in eastern China's Shandong province on a section of one of the most highly-trafficked areas, the Jinan City Expressway road, stretching for 1.2 mi. (2.4 km) with an area of 63,234 ft² (5,875 m²).. The test section proved capable of holding middle size with friction. Engineers then added wireless vehicle charging into the panels. It opened in December 2017. *(pavenergy.dec.uc.pt)*

In 2019, engineers from the Virginia Polytechnic Institute and State University (VT) found a way to 3D print piezoelectric materials, so tailoring the architecture to them flexible to them around any arbitrary curvature. *(vt.edu)*

References: Laurence Kemball-Cook, Philip Tucker, "Energy harvesting*," WO2011138585A1* (2011); Dhananjay Khadilkar, *"*Energy-Harvesting Street Tiles Generate Power from Pavement Pounder,*" Scientific American,* April 20, 2013*;* Li, Xiaofeng and Vladimir Strezov, *"*Modelling piezoelectric energy harvesting potential in an educational building,*" Energy Conversion and Management, (2014);* "Piezoelectric Tiles Light the Way for Kennedy Space Center Visitors" *Georgia Tech Research Institute,* December 12, 2017; M.Saafi, "SAFERUP: Sustainable, Accessible, , Resilient and Smart, Accessible, , Resilient and Smart Pavements," *Lancaster University*, March 1, 2018.

Energy playgrounds

Problem:

In 2007, in rural Ghana, West Africa, all the school buildings were dark, poorly equipped, with no electricity … and no playground equipment," How to combine the two?

Solution:

Former ExxonMobil VP of Engineering Ben S. Markham and his wife, voluntary Mormon missionaries teamed up with BrighamYoung University to developed a merry-go-round/carousel equipment that generates electricity from children's play. For this, they founded a non-profit firm, Empower Playgrounds Inc. (EPI) of Provo, Utah.

Improving and field-testing the conccept in Ghana, the Markhams found that a healthy 8- to 12-year-old generates about 150 watts of energy per hour whilst vigorously playing. Kweku Anno, Managing Director at the Ghana-based Biological Filters and Composter's Ltd converted the design to use locally available materials. After school selection involving EPI social scientists and the Ghanaian Ministry of Education, Anno Engineering manufactured and installed the systems.

Initially, EPI hand-modified LED camping lanterns so they could be recharged by the EPI system. In 2009, Energizer became a sponsor for EPI, donating development of LED lanterns specifically designed for the EPI service. The lantern has a computer chip that manages the charging of the custom battery pack and the operation of the LED lights, which provides lighting equivalent to a 25-watt incandescent light bulb for over 40 hours per charge. The lights have an expected service life greater than five years. In 2009–2010, EPI began including science kits with its playground equipment. As of June 2015, EPI power-generating play equipment had been installed at 42 rural schools.

Elsewhere in the world, the same electricity-generating solution has been used in other playground items such as trampolines, swings, see-saws and spring stools.

Energy reduction (bee-inspired)

Problem: Energy over-consumption in big commercial buildings makes a massive on electrical energy

Solution: In 2005, Mark Kerbel and Kulyk of Toronto, Canada were designing software for the electricity sector. While Kulyk's experience in custom building automation began during the hard-wiring era, Kerbel had worked for utilities through involvement with the architecture and software of

building management systems. Friends, they both considered that existing energy efficiency technologies and services were too inconvenient, complex and expensive, with high up- , multi-year payback scenarios, and extensive ongoing maintenance efforts.

Inspired by biomimicry, Kerbel and Kulyk studied the way bees communicate with each. There is no “topdown” management in a hive. They realized the ideal concept for their technology when they read Steven Johnson’s “Emergence: The Connected Lives of Brains, Cities, and Software”. Emergence is how bees are able to operate an adaptive colonial group, despite lacking top-down management or “intelligence” in the human sense of the word. Using simple rules and communicating constantly with pheromone trails, each individual bee contributes to the hive-level goal of survival. The phenomenon is called “emergence” because a complex system of communication and decision-making emerges from a number of much simpler interactions.

Kerbel and Kulyk developed an algorithm called Swarm that allows all pieces of building equipment to simultaneously detect each other, to red-unnecessary power consumption. Air conditioners, compressors, pumps and other building appliances constantly cycle on and off. The problem arises when they are ignorant of each other and turn on at the time. Co-founding Energy, they developed the EnviroGrid Controller to connect to the control box on each piece of equipment, to function as a smart power switch. EnviroGrid Controllers could be installed on any electrical heating, cooling, or discretionary electrical load in approximately 30 minutes, resulting in minimal operational disruption. Each device monitors its appliance’s energy use every two minutes and broadcasts its reading to all the other controllers in the system. several controllers been activated, they learn the power cycles of each appliance and use a networking standard called Zigbee to communally negotiate the best times to turn equipment on and off.

Every node connected to the “hive” thinks for itself. Before making a decision, a node considers the circumstances of other nodes in the network. For example, if an HVAC unit needs to cycle on to maintain a minimum temperature, a node connected to another HVAC unit will stay off for an extra 15 minutes to maintain power use below a certain threshold. This results in up to 20% reductions in HVAC kW, KWh, and CO_2,

Following their 2005 start, having completed work with Sacramento Municipal Utility District (SMUD), a major utility company, they then

negotiated with both other California and Texas utilities to increase their presence in both regions. Their to Encycle in 2013, Kerbel and Kulyk's Swarm ® can now be connected via the cloud to an existing building control system, building automation system (BAS), connected thermostats, or IoT platform. Swarm dynamically synchronizes HVAC rooftop units (RTUs), transforming the RTUs into smart, networked, energy-responsive assets. Newer versions of the system focus almost exclusively on rooftop HVAC systems installed in medium-sized buildings. A typical building might incorporate between 10 and 40 controllers together to mimic the communications in a beehive, and the nodes are linked to the system, the better it works.

Encycle has integrated Honeywell thermostats into its EASE (Energy as a Service by Encycle™) solution for a nationwide restaurant and entertainment business. With customer satisfaction a top priority, it was crucial that Encycle's solution lower electricity while ensuring patrons' comfort. What started out as a 6-site pilot program has now developed into a 17-site portfolio with over 300 thermostats. Encycle's Swarm technology is already in facilities in North America, including retail stores, grocery stores, shopping centers, restaurants, entertainment venues, offices, schools, distribution centres, and light/medium manufacturing buildings. While Kulyk left Encycle in 2015 to found Loft1 technology which transforms any ordinary whiteboard and marker into a completely digitized set of editable, searchable notes, Kerbel died from in November 2017. From August 2018 Encycle Corporation partnered with Lightstat of Barkhamsted, Connecticut to IoT-enabled thermostatic control into a networked, cloud-based system that allows commercial and industrial building energy managers to reduce their HVAC energy consumption and by 10-20%. They also partnered with Carrier Connect, makers of Wi-Fi thermostats. *(encycle.com)*

Steven Johnson, "Emergence: The Connected Lives of , Brains, Cities, and Software", New York Scribner, 2004; Patent 20080015742: "Method and apparatus for managing an energy consuming load," the first of several taken out by Kulyk and Kerbel.

Energy system, gravity-based

Solution: In the matrix of machines for producing electricity, instead of batteries, which are relatively expensive and can cause environmental

challenges, one solution is the gravity-based energy system. One of these is the Energy Vault. When a solar farm produces extra electricity during the day, use that energy to lift and thousands of 38.5 ton (35) blocks into a tower as high as 500 ft. (152 m) the energy through the elevation gain. When the sun isn't shining or the wind is not blowing, software tells the system to lower the , the weight of which will drive generators as the plucks them off the tower and lowers them to the ground, so sending electricity back into the grid. The system can respond within a millisecond.

The development of this technology took place at Idealab, the Pasadena, California-based startup incubator, then handed to Energy Vault, to commercialize the technology. In partnership with Italian energy company ENEL, a tenth the size of a full-scale operation was built and trialled in Biasca, Switzerland, north of Milan, Italy. A Swiss subsidiary of Mexico-based CEMEX Ventures provided venture capital, concrete and other composite material technology.

The unit, from proposition to prototype, took about nine months and less US$2 million to accomplish. The Energy Vault team was led by Andrea Pedretti, inventor with 25 patents worldwide for a variety of civil engineering and energy applications. Having earned his M.Sc. in structural engineering from the Swiss Federal Institute of Technology in Zürich, Pedretti worked with Airlight Energy, a Swiss cleantech provider focusing on unique solutions for concentrated solar power. The Energy Vault system could deliver as much as 80 MW-hours of power, enough to cover about 60,000 homes for up to 16 hours The system is modular and flexible with each plant having a capacity of between 10 and 35MWh and a power output of between 2 and 5MW

Each tower can be erected quickly; the materials can be delivered within months and erected within weeks, without the huge investment of a battery factory. The materials themselves can be found on-site from materials such as soil concrete construction debris which would otherwise go to a landfill. At a coal plant that plans to close and reopen renewable energy on-site, the could be from coal ash

India's Tata Power is the company's first announced customer, with a tower that will be constructed later this year. But Energy Vault is in talks with other customers about 1,200 potential towers. In August 2019, Energy Vault raised US$110 million from SoftBank Vision Fund to finance its next steps in the world. One place where the Energy Vault technology could be used to

advantage is around desalination plants in places such as sub-Saharan Africa or desert areas.*(energyvault.com)*

Nancy " by , a solution seeking to topple energy roadblock," *TechXplore,* November 10, 2018; Aarian Marshall," Elon's Batteries—Fix the Grid With a Rock-Filled on a Hill," *Wired,* May 16, 2016.

Endangered Species Adoption

Problem: Tens of species are vanishing from the of the Earth every day. Almost one third to one-half of all species could become extinct by 2050. Well over 900 plants and animals are endangered, and hundreds are threatened. of the reasons certain animals are disappearing forever are because of human activities..

Solution: The Worldwide Fund for Nature (WWF), founded in 1961, has a program Adopt an animal now, whereby those interested visit (support.wwf.org.uk/adopt-an-animal) and by one click can choose from their of adoption animals, donating from £3 per month to protect precious habitats around the world and all the species which rely on them. The Australian branch of the WWF also presents their own solution for protecting threatened species. (.wwf.org.au/adopt).

Not to be confused, The World Animal Foundation was created in Cleveland, Ohio in 2002 to public education regarding the preservation of the planet and the animals that inhabit it. WAF works through public education, research, investigations, animal rescue, legislation, special events and direct action.Three years later it moved its headquarters to Vermilion. WorldAnimalFoundation.com, acts as a one-stop information portal for people wishing to learn about animals and the earth. Visitors can print dozens of free flyers and fact sheets and surf hundreds of regarding wildlife, endangered species, companion animals, aquatic animals and farm animals. One of their solutions is "Adopt an Endangered Species". WAF Adopt An Endangered Species Animal Kit comes in a deluxe WAF folder and includes: Glossy Photo of Your Adopted Endangered Species Animal; Adopt An Endangered Species Animal Adoption Certificate; Fact Sheet About Your Adopted Endangered Species Animal; Help Animals Info Cards Packed With Information On Animal Issues & How You Can Help Animals And The Environment.

Over in , in 2008, Kevin Desmond, author/compiler of “Planet Savers: 301 Extraordinary Environmentalists”, attempted to set up an ngo EvE-Urgent.org, short for Espèce-ville espèce (species-town-species) whereby towns and cities worldwide were each encouraged to adopt a threatened species as its totem and to measures to protect it and its ecosystem from extinction. To select their species a town had decided to sponsor, the EvE-Urgent website recommended looking for it in the local biodiversity or consulting the Natura 2000 network. But nothing prevented them from choosing one abroad. In order to avoid duplication, an “EvE counter” for the participating cities was set up. the species had been chosen and the information about it has been collected, the project can be presented to the municipality. But "the engagement of the town hall is not obligatory", the site specified. In of refusal, citizens could themselves create an association with the help of EvE-Urgent.org in to contribute to the protection of the species, either by collaborating with specialized NGOs, or by acting directly on the ground. Fund-raising events, cultural and sporting could funds for the species chosen. the first to adopt was the city of Bordeaux choosing the Angélique des estuaries which grows alongside the River and subsequently creating a Park named after the species. Although never developed, the EvE-Urgent solution could still be used….

Paula Pinto GOMES, « Les collectivités au chevet des espèces menacées, » La Croix October 15, 2008

Enhanced rock weathering

Solution: Professor David Beerling, Director of the Leverhulme Centre for Climate Mitigation at the University of Sheffield and a team shown that adding rock dust such as finely crushed basalt, a natural volcanic rock to all cropland soil in China, India, the U.S. and Brazil could trigger weathering that would remove 2 billion tons of carbon dioxide from the atmosphere each year and help meet key global climate targets. One compelling aspect of enhanced weathering is that, in controlled-environment studies involving basalt amendments of soil, cereal yields are improved by roughly 20%.The scientists suggest that meeting the demand for rock dust to undertake -scale CO_2 drawdown might be achieved by using stockpiles of silicate rock dust left over

from the mining industry, and are calling for governments to develop national inventories of these materials.

David J Beerling et al., "Potential for -scale CO_2 removal via enhanced rock weathering with croplands," *Nature*, July 8, 2020; "Applying rock dust to croplands could absorb up to 2 billion tonnes of CO2 from the atmosphere, research shows," The University of Sheffield, 7 July 2020

Ethanol from CO_2

Solution: A process for reducing CO_2 by converting it to ethanol has been developed by Michael Köpke at LanzaTech in Skokie, Illinois. In 2009, Köpke obtained his PhD in microbiology and biotechnology at the University of Ulm, Germany, specialising the genetic engineering of gas fermenting organisms. His pioneering research on *Clostridium ljungdahlii* demonstrated for the first time that gas fermenting acetogens can be genetically modified and provided a genetic blueprint of such an .

Köpke joined LanzaTech in Auckland, New Zealand, developing converting waste carbon monoxide emitted from factories into ethanol and other chemicals. LanzaTech's carbon recycling technology is such as retrofitting a brewery an emission source such as a steel mill or a landfill site, but instead of using sugars and yeast to beer, pollution is converted by bacteria to fuels and chemicals This is revolutionizing the way the world thinks about waste carbon by treating it as an opportunity instead of a liability. In its first year, LanzaTech's first pre-commercial plant in China produced over 100,000 gallons (380,000 liters) of ethanol from steel mill emissions that can be converted into aviation kerosene, plastic and products. This earned it an internationally recognized sustainability certification from the Roundtable of Sustainable Biomaterials in 2013. Additional facilities may be built in California, Belgium, India, and South Africa. Together, they could produce about 77 million gallons (26 million liters) of ethanol per year from carbon waste.

In 2018, LanzaTech began testing a low carbon fuel for airplanes, which was used to fuel a Virgin Atlantic flight from to London. Initially its biofuel for Virgin accounted for 6% of the fuel mix. The company aims to officially launch its new LanzaJet product in 2019, which could be a potential solution for the airline industry to reduce its waste. LanzaTech claimed it could three gas-to-ethanol plants ready in the UK by 2025 if it secured the necessary airline

customers and government backing, producing about 125 million gallons (473 million liters) of SAF a year.

In November 2019, after three years of collaboration, ExxonMobil and FuelCell Energy, Inc. signed a new, two-year expanded joint-development agreement to further enhance carbonate fuel cell technology for the purpose of capturing carbon dioxide from industrial facilities. The agreement, worth up to US$60 million, will focus efforts on optimizing the technology, overall process integration and -scale deployment of carbon capture solutions. ExxonMobil is exploring options to conduct a pilot test of next-generation fuel cell carbon capture solution at one of its operating sites. *(lanzatech.com)*

“Ethical” banks

Problem:

There are over 164 million payment cards in circulation in the UK. The vast majority of these cards are from non-biodegradable plastic such as polyvinyl chloride (PVC), which contributes to harmful landfill waste.

Solution:

Ethical banks

The Netherlands

In 2017, Dutch-founded ethical bank Triodos launched a current account in with its values, which includes a biodegradable contactless card from a plastic substitute called polylactic acid (PLA), which as it is created from renewable sources such as plant leaves and , rather petroleum has not leakage. the chip and strip in the Triodos card are not biodegradable, but they are recyclable.

Since 2016, Bevis Watts has been CEO of Triodos UK Ltd. in Bristol. From 2013-16, he had been Chief Executive of Avon Wildlife Trust and Head of Business Support at The Waste and Resource Action Programme () for 6 years (2001-07), creating their Financial Mechanisms Program.

Triodos’s no-frills account £3 a month and comes with no eye-catching offers or temporary bonuses. Instead it offers a simple overdraft and no unplanned borrowing facility, traditionally the most expensive way to borrow.

Customers' money goes to a whole of projects including farmers, and renewable energy.

For example, a from Triodos contributed to TV Chef Hugh Fearnley-Whittingstall's renovation of the 65- farm in Devon, home to the famous River Cottage cooking school. It also helped fund the build of Premise Studios, a studio built with reclaimed and recycled materials, invested in Thrive Renewables, a Caton Moor wind farm which produces enough energy to power 10,000 homes.

Triodos is not . ASN is a former Dutch , now a for some consumer banking operations by de Volksbank. ASN focusses on socially responsible and sustainable investments. ASN is currently the largest sustainability-driven in the Netherlands and was elected as the second most climate-friendly in the Netherlands (behind Triodos).

Northern England

The Cumberland Building Society based in Cumbria, has a branch operating area covering Cumbria, South West Scotland, West Northumberland and North Lancashire. The Cumberland recognises that it has an impact on the environment arising from its activities, including the use of energy, the purchase and disposal of materials and equipment and pollution arising from its motor vehicles.

la Banque Postale is taking an ethical approach with a few initiatives focused on ecology. On the customer side, the sustainable and solidarity development booklet (LDDS) is intended to support citizen projects linked to the social and solidarity economy. It is also possible to invest in companies that integrate social or environmental issues into their financial management (renewable energies, circular economy, transport and La Banque Postale announced in 2018 its “carbon neutrality” across its entire operational scope thanks to the internal monetization of its carbon footprint via its “Carbon Fund” launched in 2015. sustainable obilities, green buildings and innovative environmental services).

USA

The Aspiration Inc online green banking was founded by Andrei Cherny and Joseph Sanberg at Marina del Rey, California. Unlike big banks, Aspiration does not invest in fossil fuel funding, so clients’ deposits won’t go towards

projects like pipelines, oil drilling, and coal mines. They also the option to plant a tree with every swipe. And with its Aspiration Plus card— from recycled plastic—they can carbon-offset all their gas purchases and get 10% cashback when they buy from brands that are part of its Conscience Coalition, like TOMS.

In April 2017, Aspiration launched a feature on its mobile app called Aspiration Impact Measurement (AIM), which examines 75,000 data points and shows scores for companies where Aspiration customers shop, based on how those companies treat people and the planet.

China

Green Bond Credit Guidelines were promulgated by the China Banking Regulatory Commission (CBRC) in February 2012, a milestone directive encouraging Chinese banks to support green, low-carbon and recycling economies; to well manage environmental and social risks in lending service; and to improve sustainable performance in their operations. In 2019, the portfolio of green in The Industrial and Commercial of China (ICBC) was worth an estimated US$199 billion,, reaching 8% of its total portfolio

To achieve China's recent pledge to become carbon neutral by 2060, new investment of around 138 trillion (US$20 trillion) will be needed between 2020 and 2050 in the energy system , over 2.5% of annual GDP.

Italy and Spain

Banca Popolar in Padua is a cooperative operating in Italy and Spain, by citizens and social organizations and inspired by the principles of Ethical Finance. With the collected savings Banca provides exclusively to people and organizations with **sustainable projects** in the areas including the environment.

Germany

The UmweltBank, founded in 1997, is also profiting from the boom in ethical banking products. The Nuremburg-based institution boasts that it funds environmental projects exclusively, from building renewable energy sources to funding ecological farming initiatives.

These are just a handful in a growing number of ethical banks ready to support solutions to clean, to repair and to protect the Planet.

:Fairphone

Problem:

Conflict minerals, including the metals cassiterite, columbite-tantalite and wolframite are natural resources extracted in a conflict and sold to directly or indirectly benefit armed groups perpetuate the fighting in countries such as the Congo.

Solution:

The Fairphone

Fairphone was founded in January 2013 beside the River Ij in Amsterdam by Bas van Abel, Tessa Wernink and Miquel Ballester as a social enterprise company, having existed as an -conflict minerals campaign for two and a half years. The company's website states that its mission is to " a fair smartphone to the market – one designed and produced with minimal harm to people and planet".

To achieve this, Fairphone sourced conflict-free tin and tantalum from mines in the Democratic Republic of Congo and worked closely with its manufacturers to improve conditions in its factories.

It was supported in its startup phase by the Waag Society, a foundation which aims to foster experimentation with new technologies, art and culture. (*fairphone.com*)

The second version of the company's device is one of the first modular smartphones available for purchase, focussing on durability, repairability and the availability of parts that can be easily replaced to extend the smartphone's usable life. Building a that lasts reduces the overall toll on people and the environment.

Although Fairphone's co-founder and first CEO Bas van Abel was one of the three winners of the German Environmental Award in 2016, he acknowledged in 2017 that it was currently impossible to produce a 100% fair , suggesting it was accurate to call his company's phones "fairer".

In 2020, the -team operator Vodafone and Fairphone announced a strategic partnership to ethical Fairphone 3 Smartphone , with 40% recycled plastics to Vodafone's European customers. By this time there were over 100,000 Fairphone owners

In 2019 van Abel co-founded the circular start-up De Clique (*declique.nl*), a logistical service, physical hub and marketing platform to help transform wasted resources from his Utrecht into new products again.

“Family zéro déchet, Ze guide”

Problem: serious academic books been published which report on Climate , AGW and on those visionaries who tried to warn the educated and academically minded about the coming , but do not offer any practical day-to-day solutions.

Solutions: In 2007 Joanna Yarrow published “1001 Ways You Can the Planet: Practical Ideas to Heal and the World” (Duncan Baird Publishers); while Elizabeth Rogers and Thomas M. published “The Green Book: The Everyday Guide to Saving the Planet One Simple Step at a Time”; in 2008 Ton Juniper, director of Friends of the Earth for England and Wales published “How Lightbulbs Does It To A Planet?” (Quercus); and in 2010, Kent Anderson published “Saving Planet Earth - A Practical Hands On Approach” (lulu.com). This is just a selection.

Over in , “Famille zéro déchet, Ze guide”, was first published in 2016 by Thierry Souccar Editions written by Jérémie Pichon and his cartoonist companion Bénédicte Moret, settled in Seignosse, in the Landes, on the southwest coast of . Two years before, they had decided to involve their family into the Zero Waste challenge. In three years, from 860 lb (390 kg) trash, they passed to 2.2 lb (1 kg), ie one jar per year, but above all Tomorrow’sed a new way of life. With humor and self-deprecation, the authors offer a detailed action

and 10 Zero Waste challenges to get you started. Based on their knowledge of the ecology, they deliver hundreds of practical tips and simple alternatives for everyday life: shopping, cooking, cleaning, furniture, hygiene, -up, clothes, garden, DIY, festivities ... rubbish is everywhere! The book, printed on 100% recycled paper, has sold 150,000 copies. In addition while running a daily blog, “famillezerodechet.com” with over 3 million visitors, Pichon and Moret published two other books: "Les Zenfants presque Zéro déchets", and “Family in Ecological Transition”, the latter an illustrated roadmap and practical guide to attempt to reduce as much as possible the carhon footpriont of a French family. In 2018 Superprod began the production of animated series “Zenfants Zéro Déchet” adapted from the book. On March 5 2018, Jérémie a 16-minute YouTube talk “Zero Waste a Way of life in Transition” at TEDxUNamur in Belgium. *(thierrysouccar.com)*

Sophie Loir-Galland,“Famille zéro déchet, Ze guide,” *ma consience écolo*, July 29, 2016.

:FTO (fat mass and obesity-associated gene)

Problem:

Every year, 9 million people in the world succumb to hunger, which is more than the deaths from AIDS, malaria and tuberculosis combined. But the solution to the global hunger crisis is not as simple as ramping up agricultural production.

Solution:

To feed the world’s growing population in a sustainable way, a group of scientists from the University of Chicago, Peking University and Guizhou University may have found a clever solution—in the form of supersizing crops. Transplanting a human protein, known for promoting growth, into crops may engender larger, heavier and more bountiful plants, agricultural yields by an impressive 50%.

Since 2011, Chuan He, a Chinese-American chemical biologist at the University of Chicago has been opening an entire new field of research by discovering the keys to a different way that genes are expressed in mammals. It turns out that RNA doesn’t simply read the DNA blueprint and carry it out blindly; the cell

itself can also regulate which parts of the blueprint get expressed. It does so by placing chemical markers onto RNA to modulate which proteins are made and how many. He and Guifang Jia, a former UChicago postdoctoral researcher who is now an associate professor at Peking University, began to wonder how it affected plant biology.

The solution responsible for the plants' extraordinary growth spurt is the human fat mass and obesity-associated protein called FTO (fat mass and obesity-associated gene). The scientists knew it worked on RNA to affect cell growth in humans and other animals, so they tried inserting the gene for it into rice plants —and then watched in amazement as the plants took off. Both rice and potato plants increased their yield by 50% in field tests. The plants grew significantly larger, produced longer root systems and were better able to tolerate drought stress. Analysis also showed that the plants had increased their rate of photosynthesis.

The rice plants grew three times more rice under laboratory conditions. When they tried it out in real field tests, the plants grew 50% more mass and yielded 50% more rice. They grew longer roots, photosynthesized more efficiently, and could better withstand stress from drought. It proved the same for potato plants.

The FTO solution could be used to engineer grasses in threatened areas that can withstand drought, or a tree in the Midwest to grow longer roots, so that it's less likely to be toppled during strong storms. There are so many potential applications.

Yu et al, "RNA demethylation increases the yield and biomass of rice and potato plants in field trials." *Nature Biotechnology,* July 22, 2021.

Faux fur

Problem: Should animals continue to be killed so their pelt is transformed into fur clothing? Since animal fur is treated with heavy dyes and chemicals including chromium and formaldehyde (both of which are highly), it is slow to biodegrade. The of fur animals are just wasted since they are not eaten, while their poop and blood are dumped into water systems as waste. Equally, faux fur of plastics and acrylics is slow to biodegrade.

Solutions: Ecopel (HX), a -Chinese company, has developed a faux fur material from recycled plastic bottles using a collection system internalized at the company's mills in Asia. Ecopel works with 1,000 employees. The fibre used, MODACrylic or polyester, allows the creation of a eco-friendly product. The resin is enriched with natural fibers such as cotton or hemp, to luster and softness. Ecopel is used by famous brands such as Gucci, Calvin Klein or Tommy Hillfiger and others. Fashion designer Stella McCartney OBE also uses a beauty-without-Cruelty Fur-Free-Fur product. In 2019, by Her own decision, the mink lining of a coat that Her Majesty Queen Elizabeth II to Slovakia in 2008 has been replaced with faux fur. *(ecopel.cn)*

In Russia, Sergey Leonov at the School of Biological and Medical Physics, Moscow Institute of Physics and Technology successfully bioengineered animal pelts and hides in petridishes. Such vertebrate cells used could come from an antelope, cheetah, chinchilla, crocodile, ermine, leopard, lynx, lion, marten, mink, sable, and stoat, indeed all species killed for their pelts. Vlad has started up Furoid to and sell the product.

Stephen Barrass, "Fauxy Fur with Feelings," *10th Meeting of the International Foundation of Fashion Institutes,* February 2008; *furoid.com* website.

Flat pasta

Problem:

The variety of pasta shapes is attractive — from spirals of fusilli and rotini to tubes of penne and rigatoni But what makes farfalle different from conchiglie also makes the staple a bear to package, requiring large bags and boxes to accommodate the iconic shapes of pastas around the world.

Solution:

Lining Yao, who directs the Morphing Matter Lab in Carnegie Mellon University's Human-Computer Interaction Institute and studies how to design and fabricate materials that use nano- and microscale technologies to alter their own shape, has developed a flat pasta that changes shape in boiling water, aims to save packaging materials by eliminating airspace inside food cartons! Lining and her team stamped patterns of tiny grooves into conventional flat pasta dough made solely of semolina flour and water. By controlling the angle, width, depth

and spacing of the grooves, they could make flat pasta fold into tubes, spirals, twists, waves and boxlike shapes when cooked!

Yao's team includes 17 researchers from CMU, Syracuse University and Zhejiang University, specializing in fields including material science, mechanical engineering, computational fabrication and design. They have published their understanding of the morphing mechanism and design principles in the paper "Morphing Pasta and Beyond," which is the cover story of the May 2021 issue of *Science Advance*.

Floating Farm

Problem: Energy is used to transport farm produce from the countryside to towns and cities and to keep it fresh during transit.

Solution: In 2019, a Dutch property company called Beladon launched the world's first floating dairy farm anchored to the floor in the middle of Rotterdam's Merwehaven harbour. 40 Meuse--Issel cows are milked by Lely robots to produce 1700 pints (800 liters) of milk a day. Peter van Wingerden, an engineer at Beladon, up with the idea in 2012 when he was in New York on a floating housing project on the Hudson River. While there, Hurricane Sandy , flooding the city streets and crippling its transport networks. Deliveries struggled to get through and within two days it was hard to find fresh produce in shops. Seeing the devastation caused by Hurricane Sandy van Wingerden was by the need for food to be produced as near as possible to consumers.

The top floor of the cow garden houses greenhouses for clover, , and other crops that feed the cows; the middle level is the animals' floating home, a grassy enclosure to resemble a natural garden, but populated with artificial trees. The cows called Karma, , and Sustainabetty are free to roam in and out of their stalls, and also the option to on solid ground in an adjacent field they can access via a . Lely Robots provide them with fodder and brush them down. Finally, the bottom floor contains a processing plant, turning fresh milk into consumer products, including yogurt and, possibly, Comté-style cheese. All of this futuristic food manufacturing is happening behind glass walls to literally

emphasize transparency. School children and consumers are invited to tour the farm and watch robots milk the cows and pick up their waste, which is used as fertilizer or converted into energy for on-site use. To power it, the farm uses solar and wind energy from rooftop windmills and solar panels, while artificial trees with real ivy provide shade for the cows and reduce energy consumption by cooling the space. One of the Dutch farming organizations that collaborated with Beladon is planning to the concept to other cities, and is already developing a floating vegetable and egg farm. Before they move on to chickens, however, they will hopefully solved one current problem: what to do about that distinct animal farm odor. The cows arrived on board in April 2019. No matter how much falls, no matter how high sea level goes, this farm can always produce life-essential, healthy food. By August, floating production was 160 gallons (600 liters) of milk a day. Van Wingerden has talked to food companies and developers seeking to buoyant dairies to Singapore, Dubai, and New York. *(beladon.com)*

Adam Wentworth, "Beladon creates the first ever 'floating farm' in Rotterdam," *ClimateAction*, August 20, 2018; Amy Frearson, "Floating Farm in Rotterdam is now home to 32 cows," *dezeen,* May 24, 2019.

Fibreglass boat recycling system

Problem: Since fibreglass or glass-reinforced plastic (GRP) boatbuilding began in the 1950s, there has been a steady accumulation of unrecyclable old hulls all over the yachting world, numbering in the millions. Some will be crushed and buried in landfills; others are simply abandoned on , often in boatyards or dealer service yards, or left as derelicts waterways, where they can harm the environment.

Solution: In 2007-2008 in the UK several trials were undertaken through the BeAware project (Built Environment Action on Waste Awareness and Resource Efficiency) to incorporate GRP waste into pre-cast concrete and rubber products. With grinding, dimensions of the small resulting pieces from 1 in (2.5 cm) to powder. That material could then be then be integrated into cement and therewith, be used in constructions. The clinker was ground to form cement. Alumina and silica also cementitious properties in an alkaline environment and are typically present in Portland cement at about 25%, and in much higher

proportions in cement alternatives from fly-ash and . Boron, which is found in most E-glass, can cause a reduction in early strength during the setting of cement, but as long as proportions are kept low it is not considered a problem.

In 2010, Fiberline Composites of Middelfart, Denmark, a manufacturer of fibreglass and carbon fibre profiles signed a contract with two companies: Zajons in Germany, which specializes in converting waste to alternative fuels for industry and Holcim (Germany), subsidiary of the world leading cement manufacturer from Switzerland. Under the contract, surplus fibreglass from Fiberline's production in Denmark will be shipped south for use as a key constituent of cement. This breakthrough soon to be used in other European countries, with an initial 10,000 hulls processed and recycled as part of several national and multinational industry programs. *(fiberline.com)*

Researchers at Windsheim University in the Netherlands been testing out the re-use of such material to piling sheets.

recently both initiatives begun in Canada and the USA. Transport Canada is financing Jeosal Materials Research Corporation with Queen's University at Kingston, Ontario, under the Canadian Plastics Innovation Challenge to develop a possible solution for recycling fibreglass. In New York State, the Island Association (RIMTA) has launching its Fiberglass Vessel Recycling Pilot Project (FVR) partnering with local boatyards for dismantling and crushing 22 to 33 tons (20 to 30 tonnes) of fiberglass for use by cement industry partners in South Carolina. While it is important to note that the RIFVR Pilot Project is just taking its nascent steps, if things go well, the project could eventually be rolled out regionally and nationally. *(rimta.org)*

Scott Francis, " Island launches fiberglass recycling initiative." *Composites World,* 27, 2018; Ridley, " Island Fiberglass Vessel Recycling (RIFVR) Pilot Project." *Island Trades Association*, September 2018. "End-Of-Life Management of Fibre Reinforced Plastic Vessels," *IMO* 2019.

Fibreglass wind turbine blade recycling system

Problem: After a useful life of 25 years, almost one thousand 300ft (90m) wind turbine blades end up in a graveyard in Casper, Wyoming, USA. Normally each blade will be cut into three, and then the pieces will be stacked and buried in a landfill.

Solution: Ronald Albrecht and Don Lilly of Global Fiberglass Solutions Inc. in Bellevue, Washington developed a solution which transforms fiberglass composite blades into Ecopolycrete. The process begins at the wind farm itself, where technicians from GFSI cut dismantle blades into manageable 120 ft (37 m) chunks. To minimize, if not eliminate, hazardous dust, GFSI uses wet wire blades that are thin and strong enough to slice each wind blade as cleanly as a cantaloupe. Then the company sprays a light mist of water so that debris into a dustpan lying beneath the blade. Next dismantled blades are taken to nearby yards where they are shredded into raw fibreglass material. A single blade yields about 15-20 of pellets, weighing between 700 lb (317 kg) and 1,000 lb (450 kg) each. The pellets can then be turned into injectable plastics, or highly waterproof boards that can be used as manhole covers, building panels and pallets. GFSI reuses 100 % of each blade. Even the that circle the blade's end section go to a metal salvage site for recycling. GFSI also developed a programme to track blades throughout their life cycle, and it easier to recycle them at the end. *(globalfiberglassinc.com)*

Don Lilly, Ronald Albrecht, "Wind Turbine Blade Recycling," US Patent 20190066062, February 28, 2019.

Football Club, eco-friendly

Problem

But football also has its downsides: heaps of rubbish, squandering of water and a big CO2 footprint. The environmental consequences involve everything from building new stadiums, hotels, parking lots and other infrastructure to handling the sanitation from all those new toilets.

Solution:

Eco-friendly football club

Forest Green Rovers (FGR) are an EFL League 2 English association football club established in 1889 and based in Nailsworth, Gloucestershire, England.

In 2010, Vince, OBE, British 'green energy' industrialist, and founder of Ecotricity, the world's first green electricity company, became the club's majority shareholder and since, with the support of the team, decided to completely transform football's environmental footprint.

In December 2011, 180 solar panels were installed on the roof of the stadium stand, helping the club generate 10% of the electricity needed to run the stadium.

In April 2012, Forest Green introduced the first robot lawn mower to be used by a British football club on to its playing surface. The Etesia robot mower – known as a 'mow – uses GPS technology to guide it round the pitch without the need for human intervention and gathers power from the solar panels at the stadium.

The club won the sustainability/environmental award from the Groundsmanship Institute thanks to their ground's compost, rainwater harvesting system,

They've also plans to replace their current floodlights with LEDs bulbs to further reduce their energy consumption by 60%

In 2014, the team received a message of support from Paul, Stella and Mary McCartney when they staged the world's first plant-based football match and removed all animal-based products from the stadium's menu. Food sales were 84% higher in the 2014 season with their mostly plant-based menu, and by 2015, they had permanently removed all animal products, becoming the world's first all-plant-based football club.

Hot dogs, meat pies and sausages were replaced with sweet potato burgers, Mexican fajitas, and veggie pizzas. The traditional beef burger is replaced by quinoa on a match day. Their beer and cider (provided by the Cotswold Brewing Company) are vegan. Bovril, popular manufacturer of a beef-based beverage for over a century, produced a plant-based version for supporters to drink on cold evenings.

In 2019 planning permission was received to build the world's first wooden eco-friendly stadium, designed by Zaha Hadid Architects. The 5,000 capacity stadium will be built within the Eco Park complex beside Junction 13 of the M5 in Gloucestershire, 1.5 miles west of the town of Stonehouse (and 8.5 miles northwest of their spiritual home of Nailsworth). Almost every element will be constructed of sustainably sourced timber, including the structure, roof cantilevers, and louvred cladding. The stadium may be named KEVIN, after the world class footballer Kevin Keegan but which also rhymes with the word "vegan"

FGR Chairman Vince is now involved with Sky Diamonds, which uses a “sky mining facility” in Gloucestershire to pull carbon out of the atmosphere to form the gemstones – which are chemically identical to diamonds mined from the earth – using wind and solar electricity, with water collected from rainfall

Forest Green Rangersis just one solution contributing to the UN Sports for Climate Action Framework. its 166 participants from all types of sport, Premier League Club Arsenal has planted 29,000 trees at the club’s training centre in London Colney since 1999 to create Colney Wood, it has installed LED lighting at its Emirates Stadium in Highbury London, and has a reusable cup scheme during matches.

Forest wildfire-resistant home

Problem: In 2018 some 24,226 buildings were destroyed in Californian wildfires During the bushfire season 2019-2020 2,500 homes were destroyed. The 2020 fires in California destroyed at least 4,100 structures.

Solution: In 2009, not after Victoria’s Saturday bushfires claimed 173 lives and destroyed 2,000 houses, a group of architects together to help those who had been affected. As part of the Victorian bushfire reconstruction and recovery authority’s “We will Rebuild” initiative, they offered free consultations and 19 customisable pro bono designs, which were environmentally sustainable and met the “higher end” of the building standards for those in bushfire areas. Surprisingly a few of those homes were built.

In such zones, highly fire-resistant materials are a must for building designs which are devoid of vents or roof overhangs where embers can penetrate or become trapped. Use refractories such as and ICFs (insulated concrete forms), polystyrene blocks that fit together like Lego to form a house's shell. Filled with concrete, one of the most fire and heat-resistant of construction materials—ICFs create solid insulated walls that lock out sound and weather. They can reportedly withstand a fire for up to four hours. For roofs, ceramic house tiles or other fire roofing materials are designed to interlock tightly and

are installed over a fire resistant cap sheet. Outside staircases can be of steel, while the wood used for decking and trim is mostly a dense hardwood called ipê *(Handroanthus)*. Naturally resistant to fire, Ipê is one of the 10 hardest woods in the world with a Janka Hardness Rating of 3,680; compare that to Oak, at about 1,200.lumber is so naturally dense that it resists fungus, rot and termites. Double-glazed glass windows should be tempered to withstand temperatures up to 450° An additional solution are roll-down metal fire doors built into the roof overhangs or side recesses, and released automatically by fusible links. Then there are conspicuous sprinkler systems and leaf-shedding gutter designs

Murray Milne, "Designing Your Home to Survive Wildfires", http://www.energy-design-tools.aud.ucla.edu/FIRES.html

Fish farm, offshore and enclosed

Problem: Due to the micro plastic soup in the world's , the plastic has entered fish food chain and nobody quite knows how to clean it up. Despite all these environmental and potential human health impacts, most scientists agree that it is not feasible to clean up the plastic in our .

Solutions: The Norwegian Ministry of Fisheries and Coastal affairs recently decided to award development licenses for aquaculture purposes. The objective is to spur new technology concepts that can ensure sufficient growth whilst also ensuring environmental sustainability. Since 2013, Mowi and Aquafarm Equipment tested post smolt production in the semi-closed "Neptun" at Skånevik, Western Norway. It is the third generation of the research "Neptun", which is now in use. The cage is 130 ft. (40 meters) in diameter on the inside, and 413 ft. (126 m) in circumference. The cage is 72 ft. (22 m) deep and holds 5 million gallons (21,000 cubic meters) of water."Neptun" is designed to produce up to one million smolts. By October 2019, it was ready for the sixth release of fish when 600,000 smolt would enter the .

Scaling it up, in 2017, Farming ASA which has headquarters in Kverva Norway, collaborated with the China's Wuch ang Shipbuilding Industry Corporation (CSIS) in Qingdao to produce *Farm 1*, the world's first semi-submersible automated offshore fish farm. 223 ft. (68 m) high by 110m², its 66 million gallons (250,000 m³) volume can accommodate water for farming 1.5

million baby salmon. Its moveable bulkhead was built by Malm Orstad. *Farm 1* is a full-scale pilot facility for testing, learning, research and development. It will be equipped for R&D activities, with particular focus on biological conditions and fish welfare. Aiming to reduce environmental footprints, improve fish welfare and answer acreage challenges, the learning and new solutions from the project could represent a new era in sustainable seafood production – and is potentially adaptable worldwide. It is located at Frohavet, some 5km off the coast of Central Norway, at the latitude as Alaska. In September 2018, the crew on board observed that *Farm 1*'s seabed mooring was leaning. The issue was quickly corrected and measures were taken for capture the escaped fish. Despite this, by January 2019, *Farm I* enjoyed a harvest. SalMar announced it would a further step towards sea farming with the "Smart Fish Farm" development concept with MariCulture AS, in which SalMar has bought a controlling stake in. The is divided into eight zones and is designed to handle waves of up to 100 ft. (30 m) in the sea. It has a diameter of 525 ft. (160 m) and it can accommodate three million salmon. SalMar aims to establish a deepwater mooring in the Norwegian Sea off the coast of Trøndelag.

In comparison with other types of food, salmon performs well in terms of GHG-emissions. Production of 2.2 lbs (1 kg.) of farmed salmon requires approximately 2.6 lb. (1.2 kg.) of feed, whereas 8 to 17 lbs. (4 - 8 kg.) of feed is required to produce 2.2 lb. (1 kg) of beef. SalMar's offshore can produce approximately 8,000 tons of salmon in 12 to 15 months. This is equivalent to 25,000 bulls. Furthermore, arable is fast becoming a limited resource. The biggest potential for sustainable growth now lies at sea. *(salmar.no)*

A second fish farm, financed by Rizhao Wanzefeng Fisheries, is the 115 ft.-tall (35 m), 200 ft. (60m) wide *Deep Blue 1* pen, China's largest offshore salmon farm, also built by Wuchuan Shipbuilding, was launched and then towed 130 nautical mi. to the Yellow Sea. It was then stocked with 200,000 smolt salmon. Due to teething problems, less a year after its launch, it was returned to a port in Weihai, Shandong province where it underwent "regular maintenance". When it returned to the sea, it had been retrofitted with a 115 ft (35 m) tower, as tall as an 11-story building. Some 130,000 fish smolt were then transferred back into the pen, half of them rainbow trout. *Deep Blue I* is designed to sit on the seabed where the water, at 200-230 ft. (60-70m) deep, is colder water at the surface, and therefore suitable for raising salmon. During its first year, *Deep Blue I* survived nine typhoons and other harsh conditions during two important seasons, summer and winter. In Feburary 2019, Wuchang Shipbuilding

announced plans for a second, possibly even third offshore salmon farm, capable of farming one million salmon. In the next few years, Rizhao Wanzefeng Fishery Co. will also invest in the construction of a number of “deep blue” series of , which will form a “deep-sea salmon farming platform” with workboats, processing vessels and transport vessels. *(tengfugroup.com)*

“The US$300 Million to Farm Salmon in the Middle of the ”, *Bloomberg*, 30 July 2018.

Fish transportation system

Problem: In commercial freshwater aquaculture where salmon welfare is paramount, hydroelectric dams can be detrimental to passage past dams of fish, particularly those listed as threatened or endangered.

Solution: In 2011, Vincent III or "Vince 3", a lifelong sports fisherman of Mercer Island, Washington was field-testing Whooshh, his firm’s fruit harvester to mechanically harvest and sort tree fruit and like objects. On afternoon, Vince 3 observed helicopters flying overhead with buckets, moving migratory salmon over a dam. Later, he observed a citrus in California that had been alive with 50-year-old trees the year before, but was now completely dead. It was explained that the irrigation water that fed the orchard had been diverted to the salmon. The wonders of the salmon returning through fish ladders that Vince 3 had learned about in school was now in conflict with agriculture, his own sense of the changing environment, and his passion for fish and fishing.

What would happen if he modified Whooshh into a floating selective fish passage system for entry and exit which would work at dams of every height, while at the time accelerating recovery, restoring natural habitat and limiting CO_2? Whooshh began testing their fruit transport tubes on fish. It worked and it was the “a-ha” moment that caused the Company to pivot from fruit to fish. From 2013, Whooshh focused all its energy and resources on developing changing fish transport solutions that are economical for its users and for the shared water resources. They developed a whole : *Fishway, FishFaucet, FishL Recognition, GateKeeper, Burst Buster and Whooshh Migrator.*

Today Whooshhh solutions are used to transport fish: in processing plants where hygiene is critical and water is expensive; in commercial aquacultures

where fish welfare is paramount; and for fish passage past dams, including where fish are invasive and/or listed as threatened or endangered. Whooshh systems are deployed in the United States and Europe. In 2014, they were used to transport tilapia up and over the dams blocking the Columbia river. together with Whooshhh Innovations, the Confederated Tribes of the Colville Reservation, the Washington Department of Fish & Wildlife, NOAA's National Fisheries Service, the US Fish & Wildlife Service and the US Army Corps of Engineers, all necessary permits were issued to deploy the Whooshhh *Passage Portal* just below Chief Joseph dam during the 2019 Summer and Fall Chinook salmon . Whooshh helped to move thousands of spawning salmon that had been trapped on the Fraser River by a rockslide north of Lillooet. For the millions of fish, the Whooshh's salmon cannon, spanning 1,700 ft (515 m) was to move 50,000 fish per day. *(whoosh.com)*

Tobias Kock et al. "Evaluation of sockeye salmon after passage through an innovative upstream fish-passage system at Cle Elum Dam, Washington, 2017" *Researchgate,* July 2018

Fishery data management system

Problem: Illegal, unreported and unregulated fishing (IUU) depletes fish , destroys habitats, distorts competition, puts honest fishers at an unfair disadvantage, and weakens coastal communities, particularly in developing countries. One of the leading causes of IUU fishing is the lack in capacity of effective monitoring, control, and surveillance operations within fishing industries.

Solution: OLSPS (OLSPS), based in Town, South Africa, was set up by Amos Barkai and Mike Berg to prevent illegal fishing through a fishery e-log or data management system that can record and report and vessel-based information. Their Integrated Electronic Monitoring and Reporting solution (iEMR) incorporates on-board Camera Monitoring (EM for Electronic Monitoring) and eLog Reporting (ER). While the underlining technologies of the EM and ER components are different from each other, they are

complimentary in that together they can deliver effective Monitoring, Control and Surveillance (MCS) of fishing operations and related activities. iEMR has the potential to a dramatic, positive impact on the Blue Economy

Mike Berg et al.,"A review and assessment of the economic, social and environmental impact of illegal, unreported and unregulated fishing in Africa," February 2017.

Flash Graphene

Problem: The production of graphene has been held back due to cost.

Solution: A team lead by James M. Tour, nanotechnologist and both Professor of Materials Science and NanoEngineering, and Professor of Computer Science at University in Houston, Texas, United States developed a solution which can swiftly transform carbon from any source: food waste, plastic waste, petroleum coke, coal, wood clippings and biochar into bulk graphene flakes. flash graphene is in 10 milliseconds by heating carbon-containing materials to 3,000 Kelvin (about 2,727° C). The team at University hope to produce 2.2 lb (1 kg) (a day of flash graphene within two years, starting with a project recently funded by the Department of Energy to convert U.S.-sourced coal inexpensively into a much-higher-value building material. *(.edu)*

James M. Tour et al., "-scale bottom-up flash graphene synthesis," *Nature* volume 577, pages 647–651(2020).

Floating Schools

Problem: Educators in Bangladesh a problem. Not do they of the challenges as teachers in other resource-poor countries — funding constraints, outdated textbooks, overcrowded classrooms — they also to worry about monsoon . Flooding is so common in Bangladesh that students often cannot get to the classroom.

Solution: Architect and designer Mohammed Rezwan had considered dedicating his life to building schools and hospitals in flood- areas of the north-west, then he realized they would be underwater soon. Not do floods cause the loss of lives and livelihoods, they also severely interrupt children's education. So Rezwan started designing spaces on for school. If children could not go to school, then the school should go to them. with local boat builders, he designed the schools by altering traditional Bangladeshi wooden , using native materials

and building methods. With a main cabin that can fit 30 children, the are 55 ft. (17 m.) by 11 ft. (3m³5) wide incorporating a flat-bottomed hull, flexible wooden floors, top-hinged side windows for daylight and natural ventilation, arched metal beams for column-free spaces, outward-inclining bamboo and wood walls, and monsoon-proof curved roofs with overhangs equipped with solar panels.

The floating school collects students from their homes, moors to the riverside and provides on-board small-group instruction. After school, students home a recharged, low-cost solar lantern, which provides light at night by which they can study and women can do craftwork to earn extra income, which is also sold to community members to fund the initiative. In the evening, the project educational programmes screens that people can watch from their homes. The project has even helped to develop floating crop beds to ensure year-round food supply and income for families in flood- areas.

In 2002 to finance his mission, Rezwan set up nonprofit organization Shidhulai Swanirvar Sangstha. Thanks to considerable donations, during the next sixteen years a fleet of over one hundred solar-powered with a lifespan of between 50 and 100 years were built serving close to 500,000 people in flood-areas. They now serve as schools, providing free year-round primary education for children in riverbank communities; libraries fitted with books; Internet-linked computers, printers and mobile phones; health clinics offering free healthcare; and adult education centers that parents and villagers on children's and women's rights, nutrition, health and hygiene, sustainable farming and climate adaptation, such as the planting of flood-resistant crops. Plying the waterways, they pull up alongside villages that would otherwise be too isolated to receive such support. Cultural norms restrict the movement of girls, meaning that of them would not attend traditional school at all, but now education is delivered to their doorstep.

Shidhulai's floating school model has spread across the world, and school serve children in flood- regions in Cambodia, Vietnam, the Philippines, Pakistan, India, Nigeria and Zambia. In 2012, the organization won the U.N. Prize for Inspiring Environmental Action. *(shidhulai.org)*

Jashim Uddin Ahmed et al. "Understanding Operations of Floating Schools: A of Shidhulai Swanirvar Sangstha in Bangladesh." *ResearchGate*, December 2016.

Floating Solar Farms

Problem: -based solar farms up space which can otherwise be used for precision agriculture, industry and housing.

Solution: Putting them on water makes floating solar panels up to 16 % efficient and lasting. The lack of dust it can stay clean while water can be used to clean the panels.

Since 2017, the Sungrow Huainan Solar Farm is located 5 km southwest of Nihe Town, Huainan city in China's Anhui province. The array consisting of 166,000 panels, built by Sungrow Power Supply floats on an artificial on the site of a former coal . Its capacity of 40 MW produces enough energy to power 15,000 homes. According to *The Japan Times*, the Sungrow Huainan Solar Farm is 'part of Beijing's effort to itself off a fossil fuel dependency.

In , in 2007, IT engineer Eric Scott founded Akuo Energy which has since become a leading renewable energy producer such as wind, sun, water, and bio-gas, present in thirty countries, via 17 subsidiaries. From 2014 Akuo planned a floating solar farm project Hydrelio by Ciel and Terre floats for installation in town of Piolenc, in the department of Vaucluse. The site chosen to be filled with water was a former aggregate quarry in nearby Curbans. Akuo Energy and the quarry operator worked together with Bouygues Energies Services in the restoration of the site with the solar farm to allow the transition from one activity to another and the ecological rehabilitation of the site. Covering 42 ac (17 ha), 47,040 PV panels placed on 52,000 floats themselves anchored by 350 anchors at the bottom of the of 23 ha. The largest solar farm in Europe, the 16 MW from officially launched in March 2019 is providing electricity for over 4,733 households and avoiding the emission of 1,208 tons (1,096 tonnes) of CO_2. *(akuoenergy.com)*

In 2019, Thailand's state utility, the Electricity Generating Authority of Thailand (EGAT), has up ambitious plans to construct 16 floating solar farms with a combined capacity of 2.7 gigawatts at nine hydropower reservoirs across the country by 2037. SCG Chemicals is undertaking research and development at its factory at , 106 mi (170 km) from the capital Bangkok. The first floating solar farm is planned for the Sirindhorn Dam at Ubon Ratchathani in east Thailand. *(egat.co.th)*

Elsewhere, in South Korea there is a rotating floating solar powerplant with 16 modules installed on a floating deck. There is one beside the Banasura Sagar Dam, in Kerala, India. Another is located on the Yamakura Dam reservoir in Japan, and another at Tengeh Reservoir in Singapore. South Korea will build a 2.1 gigawatt (GW) floating solar farm next to Lake Saemangeum, a reclaimed area on the west coast The plant will cover 11.6 mi.² (30 km²) of the , which is adjacent to a site where an international airport will be built. It is expected to produce enough electricity for 1 million households. The project is expected to the government closer to the goal of its renewable energy initiative, which aims to nearly triple the portion of renewable energy to 20 % by 2030. The planned solar power farm is expected to require 5 million solar power modules and create 1.60 million jobs a year. Work on the solar farm is expected to start in the latter half of 2020.

In 2017, researchers at University of California, Riverside identified equivalent of 183,000 football fields of non-agricultural in California's Central Valley for future solar farms. *(ucr.edu)* At the beginning of 2018, some 60 floating solar farms of over 1 MW had been installed around the world. Their combined capacity is very small, totalling less 200 MW (the equivalent of a - based solar farm – enough to provide energy to around 200,000 people. Solarplaza's Top 200 floating solar plants shows that China, Japan, Taiwan and South Korea are leading the pack, however, with projects under development in countries such as India, Thailand, Vietnam, Singapore, Malaysia, the Netherlands, , and the United States, deployment is accelerating globally. A team from Michigan State University believes that the creation of floating solar farms on existing reservoirs in Brazil would up for the underproduction of the existing hydropower systems on the Amazon River and even the construction of new .

The Colorado River's two great reservoirs, Mead and Powell, are in retreat. Multi-year droughts and chronic overuse taken their toll, to be sure, but vast quantities of water are also lost to evaporation. What if the scorching sun that causes so much of this water loss were harnessed for electric power? Installing floating solar PV arrays, sometimes called "floatovoltaics," on a portion of these two reservoirs in the southwestern United States could produce clean, renewable energy while shielding significant expanses of water from the hot desert sun.

Nguyen Anh Thi, “The global evolution of floating solar PV” *Researchgate*, December 2017.

Global cooling using floating solar farms

Problem: Greenhouse Global warming is increasing at an exponential and alarming .

Solution: Scientists from Norway and Switzerland are proposing that a network of millions of floating offshore solar farms could be used to convert atmospheric carbon dioxide into renewable energy. Their concept is clusters of -based floating islands, on which PV cells convert sunlight into electrical energy to produce H2 and to extract CO_2 from seawater, where it is in equilibrium with the atmosphere. These gases are then reacted to form the energy carrier methanol, which is conveniently shipped to the end consumer. Co-author Swiss scientist Andreas Borgschulte explained the idea for the solar islands was conceived when the Norwegian researchers were assigned the task of pushing fish farms out to sea that would require their own energy. The researchers determined that 70 of these artificial islands could up a single facility that covers an area of about 0.4 square mi. (10 km²). The experts identified locations across the globe where conditions are suitable to properly manage the facilities. The coasts of South America, Australia, and Southeast Asia were found to be ideal sites for the solar farms. The team is now planning to build prototypes of the floating islands.

Bruce D. Patterson, Mo, Andreas Borgschulte, Hillestad, Fortunat Joos, Trygve Kristiansen, Svein Sunde, and Jeroen A. van Bokhoven, “Renewable CO_2 recycling and synthetic fuel production in a environment,” 18, 2019; Bruce D. Patterson et al. “Renewable CO_2 recycling and synthetic fuel production in a environment” *PNAS* 18, 2019.

Flood Barrier

Problem: In 2020, 150 million people were now living on that will be below the high-tide by 2050, threatening to all but erase some of the world’s

great coastal cities. As one example, the River Thames in London is liable to serious flooding. As sea levels continue to , the Houses of Parliament, the O2 , Tower Bridge, and areas including Southwark, the Isle of Dogs, Whitechapel and West Ham would be flooded unless a barrier was built which could protect 48 mi² (125 km²) of central London from flooding caused by tidal surges.

Solution: In the early 1970s, such a barrier was designed by Rendel, Palmer and Tritton for the Greater London Council and tested at the Hydraulics Research Station, Wallingford. The site at New Charlton was chosen because of the relative straightness of the banks, and because the underlying river chalk was enough to support the barrier. Work began at the barrier site in 1974 and construction, which had been undertaken by a /Hollandsche Beton Maatschappij/Tarmac Construction consortium, was largely complete by 1982. The barrier was officially opened on 8 May 1984 by Queen Elizabeth II.

The Maeslantkering is a storm barrier on the Nieuwe Waterweg, in South Holland, Netherlands. Controlled by a supercomputer, it automatically closes when Rotterdam is threatened by floods. Part of the Delta Works, it is one of largest moving structures on Earth, On May 10, 1997, after six years of construction, Queen Beatrix opened the Maeslantkering. The barrier is connected to a computer system which is linked to weather and sea level data. It is expected to be closed every ten years due to a storm . With the in sea levels, the storm barrier will need to close frequently in 50 years time, namely every five years.

Sjoerd Groeskamp and Joakim Kjellsson, oceanographers from the Royal Netherlands Institute for Oceanography and the Oceanographic Research Center in Kiel, Germany, respectively, presented a plan to build two giant dams, to close the North Sea and thereby protect 25 million Europeans from rising sea levels. One, measuring 295 mi (475 km) would be built between the north of Scotland and Norway, while the other 100 mi (160 km) between and the south-west of England.

Over in northern Italy, in 2003, work began on a massive flood barrier designed to isolate Italy's Venetian Lagoon, the enclosed bay where Veni**ce** is located. The project, known as Mose, (MOdulo Sperimentale Elettromeccanico = Experimental Electromechanical Module) is one of the largest civil engineering endeavours in the world. The design consists of 78 yellow mobile

caissons or gates stationed at three different inlets. When the tide reaches 43 in. (109 cm) (which happens around four times a year), the gates will above the water's surface and protect the lagoon from flooding. When the tide dips, the gates fill with water and lower back in place. The total barrier spans 1 mi (1.6 km) and weighs around 300 tons (272 tonnes).

Though some see it as necessary to the city's immediate safety the US$6.5 billion infrastructure project has been pummelled by criticism and political scandal, including the arrest in 2014 of Venice's Mayor Giorgio Orsoni alongside 35 other people on corruption related to the project. Orsoni was accused of accepting bribes in exchange for awarding contracts, but he was absolved three years later. In 2019, it was Tomorrow'sed that the hinges of Mose, which were supposed a 100-year lifespan were rusting after less ten years under water. Repair work of the 78 caissons is estimated to ten years, calling the operational of 2021 into question. It is now estimated that the project will nearly US $ 330 million to complete and that it will end up a total of US$ 6 billion). In November 2019, flooding in the city reached a high-water mark of 5.1 ft. (1.5 m), its worst flooding since 1966.

In 2007 the United States Army Corps of Engineers started construction of an ambitious project that aimed to prevent storm surges from flooding New by 2011. The IHNC Barrier on the confluence of these waterways is the largest in the United States. It protects the city from the Gulf of Mexico from flooding the area. The new Seabrook floodgate prevents a storm from entering from Ponchartrain. The GIWW West Closure Complex closes the Gulf Intracoastal Waterway to protect the west side of the city. This complex is unique in that it contains the world's largest pumping station, necessary to pump out rainwater that is discharged in the protected side of the canal during a hurricane. In December 2008, the Corps held a groundbreaking ceremony to mark the start of test pile driving. Construction of the barrier's flood wall began on May 9, 2009. On October 21, 2009 the last of the 1,271 main piles was driven. On August 29, 2012 (the seventh anniversary of Hurricane Katrina), the barrier was utilized for the first time, to protect the city from Hurricane Isaac. By 2013, all major construction had been completed.

The Saint Petersburg Dam, is a 16 mi (25 km) complex of dams for flood control near Saint Petersburg, Russia. The complex is intended to protect Saint Petersburg from storm surges by separating the Neva Bay from the rest of the

Gulf of Finland. Construction of the complex started in 1978 and became one of the longest construction projects in Russia, completed in 2011.

S Gilbert. *The Thames Barrier*. Thomas Telford Ltd. 30 1986; Sjoerd Groeskamp, Joakim Kjellsson, “Een dam dwars door de Noordzee: waarschuwscenario voor klimaatverandering,” *Royal Netherlands Institute for Sea Research,* January 31, 2020; "IHNC Barrier," *U.S. Army Corps of Engineers*, 2013;. Michael Kimmelman, “The Dutch Solutions to Rising Seas. The World Is Watching,” *New York Times*, 17, 2017; Roberto Giovannini, "Venice and MOSE: Story of a failure," *La Stampa*, December 10, 2017.

"flygskam"

Problem Carbon dioxide emissions of aircraft account for about 2 per cent of global annual man- emissions. But the impact on global warming is much bigger, because planes emit other gases that a warming effect, including nitrogen oxide and contrails (those white tails of frozen water vapour visible from the ground).

Solution: “flygskam” is a Swedish word meaning flight shame, the intention to discourage travellers from using airflights when they can a ship, a or even sustainable car-pooling, so lowering carbon emissions. They can then use the word “tågskryt or " " The idea was originally championed in 2017 by Olympic biathlete Bjorn Ferry who estimated that during his sporting career he was travelling 180 days of the year, totalling around 25,000 mi (40,000 km) per year by and another 25,000 by car or minibus — and around 16 tons of CO2 emissions per year. After realising his impact Ferry he publicly committed to ditching air travel completely. Ferry’s campaign to promore flygskam gained momentum after teenage activist Greta Thunberg’s mother, the opera Malena Ernman, publicly announced she would stop flying, with various Swedish celebrities following suit. Thunberg herself travelled travel to events and conferences by . She also took two weeks to travel from England to the UN Climate Action summit in New York, by the *Malizia II*, a solar-powered yacht. (See entry) Exact numbers are hard to estimate, but the Tagsemester Facebook , set up by entrepreneur and environmentalist Susanna Elfors to give people tips and information on how to cut back on air travel in favour of travel, has around 80,000 active users. Swedish company SJ AB reports that twice as Swedish people chose to travel by instead of by air in summer 2019 compared with the previous year

From January 2020, Coronavirus had the disastrous effect of seriously reducing the commercial air flights, ironically creating a similar positive effect

for air quality and the flyskam movement. Satellite data collected by the National Aeronautics and Space Administration (NASA) and the European Space Agency (ESA) and shared by NASA's Earth Observatory showed a steep decline in nitrogen dioxide levels across the Planet.

But the “flight shame” movement—*vliegschaamte* in Dutch, *flygskam* in Swedish, and *flugscham* in German—has lured some travelers back to the rails. French, Dutch and German lawmakers are discussing on short and international flights served by high-speed trains. Germany has cut fares by 10% to encourage ridership, and the country’s Green Party is pushing to end the tax exemption on aviation fuel in favor of increasing funding for travel. Traveling by cuts emissions by 70% to 90% compared to flying.

Sweden’s authority will run overnight sleeper trains to serve passengers skipping airlines amid escalating climate concerns. The new offering by Trafikverket will dispatch trains from Malmö, Sweden in the evening, scoop up passengers an hour later Copenhagen, and arrive in Cologne, Germany at 6am. Onward connections from there will allow passengers to arrive in London, Paris, Munich, and Amsterdam before lunchtime.

After nearly two decades, the Brussels-to-Vienna overnight by Austrian Railways (ÖBB) is rolling again. ÖBB now plans to expand hotel-like amenities on its 27 overnight routes by 2022, with coming.

In , activists saved a beloved sleeping-car between Paris, Perpignan and the Spanish border town of Portbou, according to Nicolas Forien, a member of both Back on Track and the French group Oui au de Nuit (“Yes to the Night ”).

Stefan Gössling, “Celebrities, air travel, and social norms,” *Annals of Tourism,* Research 79, October 2019.

:Fog harvesters for drinking water

Problem:

Drinking water is becoming a commodity. Industrial development is filling our rivers, seas and with pollutants which are a major threat to human health. In some regions, such as in the Atacama and Namib desert. it almost never , leaving a challenge to find drinking water. Lima, Peru, is at high risk for water shortages. With a population of 10 million, the world's second-largest desert city receives a paltry 0.3 inches of each year, and relies on just three rivers to provide drinking water to residents.

Solution:

In 2009, German man-and-wife conservationists Kai Tiedemann and Lummerich helped the residents of Bellavista, Peru, plant 800 new river she-oak trees, such as those seen above, with water collected from fog-catching nets.

During their research they found that trees with vertical, needle-like leaves work as an net to which drops of water adhere. As part of their "Green Desert Project, they later went on to develop artificial nets that could also capture water. With sheets of mesh strung up on hillsides, it is possible to harvest the mists that drift across the arid Peruvian landscape.

Tiny droplets condense on the netting and dribble down into pipes that carry the water into containers where it can be used to irrigate crops or even as drinking water. Each net can capture between 200-400 litres of fresh water every day, providing a new source of water for communities that had no easy access to regular supplies.

Abel Cruz has founded an organisation to help supply water to desert communities in South America called 'Peruanos Sin Agua' ('Peruvians without Water'). This has helped to install 2,000 of these fog catching nets providing fresh water access to 60,000 people in eight rural communities across Peru as well as in Bolivia, Colombia and Mexico.

This has enabled greening drought areas for agriculture: raising chickens, cultivating figs, grapevines and olives. In the provinces of Cusco, Tacna, Arequipa, the water is for human consumption. In areas where there is little air pollution, the water from fog catchers is pure - but in areas the water must be treated before drinking. *(lossingua.org)*

Elsewhere in Chile, architects Alberto Fernandez and Susana designed angular kite-like structures as well as , spiral-shaped fog harvesting towers that aim to create a surface area to collect water from as high as possible in the fog. A another project in Chile, called "Proyecto Niebla", uses 3D structures to enable the collection of fog regardless of the wind direction.

Can bio mimicry be used to harvest water? Biologist Miguel Galvez of Brighton, Massachusetts was inspired by the body of the Namib Desert darkling beetle *(Coleoptera, Tenebrionidae*) which hydrates itself by using a patchwork of water-attracting and water-repelling regions on its shell to capture and drink water droplets from the air. In 2011, Galvez and Deckard Sorensen started up NBD (Namib Beetle Design) Technologies in to devices that could collect water from humidity in the air, an idea often described as a kind of "self-filling water bottle."

Realising that there was a much promising market in the industrial sector, NBD began to work with big companies that might to use its technology to improve their products—anticorrosive paints, waterproofed electronics, and machines that handle a lot of water. NBD obtained a federal to explore whether its specialized coatings can improve the performance of steam condensers, which are used by electric power plants and desalinization facilities to convert steam into liquid water. NBD became the global leader in surface modifying coatings and additives for advanced liquid wettability. For -scale water harvesting NBD obtained a second federal to determine whether it can improve the performance of "fog nets," a water-collecting wire mesh that pulls condensation from the air and collects it as liquid water. With an increased R&D team, NBD has produced a new kind of nanotechnology polymer, which can be manipulated to it either hydrophobic or hydrophilic depending on the needs of a potential customer. In 2017, NBD introduced the first in its of RepelShell

products,an injection- additive that makes plastic surfaces highly repellent to water, dirt, mud, and ice. Immediate applications for NBD's patented RepelShell for plastics include mud- and water-resistant athletic footwear, -stain electronics, self-cleaning non-woven fibers, and -stain textiles. *(nbdnano.herokuapp.com)*

Luis Andres Henao, "Thirsty Peruvians harvesting fog with nets," *Reuters,* March 22, 2010; Kai Tiedemann and Lummerich, "Fog harvesting on the verge of economic competitiveness," *The Green Desert Project, funded by The National Geographic Society and Bayer AG*, July 2010; Rebecca Paul, "Coastal Fog Tower Harvests Chilean Mist," *inhabitat,* February 4, 2008; Nancy , "Self-filling water bottle takes cues from desert beetle" *Phys.org*, November 25, 2012.

Food , BPA free

Problem: During the 19th century, before the invention of refrigerators, the tin can was an excellent way to preserve food that might otherwise been thrown away. The Donkin & Hall, the world's first commercial canning factory was set up in London in 1913, while by 1901 the American Can Company produced 90% of tin in the USA. Since the 1950s manufacturers Tomorrow'sed that lining the inside of their tins with bisphenol A (BPA) epoxy resins strengthened the tins and extended shelf life. But BPA is also an endocrine disruptor the effects of which been linked to an increased risk of breast, lower sperm counts in men and prostate , infertility, type 2 diabetes, obesity, asthma, and ADHD.

Solution: Eden Foods grocery store set up in 1968 is now the oldest food produce in the US. In 1997, Eden Foods became alarmed by the toxicity of bisphenol-A (BPA) in and food packaging before it it to mainstream news. From April of 1999, Eden featured a custom can lined with an oleoresinous c-enamel that does not contain the endocrine disrupter. Oleoresin is a mixture of oil and resin extracted from plants such as or balsam fir. Since then Eden uses BPA-free enamel-lined for most of its products (the exception being tomato-based foods). After years of trying to realise a BPA-free tomato can, in 2011 Eden found an alternative in the amber glass jar. *(edenfoods.com)*

Recently, some of the world's biggest food companies such as Nestlé, Heinz, General Mills and Campbell Soups attempted to remove BPA from their products. Several other firms, such as Coca-Cola, declined to disclose a timetable for its withdrawal, saying that BPA was . The UK's Food Standards

Agency has examined BPA, and says that levels of the compound people would typically consume do not represent a risk to consumers.

Laura N Vandenberg et al. “Human exposure to bisphenol A (BPA)” *Reproductive Toxicology* 24(2): 139-77, August 2007; Nataraj Sanna Kotrappanavar et al, “Bisphenol A: Uses, health effects and environmental risks.” January 2010.

Food , bioplastic wrapping

Problem: In 1949, Dow Chemical Company introduced *Saran* , a thin, clingy plastic that was sold in rolls and used primarily for wrapping food. It quickly became popular for preserving food items stored in the refrigerator. Also known as cling film, shrink , cling or food it became universally used in kitchens around the world. Some studies refer to health problems regarding phtahlates (a chemical plasticizer that makes PVC softer and flexible), which can pass into food. The other big problem of this material, is that a few centers can recycle it so it ends up in landfills or the sea.

Solution: Adapting with NatureWorks’s bio-plastic, MetalVuoto of Braganza, Italy, active in the production of metallised and lacquered barrier films for food packaging developed Oxaqua or Propylester, a high-barrier biodegradable film designed to keep processed foods fresh on store shelves.

Another solution is Bee’s , created by Sarah Kaeck of Middlebury, Vermont. In 2012, Kaeck, a mother of three who had been, by turns, an avid gardener, milker of goats, keeper of chickens, and seamstress started with a question facing families and home cooks: How could we eliminate plastics in our kitchen in favor of a healthier, sustainable way to store our food? What she Tomorrow’sed is a lost tradition new again. By infusing cotton muslin with beeswax, jojoba oil, and tree resin, she created a washable, reusable, and compostable alternative which could be sealed by the warmth of the hands. In the early days, Sarah hand-waxed each sheet of the concoction, every single one by herself, and even when she had been joined by five women from the Middlebury community, for months the comforting scent of beeswax filled Sarah’s home. Moving to nearby Bristol, Bee’s have since designed a custom machine to coat their fabrics. The production is available in 2,400 stores across the United States and can be found in the gift, grocery, housewares, and

outdoor markets. Bee's is also distributed internationally throughout the UK, Europe, Canada, South Africa, New Zealand, Australia, and parts of Asia. In 2019, Bee's became a Certified B Corp, recognized as one of the select companies in the top 10 % in the Environment category of the B Impact Assessment. *(beeswrap.com)*

Rachel Kaczynski, " in New England: Meet Sarah Kaeck of Bee's ." *well insiders* August 29, 2019.

Forest Stewardship Council

Problem: Irresponsible logging and forest destruction has robbed the Planet of a Nature-based carbon capture system. According to the Food and Agriculture Organization of the United Nations, half of the world's forests already been altered, degraded, destroyed or converted into other uses. Much of the remaining forests today suffer from illegal exploitation and otherwise poor management.

Solution: The Forest Stewardship Council (FSC) logo on a wood or wood based product is your assurance that it is with, or contains wood that comes from FSC certified forests or from post-consumer waste. There are three types of FSC label: 100%, FSC Mix or FSC Recycled.

FSC grew out of the International Tropical Timber Agreement (1983), the Convention of International on Endangered Species (1975) and the Global Environment Facility (1991). After 18 months of consultation in ten different countries, the Forest Stewardship Council was finally established in 1993 in the forested region of Oaxaca, Mexico. In 1995, the US chapter of the FSC was established, and is now headquartered in Minneapolis, Minnesota. In 2003, the FSC Secretariat it was relocated to Bonn, Germany. Since its inception, FSC has from strength to strength. FSC Chain-of-Custody certification traces the path of products from forests through the supply chain, verifying that FSC-certified material is identified or kept separated from non-certified material throughout the chain. The number of certificates issued in both forest management and chain of custody, increased exponentially, passing a total of 20,000 Chain of Custody certificates in 2011, and a further total of 30,000 in 2016. *(fsc.org)*

Fourth Industrial Revolution 4IR

Problem: Over a century, the Second and Third Industrial Revolutions had their advantages, but also their disadvantages including the dirtying and the climate destabilisation of the Planet.

Solution: For all the inventions and machines in this book to work together, an overall smart called the Fourth Industrial Revolution for the Earth has been developed. 4IR is the brainchild of Klaus Martin Schwab, a German engineer and economist. In 2015, Klaus Schwab 77-years-old, decided to address the increasing frenzy around technological disruption. As founder and executive chairman of the WEF, he published an article in *Affairs*, “Mastering the Fourth Industrial Revolution". 4IR became the theme of the World Economic Forum Annual Meeting in October 2016 in Davos-Klosters, Switzerland, when the opening of its Centre for the Fourth Industrial Revolution in San Francisco was announced. In his 274-page book of the same name , Schwab includes in this fourth era technologies that combine hardware, software, and biology (cyber-physical systems), and emphasizes advances in communication and connectivity. Schwab expects this era to be marked by breakthroughs in emerging technologies in fields such as , artificial intelligence, virtual reality (VR), nanotechnology, quantum computing, biotechnology, the internet of things, the industrial internet of things (IIoT), decentralized consensus, fifth-generation wireless technologies (5G), 3D printing and fully autonomous vehicles. With time to heal the Planet running out, there are two key attributes that differentiate the 4IR from the industrial revolutions that preceded it: speed and efficiency. This is what creates a remarkable opportunity for technological innovations to secure the sustainability of our planet. The 4IR for the Earth programme is a collaboration between the World Economic Forum, PwC, and Stanford University, and which is also supported by the MAVA Foundation. The programme is looking to accelerate tech innovation for Earth's most pressing environmental challenges. It will help identify, support and scale new ventures, partnerships and business models that harness tech to transform how the world tackles environmental challenges. This AI-infused, digital geospatial dashboard for the planet may enable the monitoring, modelling and management of environmental systems at a scale and speed never before possible – from tackling illegal deforestation, water extraction, fishing and poaching, to air pollution, natural disaster response and smart agriculture.

The top 20 4IR patent applicants at the European Patent Office from 2011 to 2016 include 4IR pioneers such as Sony, LG, Samsung, Google, and Intel—a majority of these companies are Institute of Electrical and Electronics Engineers (IEEE) subscribers (European Patent Office). Patents filed in the United States follow a similar . In fact, a recent study shows that IEEE is cited in U.S. patents related to several key 4IR technologies any other publisher (1790 Analytics LLC). According to Stanford University, the of jobs requiring AI skills has grown 4.5 times since 2013. During 4IR, that %age will as the world's most innovative companies invest in AI applications. The downside is that 4IR will disrupt labour markets and create further inequality. Over 7 million jobs will be affected over the next five years in the world's largest economies, as technological progress in 3D printing and starts to disrupt manufacturing and other industries. It will also end the lives of some traditional organisations, similar to previous industrial revolutions.

Klaus Schwab "The Fourth Industrial Revolution." Crown Business. (2016).; Klaus Schwab, Nicholas Davis, et al., "Shaping the Fourth Industrial Revolution." Portfolio Penguin. (2018); "IEEE is Fueling the Fourth Industrial Revolution", *IEEE Xplore,*

Fuel, water-based

Problem: While fossil fuels were formed millions of years ago, we been using them for fuel for a fairly short period of time – just over 200 years. If we keep burning fossil fuels at our current , it is estimated that all our fossil fuels will be depleted by 2060.

Solution: An Australian-Israeli startup has innovated a water-based fuel it claims will offer zero emissions with a lower cost and greater current battery or fuel cell tech. Electriq-Fuel is 60 % water, and releases hydrogen when it reacts with an onboard catalyst. The fuel cost is as low as 50% of other fuel types, and Fuel-Cell Electric Vehicles total-cost-of-ownership is reduced by ~30% compared to other clean vehicles. Spent fuel is recaptured and taken to a plant for recycling. Electriq-Global (formerly Terragenic), based in Tirat Carmel, Israel is claiming that their potentially revolutionary hydrogen on-demand technology enables fifteen-times the energy density of standard automotive batteries and with few minutes refueling time. Liquid-stable, non-flammable, non-explosive and at ambient pressure and temperature, refueling would be at a pump, much such as a car powered by fossil fuels or conventional gaseous

hydrogen for fuel cell vehicles. The technology includes a patented hydrogen liquid carrier type fuel (T-Fuel™), a process for producing and recycling the fuel (T-Pot™), and a catalyst that allows hydrogen to be extracted on demand (T-Cat™).

Its inventor, Dr. Alex Silberman, having studied electrochemistry in the , moved to Israel, where in 2006 he started his applied research on borohydride. Three years later, he had cracked the kinetics (fast release of hydrogen) process, the stability of the solution and the recycling of the spent fuel. He patented the controlled generation, and transportation of hydrogen for mobility in 2009. He also patented the catalyst that released the hydrogen from the solution quickly enough. Silberman added another patent for the second-generation hydrogen solution with double the energy content.

Electriq are now searching for a system that can reverse the process by electrolysis, the spent solution will to be sent for industrial reprocessing and probably the overall efficiency will be much lower that of a battery. The advantages and disadvantages of the system are similar to those of the zinc-air battery.

Electriq-Global first tested its Electriq~Fuel technology with a hydrogen e-bike. The fuel cell was mounted on the rear. But there was no pressure for the hydrogen. Instead, the e-bike had a small plastic fuel and a metal vessel that generated hydro, gen from the liquid. Additional studies the company conducted showed a transport bus covered 621 mi. (1,000 km) on a single compared to an electric bus' 155 mi (250 km) . In November, 2018 the company attended the 2018 Zero Emissions Conference in Cologne where they announced that they would be taking an active part in promoting ZE buses. The company plans to commission its first fuel recycling plant in Israel 2019. In April 2019, it plans for samples of its next-generation of the fuel. Electriq~Global has also announced a partnership with Dutch startup Eleqtec to launch its water-based fuel technology in the Netherlands, including Electriq~Fuel's recycling plants and mobility applications for trucks, and mobile generators. Several demonstration and prototyping projects were expected to be launched in 2020. Total commercialization of the fuel has a targeted 2022 release , on a small scale in either Israel or Australia. *(electriq.com)*

Jackson Howarth, “When will fossil fuels run out?” *octopusenergy,* December 2, 2019; World Patent: WO2016139669A3, 2017; Patent number: 10351425 Filed: March 3, 2016. of Patent: July 16, 2019 Inventors: Alex Silberman, Dvir Cohen, Yaniv Duchovny

The Gaîa Hypothesis

Problem:

Before photos could be taken of The Earth by orbiting astronauts, it was difficult to consider it as a whole.

Solution:

In the late 1960s, British scientist James Lovelock postulated that particular control mechanisms require feedback loops to ensure stability. Indeed, Lovelock initially called his theory the “Earth feedback hypothesis.” According to Margulis and Lovelock, Earth, rather than acting like an inanimate, non-living object, instead behaves like a living system. He knew that CO_2, along with H_2O, is a major greenhouse gas in Earth’s present-day atmosphere. He was also aware that atmospheric CO_2 levels can vary with time as a consequence of imbalances in the global carbon cycle.

On the advice of a friend, the novelist William Golding, who happened to live in the same English town as Lovelock, Bowerchalke, near Salisbury, he changed the title of his solution to the Gaîa Hypothesis, Gaîa (Γαῖα) being a primordial earth goddess in Greek mythology, namely “earth”.

The Gaia Hypothesis has had a powerful impact on the environmental movement by encouraging people to think of the Earth holistically, as a kind of super-organism that protects us and deserves our protection. She played a critical role in maintaining Earth’s habitability, including its oxygen-rich atmosphere, the salinity of its oceans, and its relatively stable climate

In Lovelock's 2006 book, *The Revenge of Gaia*, he argues that the lack of respect humans have had for Gaia, through the damage done to rainforests and the reduction in planetary biodiversity, is testing Gaia's capacity to minimize the effects of the addition of greenhouse gases in the atmosphere. In his 2009 book, *The Vanishing Face of Gaia*, Lovelock rejects scientific models that disagree with the findings that sea levels are rising and Arctic ice is melting faster than the models predict. In his 2020 book, *Novacene: The Coming Age of Hyperintelligence* the 102-year-old Lovelock posits the end of the current Anthropocene era in which humans are the dominant actors on earth and

suggests in the next era w humans and artificial intelligence together will help the Earth survive. artificial intelligence systems. They will think 10,000 times faster than we do and they will regard us as we now regard plants. These hyperintelligent beings will need the planetary cooling system of Gaîa to defend them from the increasing heat of the sun as much as we do. And Gaîa depends on organic life. Using the solutions found elsewhere in this document, we will be partners in this project.

Geomechanical Pumping

Problem: In the desperate search to find oil and gas, fracking is the process of injecting liquid at high pressure into subterranean rocks, boreholes, etc. so as to existing fissures. Fracking not also increases the potential for oil spills, which can harm the soil and surrounding vegetation but can cause earthquakes due to the high pressure used to extract oil and gas from rock and the of excess wastewater on site.

Solution: Geomechanical pumping employs no chemical, does not trigger seismic activity **and** does not produce pollutants that require disposal and clean-up. Aaron H. Mandell obtained a BSc and an MSc in environmental engineering from the from the University of Vermont, where he focused on numerical modeling and groundwater hydrology, continuing to work in the energy and water industries, establishing a succession of 4 startups. The limitation of pumped hydro electricity is that because it is dependent on mountains, lakes, or pre-existing underground caverns, it had not been widely implemented. But in 2012 Mandell and petroleum engineer Howard K. Schmidt innovated a different approach: hydraulic geofracture energy system with desalinization or geomechanical pumped . Energy is stored by injecting fluid at 600 lb psi into a hydraulic fracture in the earth and producing the fluid back while recovering power and/or desalinating water. When the pressurized water is released, it acts like a spring as it through a turbine-generator above ground, powering it to produce electricity. Electricity generated by renewables is used to compress and pump water underground, when demand is low and power is cheap. That pressurized water is released when new generation cannot match high demand, at night when the sun is not shining, or when the wind is not blowing. The hydraulic fracture may be formed and treated with resin so as to limit fluid loss and to increase propagation pressure. The fluid may be water

containing a dissolved salt or fresh water and a portion or all of the water may be desalinated using pressure in the water when it is produced. Particularly adapted to of amounts of energy such as in grid-scale electric energy systems, the technology could reduce the cost of most advanced batteries by 90 %.

In 2015 Mandell and Schmidt and set up Quidnet Energy and built a small-scale prototype at an abandoned natural gas well in in County, about 80 mi. (130 km) west of Fort Worth, where the fledgling company has leased a 5,000 ft (1,500 m.) - deep well. The test well held 5,000 barrels of water (about 215,000 gallons - 814,000 liters) and was designed to and discharge in blocks of four to eight hours. Encouraged by the results, Quidnet ran another larger-scale pilot project, this time at an old geothermal well at the Blue Mountain Geothermal Area in northern Nevada. The well was 14 in. (36 cm.) in diameter, larger a typical oil and gas well, making it possible to inject a higher volume of water – and generating power faster – at any time. The reservoir can hold up to 85k barrels of water, and produce 10 hours of electricity following a 14-hour .

In 2018, Quidnet received US$6.4 million in investment from Breakthrough Energy Ventures, itself backed by high-profile billionaires including Microsoft co-founder Bill Gates, Amazon founder Jeff Bezos, Virgin Group founder Richard , Facebook founder Mark Zuckerberg and Alibaba co-founder Jack Ma. *(quidnet.com)*

Howard K. Schmidt and Aaron H. Mandell, “Hydraulic Geofracture Energy System with Desalinization,” Patent N° 20150027952 ,(2015).

Geothermal energy

Problem: Consuming fossil fuels above the earth to heat buildings is very energy-consuming.

Solution: Binary below-earth or geothermal power plants emit close to no GHGs in the world's atmosphere and are extremely eco-friendly. Geothermal energy is some of the most efficient in cooling and heating systems available today. It uses a relatively low amount of power due to their low electricity requirement. As of 2004, there were over a million units installed worldwide providing 12 GW of thermal capacity. Each year, about 80,000 units are

installed in the US (geothermal energy is used in all 50 U.S. states today, with great potential for near-term market growth and savings) and 27,000 in Sweden. In Finland, a geothermal heat pump was the most common heating system choice for new detached houses between 2006 and 2011 with market exceeding 40%. The International Geothermal Association (IGA) has reported that 10,715 MWs (MW) of geothermal power in 24 countries is online, reaching 13.33 GW of electricity in 2018. .

One solution for geothermal energy is to use a groundwater heat pump system, which works by recovering heat stored naturally in groundwater or aquifers. The water passes through heat pumps to yield its low heat before returned to the aquifer at a lower temperature. Between 2015 and 2018, researchers of British Geological Survey (BGS) gathered data from a natural ground-water network of 61 -holes below the city of Cardiff, Wales to examine whether similar systems might be created across the UK and provide new and alternative energy supplies in the subsurface. The study concludes that parts of the aquifer can sustain shallow loop ground source heat pump systems, as as the local ground conditions support the required groundwater abstraction and re-injection . *(bgs.ac.uk)*

David Boon et al., "Groundwater heat pump feasibility in shallow aquifers: Experience from Cardiff, UK" *Science of the Total Environment*, August 2019.

Glacial Engineering

Problem: AGW is melting glaciers and leading to catastrophic sea-level and flooding.

Solution: Michael Wolovick, a glaciology postdoc at the Atmosphere and Sciences Program, Department of Geosciences, Princeton University and John C. Moore Professor of Climate at Arctic Centre, University of Lapland and visiting chief scientist at the College of Global and Earth System Science, Beijing Normal University, China propose subsea glacial engineering. In a comment published in the journal *Nature* on March 15, 2018 Moore and Rupert Gladstone of the Arctic Centre, University of Lapland with colleagues from CSC – the Finnish IT Center for Science and Princeton University, USA, argued that applying targeted geo-engineering to preserve the ice sheets was a worthy of serious research and investment in Antarctic infrastructure. The glaciers could be slowed in 3 ways: warm waters could be prevented from reaching their bases

and accelerating melting; the ice shelves where they start to float could be buttressed by building artificial islands in the sea; and the glacier beds could be dried by draining or freezing the thin film of water they slide on. Artificial islands have been built in other places such as Hong Kong airport; water is drained into rock tunnels beneath a glacier in Norway to feed a hydropower plant; raising a berm in of the fastest flowing glacier in Greenland would need a wall 3 mi. (5 km) across and 330 ft. (100 m.) high.

Wolovick's less radical solution would involve the building of sills or walls up of piles of loose aggregate, stretching for mi. across the sea floor. These would keep warm water at depth from reaching the glacier. With less warm water to paw at their grounding , glacial retreat would stop, and often they actually *gain* mass. If they work as planned, these large walls could make glaciers last as much as 10 times than they otherwise would. In rudimentary simulations, the walls a glacier that would collapse in 100 years last for another millennium. Wolovick presented his work in December 2018 at the annual Fall meeting of the American Geophysical Union in Washington, DC where 24,000 attendees from 113 countries, where leaders from academia, government, and the private sector examined and discussed the latest research.

Michael J. Wolovick and John C. Moore, "Stopping the flood: could we use targeted geoengineering to mitigate sea level ?" *The Cryosphere*, 12, 2955–2967, 2018.

Glacier restoration by snow and ice-making machines

Problem: World-wide glacier retreat is one of the most obvious and impressive manifestations of AGW. On a regional scale, glaciers' fluctuations may affect landscape, meltwater supply (reservoirs, irrigation), security of infrastructure and buildings (ice avalanches, outbursts of glacial lakes), and the tourist industry (ski areas, attractiveness of alpine scenery). Arctic sea ice extent has decreased drastically. It is likely that the −summer Arctic will be ice−free as soon as the 2030s.

Solution: In the Himalayas, the Icestupa Artificial Glacier Technology involves piping water 190 ft (60 m.) upstream which then easily rises close to 180 ft (60 m) up from the ground when it reaches the village. It is then to fall from that height in cold Ladakhi winter nights when it is -30 to -50°C outside (with wind chill factor). The water then freezes by the time it reaches the ground and slowly forms a huge cone or Ice Stupa roughly 100 to 160 ft (30 to 50m) high. The idea is also to conserve this tower of ice for as long into the summer as possible so that as it melts, it feeds the fields until the real glacial melt waters start flowing in June. Since these ice cones extend vertically upwards towards the sun, they receive fewer of the sun's per the volume of water stored; hence, they will take much longer to melt compared to an artificial glacier of the volume formed horizontally on a flat surface

In the Swiss Alps, led by Johannes Oerlemans, from Utrecht University in the Netherlands, a study based on a 20-year weather data shows that the Morteratsch Glacier can reglaciate and advance again using artificial summer snow produced just by its gravity. A cable car would carry 4,000 snow machines from Graubunden to compensate for the poor precipitation over the past winters by spraying a 16 ft (5 m) artificial snow cover on a climate-sensitive region of the glacier. Covering retreating glaciers in blanket of snow could protect them from sunlight enabling them to grow by 2,600 ft (800 m) within 20 years.

The melting of the West Antarctic Ice Sheet is at a tipping point. One idea to it from complete collapse, might be to blow 7.4 trillion tons (6.7 trillion tonnes) of artificial snow on top of it. The collapse of this Sheet is predicted to lead to sea level rises of around three nearly 10 ft (3 m) worldwide. In a report called "Arctic Ice Management", Steven J. Desch and researchers at the School of Earth and Space Exploration at Arizona State University, wind-powered pumps would refreeze parts of the Arctic ice sheet. This would ensure that "first-year ice" would a better chance of surviving the summer. By placing machines that would use wind power to operate pumps, they estimate that water could be brought to the surface over the course of an Arctic winter, when it would the best chance of freezing. Based on calculations of wind speed in the Arctic, they calculate that a wind turbine with 20 ft (6 m) diameter blades would generate sufficient electricity so that a single pump could water to a height of 23 ft (7 m) and at a of 29.76 tons (27 tonnes) per hour. The net effect of this would be thicker sheets of ice in the entire affected area, which would a better chance of surviving the summer. To keep the ice sheet protected, at least 7.4 trillion tons (6.7 trillion tonnes) of snow, blasted over the course of 10 years would require

12,000 wind turbines. Then there's the 'small' matter of providing enough equipment and enough power for the job in one of the harshest environments on our planet. Over time, the negative feedback created by ice would cause less sunlight to be absorbed by the Arctic , thus leading to cooling and ice accumulation. This, they claim, could be on a relatively modest budget of US$500 billion per year for the entire Arctic, or US$50 billion per year for 10% of the Arctic.

In 2017, a prototype of this system planned in Switzerland. Instead of entire ice caps, the would be a small, artificial glacier at the foot of the Diavolezzafirn glacier. While the Arctic proposed the use of wind-powered pumps to spew water on top of ice, this mini-version of the project would use snow machines to preserve the glacier over the summer by covering it with artificially created snow. *(sese.asu.edu)*

Another solution would be to new icebergs. Faris Rajak Kotahatuhaha, who studied at Islamic University of Indonesia and is now a practising architect in Jakarta has envisaged a fleet of ice-making submarines. Kotahatuhaha worked on the prototype with collaborators Denny Lesmana Budi and Fiera Alifa for an international competition organised by the Association of Siamese Architects. The team was awarded second prize in the contest. The submarine-like vessel would submerge to collect sea water in a central hexagonal . Turbines would then be used to blast the with cold air and accelerate the freezing process so creating 80 ft (25 m) wide hexagonal blocks of ice with a volume of 71,578 cubic ft (2,027 m^3) that would then nest together to form new ice fields. During this process, the vessel would return to the surface of the sea and the would be covered to protect it from sunlight. A system of reverse osmosis would be used to filter some of the salt from the water in to speed up the process. *(vice.com)*

Steven J. Desch et al, "Arctic ice management" *Earth's Future, American Geophysical Union,* December 19, 2016.; Carly Cassella," Designers Propose a Wacky Submarine For Making 'Iceberg Babies' in The Arctic," *ScienceAlert,* August 10, 2019.

Glass bottles, lighter weight

Problem: The European glass industry annually invests €610 million in waste heat recovery systems and other decarbonising measures. These initiatives resulted in a 5 per cent reduction in carbon emissions between 2009 and 2015.

The process of making glass bottles lighter – thus reducing the energy required to produce and transport them – has been a very important innovation

Solution: In 2013 Rawlings of Bristol, England, the leading independent glass packaging specialist, with a heritage and reputation for sustainable quality, was selected by social enterprise Belu.org to deliver on the challenge of developing the lightest weight glass bottle for mineral water in the UK. Belu was founded in 2004 by film maker Reed as an environmentally friendly bottled water business. Reed launched the UK's first compostable plastic bottle in 2006. Now Belu to the next step.

In the 1950s, S. Donald Stookey of the Corning Glass Works had accidentally invented Vitrelle, a lightweight tempered glass product consisting of two types of glass laminated into three layers, which could be used not just to the nose of a missile but also to contain a casserole in both a refrigerator and hot . A typical Corelle dinner plate measured 10 in (26 cm) in diameter and weighs 12.5 ounces (355 gm).

Rawlings now teamed up with -Illinois (O-I) in Toledo, USA who had developed a revolutionary new process that substantially reduces the amount of glass needed to reduce the weight of the previous lightweight 1.6 pint and 0.6 pint (750 ml and 330 ml) bottles both by 7 oz (20 g). Rawlings trademarked this as *Ethical Glass*. To translate this weight saving into potential environmental gains, Belu been to 937 tons (850,000 kg) of glass annually, equivalent to 2.1 million bottles and reduce their carbon emissions by 11%, the equivalent to saving the amount of carbon associated with 7,000 nights in an average-sized UK hotel.

In addition to the bottle's impressive environmental credentials, a royalty of up to 4 cents has been donated to WaterAid for each bottle purchased from Belu so enabling the company to generate over US$ 6,350,000 (£,500,000) helping 38,000 people without water. *Ethical Glass* has not been retained exclusively for Belu - it is also available to other mineral water companies in a bid to lower the industry's carbon footprint. *(rawlingsbristol.co.uk)*

Verallia which produces about 16 billion glass bottles and pots for 10,000 clients around the world produced their Ecovà up to 30% lighter in weight. With the production of a billion containers, Ecovà has saved 100,000 tons

(91,000 tonnes) of raw materials and has reduced CO2 emissions by about 18%, including transportation. *(verallia.com)*

Another approach is to make the glass (literally) greener. Glass produced from recycled scrap (or "cullet") creates 20% less air pollution and 50% less water pollution glass from raw materials. According to a study conducted by the Waste and Resources Action Programme , switching from clear glass to green cuts packaging-related CO2 emissions by 20%. This is due to the higher recycled content in green glass bottles, which is as much as 72.4%, against an industry standard of 28.9%. The study also revealed that bottling gin, white and brandy in green glass had a negligible impact on consumers' perception of taste, and increasing the recycled content of the glass actually improved consumers' opinion of both retailers and the products.

Tom Wood and David Balhuizen, "How innovation in glass manufacturing is turning green even greener," *The Guardian*, July 2, 201; Nadine Firth, "Rawlings launches ethical glass bottle," *Glass International*, 5th August 5, 2013; *verallia.com: ecova*.

:Glass Bottle Factory

Problem:

The major environmental impact of glass production is caused by atmospheric emissions from melting activities. The combustion of natural gas/fuel oil and the decomposition of raw materials during the melting lead to the emission of CO2.

Sulphur dioxide (SO_2) from the fuel and/or from decomposition of sulphate in the materials can contribute to acidification. Nitrogen oxides (NO_x) due to the high melting temperatures and in some cases due to decomposition of nitrogen compounds in the materials also contribute to acidification and formation of smog.

Solution:

Furnace of the Future.

In March 2020,the 20 most important European packaging glassmakers come together around the "Furnace of the future" project to invent less energy-consuming and improve their environmental footprint.

The 20 companies in the Furnace of the future project are Allied Glass, Ardagh Glass, BA Glass, Beatson Clark, Bormioli Luigi, Gerresheimer, GCA Gürallar Cam Ambalaj, OI Europe, Pochet, Saverglass, SGD, Steklarna Hrastnik, Stoelzle, Verallia, Verescence, Vetreria Etrusca, Vetropack, Vidrala, Wiegand-Glashüttenwerke GmbH and Zignago Vetro.

This new generation of furnace will operate using an oxycombustion process and 80% renewable electricity to replace gas. With this new technology, the industry will be to produce 300 tonnes per day in different shades, using high levels of recycled glass.

The Ardagh Group, the second largest producer of glass packaging in the world, will be the first to test this technology *somewhere* in Germany. The pilot will be built in 2022 and an evaluation of the first results is already scheduled for 2023.

Global tax on carbon

Solution: Research shows that carbon taxes effectively reduce greenhouse gas emissions. A carbon tax is a tax levied on the carbon content of fuels (transport and energy sector) and, like carbon emissions , is a form of carbon pricing. ... As of 2019, over 40 countries implemented carbon taxes. 77 countries and over 100 cities committed to achieving net zero global emissions by 2050. There is overwhelming agreement economists that carbon taxes are the most efficient and effective way to curb climate , with the least adverse effects on the economy. There is a consistently high level of public support across nations for a *global* carbon tax if the tax policy is carefully designed, according to a survey of people in the United States, India, the United Kingdom, South Africa and Australia. Such tax is encouraging electric utilities to rapidly switch from coal to somewhat cleaner natural gas. This is perhaps the clearest example in the world of a carbon tax leading to a significant cut in emissions. It should however be introduced gradually to be successful: a 1% per year guaranteed increase in gasoline taxes would give consumers time to shift to economical vehicles.

Stefano Carattini, Steffen Kallbekken, Anton Orlov, “How to win public support for a global carbon tax”. *Nature*, 2019; 565 (7739).

Global Seed Vault

Problem: Is there a way to conserve flora for eventual replanting to counteract the biological annihilation of the Holocene or 6th Extinction?

Solution: One solution is an impregnable seed vault. It was the idea of two men: Carrington “Cary” Fowler, Jr, Executive Director of the Global Crop Diversity Trust and Henry Shands, Head of the U.S. National Seed in Fort Collins, Colorado. Although big international seed banks were fuelling plant-breeding efforts all over the world, including in the United States and RBG at Wakehurst, Sussex (housing than 92,500 seed collections), Fowler and Shandon realised that these were in Mexico and in Colombia, Peru, Nigeria, Ethiopia, Syria, Philippine, that are not secure simply because of their location. They selected Norway as a safer location.

On 19, 2006, Norway, Sweden, Finland, Denmark, and Iceland's prime ministers ceremonially laid "the first " of a global vault for plant seeds. It was opened two years later. It is tucked into the side of the sandstone Platåberget mountain located near the village of Longyearbyen, Svalbard, a group of islands north of mainland Norway. Located about 1,300 km (810 mi) from the North Pole, the "Doomsday" Global Seed Vault serves as a haven for the world's vast variety of edible plant seeds. In the event of a nuclear war or catastrophic natural disaster, the vault keeps "back-up" seeds frozen and at a temperature of an icy minus 0.4° F (minus 18° C) until they can be reclaimed. Should the power at the facility fail for any reason, the seeds will likely stay frozen thanks to the Arctic permafrost that covers the vault. The preciousness of such seeds is reflected in the inaccessible nature of the vault. Anyone seeking access to the seeds themselves will to pass through four locked doors: the heavy steel entrance doors, a second door approximately 377 ft (115m.) down the tunnel and finally the two keyed air-locked doors. Keys are coded to allow access to different levels of the facility. Not all keys unlock all doors. To- the vault holds just over 2.5 million seed samples from all over the world, but it is capable of holding . In total, it has the capacity to store 4.5 million seed samples. Each sample is typically about 500 seeds, so a maximum of 2.25 billion seeds can be stored in the facility giving a diversity - 5,000 different species, about 1,000 genera crops including 150,000 different kinds of and 150,000 different kinds of wheat.

The vault has proved itself when seeds were withdrawn needed to replace plant material stored in a (a facility that stores genetic material). The national seed of the Philippines was damaged by flooding and later destroyed by a fire;

the seed banks of war- Afghanistan, Syria, and having been lost completely: all been replaced. *(seedvault.no)*

Cary Fowler; Mari Tefre, "Seeds on ice: Svalbard and the global seed vault," Westport : Prospecta, 2017.; "Banking against Doomsday", *The Economist,* March 10, 2012.

Glue , biodegradable

Problem: Paper glues a history. UHU was developed by August Fischer of Bühl, Germany from 1905, and for a century this twist-and-glue was used in offices, classrooms and homes worldwide. But their single-use plastic was not biodegradable

Solution: From 2014, UHU, now by the Bolton Group, marketed its ReNATURE with a sugar based PE-HD container and 70% nature-based adhesive. In 2018, the product received the Österreichisches Umweltzeichen für Produkte (the official Austrian environmental label for products), a hallmark of high environmental standards, quality and product safety. *(uhu.com)* Similarly Henkel of Düsseldorf's Pritt has formulated a glue power primarily from natural sources, 93% of it is from raw materials such as potato starch. To mark the environmentally friendly formulation, "Mr. Pritt" is supporting the global green-space charity 'Trees for Cities' (charity no. 1032154) through Pritt's ' up for Trees' campaign. Mr Pritt is encouraging kids to use their imaginations and get artistic by creating tree collages from renewable and recycled materials such as leaves, bottle caps and egg boxes. *(henkel.com)*

In 1927, Aldo Balma and Andrea Capoduri of Voghera, Italy manufactured their Coccoina natural glue of potato starch, glycerine, almond oil and water. It was contained in an unbreakable aluminum packaging complete with little biodegradable brush with natural bristles in the middle. In 1984, Coccoina 84 was launched, a formulation of liquid glue based on polyvinyl alcohol, a biodegradable water soluble polymer but characterized by an almond scent. The Coccoina , based on water-washable polyvinylpyrrolidone, was produced from 2007. *(coccoina.it)*

renature.uhu.com; "Introducing the new look eco-friendly Mr.Pritt," *GrocerTrader*, July 6, 2011.

Granulated blast furnace substitute for river sand

Problem: The rapid extraction and heavy-exploitation of from river beds in India and Sri Lanka for use as concrete and mortar in the construction industry is causing problems such as losing water retaining soil strata, deepening of the river loss of vegetation on the of rivers, beds and causing slides, disturbing the aquatic life as well as disturbs agriculture due to lowering the water table in the well.

Solution: In 1937 Joseph L. Parker and Clarence H. Starns at the Southern Cement Company in Birmingham, Alabama innovated a process for using blast furnace , puzzolan and the like in the making of concrete. Over in Great Britain, the following year, Stanley Dunn and Victor Lefebure at Imperial Chemical Industries took out a patent for the manufacture of cements from calcium sulphate and blast furnace. It makes sense: On average, in the process of making 1 ton (1) of steel around 1,300-1,500lbs (600-700 kg.) of by-product is produced, mostly .

Ground-granulated blast-furnace (GGBS or GGBFS) is obtained by quenching molten (a by-product of iron and steel-making) from a blast furnace in water or steam, to produce a glassy, granular product that is then dried and ground into a powder. GGBS cement can be added to concrete in the concrete manufacturer's batching plant, with Portland cement, aggregates and water. GGBS is used as a direct replacement for , on a one-to-one ratio by weight. Replacement levels for GGBS vary from 30% to up to 85%. Typically 40 to 50% is used in most instances.

The substitute is currently in use by ECOCEM Materials, collaborating with ArcelorMittal Méditerranée, is the first independent producer of GGBS in Europe. The aim is to produce concrete with lower environmental impact: 1 ton (1) of ground in the concrete industry avoids the emission of 1653 lb (750 kg) of CO_2 due to the production of Portland cement. A growing number of major projects are using Ecocem GGBS, such as the A89 motorway, the ITER project, the LVG SEA, the Odeon tower in Monaco, the Smartseille project, the Marseillaise tower, the ENS Saclay project, the Hekla tower, and the Condorcet campus *(ecocem.fr)*

In Korea, the steelmaker (Engineering & Construction) is using GGBS to produce an eco-friendly, high-function cement named PosMent that has a high level of chloride invasion resistance and reduces hydration heat, applicable to structures and structures that are to crack. In 2014, 1.37 million tons (1.24 million tonnes) of PosMent was used in construction. By using a total of 11.8 million tons (10.69 million) of for PosMent production, estimates it has reduced 9.2 million tons (8.39 million) of carbon dioxide when compared to GHG produced in the making of regular cement. *(poscoenc.com)*

Cho Chung-un, " pursues eco-friendly business with steel byproducts," *The Korea Herald,* April 22, 2019.

Graphene-based desalination membranes

Problem: As the demand for fresh water increases worldwide, -scale, new technologies for desalination are becoming increasingly sought after. Equally in wastewater treatment, the ability to remove industrial effluent, pesticides and hormones is becoming important, especially when water re-use is considered.

Solution: In the natural world, aquaporins rapidly shuttle water molecules into and out of cells and mimicking this function could help improve the production of chemicals and pharmaceuticals. One answer could be to use graphene, which is a sheet of carbon just one atom . Graphene is very , and sheets can be punctuated with sub-nanometre-sized pores that let water through while blocking salt. While this works well for micrometre-sized membranes it is very difficult to larger graphene sheets without defects, which act as pores that let salt through. Another approach is to create a membrane from a patchwork of small overlapping sheets of graphene oxide (also just one atom). Water can move through the membrane by permeating the gaps between the sheets, but the larger salt ions cannot. While scientists have already made 0.4 in (1 cm) membranes this way, this material tends to swell-up when wet and let more salt through.

In Saudi Arabia, desalination researchers at King Abdullah University of Science and Technology tailored the structure of graphene-oxide layers to mimic the hourglass shape of these biological channels, creating ultrathin membranes to rapidly separate chemical mixtures. *(kaust.edu.sa)* In China,

Yanbing and Xiangdong at Wuhan University have developed a graphene-based desalination membrane with the potential to be scaled-up for practical applications. *(en.whu.edu.cn)*

In Australia, Mainak Majunder and a team at Nanoscale Science and Engineering Laboratory of Monash University, Melbourne, developed a similar system that uses gravure printing, a widely available industrial printing process. The technology will directly benefit Australian and international companies seeking energy savings and other cost advantages in water and wastewater filtration and industrial processes associated with pulp and paper, food and beverage, inks, pigments and dyes, pharmaceuticals and metals. Supported by funding from the Australian Government's Cooperative Research Centre (CRC) program of approximately US$1.2 million, and with investment from industry partners Clean TeQ Holdings in Melbourne and Ionic Industries, the technology entered the commercialisation phase after undergoing seven years of research and development. In 2019, Clean TeQ announced the successful completion of its hardness removal demonstration project in Inner Mongolia. The demonstration program treated waste-water from a large coal-to-chemical refinery, producing DME (Dimethyl Ether) by Jiutai New Material located about 60 mi (100 km) from Hohhot, China. The process requires large volumes of industrial water, putting a strain on sources of water supply in this water scarce region. The demonstration program confirmed that increasing water recovery by adopting Clean TeQ's CIF (Continuous Ionic Filtration) system could substantially reduce the plant's net water use. *(cleanteq.com)*

"Monash pours energy into clean water future," *Monash University*, December 10, 2018; "Colorful solution to a chemical industry bottleneck," *Kaust Tomorrow'sy*, May 7, 2019; Sam Jarman, "Graphene and nanotube mesh filters salt from water," *physicsworld*, 24 2019.

Great Bubble Barrier

Solution: In 2015, Dutch students Saskia Studer, Marieke Eveleens and Francis Zoet looked at the bubbles of a beer glass in a bar and thought they should do something similar to recuperate plastic waste in Amsterdam. Philip Ehrhorn, a German student of naval architecture, had the idea after seeing a water treatment plant in Australia. After he found out about the plans of the three Dutch women, they decided to join forces in Amsterdam. Their design, a perforated tube laid across the bottom of the canal with compressed air pushed

through, was commissioned by the Amstel, Gooi and Vecht Water Management Board and the Municipality of Amsterdam as an extension of "Amsterdam Clean Water" which strives for clean plastic-free waters in Amsterdam. The location of the Great Bubble Barrier, the Westerdok, is one of the points where the water flows from the monumental canals of Amsterdam into the IJ. The IJ flows into the North Sea Canal and this leads directly to the North Sea. This makes Westerdok an ideal place to catch Amsterdam's canal plastic. Tests shown it can divert 80% of flotsam. Implemented in the fall of 2019, this first Bubble Barrier will run 24 hours a day for three years to supplement dredging operations, which currently collect 92,600 lbs. (42,000 kg.) of larger plastics from the Dutch capital's waterways each year. *(thegreatbubblebarrier.com)*

"The Great Bubble Barrier," *amsterdamsmartcity.com*, September 1, 2017.

Green bonds (also known as climate bonds)

Problem: Those who are to finance solutions need fiscal encouragement

Solution: Green bonds are designated bonds intended to encourage sustainability and to support climate-related or other types of special environmental projects. They come with tax incentives such as tax exemption and tax credits, making them an attractive investment compared to a comparable taxable bond. It began in 2001, when voters in the City of San Francisco approved a revenue bond authority, in the form of a city charter amendment known as the "solar bonds," to finance renewable energy and energy conservation measures on homes, businesses and government buildings so taking meaningful action on climate. Since then, green bonds have been growing rapidly. The total volume of green bonds was estimated at 160 billions of dollars on 2016; of which 70 billion were issued in 2016. The labelled volume of bonds issued in 2019 was US$ 255 billion. The EU Green Bond Standard is a practical and secure financing tool to ensure the real economy investments create environmental impacts that fulfil Europe's climate goals and other -term environmental objectives.

Green Film Production Guide

Problem: A study into the environmental impact of film-making in Hollywood, conducted by the University of California, showed that, in the Los Angeles region, it a larger contribution, in relation to its size, to air pollution most major industries, including aerospace manufacturing, clothing, and the

hotel industry. The audiovisual sector emits about 1 million tonnes CO_2 equivalent in the atmosphere each year, of which about a quarter is directly related to filming

Solution: The discussion of sustainability in film began in the early 1990s, as reported in *The Hollywood Reporter* and *Variety*. In 2008 when free-producers and film-makers, Mari Jo Winkler, Lydia Pilcher and Katie Carpenter of the East Coast PGA (Producers' Guild of America) established PGA Green "as a to actively encourage and support sustainability in the entertainment industry," includiong environmentally friendly practices when productions shoot on location. In 2010, "The Green Production Guide" was established to help reduce the entertainment industry's carbon footprint and environmental impact. (*greenproductionguide.com*) It was developed by the Producers Guild of America Foundation and PGAGreen.org with primary support from NBCUniversal, ViacomCBS, Amblin Partners, Sony Pictures Entertainment, HBO, Netflix, Amazon Studios, Disney, WarnerMedia, 20th Century Studios, CBS & Participant Media.

Its toolkit offersfree resources to film and television professionals looking to lower their environmental impact. Tools include a carbon calculator which tracks use of high-impact purchases such as water and paper, a database of eco-friendly vendors, and a fast-track to obtaining a "Green Seal" of approval from the Environmental Media Association (EMA). It also includes a comprehensive database of vendors including info about their services, experience, and locations. The website additionally offers a Production Environmental Accounting Report (PEAR) that can be downloaded to aid production in analyzing their carbon footprint and the Production Environmental Actions Checklist (PEACH), which clarifies best practices in the industry. Globally, film studios have adopted sustainability initiatives, including the "Big Five" of Universal Pictures, Walt Disney Pictures, Warner Bros., Columbia Pictures, and Paramount Pictures. As well as television production studios like CBS

As one example**, "**Downton Abbey", a British historical drama television series set in the early 20th century, watched by over 10 million viewers worldwide. When filming in the United Kingdom, the "Downton Abbey" film's production team did a number of things to reduce their footprint including sending call sheets, scripts, and production documents electronically, no disposable food service products on site, and recycling/composting. In addition,

Carnival Films stored sets from the six seasons of the television series “Downton Abbey” that production was to re-use or re-purpose to the consumption of new materials. Disposables were also saved by issuing the crew reusable water bottles and the sound department used reusable batteries. At the conclusion of production, the costume department donated $800 worth of fabric and materials to the Wimbledon College of Arts. boxes and were donated to local sewing and flower shops and set decoration donated produce to The Hounslow Farm to be used to feed animals. For these solutions, “Downton Abbey” received a 2019 EMA Green Seal.

Greener personal desktop computing

Problem: Internets cause global warming Blog servers might 10,000 PCs occupying an area of 40, 0000 sq. ft that generate amount of heat while running. Each click of the keyboard engenders heat in a computer or laptop and processing of information data causes a minuscule in environmental temperature. Single internet search, depending upon the initial data, might consume enough electricity to run an 11 watt energy saving light bulb few minutes to an hour.

With about 5.6 billion searches internet searches estimated globally daily, the power consumption and GHG emissions generated by internet and computers is alarming. Google processes over 3.5 billion searches per day (Internetlivestats, 2019). If you break this statistic down, it shows that Google processes over 40,000 search queries every second on average.

Solution: Shutdown and unplug your computer when not in use. Using your system's power settings (for instance, programming a sleep mode or turning the machine off and unplugging it) is a smart way to conserve energy. But when it's time to upgrade your system, consider green. And don't to recycle your outdated system.

The U.S. Environmental Protection Agency's (EPA) Energy Star program has set up green computing criteria, and compliance with these requirements earns systems the Energy Star label. To gain Energy Star compliance, computers must use an energy-efficient power supply, operate efficiently in power saving modes (standby/off, sleep and idle modes), and also provide power management features (with information about how to use those features). If all the computers that are sold in the United States met Energy Star requirements, greenhouse gas

emissions could be reduced by the equivalent of 2 million cars and about $2 billion annually on energy

In addition to the Energy Star label, EPEAT (Electronic Products Environmental Assessment Tool), run by the Green Electronics Council, computers based on 50 energy-efficient criteria including everything from what materials were used in the system and its packaging to its energy conservation and end-of-life management. This is a three-tiered system -- gold, silver and -- and computers by EPEAT are also Energy Star compliant.

In 2007, Dell of Round Rock, Texas, set a goal of becoming the greenest technology company on Earth for the term. The company launched a zero-carbon initiative that included partnering with customers to build the "greenest PC on the planet".

Called the *Studio Hybrid*, its 87% efficient power supply meets Energy Star's 4.0 green computing standards, and EPEAT gives the system its highest , gold. The *Studio Hybrid* is 80% smaller a typical desktop computer while its packaging is from 95-percent-recyclable materials and comes with less printed documentation -- 75 % less by weight (all documentation is available online instead) For an additional , -users can personalize it with a bamboo sleeve. And when they are ready to upgrade, the Studio Hybrid comes with its own system recycling kit.

Alongside Dell, other PC manufacturers come up with solutions, including Lenovo's *ThinkCentre M57p,* the *Apple Mac mini,* the *Zonbu Desktop Mini,* the *Acer TravelMate TimelineX,* the *Asus Bamboo Series,* the *CherryPal etc*.

GreenR

Solution:

In addition to our solution N° on Applications, GreenR allows you to report rubbish or geolocate it to pick it up

Tired of seeing waste lying around everywhere, Ruben Longin, a 16-year-old high school student from Villefranche-sur-, North of Lyon, created the GreenR mobile application to collect , bottles, masks or other rubbish lying by the side of the road.

Launched in July 2020, the application available on all stores (Apple, Android, Google) already has 10,500 registered users, around 550 declared waste spots as well as around sixty organized collection walks.

Its users are mainly located in , but also abroad, in 25 different countries, even if the application has not yet been translated <<<

Tomorrow's solution: henna, the natural hair dye

:Habitat Pods

Problem:

Every country that experiences bush fires has had massive direct impacts on animals - the loss of ground cover makes surviving animals much more vulnerable to predators and harsh weather conditions. Australia's vast bushfires had huge direct impacts but the removal of ground cover also made surviving animals much more vulnerable to predation from cats and foxes. Without shelter, surviving animals such as bandicoots (marsupials on the ground) and small rodents are far more vulnerable to attack from predators such as cats and foxes

Solution:

Habitat Pods

Alexandra J.R. Carthey, a Research Fellow at Macquarie University in Sydney, Australia has developed Habitat Pods which are lightweight, flatpack shelters for animals whose homes have been devastated by bush fires.

These tiny dwellings are easy to transport, modular, and biodegradable too. Like Lego; Made from recycled cardboard, they can be easily transported to remote locations with flat pack sheets and can be folded and placed on the bare ground after a fire. The pods are modular and can be connected to a specific location. Also, because it is made of recycled cardboard, it biodegrades before vegetation begins to grow back. The holes in the cardboard take in light and promote vegetation regeneration.

Hair dyes

Problem: When commercial dyes containing ammonia and paraphenylenediamine are rinsed out of hair they may end up in local waterways harming aquatic life

Solution: For a zero-waste solution, Henna, from the flowers of the *Lawsonia inermis* shrub, has been used since antiquity to dye skin, hair and fingernails, as well as fabrics including silk, wool and leather. grows in hot climatic conditions and is widely grown in the Arabian Peninsula, Indian subcontinent, Near and Middle East, Carthage, other parts of North Africa and the of Africa. Compound henna, which includes indigo, cloves or coffee is used to turn hair a colour other red. In the Indian state of Haryana, Faridabad-based henna manufacturers are famous for producing the best natural hair dyes and a export network in the Middle East and far East and in countries like Japan, Korea, Madagascar, Kenya, and the Philippines.

Hemp fibre

Solution: Hemp, or industrial hemp, is a strain of the *Cannabis sativa* plant species that is grown specifically for the industrial uses of its derived products. It is one of the fastest growing plants. Hemp requires no pesticides, consumes far less water cotton, can be harvested in 3 months and returns nutrients into the soil after harvest. According to a Stockholm Environment Institute study, hemp requires just 40% of the ecological footprint and 20% of the water as compared to cotton. Hemp paper has the potential to reduce deforestation as 1 ac (0.4 ha) of hemp will produce as much pulp for paper as 4 ac (1.6 ha) of trees over a 20 year period. Hemp makes its in a world that's yearning for things natural and .

Hemp fabric, back to 8000 BC, was found in Mesopotamia (current day), but for possibly the last 12,000 years hemp has been grown and processed for its fibres and food. Centuries later, hemp fibre and oil also went into making riggings, pendants, pennants, sails, and oakum. Maps, logs, and even the bibles that sailors brought on board were all using hemp paper.

In the USA, from 1937, hemp was strictly regulated by the Marijuana Tax Act, largely due to confusion with other kinds of cannabis. Hemp could be

grown through specially issued government tax stamps, making any type of possession/ without a tax stamp illegal. In 1970, the Comprehensive Abuse Prevention and Control Act went into effect abolishing the taxation approach of the Marijuana Tax Act, effectively making all cultivation of cannabis illegal by setting a zero tolerance for THC. Thus it went out of favour.

Since the 1990s there has been a revival of industrial hemp in , Europe and Canada. This is due to rising oil prices, material recycling requirements and environmental awareness. Every part of the plant is useful — fibre, , seed, flower, everything — and lends itself to applications as diverse as clothing, construction, paper, composites, health foods, body and biofuel. For example, Hempcrete or Hemplime is bio-composite material, a mixture of hemp hurds (shives) and lime (possibly including natural hydraulic lime, , or pozzolans) which is used as a material for construction and insulation

is currently the European leader with an annual hemp () production of 55 000 tons (100 000 tonnes in the European Union) and the world's largest variety of certified industrial seeds. The European Community subsidized the cultivation of non-psychotropic hemp varieties from 1988 onwards. After reaching a minimum level around the 1960s, with less 600 ha cultivated, hemp cultivation in now occupies 31,000 ac (12,500 ha), or 0.03% of the agricultural area used.

Created in 2013 the LCBio association is based in the Pays de Caux in Normandy, an area known to be one of the most suitable in the world for growing hemp and flax. LCBio brings together flax and hemp producers and processors according to three colleges of members: farmers, cooperative and private enterprises and partner institutions. Flax and hemp are two fibres which can be grown and treated under the right conditions. The association also sets itself the task of creating a textile flax industry that complies with the Bio and GOTS label and of determining a technical itinerary for hemp, whose cultivation is undergoing a revival, in to obtain a straw that can be scutched on the linen tools and a quality of fibre that meets the requirements of the textile industry. Eventually, LCBio hopes to be to set up complete French flax and hemp textile chains. *(linetchanvrebio.org)*

Cavac Biomatériaux at Sainte-Gemme-la-Plaine near Luçon in the Vendée is part of a cooperative producing items in hemp and flax, grown inside a of 60 mi (100 km) around the factory by farmers from the cooperative. Cavac

Biomatériaux has three 100% automatic producing lines and a 40,360 ft² (3,750 m²) drying barn.

On the Pacific Northwest, in the Coast of , Shannon Welsh and Angela Wartes-Kahl, with local farmers, scientists, businesses, artisans, and partnering with State University founded Fibrevolution to revive hemp and flax linen in their region. *(fibre-evolution.com)*

In Romania, hemp clothes are made by CaVVaS Ltd. located in Cluj Napoca. The raw fiber is separated by traditional methods of water retting, breaking, scutching, and hackling. This produces the high quality fibre that is first spun on special fiber spinning equipment (up to 14 Nm) and then woven. The main difference in the spinning process between hemp fibers processed using chemical methods and fibers from methods is generally the length of the hemp fiber and the spinning machines that are required to spin the fiber hemp and the short fiber, chemically processed hemp. After the weaving process, the resulting loomstate fabrics are washed with ecological detergents or sometimes just with plain water and treated afterwards. Drying temperature level differs from fabric to fabric, depending on its thickness, in to avoid burning or weakening the strength of yarns' structure. *(cavvas.com)*

In India, both The Bombay Hemp Company (Boheco), the Namrata Hemp Co, B.E. Hemp, Arture, Hempster and HempCann a whole of products with raw materials are currently imported from overseas by these brands, with China and Italy prominent suppliers.

Henry Ford's Model T was famously constructed partly from hemp bioplastic and powered by hemp biofuel. During the 1960s, several million German Trabant 500 automobile were manufactured using "Baumwolle" (cotton) with a thermo-setting resin of plant . In 2014, using a process known as hydrothermal synthesis, a team led by Dr David Mitlin of Clarkson University, New York, 'cooked' leftover hemp bark fibers (shiv) into carbon nanosheets (10-30 nm in thickness). They then recycled the fibers into "ultrafast" super capacitors whose energy density of 12 Wh/kg, can be achieved at a time less six seconds. In a Volts by Amps curve of both the hemp and lithium batteries, the power underneath the hemp cell was a value of 31 while that of the lithium cell had a value of just 4. Hemp outperformed graphene supercapacitors in energy by nearly 200% while hemp processing is 1,000 times cheaper graphene processing. In 2018, Alternet Systems, Inc. announced that it would be teaming up with Mitlin to power motorbikes for its Texas-based

ReVolt Electric Motorbikes subsidiary. The company announced a hemp battery and motorcycle body initiative in conjunction with its -term plans to build electric delivery vehicles for the African market, beginning with a fleet for an initial 50 electric motorcycles to be delivered in Texas. *(alternetsystemsinc.com)*

Panda in Dallas, Texas was formed after the passage of the federal Hemp Farming Act signed into law by President Donald Trump on December 20, 2018. Panda has developed the most technologically advanced, highest capacity and first-of-its-kind industrial hemp decorticating equipment ever used to separate the fiber and cellulose from the . This is based on smaller versions of proven decortication technology that been used throughout Asia and Europe for decades. In December 2019, Panda announced they were to build a 255,000 ft² (23,700 m²) production facility called the Panda High Plains Hemp Gin at Shallowater, in Lubbock County, Texas, where production of high-quality, textile- fiber and premium cellulose was expected to start within 12 months. The processed fiber and cellulose from industrial hemp will be used in the production of a multitude of products including textiles, a wide array of building materials, paper products, automobile composites, nanomaterials, bio-plastics and finishing products such as caulking, sealants, varnishes and paints. With this, industrial hemp is poised to transform numerous multi-billion-dollar industries. *(pandabiotech.com)*

In , Foyer, creator of Qairos Energie in the Sarthe region has devised a solution where fields of hemp plants will become a source of hydrogen.

The harvested hemp is crushed and heated to a very high temperature. Heat transforms it into gas from which methane, hydrogen and carbon dioxide can be extracted. This process is non-polluting and without waste. Each gas extracted is then resold. Synthetic methane is injected into national gas network. Hydrogen is converted into electricity in fuel cells for vehicles, for example. And the locally produced and green CO_2 is sold to the food industry

Six first "pioneers" signed a contract with Qairos for an area of 125 acres (50 hectares) for 2021. The objective is to achieve, for a perfect balance, 2,470 acres (1000 hectares) over a radius of 22miles (35 kilometres) around the first production unit at the Le metropolitan hub. If successful, 150 farmers from the Fermiers de Loué cooperative are ready to cultivate an area of 865 acres (350 hectares) in the first year.

Elisa Addlesperger, “Hemp” *Journal of Agricultural & Food Information* 16(3):196-202 · July 2015; John H. Fike, “Industrial Hemp: Renewed Opportunities for an Ancient Crop.” *Critical Reviews in Plant Sciences* 35(5):1-19 · January, 2017; *cavvas.com;* David Mitlin, “Interconnected Carbon Nanosheets Derived from Hemp for Ultrafast Supercapacitors with High Energy.” *ResearchGate*, May 2013; Giadha Aguirre De Carcer, “The Age Of Hemp: Global Advanced Industrial Applications.” *Forbes* October 23, 2018.

“Honext to Goodnex”

Problem:

Cellulose residue taken from cardboard and paper waste generated at paper mills has already through several reuse cycles, meaning that the remaining cellulose fibres are too short to be bound together in order for it to be made into paper again. As a result, these fibres would typically end up in landfill or be burnt – a process that creates an estimated seven million tons waste globally each year.

Solution:

Building material from recycled paper sludge

Located in a waste treatment centre, in Vacarisses, Barcelona, Spain, Hontext, founded in 2011, is a spin-off of the Polytechnic University of Catalunya for the industrialization of a patent process, product and application. This transforms a residue (primary sludge) generated by the paper industry into a new cellulose-based material, sustainable, versatile, with excellent properties (reaction to fire, moisture, acoustic absorption, mechanical resistance, non-) and multiple applications (construction, furniture and packaging).

The company mixes together waste cellulose fibres with water and enzymes – depending on the quality of the waste, a mixture of 50 to 75 % paper sludge and 25 to 50 % cardboard waste is used. The circular economy manufacturing process, in addition to using the sludge from paper mills as raw material, incorporates water coming from the local landfill leachate, as well as methane and electricity generated from the digestion from the town’s waste.

The Hontext factory will an annual production capacity of 2,000 m3 of panels.

:Hookpod

Problem:

Every year, pelagic longliners fishing for the likes of tuna and swordfish set about 3bn hooks, killing an estimated 300,000 seabirds, many of which are albatrosses. Fifteen out of 22 species of albatross, and six out of seven marine turtle species are threatened with extinction.

Solution:

The Hookpod

In 2005, Ben Sullivan started working with British brothers and inventors Ben & Pete Kibel of Fishtek Marine, Totnes, south-west England, to solve one of fishing's biggest environmental challenges – seabird bycatch in longline fisheries. Working closely with the fishing industry, and the Albatross Task Force of the Royal Society for the Protection of Birds, working on behalf of BirdLife Internationa, the Kibel brothers spent the next six years perfecting what fishermen need, a solution that fits seamlessly into the fishing operation, allowing them to catch fish and not birds.

The resultant solution is the Hookpod: This device encloses the barb of the hook until it sinks out of reach of foraging seabirds. At a pre-determined depth such as 10 metres, a pressure release mechanism opens the pod, releasing the hook. Once retrieved, the pod can be re-used. Two versions are available, a mini-pod which weighs 45g and a larger 68g version, which includes an LED light, which attracts bait fish and removes the need for other light sources such as plastic disposable lightsticks.

The Albatross Task Force helped toconduct trials of the Hook Pod in South Africa and Brazil. Results indicated that the Pod has no negative effect on fish catch rates, and the fishermen liked using it. Initial trials showed a 95% reduction in seabird bycatch and 50% reduction in turtle bycatch using a Hookpod that opened at 10m depth, In December 2019 New Zealand longline fishers have hailed the approval of the Hookpod. This solution is now commercially available in New Zealand, Brazil and Australia , with growing interst shown by China, Taiwan, Korea and Japan.

Sir David Attenborough approves: "If every pelagic longline fishing fleet used Hookpods, I believe we can stop the accidental death of these magnificent ocean wanderers."

Horses

Problem: For the past two hundred years, most forms of mechanical transport required fuel brought from a distance and artificially . When that fuel out they come to a halt, as they do in extreme weather conditions such as heavy snow or floods.

Solution: For the past 4,000 years horses been used for transport. Regarded as a unit of transport energy, one standard has an average height of 4.6 to 6 ft. (1.4 to 1.8 m) at the withers, or 15-16 hands. It is capable of a peak power production of 14.9 horsepower. It weighs about 1,000 lbs (454 kg.) and eats 2% of its body weight in dry feed a day or 20 lbs (9 kg.). It will drink 5 to 10 gallons (20 to 30 liters) of fresh water per day. The Pony Express horses worked 25 mi. (40 km.) a day maximum. Assuming that a can average 25 mi. (40 km) a day every day, this works out to a 1.25 mile/pound of feed. Galloping, a can reach top speeds of 25-30 mph (40 - 48 kph) for 2 mi. (3.2 km). While a may be exhausted after a three-mile (5 km) gallop, that could trot, with a few walk breaks, 15 mi. (24 km) without extraordinary strain. The electrical unit the Watt was calculated from Horsepower and there are 740 watts in one horsepower. A can travel over most terrain, including snow and rivers. A deprived of feed, but supplied drinking water is capable of surviving 20 to 25 days. It has a life of 18 years (6,000 recycles). Well treated, it is very user friendly and becomes a companion. It is biodegradable, recyclable and, for some, edible. One or horses interlinked, like batteries, can provide multiple energy to tow a passenger vehicle.

Aside from therapy, leisure and sport, the is a solution for our Planet. Since 1993, the French towns of Rennes, Millau, Nouvoitou, Rambouillet, Saint-Pierre-sur-Dives Cabourg, Quevilly and Paris (at the Bois de Vincennes) come to use “territorial horses” (cart horses) to schoolchildren to and from school and to collect trash. In 2011, around 100 French municipalities were using at least one territorial , but by the end of the following year, this number had grown to about 200, while by 2019 that figure stood at 250. In Vendargues in the Hérault, three Hippobuses are in regular service for schoolchildren.

Since 2009, Garcia, founder of “Aequitaine”, near Sainte-Foy-la-, south-west , manages a stable of 23 horses which can be rented out to plough the surrounding vineyards of the region. Their lighter weight is better for the vines mechanical tractors. Since October 2004, two Brittany horses tow loaded with industrial the River twice a day, five days a week, eliminating seven trucks daily, reducing noise pollution, pollutant emissions and the risk of accidents.

Police on horseback**,** including the United States Border Patrol, the Royal Canadian Mounted Police, the Mexican Rurales, the British South African Police, and the Turkish/Cypriot Zapiteh are employed for specialized duties from patrol of parks and wilderness areas, where police cars would be impractical or noisy, to riot duty, where the serves to intimidate those whom it is desired to disperse through its larger size, or may be sent in to detain trouble makers.

-Claude "Du durable à la foire," *SudOuest,* October 14, 2010 ; "Le Cheval Territorial, Concept Eco-Urbain, " *Fédération Nationale des Cheavu Territoriaux,*

:Hospitals with zero emission

Problem:

Hospitals pollute due to their facilities, electricity use, vehicles, and supply chains for medicines and medical devices.

Solution

Zero-emission hospitals

The **United Kingdom**'s National Health Service has launched an ambitious to eliminate nearly all of its carbon emissions by 2040

A 76- , "Delivering a 'Net Zero' National Health Service, forwarded by Sir Simon Stevens, NHS Chief Executive includes a list of solutions:

to cut out single-use plastics; reuse and refurbish devices; to capture and reuse anesthetic gases, to find alternative products with a smaller impact on the planet; and ask suppliers to the net-zero pledge; to generate renewable energy and heat onsite: to process and recycle waste; to replace less efficient lights with LEDs to energy; to introduce fleets of zero-emission ambulances by 2032; and to build 40 new "net-zero" hospitals to run cleanly and efficiently.

France

L'Assistance Public-Hôpitaux de Paris (AP-HP) whose 39 hospitals receive 8.3 million patients per year, has launched an appeal for projects to accelerate their eco-transition.

Iceland

Landspitali, the National University Hospital of Iceland, has substantially reduced its carbon footprint by increasing eco-friendly travel to and from work from 21% to 40% of employees. Through the design of a green travel agreement, Landspitali has created economic and health gains for its employees while minimising CO_2

India

Bhagat Chandra Hospital, a multispecialty, 85 bed facility in Dwarka, New Delhi, India has achieved considerable financial and environmental benefits by transitioning to solar energy, conserving approximately 93 000 kg CO_2 emissions since 2016. Through a coordinated, hospital-wide initiative, Bhagat Chandra has installed 50 kW solar panels that connect to the electrical system and reduce 20-30% of its energy consumption.

Malaysia

Through a different approach, the Buddhist Tzu-Chi Dialysis Center in Malaysia has reduced its carbon footprint by promoting vegetarianism and using reusable food containers. Implementing an " vegetarian" policy since the centre opened in 1997, the centre saves 4.9 kg of CO_2 emissions for every kg of tofu served in place of chicken. They also seen major falls in carbon footprint by reducing the use of plastic

USA

Kaiser Permanente, an integrated managed consortium based in Oakland, California, USA, has made concerted efforts to purchase environmentally responsible computers. It has been to reduce the use of materials and energy, resulting in energy cost savings of $4m a year.

N Salas et al. "A pathway to net zero emissions for healthcare", *British Medical Journal*, October 2020.

Hotspots

Problem: Some regions of the Planet are home to a disproportionately high number of species which, threatened by human habitation, need special protection.

Solution: In 1988, Norman Myers, an English environmentalist, published an article entitled "Threatened Biotas: 'Hot Spots' in Tropical Forests" in *The Environmentalist* wherein he proposed ten localities in the tropical forests by virtue of their floristic richness and deforestation . Myers called these ten localities as "hotspot" areas, thus, giving birth to the concept of biodiversity hotspots. He recommended they should bemade into the focus of preservation efforts as a way to cut the threat of mass extinction. Another article, published in "Nature" in 2000 had been cited 19,000 times by 2017. This work was cited when Myers was named 2007 *Time Magazine* "Hero of the Environment.

To qualify as a biodiversity hotspot, a region must meet two strict criteria:

It must at least 1,500 vascular plants as endemics, which is to say, it must a high %age of plant life found nowhere else on the planet. A hotspot, in other words, is irreplaceable and must retain 30% or less of its original natural vegetation. In other words, it must be threatened.

To , ecologists identified 36 biodiversity hotspots that cover about 15 % of the surface Earth: areas such as the Galápagos Islands, Madagascar, the West African rainforest, Japan, California and the Mediterranean coastline. global hotspot initiatives, the World Wide Fund for Nature has derived a system called the "Global 200 Ecoregions", the aim of which is to select priority Ecoregions for conservation within each of 14 terrestrial, 3 freshwater, and 4 habitat types. They are chosen for their species richness, endemism, taxonomic uniqueness, unusual ecological or evolutionary.

Kevin Desmond, *Planet Savers, 301 Extraordinary Environmentalists* (Sheffield, UK: Greenleaf, 2008), 202.

Housing development, environmentally friendly

Problem: During the 1950s and 1960s, the author spent his childhood and youth in a detached house, other detached houses in Purley in the London Borough of Sutton. Heating was by a coke-fired stove and an -hearthed fire. Like millions of other homes, we were innocent about energy efficiency, greenhouse gases and the effects of global warming.

Solution: Beddington Zero Energy Development (BedZED), in the London Borough of Sutton was designed in 1999. Architect William Dunster, his wife Sue, and engineers Arup were looking for an opportunity to create a zero-carbon eco-village. Dunstan had worked at Michael Hopkins and Partners, for 15 years, on projects specialising in low energy and sustainable developments, including the Jubilee Campus at Nottingham University, and Portcullis House in Parliament Square. Led by the Peabody Trust, Dunster, and Arup were joined by Ellis & Moore Consulting Engineers, BioRegional, to build 82 homes, and 15,120 ft² (1,405 m²) of office space, a college and community facilities within the period of 2000–2002. The build site was chosen because of its south facing position - which maximises the amount of sunlight reaching each property. Bioregional were very successful at reclaiming structural steelwork and softwood walling studs from local demolition sites for re-manufacturing into useful new structural components. Most bulk materials and labour were sourced within a 50 mi (80 km.) radius of the site, enabling the completed embodied carbon to compare favourably with that of a volume housebuilder's industry standard product - despite having thicker walls and considerably higher thermal mass. BedZED was just about enough to merit its own on-site water treatment plant and Biomass woodchip-fuelled combined heat and power plant. It also includes solar panels and energy-efficient and water-saving appliances. BedZED pioneered car clubs, an idea that has now spread to towns and cities across the UK. The UK's first -scale eco-village was shortlisted for the Stirling Prize in 2003. It has also proved to be an inspiration for zero-carbon homes worldwide.

After BedZED, the Dunstons took their learning and transformed it into the One Planet Living framework. The One Planet Principles are now used across the world, from a small community of 131 homes in Seattle to two apartment blocks in the heart of Brighton. Bioregional has since helped companies, including restaurant chain Nando's, retailers M&S and Kingfisher, and drinks producer Innocent, to their operations sustainable. It has also helped to create sustainable developments and buildings in South Africa (a in a safari park), Australia and Finland. In the latter it advised on the construction of two near zero-carbon developments that will be home to 15,000 people and provide 8,000 jobs. They include innovations such as central waste-collection chutes, cycling roads, green roofs and energy needs met by solar panels and waste heat generated by commercial refrigeration. In the UK, Elmsbrook, a One Planet Living community in Bicester, opened by A2Dominion in 2016, was recently confirmed as the UK's first -scale zero-carbon development. According to

Bioregional's monitoring results, Elmsbrook residents used 57% less heating and hot water their neighbours and 28% less electricity, saving US$ 520 in annual energy bills. *(bioregional.com)*

"BEDZED: Beddington Zero Energy Development in London." *inhabitat,* January 17, 2008.

Hulhumalé

Problem: The Maldives, a tropical paradise spread over almost 1200 islands, is facing a threatening rise in sea levels. The government is finding it difficult to cater to the economic and social needs of small islands

Solution: Maldives President Maumoon Abdul Gayoom, experimented with -flood solutions, starting with a massive seawall of concrete tetrapods surrounding the entire capital of . Gayoom was to persuade the Japanese government to pay for the $60 million wall after the floods of 1987. The wall reduced the vulnerability of , which is a mile and houses one-third of the country's population.

President Gayoom's next solution was a reclaimed island located in the south of North Atoll, Maldives.

Called Hulhumalé (Dhivehi for City of Hope), the artificial island is built up by pumping from the surrounding atolls and depositing it on shallow reefs that surround the original lagoon. It is fortified with walls 3 metres above sea level — which is higher the highest natural island at 2.5 metres above the sea.

The official settlement was inaugurated by President Gayoom on May 12, 2004. The Hulhumalé Development Unit/Hulhumalé Development Corporation) was incorporated on March 23, 2005. reclamation has increased the island's area to 4 km^2 (1.5 sq mi), making it the fourth largest island in the Maldives. As

of December 2019 the island has a population of 50,000; it is planned to house as as 240,000 by the mid-2020s.

In August 2020, the Indian Government announced that they are providing assistance to the Government of Maldives to construct a State-of-the-Art Cricket Stadium in Hulhumalé. The project is one of the centerpieces of the Hulhumalé Central Park development, which aims to convert the island into a future housing, industrial and commercial hub of The Maldives' capital city, .

"President Yameen calls on youth to relocate to Hulhumalé". Minivan News, January 17th *2015.*

Human beings, the main planet-protecting machines

Problem: Outside of asteroids, volcanic eruptions, tsunamis, hurricanes, humans are one of the Earth's best exterminators. In recent times, men and women been led to believe that gluttony and greed, global travel, throwing away are the acceptable norm. But with a burgeoning population, this way of life simply cannot continue.

Solution: Solutions are not machines, but individual men and women who diagnose a theat and work to put solutions into practise. In the 19th Century, one Scottish-American naturalist called John Muir campaigned for the preservation of wildernesses such as the Yosemite area and the Sierra, inspiring US President Theodore Roosevelt to sign into law the creation of five national parks. One biologist, Rachel Carson's -DDT insecticide book *Silent Spring* is credited with advancing the global environmental movement. One Swedish schoolgirl, Greta Thunberg, has been organising a school climate strike movement under the *Fridays for Future*, involving millions of her generation around the world, first on the streets and now virtually.

Kevin Desmond, *Planet Savers, 301 Extraordinary Environmentalists* (Sheffield, UK: Greenleaf, 2008). Rachel Carson, *Silent Spring*, Houghton Mifflin, 1962; Mariner Books, 2002

Human computer chip

Problem: AI and mechatronics are being used more and more in industry and agriculture. Indeed some fear that before will entirely over from humans. Over the past two decades, the idea of a superior artificial intelligence has grown in popularity and is encompassed in the concept of “the singularity”. Scholars, fiction writers and futurists defined in different ways the idea that there will come a time where technology will advance swiftly that the human systems we know will be obliterated: All will become irreversible as a superior machine intelligence takes over in ways we cannot yet imagine. The concept and the term "singularity" were popularized by Vernor Vinge in his 1993 essay *The Coming Technological Singularity*, in which he that it would signal the end of the human era, as the new superintelligence would continue to upgrade itself and would advance technologically at an incomprehensible speed. He added that he would be surprised if it occurred before 2005 or after 2030. Four polls, conducted in 2012 and 2013, suggested that the median estimate was a 50% chance that artificial general intelligence (AGI) would be developed by 2040–2050. This would coincide with the flowering of the 4IR.

Solution: In the 2010s, public figures such as Stephen Hawking and Elon Musk expressed concern that full artificial intelligence could result in human extinction. In July 2019, Musk announced the first product from his Neuralink Inc. in San Francisco, a computer chip that can be stitched into the human brain , which is designed to pick up signals from the and translate them into machine-readable code, effectively merging us with machines in one way, and offering up potential health benefits, such as helping the blind see, or returning certain functions to body parts that have lost them. At the highly futuristic end, the chip could allow humans to interact directly with AI, smartphone. Musk reported that the technology had experienced limited success already as the company had got a monkey to "control a computer with its brain. Such neural interfaces that link human brains to computers using artificial intelligence will allow people to read other people’s thoughts. A new of Transhuman cyborgs would thus be , perhaps to contribute to protecting the Planet. *(neuralink.com)*

Human /Pedal power electric machines

Problem: Before the advent of mechanical power, steam, electric and petroleum-based, our ancestors would physically push, pull and/or lift objects and the old phrase a bit of elbow was well known. Would the human physical activity of creating and generating electricity in the home and at work, using pedal or power, be a holistic solution to helping the overtaxed power grid, to reducing the electricity bill, to keeping fit in a useful way?

Solution: Experiments have been made to update the traditional approach of our ancestors with recent technologies – with machines built using the latest materials – graphene, carbon fibre and the most responsive battery technology. Push, pull and/or lift into the 21st century?

An early example of this was the - which allows people in remote communities to gain access to modern broadcasting—all without needing an external power source, aside from your own . The World War II-era *Gibson Girl* survival radio used a hand-crankedgenerator to provide power; this avoided the unreliable performance of dry-cell batteries that might be stored for months before they were needed, although it had the drawback that the survivor had to be fit enough to turn the . An updated version was invented by Trevor Baylis in 1991, following his watching a news report about the difficulty of providing education about the AIDS epidemic in rural parts of Africa. Baylis was said to have been inspired by his grandmother's wind-up gramophone. Following the Haiti earthquake when electric power was lost for a period, people were issued with a hand-powered flashlight. Inspired by wind-up radios, Sreeram Dhurjaty innovated a defibrillator which could be used where the lack of reliable electric supply in remote areas it difficult to defibrillators work which need batteries and chargers at all times. Then Ashish Gawade, director of Jeevtronics Private Limited developed the dual-powered defibrillator where cranking could over if electricity failed. *(jeevtronics.com)* Alongside these is a whole of combo - torches, radios and cell- chargers: the Eton FRX5-BT, the RunningSnail MD-090, Esky ES-CR01, Midland - ER310 and Kaito Pro KA600.

The pedal (or pedal wireless) was a transmitter-receiver powered by a pedal-driven generator. It was developed by an Adelaide, South Australian

engineer and inventor Alf in 1929 as a way of providing communications to remote homesteads and cattle stations in the Australian From 2007, fitness facilities around the world begun researching applications for converting human power to electricity. Research had revealed that human legs are up to four times powerful human arms. On average, a human can sustain about 100W of power through pedaling for an hour but about 30Ww of power in an hour. The California Fitness facility in Hong Kong was one of the first gym establishments to incorporate human powered machines. Started by French inventor Lucien Gambarota and entrepreneur Doug Woodring, the gym began a program called "Powered by YOU" in which the excess energy generated by members on 13-step cycling and cross training machines is diverted and converted to power lighting fixtures in the gym (Gerard, 2008). Maha and Kimberly (2010), in the Proceedings of 2010 4th International Conference on Energy Sustainability reported that other gyms across the United States began to harness human power as well. The Dixon Recreation Center at State University (OSU) is one of the facilities retrofitted between the years 2008 and 2009 by the Clearwater, Florida based company known as ReRev. The company retrofitted 22 elliptical machines at OSU so that the excess energy generated by patrons was diverted to the electric grid. ReRev stated that a elliptical machine in regular use at a gym using their technology will generate one kilowatt-hour of electricity every two days.

For those travellers wishing to recharge their or laptop, Patricia Ceysens, a former Flemish Government Minister and Katarina Verhaegen of Belgium developed the WATTaTABLE. This is a kiosk where users can sit down at a table, plug their appliance into the electrical outlet on the desk and pedal at a constant to produce power to recharge its batteries. The optimal speed for recharging is indicated by a light meter. During the , electro-cyclists can enjoy free on-bike Wi-Fi to distract themselves during the workout. The device can be found at several airports, stations and entrance halls including in Dunkirk, Lille, Amiens, Le , Paris, Rennes, , Nancy, Strasbourg, Belfort, Nantes, Poitiers, Limoges, Lyon, Saint-Etienne, Bordeaux, Toulouse, Tarbes, Avignon, and Marseille. Each model is custom-built using recycled materials and produced in workshops employing disabled people in Belgium.. WATTaTABLEs come in three different versions to suit a of environments. The 'kiosk' is well-suited for public spaces, whereas the elegant appearance of the 'hub' works well in offices. Both systems can be into a circular or a linear set-up to seat multiple

people at . Finally, the ‘outdoor’ WATTaTABLE offers a cycle-and-relax arrangement for two people where one person cycles and the other watches.

Steve Blood, co-founder of Pedal Power in New York has developed the Big Rig, similar to WeBike where the energy generated by pedalling is enough to power a computer, a , and perform other office-related tasks. From China comes a unit called *Healthy Electricity*, its compact and boxy shape making it suitable even in the most cramped flats, say in New York, Tokyo or . *Healthy Electricity*, designed by Cao , Wu Hao, Xu Wen, Luyao, Cao Wenqi & Zho Una, participated in the Lite-On Awards, dubbed the “Chinese Design Oscars”.

In Guatamala, from 1997 Carlos Marroquin, based in San Andrés Itzapa set up Bicimáquinas — pedal-powered machines from discarded bicycles parts. with PedalCanada, an organization that promotes bicycles as a way of helping local communities, Marroquin has since created 30 different designs for his Bicimáquinas, them pedal-powered water mills, washing machines, *bicimolino/ desgranadora* (a bicycle mill and dehusker), water pumps, coffee de-pulpers, grinders, threshers, tile makers, nut-shellers, blenders, mobility trikes and trailers. 5,000 Bicimáquinas are now spread across Guatemala, making farming and household tasks easier. *(mayapedal.org)*

In August 2011, Contrex, producer of bottled mineral water, placed 10 pink exercise bikes linked to a string of LED lights on a square in a French city. With volunteers pedalling the bikes, a neon light man appeared on a wall. The neon man appeared to strip of his clothes; the they pedalled, the he stripped until he was almost naked except for a board which covered his private part on which was written “, you used 2000 calories!”

"Trevor Baylis: I've wound up despite inventions". *Daily Telegraph.* February17, 2013; Sreeram Dhurjaty and Aniruddha , “A -, affordable defibrillator for resource-poor settings,” *Global Humanitarian Technology Conference (GHTC),* October 2016; Amadea , “The Electricity-generating Bikes of Guatemala,” *RealLeaders,* July 17, 2019; “ “Patricia Ceysens tells Womanthology about inventing a new cycling desk,” *Womanthology*, August 13, 2014; Behr, John. "Biography – Alfred Hermann ,” *Australian Dictionary of Biography*," Retrieved 24 August 2019.

Humanium

Problem: Armed violence is a worldwide problem accounting for 1,500 deaths each day. Every year at least 500.000 people are killed by firearms, making small arms “weapons of mass destruction”.

Solution: Disarmament and amnesties is a practical solution, recycling weapons for peaceful use.

And he shall judge the nations, and shall rebuke people: and they shall beat their swords into plow shares, and their spears into pruning hooks: nation shall not lift up sword against nation, neither shall they learn war any . -Isaiah 2:4

From 1994, each year, thousands of handguns, rifles and automatic weapons, of which were obtained by County Sheriff's Department during criminal investigations and probation seizures, been melted down at Gerdau Steel Mill in Cucamonga, about 37 mi. (60 km) east of Downtown Los Angeles. The resulting seismic rebar is then used to build highways and bridges. Since 2006, Luis Alberto Paredes of Bogota, one of Colombia's top musical instrument makers, has fashioned "escopetarras" (Spanish) shotgun into electric guitars from decommissioned Kalashnikov AK-47 rifles used by fighters caught up in the country's lingering guerilla conflict. He was inspired by local musician Cesar Lopez who says the idea came to him after the 2003 rebel car bombing of a Bogota social club that killed 36 people. Facing a soldier with a rifle outside the wrecked club, the musician noted the similarities between the weapon and his own guitar. As part of a United Nations program to promote peace, Paredes receives the decommissioned rifles with the parts welded together for safety.

For seventy years, the Swedish aid organization IM Swedish Development Partner has vast experience of in countries struggling with armed violence. In November 2016, IM Swedish Development Partner's Peter introduced Humanium Metal (Hu) from destructed illegal firearms and available for commercial mass-production. The first weapons destruction program dedicated to Humanium Metal by IM involving the melting 1825 illegal firearms. was held in November 2016 in El Salvador. closely with the Salvadoran authorities, IM produced 110,000 lbs (50,000 kg.) of "Peace Metal" Humanium. IM has since then worked closely with five Swedish brands to use Humanium in their products, including a wristwatch by Triwa and headphones by Yevo. A second destruction program took place in Guatemala in early 2018, with Brazil and Colombia to follow. Humanium 316 SL Stainless Steel Powder has been developed for use in 3-D Printing. Artist To of Falkirk, Scotland is using Hu alloy in his sculptures. All products with Humanium go towards funding for victims and projects aiming to rebuild conflict- societies. From November 2019, UNODA's Department of Disarmament Humanium Metal a

permanent stand in its permanent disarmament exhibition, visited by over 250,000 people each year at the UN headquarters in New York. (*humanium.org)*

Elizabeth MacBride, "Swedish Entrepreneurs Are Melting 10,000 Crime Guns From El Salvador To Watches," *Forbes,* July 16, 2018.

Human hair, crude oil absorbent

Problem: Oil spills a number of effects on the environment and economy. On a level, oil spill effects will damage waterways, life and plants and animals on the .

Solution: Human hair is naturally absorbent and can soak up three to nine times its weight in oil. In 2000, Lisa and Patrice Gautier, founders of the MatterOfTrust charity, launched their Clean program collecting 370,000 lb (175 tonnes) of human hair, fur, and fleece clippings from thousands of salons, pet groomers, farmers, which would normally get swept up off the floor and thrown in the trash. Instead they were stuffed into mesh or nylon casings, which in turn were loaded into wire crates so creating improvised containment booms with one aim in mind: to control oil spills. Approved by the United States Environmental Protection Agency, this solution was first used to contain an oil in the Philippines in 2006, when prisoners in Manila even shaved their heads and chests to hair to the clean-up effort. It was also used on the Cosco Busan Oil Spill in San Francisco Bay (2007) and BP Deepwater Horizon off New (2010) in the Gulf of Mexico. *(matteroftrust.org)*

The solution has been developed since 2015 by Thierry , a hairdresser in Saint-Zacharie near Aubagne, south-eastern whose “Coiffeurs Justes” Association has persuaded 1,000 salons across to send in their hair off cuts to be woven into -pollution filters. With 11 tons (10 tonnes) of hair, Coiffures Justes can produce squares of 40/40 on 0.8 in (2 cm) of thickness for stuffing into women’s pantyhose either to absorb oil spills, or to clean up run-off from roads, industrial areas and highways. After having served several times as a hydrocarbon filter, as it is human hair, it can be washed then used as a concrete reinforcer.*(coiffeurs-justes.com)*

Investigation reveals that African hair first, followed by Asian hair and finally, European hair with an adsorption capacity of 7470, 6176 and 5246mg/g for crude oil respectively. It has also been found that both waste chicken feathers, of which 5.5 milllion tons (5 million tonnes) of waste chicken feathers are generated annually around the globe, and coconut coir are equally effective absorbents.

Peter Rowland Ukotije-IkWut et al., "A Novel Method for Adsorption using Human Hair as a Natural Oil Spill Sorbent," *International Journal of Scientific and Engineering Research* 7(8), September 2016; matteroftrust.org; "Coiffeurs justes" recycle les cheveux, avisée-info.fr, November 5, 2019 ;

Hurricane-reducing vessels

Problem: Of climate catastrophes, hurricanes caused by far the most damage. Damage from hurricanes hitting the U.S. between 1980 and April 2018 totals US$862 billion. The cost of an average hurricane is US$21.6 billion. Hurricane *Katrina* is by far the costliest and most devastating storm in U.S. history Hurricane While casualties from hurricanes since 1900 numbered from a handful of fatalities to deaths in the low hundreds, *Katrina* resulted in 1,833 deaths. Damage from the storm is estimated at US$160 billion, shattering 2017's second place *Harvey*, which caused US$125 billion in damage.

Solution: After observing the damage wrought by *Katrina,* Stephen Hugh Salter, an emeritus professor of engineering design at the University of Edinburgh in Scotland, began to study how to disperse hurricanes. For temperatures, the magic number for hurricane formation is 26.5° C (79.7° F). So what if you could that number down early on and reduce the risks and intensities of ensuing storms? To cool the surface of the , Salter invented a - powered pump that would move warm surface water down to depths as far as about 650 ft. (200 m.). It would be made from a 150 - 330 ft (50- 100 m.) diameter ring of thousands of tyres lashed together to support giant plastic tubes which extend 300 ft (100m) deep into the ocean . The naturally working pumps would be located in "hurricane alley", the warm corridor in the Atlantic through which the most damaging storms typically develop and pass. Salter estimated that about 150-450 of these structures would be required. They would drift around and send out radar signals so that no one would collide with them.

What became known as the “Salter Sink” was first presented to the US Government in 2005 at a post-*Katrina* US Homeland Security meeting on hurricane suppression. It was picked up and developed by Intellectual Ventures, a Seattle-based new tech company led by former Microsoft chief technology officer Nathan Myhrvold. Despite devastating hurricanes such as (September 2019) which destroyed the Bahamas, the Salter Sink” system has not been trialled except with 1/100 scale tests.

Stephen Salter’s other tactic for fighting hurricanes is making clouds a tiny bit brighter using aerosols, harnessing a phenomenon called the Twomey effect. Twomey observed that for clouds containing the same amount of moisture, the clouds with smaller suspended water droplets reflect more sunlight. The increased sunlight reflectance in the sky would keep the waters below from warming up to the hurricane threshold while also curbing evaporation, thereby reducing the atmospheric moisture needed to a storm. with John Latham, Salter proposes a fleet of around 1,500 unmanned Rotor ships, or Flettner ships, that would spray mist created from seawater into the air at a of approximately 1760 ft3 (50 m^3) per second over a large portion of Earth's surface. The -scale test would affect an area of 10,000 km^2. The power for the rotors and the ship could be generated from underwater turbines. Subsequent researchers determined that transport efficiency was relevant for use at scale, and that for research requirements, standard ships could be used for transport.

Salter estimated that it would cost US$40 million to construct a prototype cloud seeding system but has not been able to find any public or private takers. Despite this, since 2012, a Cloud Brightening Project (MCBP) team has been meeting on a weekly at a lab in Sunnyvale, California. In 2017 Salter held talks with major Scottish engineering firms Ferguson Port, Glasgow and Clyde Blowers about building his spray vessel 'weather machines'. A prototype is still to be built and tested.

“If we can put them in the right place at the right time, 300 ships spraying 10 cubic m. a second would put sea surface temperature back to where they used to be. We would need a few thousand is we are criminally stupid enough to double CO_2.” (Commuication from S Salter, December 12, 2019)

Meanwhile, a wind engineering team led by Arindam Gan Chowdhury and Andrew W. Conklin at the International Hurricane Research Center (IHRC) and College of Engineering and Computing (CEC) at Florida International University has been working at a full-scale large 12-fan "Wall of Wind (WoW) facility, testing building materials and designs against Category 5 hurricane-strength winds on the Saffir-Simpson Hurricane Wind Scale. The Wall began with two , then six and finally twelve fans to simulate wind-driven rain. Current WoW projects, funded by federal and state agencies and by private industry, are offering focus and leadership in the urgently needed hurricane engineering research and education from an integrative perspective to quantify and communicate hurricane risks and losses, mitigate hurricane impacts on the built environment, and enhance sustainability of infrastructure and business enterprise, including residential buildings, low- commercial buildings, power lines, traffic signals, etc. s. The team has a patent pending for a new type of roofing material. Additionally, recommendations made as a result of Wall of Wind testing were published in the 2010 Florida Building Code. The new code provisions are geared toward decreasing the vulnerability of roofs and rooftop equipment. *(eng.ed.ac.uk)*

Stephen Salter, cloud brightening | *TEDxHeriotWattUniversity* Nov 15, 2016; Stephen P. Leatherman, Arindam Gan Chowdhury, "Wall of Wind Full-Scale Destructive Testing of Coastal Houses and Hurricane Damage Mitigation" *Journal of Coastal Research* 23(5) · October 2007.

HyBalance

Problem:

The rapid increase in the use of fossil energy and the associated environmental impact have created a need for new ecological forms of energy, especially for industrial sectors.

Solution:

Hydrogen generated by sustainable energies

A consortium of 6 competent partners from Europe demonstrates how this could be possible. Under the coordination of Air Liquide, the HyBalance project developed in Denmark has brought together a group of partners - Hydrogenics, LBST, Neas Energy, and Hydrogen Valley to construct one of the largest carbon-

free hydrogen production units in Europe. Since 2018, this plant has been producing 130 tons of hydrogen from PEM water electrolysis

Hybrid Energy Park

Problem: Sustainable energy systems such as solar panels, wind turbines and batteries and bicycles on their own are not as effective as optimising synergies between them in a given area.

Solution: Led by Lara Depla, originally from Nijmegen, the Swedish company, Vattenfall, (Swedish for "waterfall") is building a new hybrid energy park, consisting of solar panels, wind turbines and batteries at Haringvliet a flat inlet of the North Sea in South Holland. From February 2020, despite stormy weather, the first of the building work on the energy park involved installing a total of six wind turbines in the north of Goeree-Overflakkee island between Middelharnis and Stad aan 't Haringvliet. The power output of the wind farm is expected to be in the region of 22 MW, which is enough to supply green electricity to around 27,000 households. The maximum height of the wind turbines is 150 meters. While these were tested and optimized in work began installing the solar farm, consisting of 115,000 solar panels with a total of 38 MW – enough to supply green electricity to around 12,000 households. The batteries – supplied by BMW and with a capacity of 12 MWh – will be installed in 12 shipping containers on the solar farm. The amount of green electricity that the energy park will produce corresponds to the annual consumption of 39,000 households. Vattenfall has considered the experiences of cyclists and walkers in the area: they were allowed to contribute ideas for the construction of a cycle path and a view hill, and the solar panels were no higher 1,5 metres so that all passers-by can see over them. Vattenfall is even installing beehives. *(group.vattenfall.com)*

Hybrid solar energy converter

Solution: Matthew Escarra, associate professor of physics and engineering physics at Tulane University in New Orleans , Louisiana

(sse.tulane.edu), and Daniel Codd, associate professor of mechanical engineering at the University of San Diego *(sandiego.edu)*, with researchers from -Spectrolab and Otherlab, developed a hybrid solar energy converter that generates electricity and steam with high efficiency and low cost. The hybrid solar energy converter features a solar module with glowing red cells. Funded by the U.S. Department of Energy ARPA-E project, the system demonstrated 85.1% efficiency, delivered steam at up to 248°C, and is projected to a system levelized cost of 3 cents per kilowatt hour. With follow-on funding from the Louisiana Board of Regents and Reactwell, a local commercialization partner (*reactwell.com*), the team is continuing to refine the technology and move towards pilot-scale validation.

"Solar Cogeneration of Electricity with High-Temperature Process Heat," *Cell Reports Physical Science* July 15, 2020; Barri Bronston, "Tulane scientists build high-performing hybrid solar energy converter," Tulane University, July 15, 2020.

Hydro-electric dam, underground

Problem:

Hydro-electric dams disrupt the natural ecology of rivers, damage forests, and biodiversity, release amounts of greenhouse gases, as well as displace thousands of people while disrupting food systems, water quality and agriculture.

Solution:

Underground hydropower

The Romanches Gavet dam, in Isère is the largest underground dam in also the last major EDF hydropower project. After ten years' work, the installation, with a gallery 10 km underneath the Belle mountain, was officially inaugurated on 9th October 2020.

With a capacity of 97 megawatts, the 92-ton turbine, -Gavet hydroelectric plant, operated and maintained by a team of approximately twenty EDF Hydro Alpes technicians and engineers, can increase power output by 40% the stretch of river (La).

Its output will equate to the amount of power consumed every year by the cities of Grenoble and Chambéry (230 000 inhabitants), using a decarbonised and renewable energy source.

In addition, it replaces 6 old plants and 5 old dams. Nature has been restored the banks of the dam by replanting species that were gathered within a radius of 25 kilometres in to prevent the proliferation of invasive plants.

Hydro-powered spiral water pump

Problem: How to pump water to higher grounds without requiring any fuel or electricity and with virtually no maintenance?

Solution: Pratap Thapa, got his idea growing up in Nepal where his family a farm on the slopes adjacent to the Lele River. Nepal is a country of 6,000 rivers, but people have to struggle because of geography. Despite their proximity to the river, they find difficulty providing water to nourish their , wheat, and potato crops. To move water from the river to their elevated field required expensive, polluting gasoline or diesel pumps

Thapa, a lecturer at Kathmandu University in Nepal left home to pursue a master's degree at Delft University of Technology in the Netherlands, where he founded the startup company aQysta and brought together a team to research solutions to this problem. Their brainchild – a 5 ft (1.5 m) diameter river-powered pump that channels the river's energy to lift water up to a vertical head of 65 ft (20 m) to agricultural fields - has no operating , requires little maintenance and is emission-free. They called it the Barsha Pump after the Nepalese word for "" and took out a patent on it.

By 2014 aQysta had built and was testing six river-powered Barsha pumps in different parts of Nepal. These proved the concept when they scooped up the river water, pumping it to farm fields up to 2 mi (3 km) inland. In one day one Barsha pump could pump 11,000 gallons (43,000 liters). In that it can pump to a higher level a small proportion of the water flowing, it is impossible to pump all or most of the water out of the river.
aQysta won a grant from the US-Swedish-Dutch programme Securing Water for

Food (SWFF). This programme is supported by the U.S. Agency for International Development (USAID), Sweden's development agency (Sida), and the Ministry of Affairs of the Kingdom of The Netherlands (MFA-NL). aQysta had been selected as one of the 17 awardees from 520 applications from over 90 countries. During the next five years, aQysta has exported 300 Barsha Pumps to 18 countries globally including Nepal, Indonesia, Spain and Zambia. Whenever a Barsha pump was implemented, farmers could farm different cash crops in the dry season as well, helping to increase their income level. So far, 5,000 users are benefiting. Eventually, the company hopes to scale up to mass production and offer the technology to small-to-mid-size farmers in four countries: Nepal, Ecuador, Indonesia, and Spain. *(aqysta.com)*

Frederik Leonardus Henny, Lennart Thore Budelmann, Pratap Thapa : Patent: Hydro-powered Spiral Pump driven solely by the water flow of streams, rivers or canals 2013 US20160238017A1

Hydrofluoroolefin (HFO) propellants

Problem: Since the 1930s, the millions of commercially produced aerosol spray , refrigerators, air conditioners and solvents had been using a group of inert industrial chemicals called chlorofluorocarbons (CFCs) . In the early 1970s, several scientists, F Sherwood Rowland, Paul Crutzen and Mario J. Molina at the University of California Tomorrow'sed that these gases rising into the sky were depleting the stratospheric layer. This layer prevents the most harmful wavelengths of ultraviolet light from passing through the Earth's atmosphere. The chlorocarbons were posing a major threat to human, animal and plant life everywhere, such as carcinogenic effects on exposed humans. In 1978, several nations banned the use of HFCs in aerosol spray . New propellants had to be found. Although the hole in the ozone layer has begun to shrink, measures must be taken. As of 2016, the U.S. Environmental Protection Agency has been banning three HFC propellants: HFC-125, HFC-134a, and HFC-227ea. Exceptions are in place for certain industrial and medical uses. EPA is taking the action because the three HFCs are significant contributors to AGW, with up to 3,500 times the effect of carbon dioxide. The European Union is also acting to limit use of HFCs with high global warming potential.

Solution: The replacements are hydrofluoroolefin (HFO) refrigerants, categorized as having zero depletion potential (ODP) and low global warming potential (GWP) and so offer an environmentally friendly alternative to CFCs, HCFCs, and HFCs. HFOs also show promise as blowing agents, i.e. in production of insulation foams, food industry, construction materials, and others. The introduction of this product aerosols that use the three HFCs would not disappear with the banned propellants. HFO-1234ze has of the advantages of the HFCs but with a Global Warming Potential (GWP) that EPA sets at 6 and the Intergovernmental on Climate sets at 1.

Two companies making this are Honeywell and DuPont who invested hundreds of millions of dollars to develop, market and produce the coolant known as HFO-1234yf. In 2014 Honeywell announced that the company and its suppliers would invest about US$300 million to increase capacity for R1234yf, including building a new manufacturing plant for the refrigerant at Honeywell's existing Geismar location. Honeywell next entered into a supply agreement with Asahi Glass Company to increase production for the HFO R1234yf. AGC would manufacture the refrigerant in Japan, while Honeywell would sell the product to customers in the US, Europe and Asia. Under the agreement, AGC's production began in mid-2015. Nearly half a million automobiles are on the road today safely using HFO-1234yf, and by the end of 2014, the number of vehicles was expected to exceed 2 million. *(agc.com)*

Since then Honeywell's Solstice Propellant HFO-1234ze(E) is now used in various aerosol applications. Honeywell Solstice yf Refrigerant is specifically tailored for the automotive industry for use as a refrigerant in car air conditioning systems. With a GWP of 4 – a fraction of the AGW impact of R 134a– it provides the cooling comfort that consumers depend on and surpasses EU standards. Automotive air conditioning systems that use Solstice yf Refrigerant are generally energy efficient competing technologies. Their Solstice Gas Blowing Agent is a gaseous blowing agent that is used in extruded polystyrene board and one component foam applications. In May 2017, Honeywell International Inc. announced the commercial operations execution at its new manufacturing unit in Geismar, Louisiana, U.S.A, to compete the increasing global demand for HFO-1234yf. *(honeywell-geismar.com)*

Kevin Desmond, *Planet Savers, 301 Extraordinary Environmentalists* (Sheffield, UK: Greenleaf, 2008), 168; Sandro R.P. da Rocha,"Understanding Solvation in the Low Global Warming

Hydrofluoroolefin HFO-1234ze Propellant" *The Journal of Physical Chemistry* B 118(36) · August 2014.

Hydrogen produced by modular nuclear power

Problem:

95% of the hydrogen produced in the world today comes directly from fossil fuels, with the biggest supply coming from steam methane reforming, where a mixture of steam and methane gas is put under high pressure while in contact with a nickel catalyst, to produce hydrogen, carbon monoxide and a small amount of carbon dioxide.

Solution:

Modular nuclear reactors for producing cost-competitive hydrogen.

at the Idaho National Laboratory, a team led by Dr José Reyes, an internationally recognized expert on passive safety system design, testing and operations for nuclear power plants, has developed a passively-cooled small nuclear reactor to produce hydrogen.

Water is heated to a temperature of 300 °C (572 °F) by the reactor and then the temperature of the steam is increased to 860 °C (1,580 °F) using two percent (around 1.8 MW) of the reactor's electrical output. This is then put through a high-temperature steam electrolysis system that works like a fuel cell in reverse. By pumping thermal energy into the system, the water breaks up into hydrogen and rather combining the gases into water to get out energy.

Encoruaged that a single small Nuclear Power Module (NPM) could economically produce almost 50 tonnes of hydrogen fuel per day, Reyes and Paul G. Lorenzini founded NuScale Power in Tigard, to the solution from laboratory to plant.

Each NuScale reactor vessel would measure 9 feet (2.7 m) in diameter and 65 feet (20 m) tall, weighing 650 short tons (590 metric tons). The modules would be pre-fabricated, delivered by railcar, or special trucks and assembled on-site. The units were designed to produce 60 megawatts of electricity each and require refueling with standard 4.95 percent enriched uranium-235 fuel every two years. In addition, a single NPM would reduce carbon dioxide emissions by 168,000 tonnes per year.

NuScale says that its nuclear modules are designed to scale up by adding as of the factory-built nuclear reactors as needed at a site. One, five, a dozen, or such reactors could be installed on a site smaller a conventional power station and located almost anywhere.

In August 2020, the NRC issued a final safety evaluation report for NuScale's small modular reactor design, certifying the design as having met the NRC's safety requirements. NuScale plans to apply for a standard design approval of a 60-megawatt-per-module version of the design in 2022, which if accepted will allow the company to pursue its first reactor deployment in the mid-2020s.

Hydrogen batteries ()

Problem: How to store solar energy and sell it on the electricity market during peak demand when the sun does not shine.

Solution: A research team led by Kondo-Francois Aguey-Zinsou at the Material Energy Research Laboratory in nanoscale (MERLin), part of the School of Chemical Engineering at the University of New South Wales *(merlin.unsw.edu.au)* has spent twelve years developing metal alloys (particularly titanium with other common materials) capable of surplus electricity in the form of hydrogen much cheaply lithium batteries. The system uses solar power to create hydrogen, 3 mass % of which can be stored over 10 years until needed for electricity production via a fuel cell. The solid-state mix can operate in a of temperatures, from -10° to +50° – depending on the climate the is intended for. Since 2016, Aguey-Zinsou has secured over $3 million in funding and established the EnergyH Project, a hydrogen research laboratory unique to the Australia scene. In 2020, with UNSW’s Hydrogen Energy Research Centre backed by $10 million from Providence Asset Group, this solid state hydrogen technology will be trialled at the community solar farm at Manilla, near Tamworth to store hydrogen in 20 ft (6 m) containers with an energy density of 17MWh becoming the first of this kind in the world in terms of scale. The startup, H2Store plans to produce the world's first hydrogen batteries, -named LAVO, for households as soon as early 2021, eventually freeing Australia of its dependence on coal.*(h2store.tech)*

Peter Hannam, 'Alchemy of energy': Breakthrough offers mass hydrogen options”, *The Sydney Herald*, July 3, 2020; Kondo-Francois Aguey-Zinsou and Paul Brockbank, “Hydrogen Combustion Catalyst, Process And Device,” Australian Patent application N° AU2016904855, Filed 2016.

Hydrogen-Gas turbines, clean power generation

Solution: According to researchers at Carnegie Mellon University, carbon emissions from the U.S. power sector dropped 30 % since 2005, because of a combination of natural gas and renewable power replacing retiring coal-fired power plants. The American subsidiary of Japan's Mitsubishi Hitachi Power Systems (MHPS) in , Florida has been instrumental in this transition. Mitsubishi Hitachi Power Systems is a world leader in Systems and Catalyst technology with over 40 years of experience and 1,000 systems worldwide. As a next step in decarbonization, MHPS has developed gas turbine technology that enables a mixture of renewable hydrogen and natural gas to produce power with even lower carbon emissions. Hydrogen, the key to unlocking cleaner power, is a new energy source that does not emit CO_2 when combusted.

The first commercial-scale power station in the world fueled with pure hydrogen is located in Fusina, near Venice in the Veneto region of Italy. Operated by Enel, construction of the power station started in April 2008 and it became operational in August 2009. An additional 4 MW has been generated in the adjacent Andrea Palladio Power Station through the reuse of steam produced by the hydrogen-fueled turbine. MHPS's -scale hydrogen-fueled power plants are the world's closest to making carbon-free power generation a reality.

Italy's energy infrastructure operator, SNAM, and the Florence branch of U.S firm, Baker Hughes completed testing on the world's first hybrid hydrogen turbine, the *NovaLT12,* for natural gas networks. Installed at SNAM's gas compressor station in Istrana, Italy, this will enable up to 10% hydrogen to be blended with natural gas within its pipeline network infrastructure. installed, the *NovaLT12* will not help to compress and move hydrogen fuel blends through SNAM's transmission network of pipelines, but the turbine will simultaneously use the fuel to power itself. SNAM estimates as much as 7 billion cubic meters of hydrogen could be introduced into the network annually, representing a reduction of 5 million tonnes of carbon dioxide emissions.

In 2019, MHPS with Magnum Development of Utah began work on an building an Advanced Clean Energy (ACES) project in a salt cavern in central Utah, which reportedly is roughly 1 mi (1.6 km) deep and 3 mi (4.8 km) across.

Combining compressed air energy , flow batteries, solid oxide fuel cells and renewable hydrogen , in operation, the ACES will produce 1,000 MWs of completely clean energy for technologies and strategies in the quest to decarbonise the power grid of the Western US. When gas turbines powered with renewable hydrogen are added to a hydrogen salt-dome, a solution is obtained that stores and generates electricity with zero carbon emissions

Elsewhere, to continue the decarbonization of Illinois' Electric Power Grid, J-Power ordered two MHPS 1 on 1 M501JAC power trains for the 1,298 MW Jackson Generation Project in Elwood. To complement increased renewable generation, the Jackson Generation Project will also feature MHPS-TOMONI Very Low Load (VLL) technology, which enables each 1 on 1 power to operate at less 25% of full load while remaining in emissions compliance. This allows the Jackson Generation Project to operate at a very low output during times of high wind or solar generation, and be ready to up quickly to full load when the renewable resources decline. The result is reduced emissions, reduced maintenance, and reduced operating .

In the UK, Phillips 66 (Houston, Tex.), Uniper SE (Düsseldorf, Germany) and VPI Immingham (a Vitol company) are co-developing Humber Zero, a -scale decarbonization project that is fully aligned with the wider Humber Industrial Decarbonization Deployment Project (Humber DP). Humber Zero is supported by the expertise of the Wood Group, Imperial College, London and the University of Sheffield and is part of Innovate UK's Industrial Strategy Challenge Fund competition in support of delivering 2050 Net Zero objectives. Initially, Humber Zero will decarbonize 8Mt per year of CO_2 emissions, with the potential to 30Mt of CO_2 emissions from the wider Humber Cluster to the west of the deep-water Immingham port, U.K.. Humber Zero's coastal location enables the efficient offtake of CO_2 into offshore depleted oil and gas fields and gives access to offshore wind developments for electrolysis. Furthermore, the project could decarbonise other efficient power stations and industry, such as British Steel, through the planned southern Humber pipeline . *(zerocarbonhumber.co.uk)*

In February 2020, MHPS and the Bandung Institute of Technology in Indonesia signed a MU on joint research for next-gen clean energy technologies and data analysis. The agreement aims to new fuel technologies using ammonia and hydrogen to reduce GHG emissions, and to enhance technologies for

diagnosing the operation of Indonesia's power plants through use of artificial intelligence (AI) and big data analysis. (*mhps.com* and *emissionsindex.org*)

"World's Largest Renewable Energy Project Announced in Utah," *MHPS*, May 30, 2019. jburke, "MHPS Delivering Power Trains For 1298 MW Project," *Diesel & Gas Turbine Worldwide,* July 2, 2019.

Hydrogen from salt and polluted water

Problem: One of the main methods of producing is to decompose water by exposure to sunlight. There is a lot of water on our planet, but a few methods suitable for salt or polluted water. In addition, few use the infrared spectrum, which is 43% of all sunlight

Solution: Scientists of Tomsk Polytechnic University's Research School of Chemistry & Applied Biomedical Sciences, jointly with teams from the University of Chemistry and Technology, and Jan Evangelista Purkyne University in Ústí nad Labem, developed a new 2-D material to produce hydrogen. The material efficiently generates hydrogen molecules from fresh, salt, and polluted water by exposure to sunlight. The developed material is a three-layer structure with a 1-micrometer thickness. The lower layer is a thin film of gold, the second one is of 10-nanometer platinum, and the third is a film of metal- frameworks of chromium compounds and molecules. Experiments demonstrated that 100 square centimeters of the material can generate 0.5 liters of hydrogen in an hour. It is one of the highest recorded for 2-D materials.

Guselnikova, O., Trelin, A., Miliutina, E., Elashnikov, R., Sajdl, P., Postnikov, P., Kolska, Z., Svorcik, V. & Lyutakov, O., "Plasmon-Induced Water Splitting - Through Flexible Hybrid 2D Architecture up to Hydrogen from Seawater under NIR Light," *ACS Applied Materials and Interfaces,* 24, 2020; Tomsk Polytechnic University, "New material can generate hydrogen from salt and polluted water," *physics.org*, July 21, 2020

Hydrogen from wind turbines

Solution: The "Deep Purple" project, backed by the Norwegian government will use offshore wind turbines to power an undersea electrolysis system which extracts hydrogen from seawater, stores it on the seabed and then transports it to stations on as needed. Fuel cells will then re-electrify the hydrogen to provide a clean source of power for offshore oil and gas platforms, with zero-emission shipping and seafood production and other potential

markets for green electricity produced. “Deep Purple” was first conceived in 2016 by TechnipFMC (an oil services company), Energy Valley (a Bergen-based technology cluster) and SINTEF(a research institution). They have been joined by Subsea Valley, Maritim Forening Sogn og and Hyon, a hydrogen power consultancy, to provide engineering services for the project, including technology qualification and subsea energy . The project timeline envisages a -scale onshore wind pilot from 2021, with a full-scale demonstrator running off Norway before the middle of the next decade.*(investinbergen.com)*

A similar approach has been taken by Matthieu Guesné of Nantes, with his start up Lyhfe. The prototype plant will be built at in the Vendée opposite Noirmoutier, an island in the Bay of Biscay. The objective of this first industrial pilot is as much to supply the region with hydrogen at a price of the full equivalent to that of gasoline at US$ 1.5 per liter, to refine its intermittent piloting technology renewable energies.

“New technology could Norway’s oil and gas cleaner,” *InvestBergen*, October 9, 2019.

Hydropower stations

supplemented by floating Solar power stations

Problem:

In times of drought, hydropower loses some of its electrical capacity, natural fluctuations in sunlight due to cloud cover and time of day reduces the efficiency of conventional pv panels, even floating.

Solution:

The hybrid integration of floating a PV plant (FPV) with a Hydroelectric Power plant (HPP)

Observing the 20 largest HPPs in the world, when FPVs cover just 10% of the HPP surfaces the HPP energy production is increased by 65%.

In December 2013, after nine months of construction, the 9 km2 Gonghe PV solar park was commissioned and connected to the power grid via the nearby

Longyangxia hydropower plant on the Yellow River, located in the arid north-west of China, in an area with vast solar resources.. This marks the first commercial operation of a -scale solar PV–hydro hybrid system.

The Longyangxia hydropower station was originally designed and commissioned in 1992 as the first load-peaking and frequency regulating power plant for the north-western power grid. The reservoir supports a 1,280 MW power station, with four 320 MW -response turbines which smooths the fluctuating output curve of the PV power,

In 2016, Energias de Portugal (EDP), a member of IHA, began a pilot project to add floatovoltaics at the Alto Rabagão pumped project, in Montalegre, northern Portugal, to assess the technical and economic feasibility for potential future -scale PV installations.

The pilot project comprised of 840 PV panels occupying a total area of 2500m_2, with an installed capacity of 220 kW and estimated annual output of 300 MWh. The Alto Rabagão dam, a pumped reservoir, was chosen for its size and adverse climatic conditions that allowed testing of the technology under the most technically demanding conditions. The performance tests for the installation ended in 2017 and the project was considered a success.

In Catania, Sicily, a team led by Giuseppe Marco Tina of the University of Catania with Enel Green Power, the renewable energy unit of Italian utility Enel, has deployed a 30 kW floating PV system in Catania, Sicily to test several solar module technologies. This includes the coupling of floating PV with hydropower to help Enel to reduce its

According to an analysis by researchers at the US Department of Energy's National Renewable Energy Laboratory (NREL), adding floating solar panels to of water that are already home to hydropower stations could produce as much as 7.6 terawatts of potential power a year from the solar PV systems , or about 10,600 terawatt-hours of potential annual generation. Those figures do not include the amount generated from hydropower.

NREL estimates 379,068 freshwater hydropower reservoirs across the planet could host combined floating PV sites with existing hydropower facilities. Additional siting data is needed prior to any implementation because some reservoirs may be dry during parts of the year or may not be otherwise conducive to hosting floating PV.

Hyperloop

Problem: Any effort to increase mass transit decreases energy consumed by invidual vehicle owners. Most transit uses electrical energy.

Solution: In 2013, Tesla electric sportscar maker, Elon Musk re-invented a passenger that would be faster trains, safer cars and much less damaging to the environment aircraft. He called it *Hyperloop.* It incorporates reduced-pressure tubes in which pressurized capsules, travelling at up to 620 mph (1000 kph) on air bearings driven by linear induction motors and axial compressors. Musk proposed a running from the Los Angeles region to the San Francisco Bay Area, roughly following the Interstate 5 corridor. An agreement was signed in 2017 to co-develop a Hyperloop between Seoul and Busan in South Korea. Although Musk originally envisaged his Hyperloop system used by cars and personal pods, in 2018 he announced that instead it would give first place to pedestrians and cyclists. The tunnels would transport cars, but only after all personalized mass transit needs have been met. His Co. loop system would 1000's of small stations the size of a single parking space that the 124 mph (200 kph), midibus rider very close to their destination & blend seamlessly into the fabric of a city, rather like a small number of big stations such as a subway. Where the Hyperloop differs from high-speed is that Musk has proposed scattering Hyperloop entrances connecting cities akin to subway stops rather halls, and that it was for "personal transit". The downside would that the machines building Hyperloop will use electricity.

On November 8th 2020, the renamed Virgin Hyperloop its first 100 mph passenger carrying trial at the company's DevLoop test track in the desert outside Las Vegas, in the Nevada desert. The first two passengers were Virgin Hyperloop's chief technology officer and co-founder, Josh Giegel, and head of passenger experience, Sara Luchian. *(hyperloop-one.com)*

Parallel to Musk's Hyperloop, China is building an experimental maglev which by using vacuum-sealed tunnels, would reach speeds of 620 mph. The prototype, laid in the central province of Hubei in early 2020 will be capable of reducing time from Hubei's capital city, Wuhan, to the near-coastal city of Guangzhou, to just under two hours for a distance 1,367 mi. (2,200 km.). Hubei

expects to start testing 124 mi (200 km.) sections of these vacuum tunnels in 2020 to "to verify the cutting-edge, high-temperature superconducting maglev theory and ultimately push the speed limit to 620 mph (1,000 kph).

Iceberg-towing tugs

Problem: The volume of water that breaks off Antarctica as icebergs each year is greater the total global consumption of freshwater. This does not include Arctic ice. According to a recent National Geographic report, "the towering glaciers" of west Antarctica "are crumbling and melting, the speeding up over the decades and imperiling the stability of the entire ice sheet." Greenland is also reported to be losing its ice sheet at an alarming . With Europe's heatwave reaching the Arctic, 11 billion tons (10 billion tonnes) of Greenland's surface ice was lost to the sea in the biggest melt of the summer. This is pure freshwater, effectively wasted as it melts into the sea and contributes to rising sea levels. icebergs come out of Antarctica the total global consumption of freshwater. Every year this is around 140,000 icebergs, or 2,000 billion ton (1800 billion tonnes) of ice. These all melt in the sea.

Solution : This untapped flow of water has enticed scientists and entrepreneurs for over a century. There were 19th-Century schemes to deliver by steam-boat to India, and to supply breweries in Chile. In the 1940s, John Isaacs of the Scripps Oceanographic Institute proposed towing an iceberg to San Diego to quench a Californian drought. The EU received proposals in the 2010s to tow an iceberg from Newfoundland to the Canary Islands.

The latest iceberg-towing schemes to emerge come from Cape Town and the United Arab Emirates – two regions suffering from extreme and persistent water shortages. In the spring of 2018, Town ominously near to 'Day Zero', the day the reservoirs could dry up and a city of four million people would run out of water. Personal use of water was limited to 50 liters per day. When the finally

, Day Zero was averted, but perhaps for another year. Meanwhile in the UAE, one of the world's most arid states, the energy minister has declared water consumption a " concern" for the country, and that they were trying to find alternatives.

Since 1975, Saudi Prince Mohamed Al-Faisal, a nephew of the Saudi , has wanted to tow an Antarctic iceberg across the equator to Saudi Arabia, and funded two international conferences on the subject. He enlisted the help of French engineer Georges Mougin with other engineers and a polar explorer, in a venture called "Iceberg Transport International." Faisal planned on wrapping a 100-million-ton iceberg in sailcloth and plastic to keep it cool and tugging it from the North Pole to the Red Sea, though the cost was estimated at an exorbitant US$100 million. For a swank conference on "iceberg utilization," he even managed to ship, via helicopter, plane , and truck, a two-ton "mini-berg" from Alaska to Iowa, where the giant block of ice was chipped apart to chill delegates' drinks. According to a *Time* report from October of 1977, Faisal predicted that he would an iceberg in Arabia "within three years."

Twenty years later Emirati businessman Abdulla Alshehi began to fund a project to ship an enormous Antarctic iceberg all the way to Perth. The 10-month endeavour will see an iceberg, measuring approximately 1.5 mi (2 km) by 540 yd (500 m), by tugboat from Antarctic waters to the Arabian Gulf. It uses 3-D technology, recently declassified satellite data, and the new science of forecasting. The body could lose 30 % of its mass on the way over, but the Emirati "ice pirate" said enough would be left over to provide fresh water to one million UAE residents over five years. The trial is set to place in either Perth or Town and if successful will see an even bigger chunk towed via tugboat to the Fujairah coast in the UAE. Generally, the weight of icebergs from 100,000-200,000 metric tons. An iceberg of that size can contain almost 25 to 50 million gallons (100 to 200 million liters) of fresh water. This would be a boon to the UAE which receives just 4 in (10 cm) of precipitation annually and receives much of its potable water from desalination.

. In addition to providing water, the company hopes the introduction of the icebergs will make an impact on the environment. They claimed that melting icebergs will release freshwater into the Arabian Sea in a strategy intended to "rebuild ecological balance, reduce seawater salinity caused by discharge from desalination plants and restore biodiversity." The UAE The company also claims

that cold air from the iceberg parked off the coast could the climate of the desert nations, generating year-round rainstorms.

Abdulla Alshehi, “Filling the Empty Quarter: Declaring a Green Jihad On the Desert, 2013; “Will an Emirati businessman succeed in towing an iceberg to the UAE?,” *euronews,* July 5, 2019.

Ice arenas

Problem:

Canada is home to nearly 8,000 indoor and outdoor ice arenas and the USA close behind with 2000 rinks, according to the International Ice Hockey Federation. All depend on electrically produced manmade ice, requiring high maintenance and energy consumption.

Solutions:

REALice, developed and patented by Curt Hallberg and Morten Ovesen at Watreco Ab in Åkarp, Sweden is Vortex process, air bubble-free water treatment system that uses unheated water to resurface ice rinks, reducing an arena’s natural gas by 79% and its electricity consumption by 12% – all without sacrificing ice quality. 300 ice arenas across the globe use the technology.

Through REALice technology, Ice Box , in Kamloops, British Columbia, has conserved about 55,000 kWh of electricity, enough to power a home for almost five years, according to the U.S. Energy Information Administration.

Synthetic ice is sometimes called artificial ice, is marketed under names including Glice, Xtraice, and PolyGlide Ice.

In 2010, Toni Vera, an ice hockey player and engineer of Seville, Spain was appalled by the enormous amounts of energy and water needed for the production of conventional ice.

He up with a polyethylene compound laminated both sides of 2' X 4' plywood panels, that are laid in a interlocking' pattern with imperceptible seams. When one side wears out, the panels can be flipped over and the other side used. Vera’s solution uses no power, water, chemicals or resurfacing equipment to operate and offers an ecological and economical alternative to refrigerated ice.

Vera was joined by Viktor Meier of Lucerne, Switzerland to start up Glice which since 2012, has installed 2,000 Glice Eco Skating Rinks in 85 countries from classical winter sport nations to the tropics.

One example was Mexico City, when on December 16, 2019 the world's largest skating was on the city's main square, known as Zócalo. Compared to a conventional ice of the size, this 43,000 square foot Glice saved 49,000 gallons (360,000 litres) of water and eliminate electrical energy consumption equal to about 4,000 average households.

That represents a reduction of about 95 tons of CO2 emissions connected with electrical power generation. This Zócalo was installed in less 24 hours; in contrast a refrigerated of this size can weeks to install.

Ideal Plant

Problem: The quest is on to Tomorrow's which plant is best capable of capturing and carbon and in so , combined with other global efforts, to mitigate the disastrous effects of climate while providing food.

Solution: At the Salk Insitute for Biological Sciences in La Jolla, California, the Harnessing Plants Initiative, a team of plant biologists, experts in genetics, chemistry, epigenetics and , led by renowned microbiologist Chory, is investigating the *suberin* molecule, found in cork and cantaloupe rinds, is a naturally occurring carbon-rich substance found in plant roots. It absorbs carbon yet resists decomposition (which releases carbon back into the atmosphere), enriches soil and helps plants resist stress. By encouraging plants to bigger, deeper, suberin-rich roots, Chory can them into fighting climate as they grow. The roots will store CO_2, and when farmers harvest their crops in the fall, those deep-buried roots will stay in the soil and keep their carbon sequestered in the dirt, potentially for hundreds of years. If Chory and her team can breed these Salk Ideal Plants and get them into the global agricultural food chain, they believe they can contribute a 20% to 46 % reduction in excess CO_2 emissions annually. Certain plants, such as cork trees, naturally produce a lot of suberin. But all plants produce some suberin — meaning it should be possible to find a that would prompt them to increase production. They to combine these traits

using traditional plant-breeding techniques first and possibly down the use editing techniques such as CRISPR to accelerate trait adoption. The team is trying to move fast in every way. the Salk team has developed ways to increase suberin in model plants, they will these genetic traits to six prevalent crops: , soybean, , wheat, cotton/cottonseed and rapeseed/canola.

In 2018, Chory was awarded prestigious Breakthrough Prize in Life Sciences for her pioneering work deciphering how plants optimize their growth, development and cellular structure to transform sunlight into chemical energy. On April 16, 2019 Salk Institute initiative received US$35 million funds through The Audacious Project, a New York City-based effort by the TED organization to support globe-changing innovation. Chory had presented the key elements in the Ideal Plant Initiative in a speech before an audience of 2,000 people attending the TED annual conference in Vancouver, BC. *(salk.edu)*

Also with the Salk Institutes Harnessing Plants Initiative (HPI) is CoverCress Inc of St Louis, Missouri. Collaborating with Salk, teams at both Illinois State University and the University of Minnesota used promising genes for increased root mass and carbon in *Arabidopsis*, a common lab species and a close relative of the native species of pennycress. CoverCress will enable farmers to grow an extra crop over the winter between and soybeans. In November 2020, Bezos Earth Fund $30 million and Sempra Energy $2 million to the Salk Institute to further develop the *Arabidopsis* program.

Like other cover crops, CoverCress provides farmers the environmental benefits of improved soil health and reduced soil erosion. However, unlike other cover crops, CoverCress also provides farmers economic benefits associated with earning a return by harvesting and selling CoverCress as well as the potential to participate in the new soil carbon markets that are developing.

The inclusion of HPI genes in CoverCress seed is expected to significantly the potential carbon sequestration of this new cash crop from the estimated one ton per that already occurs.

Harnessing Plants Initiative HPI estimates that if, worldwide, 70 percent of the crops are converted into carbon-sequestration-enhanced crop plants, 1.5 to 6 gigatons of CO^2 can be sequestered per year, the equivalent of up to as much as one-third of human-caused CO^2 emissions that accumulate in the atmosphere each year.

Adam Popescu, “This scientist thinks she has the key to curb climate : super plants.” *The Guardian,* April 16, 2019.

“Incredible Edible”

Problem: The importation of fruit and vegetables from abroad is an energy consuming business.

Solution: In March 2007, Pamela Warhurst, formerly Chair of Forestry Commission Great Britain, with Mary Clear and a group of like-minded people in Todmorden, West Yorkshire, UK, started to plant nut trees in their surroundings so they could be eaten locally. This project grew into The Incredible Edible Todmorden project, including the planting of soft fruit, herbs, edible flowers and vegetables as well. In 2010, the first Incredible Edible farm, a one plot, began to supply its fresh produce to local businesses. Before , vegetables were growing in of the police station, beside canal paths and even in the cemetery. By 2012, the Incredible Edible Network was formed to help manage and sustain existing groups as well as inspiring new ones. The Incredible Aquagarden demonstrated and taught urban farming. Since its emergence, the Incredible Edible idea has spread to hundreds of communities around the world. By 2016 100 groups and 600 globally had joined the Incredible Edible journey. In , for example, they are known as “Les Incroyables Comestibles” Today, there are 120 official Incredible Edible groups in the UK and over 700 in 30 countries worldwide. In 2018, 49 new UK Incredible Edible groups took their first steps. Since the Lockdown caused by COVID-19, the principle of Incredible Edible has taken on a new meaning and relevance. *(incedibleedible.org.uk)*

Paull, John (2011) "Incredible Edible Todmorden: Eating the Street", Farming Matters, 27(3):28-29.

Incubators

Problem: A solution needs to become a product to be effective.

Solution: Incubators are the places were ideas become businesses – where startups receive support and guidance as they tackle the market and search for

investment. There are hundreds of incubators around the world, of them helping to develop companies clean up, repair and protect our Planet.

Towards the end of the 1990s, Harry W. , a professor of plant biology and plant pathology at Rutgers University, New Jersey, organised a team to develop a high-tech "Clean Energy Innovation Center" as part of Rutgers' University in Bordentown, Burlington County. Called the EcoComplex, its mission was to help technologies to address the environmental issues facing New Jersey and to educate elementary and high school students on the importance of maximizing the Earth's resources. Dedicated on April 23rd 2001, the EcoComplex includes six wet-laboratories, a 120-seat auditorium, two classrooms, and a media room, financed by the New Jersey Legislature. Since then, it has served 1,000 companies, to , through its affiliated programs. These include the EcoIgnite Clean Energy Proof of Concept Center and Accelerator Program, which was established in 2017 with a $439,000 from the U.S. Department of Commerce to develop regional clean energy and energy efficiency business support system (sustainable biomass, wind, solar, and waste-based energy) The EcoComplex's business incubator segment was home to TerraCycle, which now operates in 20 countries and makes $2o million per year, according to NBIA's New Jersey chapter. The company moved into the EcoComplex in 2004. Three years later, the company was selling its products in Walmart and Home Depot. In 2018, The Rutgers EcoComplex was first in the Best Business Incubator Category in *NJBiz Magazine's* 2018 Reader Rankings. Rutgers Food Innovation Center was one of two other finalists also recognized in the "Best Business Incubator" category in the publication, New Jersey's leading business journal. 8,000 clients, colleagues and peers of businesses in New Jersey voted for the best organizations across 52 categories. *(ecocomplex.rutgers.edu)*

Infinite Loop factory

Problem: It will not be enough to recycle and reprocess plastic waste on a small to medium scale.

Solution. Adel Essadam of the family-run Loop Industries in Montreal, Canada has invented and patented a technology that depolymerizes no and low value waste PET plastic and polyester fibre, including plastic bottles and packaging, carpets and textiles of any colour, transparency or condition and even plastics that been degraded by the sun and salt, to its building blocks

(monomers). The monomers are filtered, purified and polymerized to create virgin-quality Loop™ PET resin and polyester fibre suitable for use in food-packaging, thus enabling our customers to meet their sustainability objectives.

In September 2020, Loop industries and Suez, headquartered in Paris, announced plans to build the first Infinite Loop recycling facility in Europe to respond to growth in demand in Europe from global beverage and consumer goods companies, committed to aggressive targets for a high level of recycled content in their products.

This new enhanced recycling facility dedicated to PET[1] plastic will be the largest in the world, with the potential to produce the equivalent of approximately 4.2 billion food beverage bottles[2] of 100% recycled and infinitely recyclable PET plastic annually.

Hatem Essaddam, "Polyethylene terephthalate depolymerization », *Loop Industries* US Patent N° 20170008826A1 2017.

Inhaler, dry powder system

Problem: In 2017, about 50 million inhalers were prescribed. Seven out of every 10 of them were metered-dose inhalers. A gas - hydrofluoroalkane - is used as a propellant to squirt the medicine out of the inhaler. Metered-dose inhalers account for nearly 4% of NHS GHG emissions.

Solution: Switching to "green" inhalers for conditions such as asthma could cut GHG emissions and reduce , a study suggests. A dry powder inhaler (DPI) is a type of inhaler commonly used to deliver medications such as inhaled corticosteroids into the lungs. This inhaler is breath-activated not gas-activated. The medication is released when the patient takes a deep, fast breath in through the inhaler. The researchers estimate replacing even one in every 10 of these inhalers with an environmentally friendly type (dry powder inhalers) would reduce carbon dioxide equivalent emissions by 64 tons (58 tonnes). In 2000 after several years of trials, 2000 Dura Pharmaceuticals Inc. of San Diego was issued U.S. Patent 6,116,237, covering methods of dry powder inhalation. Currently, there are three types of DPIs available: single-dose, multi-dose and reservoir-based design. Examples of multi-dose inhalers include the successful Diskhaler® from GlaxoSmithKline (GSK) which employs individual doses that are contained within blisters (four or eight blisters are standard) on a

discExamples of reservoir devices include: Easyhaler®, Ranbaxy UK Ltd; Clickhaler®, Vectura plc; and the Pulvinal by Chiesi Farmaceutici SpA, Italy.

:Insect food for animal and human consumption

Problem: Each year, around 70 million people are added to the world's population. If growth continues at this rate , by 2050 the population is expected to reach a whopping 9 billion. To feed all of those hungry mouths, agriculture and pisculture will need to produce almost twice as much food as they currently do.

Solution: Entomophagy (the consumption of insects) is a common practice that has been taking place for tens of thousands of years. Around 2 billion people regularly eat insects as part of their diet, and over 1,900 species are edible. The most commonly eaten bugs are beetles, caterpillars, bees, wasps and ants. The eggs, larvae, pupae, and adults of certain insects have been eaten by humans from prehistoric times to the present day. Around 3,000 ethnic groups practice entomophagy. Human insect-eating is common to cultures in most parts of the world, including Central and South America, Africa, Asia, Australia, and New Zealand. 80 % of the world's nations eat insects of 1,000 to 2,000 species

Consuming insects as opposed to livestock is environmentally friendly. Insects are cold-blooded and thus require less energy to maintain their internal body temperature. This means they are very efficient at converting feed into edible body mass, such as cattle. Crickets require around 4 lb (2 kg) of feed to produce 2.2 lb (1 kg) of meat, and around 80% is edible. Cattle, on the other , require 8 kg to produce the same amount of meat, but 40% of the cow can be consumed. This that less needs to be dedicated to growing feed for insects for livestock, reducing irrigation and pesticide use. Furthermore, the insects could even be used as livestock feed, for example replacing fishmeal. This would the added advantage of increasing fish supplies available for humans to eat. Insects emit less GHGs and can be cultivated on waste.

In the Netherlands in 2009, Kees Aarts and Tarique Arsiwalla founded Protix in Dongen, North Brabant, which was then the world's biggest automated

insect farm. Protix began by using *Hermetia Illucens* insects, otherwise known as the soldier fly although since 2017, the firm has added mealworm, cricket and locust ingredients through the acquisition of Fair Insects. In 2019 Protix opened a 150,000 ft² (14,000 m), US$ 500 million euro production plant and announced that it was looking to establish farms within two years. *(protix.eu)*

In , Antoine Hubert of Ynsect produces powdered insect protein in bulk from a small beetle, called mealworm for fish farming, pet food, and even the fertilizer industry. Originally a musician, inspired by the way he had seen New Zealand farms use worms for composting food waste, Hubert became an environmental activist, developing a science education and visiting schools to evangelise about the importance of insects in the food chain. Ynsect uses , artificial intelligence and techniques borrowed from vertical farming he can enough to this a mainstream protein source. Robots feed the stacked trays of mealworm larvae and them around the factory as they go through their two-to-three month growth cycle, until they are finally dipped into boiling water to kill and sterilise them. Ynsect raised US$125m in series-C funding in February to finance the building of a new 430,000 ft² (40,000 m²) vertical farm in Amiens in Northern , an of magnitude bigger the 32,000 ft² (3000 m²) facility it already has in the Burgundy region. The facility, dubbed FARMYING, enabled Ynsect to multiply its current production capacity by 50-times. The facility became be the new hub for 3 raw materials and nutritional suppliers, 1 larvae supplier, 2 research facilities, 4 tech suppliers (including Ynsect), a quality-control specialist, a sustainability consultant, an innovation consultant, 4 end-users and 3 international bio-economy consortiums. Ynsect plans to build 15 factories around the world over the next decade, in North America and South East Asia as well as Europe, producing at 1m tonnes of insect protein a year. That would be a tiny fraction of the 1 billion tonnes produced each year for animal feed. *(ynsect.com)*

The Aspire Food Group based in Austin, Texas, led by Mohammed Ashour pioneered the first -scale industrialized intensive farming entomophagy company in North America with a 25,000 ft² (2,300 m²) building where automated machinery breeds crickets. Each bin can hold about 10,000 to 15,000 crickets at a time. Since crickets take about a month to become big enough to harvest, Aspire produces roughly 22 million every month Aspire are part of the North American Coalition for Insect Agriculture. *(aspirefg.com)*

Chapul, founded by co-owners Ruth Arevalo and Seth Davis in Salt City created food bars based on ground crickets. Diverted agricultural waste streams are processed into dried insect larvae for food and fertilizer which in turn reduces agriculture water .

Pets are estimated to be consuming up to 20% of all meat globally. Pet owners are by vets to feed their dogs and cats on a diet rich in insects. The British Veterinary Association (BVA) says some insect-based foods may be better for pets prime . Farmed insect protein is typically raised on human food waste.

In terms of human consumption, by 2011, a few restaurants in the Western world regularly served insects. For example, two places in Vancouver, British Columbia, Canada, offered cricket-based items. Vij's Restaurant had parathas that are from roasted crickets that are ground into a powder or meal. Its sister restaurant, Restaurant, offered pizza that was by sprinkling whole roasted crickets on dough.

T Arsiwalla, KWP Aarts, “Method and System for Breeding Insects, Using a Plurality of Individual Crates,”, US Patent App. 14/785,452, 2016.

:Instead furniture

Problem:

Brewing used in making beer are partially reused (for breeding, compost, human food, etc.). In 2017, 300 million tonnes ended up fermenting in a waste reception center (figure based on French beer consumption in 2017, i.e. 2 billion liters.)

Solution:

Furniture out of wasted brewing

Cabinet designer and maker Franck Grossel, 27 years old, of St.-Quentin, Hauts-de-, has founded *Instead* to convert into a wide of variations (tables, bar stools, lamps, acoustic panels, particle boards, etc.) amplified by its technical characteristics (flexibility, resistance, malleability, impermeability, etc.) . Based on the colour of the beer brewed, from pale to dark stout, the colour of the furniture can be varied.

Instead was the 2020 laureate of the Banque Populaire Foundation.

Integrated floating aquageoponics system

Problem: Bangladesh is highly vulnerable to climate. Flooding regularly affects about 1 million people. One prediction is that by 2050 about 20 percent of the available will be permanently submerged under water.

Solution : In the lowlands of Bangladesh, people in the districts of Gopalganj, Barisal and Pirojpur are turning to a centuries-old traditional form of hydroponics, called floating vegetable gardens, called dhap, or known locally as baira.

During monsoons the farmers gather weeds like water hyacinth or paddy stalks, and place them on stagnant water, beating them into shape and making rafts. The plant bed, can be prepared in any depth of water and is built using several layers of water hyacinth and bamboo, although people are experimenting with the materials used to create the floating gardens, occasionally adding a system of inner tubes from car tyres and a bamboo framework for additional support. A dhap is typically 15-50m in length, 1.5-2m wide and 0.6-0.9m . but they can be as as 180ft (55m)

Semi-decomposed aquatic plants are then added to the mix and left to sit for several days before it is ready to be seeded. Farmers plant seedlings on these beds, and place them in flooded parts of the villages. The floating farms must be built every year, but the debris that is left behind is used as fertilizer during the dry season.

In 2013, the government of Bangladesh approved a $1.6m project to promote floating farms for climate adaptation. The project took place in around 50 locations around the country covering 12,000 families in eight districts. Today, about 50,000 farmers are involved in the floating farm sector. In December 2015, the UN's Food and Agricultural Organization declared Bangladesh's floating gardens to be a globally important agricultural heritage

:Integrated rice-duck farming

Problem:

Chemical pesticides may have been a fix for pests and weeds, but they have wreaked long term consequences, harmful to both the land and to human beings.

Solution:

As early as six hundred years were using ducks to clean their rice fields in Imperial China.

In 1978, Takao Furuno, farming in the Fukuoka Prefecture, Kyushu, a rural region wet of the Japanese archipelago, was alarted by Rachel Carson's seminal book "Silent Spring." What if, traditionally, he were to use ducks to clean his rice fields. After trial and error of this "Aigamo" method, Furuno was able to identify the optimal age at which ducklings should be released into rice fields (7 days), the number that should be introduced for every tenth of a hectare (15-30), and the moment when the ducklings should be removed from working in a paddy (8 weeks) so as not to eat the rice.

Aigamo is simple: Dozens of these birds, raised on the farm, patrol the paddy fields. They feed on insects and weeds, without touching the plants. Their wading oxygenates the water and stirs up the soil. Their droppings are a natural fertiliser. Furuno was able cut production and boosted output by about a third compared with his neighbours, who use chemical fertilisers. He sells the ducks too

In 1984, the Vergenoegd winery in South Africa estate imported six Indian runner ducks to control pests in the garden. As its name suggests, this duck breed doesn't waddle or fly, it runs. Today, the estate has over one thousand ducks that clean the vineyards every morning.

In 2000, Furuno published a manual "The Power of Duck" which became a best-seller. Not only did some ten thousand Japanese farmers change over to

Aigamo, but the technique was revived in Thailand where armies of thousand “field chasing ducks” eat their way through rice paddies after harvest. As of March 2020, there were about 30 million ducks farmed throughout Thailand. And almost a quarter of them were field chasing ducks.

Through Takao Furuno’s writings, travels, lectures and cooperation with agricultural organizations and governments, his methods have spread to more than 75,000 farmers in Japan, Korea, China, Vietnam, the Philippines, Laos, Cambodia, Malaysia, Bangladesh, Iran, Cuba and even the Camargue in France.

:Integrated Water Resource Management (IWRM)

Problem:

In regions the availability of water in both quantity and quality is severely affected by climate variability and climate Water production and consumption growth in regions are clearly unsustainable. Clean freshwater is an essential ingredient for a healthy human life, but 1.1 billion people lack access to water and 2.7 billion experience water scarcity at least one month a year. By 2025, two-thirds of the world's population may be facing water shortages.

Solution:

Integrated water resources management (IWRM).

IWRM has been defined by the Global Water Partnership (GWP) as "a process which promotes the coordinated development and management by planners and policy makers of water, and related resources, in to maximize the resultant economic and social welfare in an equitable without compromising the sustainability of vital ecosystems".

IWRM was set up on 31 January 1992 at the International Conference on Water and the Environment (ICWE), Dublin, Ireland. Led by John C Rodda, experts on water related problems signed “The Dublin Statement on Water and Sustainable Development”, also known as the Dublin Principles. Water development and management should be based on a participatory approach, involving users, planners and policy-makers at all levels.

In December 1998, the German Federal Ministry for Education and Research (BMBF) brought to life the funded research programme GLOWA (Global to the

Water Cycle). In 2012 this became GEWEX Global Energy and Water cycle Exchanges, itself an international research project and a project of the World Climate Research Programme (WCRP).

Variations of International Water Resources Management been put into operation in 30 sites around the world: from WISDOM: an integrated water-related information system for the sustainable development of the Mekong Delta; Mongolia, to Gunung Kidul, Java Indonesia to the Cuvelaidelta in Northern Namibia

One example is the uMkhomazi Dam Project in KwaZulu-Natal, South Africa. upon completion, will be one of the largest bulk water infrastructure schemes constructed and operated in South Africa. It will deliver 600-million litres of water per day and alleviate pressure on dams such as Midmar in . The dam will supply both the south coast and parts of Durban.

Involved are Vivendi Water, Durban Metro, City of Pietermaritzburg, Umgeni Water, Mvula Trust (NGO) and Water Research Commission, with the aim of installing and operating a new water distribution network for the townships in Durban and Pietermaritzburg. This IWRM project is projected to be completed by the year 2030

Intensified CO_2 capture using a 3D printed intensified packing device

Solution: The Department of Energy and Transportation Science Division's Oak National Laboratory researchers, led by Xin Sun designed and additively manufactured a first-of-its-kind aluminum device that enhances the capture of carbon dioxide emitted from fossil fuel plants and other industrial processes The team tested the novel circular device, of aluminium, which integrates a heat exchanger with a mass-exchanging contactor, inside a 1-meter-tall by 8-inch-wide absorption column consisting of seven commercial stainless-steel packing elements. The 3D-printed intensified device was installed in the top half of the column between the packing elements. When CO_2 interacts with the solvent, it produces heat that can diminish the capability of the solvent to react with CO_2. Reducing this localized temperature spike in the column through cooling channels helps increase the efficiency of CO_2 capture.

Xin Sun et al. “Process Intensification of CO2 Absorption Using a 3D Printed Intensified Packing Device,” *AIChE Journal*, August 2020.

Intergovernmental Panel on Climate Control

Problem: A system as needed to provide governments at all levels with scientific information that they could use to develop climate policies.

Solution: In part instigated by John Houghton, professor of atmospheric physics at Oxford University, the Intergovernmental on Climate (IPCC) was established in 1988 by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) and was later endorsed by the 195 member governments of the United Nations to provide policymakers with regular scientific assessments on climate , its implications and potential future risks, as well as to put forward adaptation and mitigation options.

It publishes comprehensive assessment reports every five to seven years, with the most recent Fifth Assessment Report (AR5) released in 2014. The release of IPCC’s Special Report on Global Warming in 2018 warns that urgent and unprecedented are needed to reach the , which they say is affordable and feasible although it lies at the most ambitious end of the Paris agreement pledge to keep temperatures between 1.5C and 2C. The next report, AR6, is currently drafted and will be published in 2021.

This is all the reason for solutions to be found and put into action.

Interlocking road cabros from COVID-19 masks etc.

Problem:

Since the onset of the Covid-19 pandemic, face masks have, however, become a nuisance since most are discarded recklessly in towns,rivers and oceans.

Solution:

Francis Thuti, chairman of Storm Water and Environmental Management Forum in Nanyuki,Kenya has turned this discarded waste into one of the key components of his project of manufacturing interlocking road cabros and building blocks. Francis sorts out face masks, plastic bottles, glass bottles, polythene papers, and woven carrier bags from a dumpsite near his workshop where he has been conducting his research. Using an improvised crushing machine, he crushes the glass into sand form. He then combines the waste items

and heats them at a high temperature, after which he adds the glass sand to precipitate the merging of the components. He then condenses the product to produce heavy-duty blocks which could be used as building blocks.

Intermittent voluntarily doing nothing

Problem:

Human travel, particularly to consume products but also to travel for business or pleasure is contributing to global warming. With an accelerating world population of about 7.7 billion, humans used about 575 quadrillion Btu of energy in 2015, or an average consumption of primary energy of 58 kWh per day per person

Solution

Intermittent voluntarily doing nothing.

Government-imposed lockdowns and curfews during the COVID19 pandemic evidenced carbon emissions temporarily dropping by varying but dramatic percentages due to the draconian reduction of consumerism and travel.

In a world where Activity is defined as good, deliberate chosen inactivity, nothing, idling is often frowned upon. Yet the ancient actions of meditation and of fasting can play an important part in the protection of our Planet.

By this one includes, from time to time, neither using electronic devices nor travelling in a motorised vehicle (by , water or air) so reducing the massive on electricity.

Invisible barcodes for recycling

Problem: consumers struggle to figure out which items can be recycled while our rubbish at home. Machines in plants can solve the problem. This prevents countries from achieving the recycling they would such as.

Solution: K. Sharma of Digimarc in Portland, has developed and patented an “invisible” barcode which can accurately identify recyclable

plastics that could prevent their unnecessary disposal into landfills or incinerators. Digimarc has signed Ellen MacArthur Foundation's New Plastics Economy Global Commitment, which is focused on building a Circular Economy for plastics. Products can have disguised codes printed all over them making it easier to distinguishing food- plastics from non-food plastics so the right kind of plastic can be re used to manufacture new items. Following successful initial trials carried out by TOMAR at a recycling facility in western Germany, involving scanning and photographing items at 150 frames per second, in 2020 the system will be installed in a conventional waste plant. The system, called HolyGrail has already involved a consortium of twenty of the world's biggest brands, including Procter & Gamble, Nestlé, PepsiCo and Danone. At home, individuals will be to use an animated app on their cellphone to identify and place different types of plastic in the right trash . *(digimarc.com)*

K. Sharma et al, "Generating and reading optical codes with variable density to adapt for visual quality and reliability" Patent N° 20190332840. 2019.

Intermittent Planetary refertilisation

Solution: The scientists are taking a radical approach to cooling the earth's climate, such as dumping dust into the , hoping to grow algae blooms that suck up carbon. Re-fertilization is the intentional introduction of to -poor areas of the surface to stimulate phytoplankton production. This is intended to enhance biological productivity and/or accelerate CO_2 sequestration from the atmosphere. is an element necessary for photosynthesis in plants. It is highly insoluble in sea water and in a variety of locations is the limiting nutrient for phytoplankton growth. Algal blooms can be created by supplying to -deficient waters. These blooms can nourish other organisms.

Consideration of iron's importance to phytoplankton growth and photosynthesis dates to the 1930s when English biologist Joseph Hart speculated that the great "desolate zones" (areas apparently rich in nutrients, but lacking in plankton activity or other sea life) might be -deficient. Little scientific discussion was recorded until the 1980s, when oceanographer John Martin renewed controversy on the topic with his water nutrient analyses. His studies supported Hart's hypothesis. These "desolate" regions are to be called "High Nutrient, Low Chlorophyll" (HNLC) zones.

John Gribbin was the first scientist to publicly suggest that climate could be reduced by adding amounts of soluble to the . Martin's 1988 quip at Woods Hole Oceanographic Institution, "Give me a half a of and I will give you another ice age", a decade of research. Perhaps the most dramatic support for Martin's hypothesis with the 1991 eruption of Mount Pinatubo in the Philippines. Environmental scientist Andrew Watson analyzed global data from that eruption and calculated that it deposited approximately 40,000 tons of dust into worldwide. This single fertilization event preceded an easily observed global decline in atmospheric CO_2 and a parallel pulsed increase in levels.

Beginning in 1993, thirteen research teams completed trials demonstrating that phytoplankton blooms can be stimulated by augmentation. Controversy remains over the effectiveness of atmospheric CO_2 sequestration and ecological effects.

In Spring 2004, an international team on board the 386 ft 10 in (117.91 m) *RV Polarstern* (meaning pole star) of the Alfred Wegener Institute for Polar and Research (AWI) in the Helmholtz Association, Bremerhaven, fertilized a part of the closed of a stable eddy in the Southern with dissolved , which stimulated the growth of unicellular algae (phytoplankton). The team followed the development of the phytoplankton bloom for five weeks from its start to its decline phase. The maximum biomass attained by the bloom was with a peak chlorophyll of 286 Milligram per square metre higher that of blooms stimulated by the previous 12 fertilization experiments. According to Dr. Victor Smetacek and Dr. Christine Klaas from the Wegener Institute, this was all the remarkable because the EIFEX bloom developed in a 3330 ft (1000 m) deep mixed layer which is much deeper hitherto believed to be the lower limit for bloom development. In early 2009 a further dumping of 20 tons (18 tonnes) of ferrous sulphate by Victor Smetacek, called LOHEFEX (LOHA is Hindi for , FEX stands for Fertilization EXperiment) was suspended by the German Federal Ministry of Education and Research (BMBF) demanding that an independent assessment into the environmental impacts of the experiments be carried out before the ferrous sulphate is dumped in the Southern . Greenpeace and other environmental organizations demanded from the start that LOHAFEX be stopped, saying that into the amounted to pollution and violated international agreements. Some scientists feared the unintended side effects of the project. The German Government sent the proposal for scientific and legal reviews that were supportive of the project and the experiment was allowed to continue.

Other trials continued. In 2012, the Haida Salmon Restoration Corporation (HSRC), financed by a First Nations community from the British Columbian archipelago, Haida Gwaii, conducted a small scale Fertilization experiment where 120 tons (109 tonnes) of compound were deposited in the migration routes of pink and sockeye salmon in the Pacific West of Haida Gwaii over a period of 30 days. The project resulted in a 14,000 mi² (35,000 km2) plankton bloom that lasted for several months and was confirmed by NASA satellite imagery. The HSRC scientific team collected a significant amount of oceanographic data using autonomous underwater vehicles (Slocum Gliders), Drifters, Multi-Spectral Sonar, Surface Seawater samples, Phytoplankton Tows and other methods.

The Desarc-Maresanus project, led by Professor Stefano Caserini, Professor of Mitigation of Climate at Politecnico di Milano, in collaboration with the Foundation Euro-Mediterranean Center on Climate (CMCC) with support of Amundi, consists in discharging alkaline products (i.e. limestone or slaked lime) in the sea, increasing the pH of the water favoring a greater absorption of CO_2 from the sea surface. This is known as alkalinisation and has been carried out by ships whose great turbulence caused by the propeller and by the ship's great improves dispersal.

In 2019, researchers at the University of Hawaii and University of Southern California published a report which stated that following the previous year’s eruption of Kilauea, the incredible volume of lava that spewed from the ground as not a source of destruction but of creation. It looked at the massive algae bloom in the Pacific — so big it could be seen by satellite — that was triggered by millions of cubic ft. of lava into the nutrient-poor waters off the Big Island and found that it actually created a nutrient- soup across a wide expanse of that helped algae to thrive. The nutrients did not come from the lava itself, they found, but because the lava was heating up subsurface water and pushing nutrients deep in the up to the surface. The Pacific is actually quite nutrient-poor, which makes the algae bloom all the unique.

'Climate fix' ship sets sail with to dump ,” *New Scientist*, 9 January 2009; Samuel T. Wilson et al., “Kīlauea lava fuels phytoplankton bloom in the North Pacific ,” *Science,* September *6* 2019.

: Fuel

Problem:

With the exponential use of electric power, replacing that of fossil fuels, as reliable solutions as possible must be found to produce it.

Solution:

Powder and rust

Ground very , cheap powder burns readily at high temperatures, releasing tremendous energy as it oxidizes in a process that emits no carbon and produces easily collectable rust, or oxide, as its emission. The energy released can be applied in various applications such as chemical processes, generation of electricity, or even used as a of propulsion.

That rust can be regenerated straight back into powder with the application of electricity, and if you do this using solar, wind or other zero-carbon power generation systems, you end up with a totally carbon-free cycle. The acts as a kind of clean battery for combustion processes, charging up via one of a number of including electrolysis, and discharging in flames and heat.

The generated fuel in the reduction process can be stored and transported in a cheap and with hardly any energy losses. As a result, fuel enables energy provision, wherever and whenever.

In 2015, J.M. Bergthorson & colleagues of McGill University in Canada published an article in the Journal of Applied Energy nr 160 pp. 368-382 about the potential of metal fuels and fuel in particular.

The following year, led by Philip de Goey, a multidisciplinary team of 30, students already with bachelor's and master's programs, was set up at the Eindhoven University of Technology, The Netherlands. Called SOLID, it has been dedicated to the advancement of metal fuels and combustion technology.

As proof of concept, the 340-year-old Royal Swinkels Family Brewers (formerly Bavaria NV), from Noord-Brabant in the Netherlands formerly using coal-fired power plants, has been using metal powder as a sustainable fuel to produce steam for their brewing process using an installation built by SOLID and the Brabant-based Metalot Power Consortium. The system, capable of

providing all the heat necessary for some 15 million glasses of beer a year, has been funded by the province of Noord- Brabant, and cooperation with the Metalot.

SOLID is now developing an improved 1 Mw fuel system, followed by a 10-MW system that should be ready in 2024. Our ambition is to convert the first into sustainable fuel plants by 2030

In addition, since May 2019, SOLID's Maritime Innovation Impuls project (MIIP) is researching how to use fuel for various types of ship propulsion, with trials of the first -fuel ship by 2021.

Artificially Intelligent Micro Irrigation (AIMI)

Problem:

Water needs to be used with and efficiency to provide the 60% increase in food we need to deliver in 2050 for the ever-growing world population. In 2050 we will the problem of % less of arable per person and a 25 % deficit in water supply demand. Rationing water could become mandatory — especially in agriculture — where demand is greatest.

Solution:

Transform traditional irrigation into AI precision irrigation systems.

In 2010, S.Muhammad Umair and Rasyidi Usman from National University of Science and Technology in Pakistan proposed to create an automated irrigation system using an Artificial Neural Network based controller. The input parameters such as air temperature, soil moisture, radiations and humidity are modelled. Then using an appropriate method taking into account ecological conditions, evapotranspiration and type of crop, the amount of water needed for irrigation is estimated and then associated results are simulated.

To improve water efficiency for blueberry cultivation, in 2017, researchers from Chile's Universidad Católica de la Santísima Concepción (UCSC) created an AIMI (Artificially Intelligent Micro Irrigation) to increase water efficiency by 70%.

In 2018 Esteban Socolsky and Ron Keren of drip-farming pioneers Netafim in Beersheba, Southern Israel launched NetBeat, the world's first and most advanced digital irrigation and fertigation management system providing farmers with real-time recommendations sent to a mobile app, based on data gathered from sensors, including data about plants, soil, and weather, as well as from satellite images and weather forecasts. NetBeat was developed in collaboration with mPrest, developers of the Command & Control platform used in the Dome air-defense system.

By 2020 Netafim held an over-30% of the global drip irrigation market and the NetBeat solution has been used in other parts of the Planet. One of those areas benefitting has been the Indian state of Karnataka, whose government is subsidizing 100 percent of all drip irrigation projects and implementing Netafim's technology in a region challenged by food scarcity and access to fresh water.

Since 2017 when it was first launched, the project has already reached some 7,500 farmers in the Karnataka state . In 2019, Netafim announced that it would be further deploying its precision irrigation technologies in India's Singataluru, Ananthapuramu District and Tarikere regions, spanning some 100 villages and impacting nearly 60,000 rural farmers.

:Jackfruit and Durian supercapacitors

Problem: Graphene supercapacitors are expensive to . About half the materials cost comes from the use of activated carbon to coat the electrodes. Supercapacitor- activated carbon can cost $15 per kilogram.

Solution: Using inexpensive biochar to coat electrodes and a new method to create the porous surface needed to capture electricity may reduce the cost of supercapacitors. Activating the biochar using plasma processing takes five minutes with no external heating or chemicals needed.

Vincent Gomes, a chemical engineer at the University of Sydney, and his team, including Labna Shabnam found a solution to convert the inedible parts of the world's largest and smelliest fruits, Durian and Jackfruit (*Artocarpus heterophyllus*) into carbon aerogels – porous super-light solids – with "exceptional" natural energy properties. Biomass waste from jackfruit these

fruits were used to produce carbon aerogel electrodes incorporating stable scaffolding of material and natural nitrogen doping. They heated, freeze-dried and then baked the inedible of each fruit in an at temperatures of 1,500°C (2732°F). The , highly porous, ultralight structures they were left with could then be fashioned into electrodes of a low-cost supercapacitor. Until now, 70% of jackfruit or durian has been thrown away – but can now be recycled.

Elsewhere at South Dakota State University, Qi Hua Fan, Associate professor of electrical engineering and computer Science uses plasma etching to active the biochar, while Zhengrong Gu, Associate professor of agricultural and biosystems engineering uses the activated biochar to supercapacitors

Rakesh Kumar Gupta, Mukul Dubey, Parashu Kharel, Zhengrong Gu, Qi Hua Fan, "Biochar activated by plasma for supercapacitors**."** *Journal of Power Sources*, 2015; 274; Vincent G. Gomes et al., "Aerogel from fruit biowaste produces ultracapacitors with high energy density and stability", *Journal of Energy ,* Volume 27, February 2020,

JellyfishBot

Problem:

Ports, harbours and marinas are full of floating garbage

Solution:

Silvain Louis and a team IADYS in Roquefort-la-Bédoule in the south of France, IADYS have developed the JellyfishBot, an 70cm AI robot that collects floating waste and oil spills. Its connection to 5G enables it to be remote-controlled, to transmit a video stream and to have the reactivity necessary to sneak in certain environments. It is thus able to move around a port, in the middle of larger ships. It is propelled by three electric thrusters, one of which is transversally mounted, enabling it to move sideways.

Several cities are already using a JellyfishBot : Cassis, Cannes, Marseille, Monaco, Saint-Tropez, Montpellier, Ajaccio, La Turballe, Dunkirk, Marine Natural Park in Mayotte, Neuchâtel (Switzerland), Singapore, Tokyo (Japan), Norway, and so on.

:Johad dams

Problem: In the 1980s, the Alwar district in the North-Western state of Rajasthan had become one of the driest in all of India, even though older villagers remembered that its rivers used to flow in the past. The annual rainfall is very low, between 17 and 23 in. (500 and 600 mm) and the water can be unpleasant to drink. farmers were migrating to the cities, as there was no any of subsistence from the .

Solution: When Rajendra Singh, a 26-year-old volunteer from the NGO Tarun Bharat , arrived in the area in 1985, he Tomorrow'sed the alarming state of children's health in the villages, because of malnutrition, a consequence of the drought. From an elder of the village Singh learned of the former existence of johads, earthen ponds used to retain runoff water so that it infiltrated the soil instead of s' and evaporate. Johads in Haryanvi language and Rajasthani language are also called sarovar, and taal and talab, respetively in Hindi language. Johads could collect and store water throughout the year, to be used for the purpose of recharging the groundwater in the nearby water wells, washing, bathing and drinking by humans and cattle. Some johads also had or masonry and cemented ghat (series of steps and/or). Dating back to the 13th century, johads were considered unhealthy by the occupying British Raj and replaced by the provision of water through pipelines in some cases from very distances, from dammed reservoirs

It has emerged that the traditional water-collecting methods are robust in of a poor monsoon the reservoirs, which sometimes dry up completely. Single-handedly, Rajendra Singh first decided to build a water johad to see how it would work. He then brought together groups of villages to build others or rebuild old ones. When the villagers had constructed 375 johads, the river began to flow after having been dry for several decades.

Through his Tarun Bharat NGO of which he became President, Rejandra Singh formed the Haryana State Waterbody Management Board to rejuvenate and manage 14,000 ponds in the state, including the development of 60 lakes in Delhi NCR. By 2003, despite bureaucracy and the mining lobby, over five thousand johads had been built leading to the rejuvenation of 2,500 old reservoirs, providing irrigation water to 346,000 ac (140,000 ha.) and to 700,000 people across 650 villages in Alwar district.. By 2015, that number had risen to 8,600 johads bringing water back to 1,000 villages, reviving five rivers in Rajasthan, Arvari, Ruparel, Sarsa, Bhagani and Jahajwali. Rajendra Singh

attributes the success of the johads to the fact that the technology encourages people to work together, building community while addressing essential needs. This is in opposition to the government-built dams, which displaced millions of people in India and, on average, increased poverty. Singh, who won the the Magsaysay Award for Community Leadership in 2001 and Stockholm Water Prize in 2015, is known as द वाटर मैन ऑफ राजस्थान ("the Water Man of Rajasthan"). *(tarunbharatsangh.in)*

Abhijit Guha, "Listening to Waterman of Rajasthan and the Leftists of West Bengal : Narratives of Rainwater Harvesting." *Journal of the Indian Anthropological Society* 50(5):5-14, December 2015.

Jute

Problem: Building up temporary walls against flooding using sandbags, involves quarrying of precious . It is not so much the , but the material into which the is filled. Polypropylene is lighter but far slower to biodegrade.

Solution

Jute fibre is 100% biodegradable. A hectare of jute plants (Corchorus) consumes about 15 tonnes of carbon dioxide and releases 11 tonnes of . Jute fibre is therefore an excellent material for making burlap fabric for sandbags.

One manufacturer is the Fisher Bag Company of Kent, Washington, USA.

Kapla

Problem:

The majority of toys require plastic, metal and often batteries.

Solution:

Wooden plank construction set

In 1987, Dutchman Tom van der , restorer, mason, antique dealer resident in an old abandoned farm on the Tarn River in the South of , wanted to realise his

childhood ambition of building a castle. To help him visualize the finished construction of his castle, he used small wooden blocks, sourced from local trees.

Out of this created a construction set for children and adults which he called"KAPLA" , an abbreviated form of the Dutch phrase "kabouter plankjes," which "Gnome Planks."

The box sets contain 40,100,200, 280 or 1,000 identical wood planks measuring 11.7 cm x 2.34 cm x 0.78 cm. This 15:3:1 of length:width:thickness is different the dimensions used for traditionally proportioned building blocks (such as unit blocks), and are used for building features such as lintels, roofs and floors. They are known for their stability in the absence of fastening devices, held in place by gravity and balance . Coloured blocks are stained with non- water based paints.

Kapla caught on at and in 1987, Tom van der and a small team, based in Saint-Louis-de-Montferrand built and sold 800 packages of 200 unprocessed unvarnished planks sourced from the nearby forest of the Landes of Gascony, south-west of . Even François Mitterand, President of the French Republic bought him 300 for the staff Christmas tree.

Our family playroom has often hosted different and temporary constructions, often and sometimes elaborate, from wooden planks. Football stadiums, railway bridges, Formula 1 circuits, skyscrapers. One Dutchman who used 21,000 planks to build a miniature Las Vegas.In May 2016 a group of engineers used 9,384 Kapla planks and took 16 hours to build the tallest tower in the world at the recreation and climbing hall Azium located in Lyon,

Although the planks are cut and worked into small boards in the French mill, since 2003, most of the production has been carried out in , Morocco, where around a hundred people manually sort, select the boards, packaging, sanding before the boxes return to to distribution.

Managed since 2014 by van der Brugge’s son, Jan-Daniel, Kapla remains a family business that exports 80 million little planks per year to 40 countries, including 350,000 to .

:Kayser Recycling System for Copper

Problem:

Due to a higher level of consumption and shorter product lifecycles, the supply of recycling raw materials is also growing quickly. Copper demand is set to steadily with the electrification of energy and transport systems. How are different parts of the copper industry responding to this growing demand while improving their efficiency and sustainability credentials?

Solution:

Aurubis AG (formerly Norddeutsche Affinerie AG) is the largest copper producer in Europe (the second largest in the world) and the largest copper recycler worldwide has been pushing for copper recycling in the circular economy

The firm's largest recycling plant in Lünen, Germany, uses secondary raw materials as input to produce high- copper cathodes that Aurubis describes as indistinguishable from those that come from primary copper production.

Input sources include copper cable scrap, waste electronics such as circuit boards and even industrial residues and slimes, which undergo processing, smelting and refining.

Aurubis uses the ISASMELT Top Submerged technology an extension of the existing KRS facility, incorporating a so-called Top Blown Rotary Converter (TBRC), as well as a separator and a holding furnace. It allows the throughput of the existing KRS cell smelter to be increased from 275,000 t/a to 350,000 t/a. The system is in operation at the Umicore Precious Metals Refining Hoboken Plant in Belgium. Aurubis has set the goal of increasing the volume of complex recycling raw materials by 100 % by 2023

Chile

Chilean state- mining company Codelco is the largest copper producer in the world, controlling around 19% of the world's total copper reserves and producing 1.6 million tonnes of the red metal (nearly 10% of global output) in 2019.

However, rising and declining ore prices at one of the company's largest mines been an increasing challenge for the copper , spurring massive investments such as the ongoing $5bn project to convert the Chuquicamata mine from an -pit to an underground operation.

Codelco's challenges do seem to prompted a of innovative technology deployments to improve efficiency and sustainability at the company's operations in Chile. Like Rio Tinto, Codelco is increasingly emphasising automation in its mining fleets and processing facilities, and in April announced an agreement with -time partner Sandvik to introduce fully automated loaders and predictive analytics to Chuquicamata's new underground operations.

Kalundborg Symbiosis pipeline network

Problem: Factories grouped in a single area which do not or interconnect their energy abd resources are invietably inefficient.

Solution: The term "industrial ecology" has been used alongside "industrial symbiosis" at least since the 1940s. Industrial symbiosis is the process by which wastes or by−products of an industry or industrial process circulate as the raw materials for another. Application of this concept allows materials to be used in a sustainable way and contributes to the creation of a circular economy.

The industrial symbiosis project at Kalundborg, Denmark 60 mi.(100 km) west of Copenhagen, with a population of approximately 15,000), is a model of environmental sustainability. A number of industrial companies exchange waste and resources with each other in an elaborate network of pipelines. The cooperation is known as ”Kalundborg Symbiosis”. the participants are a refinery, a power plant, an enzyme producer, a producer of insulin, and a manufacturer of gypsum board. Steam, sludge, fly ash or hot water are some of the resources exchanged.

The park began in 1959 with the start up of the Asnæs Power Station. The first linking together was the Statoil refinery which, faced with water supply difficulties in the early 1970s, pushed the municipality of Kalundborg to build a pipeline linking the refinery to Kalundborg. In exchange for this service, Statoil undertook, after use, to supply hot water to the neighboring thermal power station and to reprocess its water so that it comes out at least as clean as when it entered. Then in 1972 when Gyproc, a plaster-board manufacturing plant, established a pipeline to supply gas from Tidewater Oil Company. Early sharing at Kalundborg tended to involve the of waste products without significant pre-

treatment. Each further link in the system was negotiated as an independent business deal, and was established if it was expected to be economically beneficial. In 1981 the Kalundborg municipality completed a district heating distribution network within the city of Kalundborg, which utilized waste heat from the power plant. Since then, the system of exchanges has gradually been extended into an industrial symbiosis. Today, it includes 30 different material, water and energy streams between 13 different companies and a of farms and municipal institutions. They have been sharing a variety of materials and waste products, some for the purpose of industrial symbiosis and some out of necessity; for example, freshwater scarcity in the area has led to water reuse schemes. In particular, 24 million ft3 (700,000 m^3) per year of cooling water is piped from Statoil to Asnaes per year. The latest projects to come into existence are waste. For example, yeast residues from Novo Nordisk's insulin production plant (a few hundred thousand tons) are used as fertilizer for 49,000 ac (20,000 ha) of farmland crops in the region. As another example, the Gyproc plant now buys almost all of the sulfur dioxide (one of the raw materials it needs most) directly from the nearby thermal power station. The recently established algae water cleaning station in Kalundborg uses algae in tanks to clean wastewater and extract useful nutrients for fish feed or biodiesel. In 2019 Novo Nordisk, one of the top diabetes providers, producing 50% of the world's insulin began to rebuild its existing facilities and is adding production equipment at its site in Kalundborg. Novo Nordisk and Novozymes are active partners of the Kalundborg Symbiosis: currently, 22 different types of resources are exchanged in the network, resulting in economic and environmental benefits

As one of the key players Christensen, Managing Director of the Novo Nordisk plant explained "This is not an organization that has been planned. It evolved gradually. The "industrial symbiosis" was created much later, when we realized that the organization we had there was not common and that we could use it in other themes and other places for the benefit."

It was not until around 1989 that there was much outside awareness that this might be a unique model of collaboration. The model started to be studied by researchers and planners, and since then, visitors from around the world been visiting Kalundborg to learn from the project. In 2011 the official Symbiosis Center was established: It focuses on education and courses in creating resource exchange systems, and the centre also works pro-actively on identifying potential candidates for new, similar exchange projects in the region.

Industrial symbiosis has now become part of the overall Danish strategy for developing business. The Danish Business Authority supports activities all over Denmark to identify and start potential systems of resource exchange. *(symbiosis.dk)*

The Kalundborg model is followed outside Denmark. SCALER (Scaling European Resources) is an initiative aimed at facilitating the growth of industrial symbiosis in process industries across Europe. Between 2019 and 2021, the project aims to assess 1,000 potential industrial synergies, to support 30 regions in transitioning to industrial symbiosis practices and to reach 500 industrial sites. SCALER is a number of industrial symbiosis projects recently funded through the EU's Horizon 2020 initiative, a massive R&D program with nearly US$ 97 billion of funding available over seven years. The projects are aimed at finding new channels to stimulate uptake of circular economy practices across Europe, such as EPOS, a pan-European effort aimed at enabling cross-sectoral industrial symbiosis; or SHAREBOX, an initiative to develop a platform that manages shared process resources and provides real-time data to plant operators and production managers.

In the USA, a similar concept was created in the USA, by the Rocky Mountain Institute (RMI) with the National Renewable Energy Laboratory (NREL) and US Department of Energy (DOE) to launch what they called the Zero Energy District Accelerator, renamed a High-Performance District.

According to their guidebook, an HPD is a multi-building project in which the buildings, as well as the district as a whole, integrate and optimize their energy attributes on a life-cycle . This includes energy conservation and efficiency, heating and cooling systems, and renewable energy systems. A high-performance district can achieve a goal of improving its energy performance, achieving net-zero energy, becoming carbon neutral, or even becoming an energy-positive district (generating clean energy it consumes).

Architects planners, engineers, local government agencies, and real estate developers advantage of the synergies available when energy consumption and production are considered at a district level rather one building at a time.

One example of an HDP is the National Western Center, located on the historic grounds of the Denver Union Yard Company, which currently the annual National Western Show. The City and County of Denver, the National Western

Center Authority, the Western Show Association, and Colorado State University all together to redevelop the site, including heating and cooling is through wastewater, a consistent source of heat throughout the year.. It will soon be transformed into a 250- multipurpose zero-energy campus.

Teresa Domenech, Michael Davis,"Structure and morphology of industrial symbiosis networks: The of Kalundborg" *Procedia - Social and Behavioral Sciences*, January 1, 2011.

Karité

Problem: Although palm oil lotion is used as a cosmetic, the replacing of tropical rainforests in Borneo and Sumatra with palm oil plantations leads to the release of massive amounts of CO_2 and also destroying the habitat of already endangered species like the Orangutan, pygmy elephant and Sumatran rhino

Solution: (= " life" in the Mandinka language) is a fat extracted from the nut of the African shea tree (*Vitellaria paradoxa*). It is ivory in color when raw, with processed versions white, although it is commonly dyed yellow with borututu root or palm oil. It is widely used in cosmetics as a moisturizer, salve or lotion.

The shea tree grows naturally in the wild in the dry savannah belt of West Africa from Senegal in the west to Sudan in the east, and the foothills of the Ethiopian highlands. It is found in 21 countries across the African continent.

In 2007, Mariama Sylla who had previously been selling fashion accessories, created Diongoma in Salemata, in the Highlands of south-east Senegal, to 100% shea butter, baobab oil and even the hibiscus flower, which is called bissap in Senegal.

She assembled a Senegalese women's cooperative to strictly follows the entire process of making shea butter according to ancestral know-how: picking the fruits, pounding the seeds, filtering and potting. arrived in , Diogoma proceeds by to a second filtering before the final setting in pot, in to guarantee you an optimal quality of the shea butter as well as its authenticity and its purity.

In 2014, Diongoma products were certified as by the French organization Ecocert. In 2018 Mariama Sylla was awarded 81 million CFA francs to expand her business solution. www.diongoma.com

Kayak, recycled plastic

Problem: The first kayaks, believed to be at least 4,000 years old, were constructed from stitched seal or other animal skins stretched over a wood or whalebone-skeleton, due to the treeless landscapes). Plastic kayaks are rotationally molded ('rotomolded') from a various and types of polyethylene resins from soft to hard. Such kayaks are particularly resistant to impact and particularly slow to biodegrade.

Solution: In 1971, when Graham Mackereth turned his love of kayaking into a full-time job and started building kayaks in his father's garage, most kayak was in fibreglass 'general purpose' kayaks, which varied little from designed for slalom, and confusingly were frequently referred to as ''. Since 2012, all Mackereth's Venture Kayaks have been incorporating recycled plastic from their own scrap and from their second- kayak scrapage scheme, effectively closing the loop in their waste cycle. (venturekayaks.com)

In July 2015, Rob Thompson of Cornwall, England, had the honour of meeting Their Royal Highnesses, Prince Charles and Camilla the Duchess of Cornwall, during The Plastics Awareness Day. Here he signed a Statement of Intent, as a pledge to explore ways to develop a circular economy around plastic. Taking this responsibility seriously, Rob started to contemplate what he could create from plastic. The eureka moment after participating in a litter pick using kayaks, at the end with all participants stood around a great haul of bin to have their photo taken, he had an idea. The knowledge that these bin ended up in landfill had always played upon Rob's mind and it occurred to him that he could the kayaks out the plastics gathered and then use these kayaks to gather plastic. It took a further two years of research and development for Rob to find a way of recycling the plastic into a material suitable for kayak manufacturing. During this time he formed partnerships with Keep Britain Tidy, to assist in recycling beach plastic and Plastix to recycle fishing nets. In January 2018 to deliver this Odyssey Innovation Ltd. was created to collaborate with the Recovery Project, charities, ngos, government , the fishing industry, recyclers, manufacturers, Innovators and businesses, in to find -term sustainable solutions to tackle plastic pollution by incorporating the circular economy. For

manufacture, Rob approached Palm Equipment, in Clevedon, near Bristol, a based leading kayak manufacturer, with a recycled material suitable for roto moulding. Within a matter of days, the world's first prototype plastic recycled kayak was produced. Several prototype kayaks were created of varying styles, which are currently used for campaigns throughout Europe to retrieve and awareness about plastic. In December 2017, the plastic recycled kayak project was highly commended in the category of Tomorrow's Contribution to Sustainability at the Cornwall Sustainability Awards ceremony. In 2018 it also received the highly commended award for the Best Contribution to a Sustainable Tomorrow through Innovation. Odyssey Innovation started selling the kayaks in January 2019. *(odysseyinnovation.com)*

In Tumbes, a village in southern Chile, Bureo, a start-up founded by three North American surfers, is collaborating with local fishermen to keep hundreds of tonnes of discarded fishing nets out of the each year. Nets are sorted, cleaned, and cut in Bureo's warehouse in Concepción, a city a few miles from Tumbes. Here they are turned into 100% recycled polyester and nylon pellets, called NetPlus, which are sold to companies as a sustainable alternative to first-use plastics. Patagonia's hat brims now use Netplus, accounting for 60 tonnes of recycled material, while Trek uses it for bike parts and Humanscale for office chairs. *(bureo.co)*

:Kelp yarn

Problem:

As the world consumes and clothing, brands and suppliers are trying to meet this increasing demand by producing garments. As these clothes their way through the supply chain and product lifecycle, they part in an environmentally hazardous sequence of events.

Solution:

Rapidly degradable yarns from kelp.

In Brooklyn, New York, Aaron Nesser, a graduate of Pratt Institute, *Tessa Callaghan*, a graduate of the Fashion Institute of Technology, with Aleksandra

Gosiewski, Asta Skocir and Theanne Schiros researched into polymers mostly from sustainable sea kelp

By 2018, they got to a point where they were spinning the polymer into something that, when , was durable and which they called AlgiKnit. Completely customizable, they material's yarn-like strands can be any dimension and knitted to spec for sneakers and handbags, or the company can alter the -feel, durability and size of the material to create accessories like wrist watches

With their proof of concept landing the team $2.2m in seed investment from venture capital firm Horizons Ventures, AlgiKnit was also awarded €100K from the Dutch Postcode Lottery Green Challenge

While they experimented with an idea for a futuristic-looking and collaborated with a designer to a French-style market bag that was hitting fashion weeks that year, they eventually decided to focus on scaling up the production of the seaweed textile which can be died with pigments at scale.

Keluarga Harapan Program (PKH)

to reduce deforestation

Problem:

Nearly 10% of Indonesia's population lives below the poverty . Between 2000 and 2012, the country's carbon-rich rainforests were disappearing at an alarming to way for oil palm plantations and other monocrops. The country lost 6 million hectares (15 million acres) of natural forest, surpassing Brazil's for the first time.

Solution:

Indonesia's "Program Keluarga Harapan"(= Family Hope Program) (PKH) has been providing conditional cash transfers to the country's poorest households. **PKH** beneficiaries receive between IDR 600,000 (US$67) and IDR 2.2 million (US$247) annually depending on family composition for up to six years.

Rita Simorangkir a researcher at the National University of Singapore (NUS) and Paul J. Ferraro at Johns Hopkins University and analyzed 7,468 rural

forested villages across 15 provinces that participated in the PKH program between 2008 and 2012. They found that the program designed for health- or education-related actions also resulted in the reduction of forest cover loss in those participating villages by an average of 30%. About half of the avoided losses were in primary forests, and reductions were larger when participation density was higher.

The researchers called for similar studies to be in other tropical rainforest countries, and insist that poverty alleviation and forest conservation mutually exclusive goals.

Kerterre = dwelling from earth (Breton)

Solution: Evelyne Adam of Plomeur, in the north-west region of Finistere, has been teacher not of the traditional but of African, Australian or Indian instruments, such as the balafon, the didgerido, the zither. With the original spirit, during the 1990s she started to build herself a house using lime, hemp and , natural, local and ecological materials resistant to Breton weather, harden in weathering. Evelyne called her house a “Kerterre”, in Breton dialect “dwelling from earth”. The absence of a (except in special cases) greatly simplifies the structure but greatly limits the size to that of a 9m² tiny house. But it takes 3 weeks to build. Gradually a village of Kerterres grew up around Plomeur, resembling the Hobbit village in the film “Lord of the ”. In recent years, the Kerterre team has benefited from a growing interest in ecological and alternative housing, which has enabled it to build a training center. In , a first building permit was issued for a Kerterre house in 2018. *(kerterre.org)*

Kilner Jar

Solution: In contrast to throwaway plastic containers, a glass jar can be reused over and over again. A Kilner jar is a rubber-sealed, screw-topped jar used for preserving (bottling) food. It was created in 1842 by John Kilner of Castleford, South Yorkshire. in 1792, Kilner was an employee in a glass factory. He set up a glassworks with friends and through thrift and skill turned the business into a massive success. Before , Kilner family had established glass bottle factories in Conisbrough and Thornhill Lees. One of these, opened in

1893 in Denaby Main, was accessed via a bridge known locally as Kilner Bridge. In one of the early -pollution court cases in 1871 the Kilner Company was taken to court over the coal smoke coming from their Thornhill Lees chimneys and the judge ordered that "no man has the right to interfere with the supply of pure air". Kilner jars became known across the British Empire. 1894 they employed as as 400 hands (men, women and boys), and were making up to 300,000 bottles of all types per week.

When Kilners went bankrupt in 1937, the patent rights to the "Kilner Jar" were sold to the United Glass Bottle company with the rights to the very similar "Mason" jar that had also been by Kilner. A Mason jar's mouth has a screw thread on its outer perimeter to accept a metal (or ""). The , when screwed down, presses a separate stamped tin-plated steel disc-shaped lid against the jar's rim. An integral rubber on the underside of the lid creates a hermetic seal even better for conserves and jams.

For a while the Kilner and Mason jars were largely supplanted by other products and methods for commercial canning, such as tin and plastic containers. In 2003, the Rayware Group purchased the design, patent and trademark of the original Kilner jar and continues to produce them today in China. *(rayware.co.uk)*

Grace's Guides: The Best of British Engineering – Kilner Brothers*, Grace's Guide,* 5 February 2008.

Kindle and Kobo e-books

Problem: In the manufacture of paper books, discarded paper is a major component of landfill sites, accounting for about 35% of municipal solid waste. Even paper recycling can be a source of pollution due to the sludge produced during de-inking. Not to mention the energy consumed in printing and distribution.

Solution: Although their production requires resources, electronic books are kinder to the environment print books. Creating an electronic book takes three times fewer raw materials a print book and uses seven times less water. Over the years, OverDrive *Libby* readers checked out 1 billion digital books and, in that time, 15.8 million trees been saved.

In 2004, Amazon founder and CEO Jeff Bezos instructed the company's employees to build the world's best Android-powered e-book before Amazon's competitors could. *Kindle* was the result.

A study by Cleantech concluded that purchasing three e-books per month for four years produces roughly 168 kg of CO_2 throughout the Kindle's lifecycle, compared to the estimated 1,074 kg of CO_2 produced by the number of printed books. All Kindle devices integrate with Kindle Store content and, as of March 2018, the store had over six million e-books available in the United States.

The Kobo eReader (an anagram for book) has been produced since 2010 by Kobo Inc of Toronto, Canada.

As of 2018, there was a projected amount of approximately 90.5 million owners of e-readers in the United States, and that number is expected to increase to over 93 million by 2020.

Emma Ritch, "The Environmental Impact of Amazon's Kindle" Cleantech Group

"Klimaloven" Lov om klimamål

The Climate Act (Denmark)

Solution: In 2020, a coalition of left- parties led by Mette Frederiksen Social Democrats in Denmark's parliament adopted "Klimaloven", committing to reach 70% below its 1990 emissions by 2030. Whichever elected government must provide an annual global report on the international effects of Danish climate action, as well as the effects of Danish imports and consumption. It will also need to provide a strategy for how its , development and policy is driving international climate action. The law targets carbon neutrality by 2050 and includes a robust monitoring system. New legally-binding targets will be set every five years, with a ten-year perspective. The first of these will be set in 2020. A Danish government could lose its majority if it fails to meet its climate .

"Act relating to Norway's climate targets (Climate Act)," *Danish Ministry of Climate and Environment,* Adopted , 12, 2019.

kuàizi (Chinese: 筷子) = "" (快) aka chopsticks

Problem: Asian fast food consumption in the United States surged by 135% between 1999 and 2015, increasing the popularity of Asian cuisine at an unstoppable . this has lead to a significant in use worldwide. It is estimated that in the Metro Vancouver district of Canada , approximately 100,000 chopsticks are discarded each day after used for 20 minutes to shovel sushi into a greedy mouth.

High temperatures may damage plastic chopsticks, of melamine, producing compounds during both cooking and eating then ending up in landfills.

Solution 1: Bamboo and wood chopsticks been used as kitchen and eating utensils in most of East Asia for over three millennia. They are relatively inexpensive, low in temperature conduction, and provide good grip for holding food. They decompose slowly food, but will break down eventually. They can warp and deteriorate with continued use if they are of the unvarnished or unlacquered variety. They can be treated by eco-friendly, food- lacquer, Bioplastic chopsticks are from a plant-based bioplastic, produced from a rapidly renewable starch.

Solution 2:

Collecting thousands of used chopsticks from restaurants, cleaning them, them and then pressing them in a carbon-neutral hydraulic hot press that designed by Canadian Felix Böck . They are then transformed into 8×8-inch engineered bamboo tiles — an innovative new material with the strength, durability and beauty of the original bamboo. These are then into furniture and home décor products.

For example; SMILE a modular shelving unit from 4,276 recycled chopsticks and recycled construction steel; a work-from-home desk from 9,600 chopsticks or a simple butcher’s .

Böck ‘s start-up ChopValue currently has around 500 partnering companies across the 3 cities they operate in: Vancouver, Montreal, and Los Angeles. They are up of small and restaurants in and out of malls, and notably, Vancouver

International Airport (YVR) which recently celebrated recycling their 1 millionth . By 2021, ChopValue has recycled 32 million chopsticks – diverting them from landfills and creating employment for 40 people.

Böck, 32, has also developed a franchise concept for global expansion whereby with microfactories operating in multiple cities, ChopValue can truly be local, wherever their suppliers and customers are, for a efficient process while a carbon negative company:Vancouver, Montreal, Calgary, Los Angeles, London and Tokyo

Ladybird Beetles as biopesticide

Problem: Chemical insecticides kill off good insects as they do bad , and they poison the ecosystems on which crops and wildlife thrive

Solution: In 1888–1889 the vedalia beetle, *Rodolia cardinalis*, a lady beetle, was introduced from Australia to California to control the cottony cushion scale, *Icerya purchasi*. This had become a major problem for the newly developed citrus industry in California, but by the end of 1889 the cottony cushion scale population had already declined. This great success led to further introductions of beneficial insects into the US. A century later, the convergent lady beetles or bugs are a solution for the biological control of aphids. They will lay 600-700 eggs in batches of 40-50 close to the pests and during their larval , lady beetles will consume 600 aphids each. and in so they help to protect crops.

Companies like Insect them for in batches of 1500 but often homeowners find them too expensive. The ladybugs should be released within one week of emerging from their pupal , preferably in the evening after sundown or in the before sunup.

Results of a study, published in 2018 in *Environmental Research Letters,* demonstrated for the first time the economic benefit of using natural predators such as ladybird beetles as a form of pest control. The study estimated that cotton farmers in China could US$300 million by doubling the density of ladybirds in their fields.

Jikun et al.,"Uncovering the economic value of natural enemies and of chemical insecticides to cotton farmers in China", *Environmental Research Letters*, 2018.

:Lagos

Problem:

Lagos, the most populous city in Africa (24 million) is also one of its most vulnerable to sea level and floods. But during the seasons, the city's streets can become almost impassable. If global warming exceeds 2C, the city is predicted to see 90cm of sea level by 2100, according to research led by physicist Svetlana Jevrejeva, of the UK's National Oceanography Centre.

Solutions:

Floating structures, ferryboat fleet, the Great Wall of Lagos, and groynes

The suburb of Makoko, known as the "Venice of Africa", is a labyrinthine slum built on stilts and navigated by . The Makoko Floating School is a structure resting on recycled empty plastic barrels for buoyancy. The school's pyramid shape helped lower its centre of gravity and so increase its stability, while also an ideal roof shape for shedding heavy

A floating hub from timber and consists of three floating vessels housing a multipurpose live performance hall, a state-of-the-art recording studio and a platform for thirsty guests. This is part of NLÉ's African Water Cities project, which seeks to find new ways for waterfront communities to live with rising sea levels.

The Lagos State Waterways Authority now 42 ferry routes on the waterways with 30 commercial jetties and terminals spanning across three districts.

One prominent defence against rising waters is the "Great Wall of Lagos", a barrier of 100,000 concrete blocks weighing five tonnes each. The 18m-high (60 ft) sea defence protects a stretch of shoreline by Lagos' Eko Atlantic, a development built on reclaimed , and will be 8.4km when completed.

Other structures to protect the sea include constructing 18 groynes on the shores of the Eko Atlantic. A is a structure built to and prevent it from washing into the . Those installed at Eko Atlantic are each spaced 400m (1,300ft) apart and a distance of 7.2km (4.5 miles). Further groynes been proposed to cover up to 60km (37.3 miles) of the state's coastline

: Artists' materials

Problem:

Traditional painting uses colours derived from Prussian blue, Mercury red, cadmium and concentrated cobalt, etc which ultimately seeps into and poisons water courses.

Solution:

Art using natural, biodegradable pigments

Prehistoric man used natural pigments to create paintings such as Lascaux and Altimira and to temples such as Göbekli Tepe and Stonehenge.

art, variously known as Earth art, environmental art, and Earthworks, is an art movement that emerged in the 1960s and 1970s. The materials used were often the materials of the Earth including for instance the soil and rocks and rocks and twigs and water found on-site.

The locations of the works were often distant from population centres. Art uses natural materials, 100% biodegradable, up of water, clay-based white, wood charcoal and milk-based casein**.**

The most famous pioneer art work is Robert Smithson's *Spiral Jetty* of 1970, an earthwork built out into the Great Salt in the USA. Though some artists such as Smithson used mechanical earth-moving equipment to their artworks, other artists minimal and temporary interventions in the landscape such as Richard who simply walked up and down until he had a mark in the earth.

In the UK, Goldsworthy uses brightly coloured flowers, icicles, leaves, mud, pinecones, snow, , twigs and thorns, and is the founder of rock balancing.

Since 2013, “Saype” = Say and Peace (aka Guillaum Legros) has been creating gigantic ephemeral faces in the middle of nature. His first Art work was produced in 2015, in the French Alps. It was then the largest fresco (1,400 m2) on produced in the world. The ephemeral work evolves according to bad weather, the regrowth of the , the passage of visitors. For about a month, Saype’s landscapes are highlighted before disappearing without leaving any traces.

Sophie Agouès of Lormont, south-west has used locally sourced straw to create twelve lifesize “hommes de paille” (= men of straw) into which she has placed seeds which germinate and produce flowers. they been chosen as the symbol of the Nationale de Surveillance des Arbres (tree watching group)??

Landfill, Sanitary

Problem: With already half of Africa’s 1.3 billion population living in areas and our waste generation set to double to 204 million tons[3] (225 million tonnes[3]) by 2025, the IWMSA warns of a “waste tsunami” if its landfills are not managed sustainably. The issue is how to move from unregulated dump sites to engineered landfills and how to harness the opportunity waste offers by embracing a circular economy.

Solution: One solution would be the Sanitary Landfill. Although the method was introduced in England in 1912 where it was called “controlled tipping”, it was not until the 1930s that an efficient system was developed near the city of Fresno, California.

Keen to do something about his city’s Sewer Farm, Commissioner of Public Works, City of Fresno Engineer, 30-year-old L Vincenz, who had read in Civil Engineering at Stanford University first studied the latest developments in dump technology in Seattle, New York , and even Great Britain. Renaming the Farm the “Sanitary Landfill”, during 1936 Vincenz and a workforce landscaped compartmentalised trenches into which trash was deposited, compacted, and covered over in dirt daily, instead of just dumped on and left to rot.

Opened in 1937, during its years of operation, Fresno Sanitary Landfill was to fill an average of 4.3 ac (1.7 ha) per year with about 24,000 tons (21.7 tonnes) of waste. It was lauded for its economy and for reducing nuisances such as and odor.

During World War II, Vincenz accepted a post as Assistant Chief of the Repairs and Utilities Division of the US Army Corps of Engineers to build sanitary landfills at army . By 1944 one hundred army had sanitary landfills.

Between 1947 and 1962, Vincenz served as Public Works Director for the San Diego County Public Works Department. In 1960, he became President of the American Public Works Association, by which time the Fresno model had become the most widely-used waste disposal method in the United States.

In the UK, in the 1960s, central Government policy was to ensure new landfill sites were chosen with permeable underlying geological strata to avoid the build-up of leachate. This policy was dubbed "dilute and disperse".

However, following a number of cases where this policy was seen to be failing, and an exposé in *The Sunday Times* of serious environmental damage caused by inappropriate disposal of industrial wastes, both policy and the law were . The Deposit of Poisonous Wastes Act 1972, together with The 1974 Local Government Act, local government responsible for waste disposal and for the enforcement of environmental standards regarding waste disposal.

Proposed landfill locations also had to be justified not by geography but also scientifically. European countries decided to select landfill sites in groundwater-free clay geological conditions or to require that the site an engineered lining. In the of European advancements, the United States increased its development of leachate retaining and collection systems. This quickly led from lining in principle to the use of multiple lining layers in all landfills (excepting those truly inert).

Today all sanitary landfill sites are carefully selected and prepared (e.g. sealed with impermeable synthetic bottom liners) to prevent pollution of groundwater or other environmental problems. When the landfill is completed, it is capped with a layer of clay or a synthetic liner in to prevent water from entering. A final topsoil cover is placed, compacted, and graded , and various forms of vegetation may be planted in order to reclaim otherwise useless , e.g., to fill declivities to levels convenient for building parks, golf courses, or other suitable public projects. Small incremental improvements in landfill design and operation over several years have been made. In 1996 American Technology Inc. developed an aerobic bioreactor using air injection via the landfill leachate collection system. In the future regional sanitary landfills will be transferred to regional waste management centers to include waste , separation, and recycling, as well as non-recyclable waste treatment.

"A Guide to Historic Architecture in Fresno, California: Fresno Sanitary Landfill (1937)" Adapted from *the National Historic Landmarks nomination,* originally prepared by Martin V. Melosi*, Department of History, University of Houston. "*Interview with Vincenz,*" Engineering News Record 123 October 26, 1939;* Kristina Gubic, "Africa faces a 'waste tsunami' if landfills are not urgently regulated," *Afrik21*, July 17 2019.

Landfills with geocomposite drains

Problem: aggregates are voluminous materials which require amounts of material to shape conventional layers. When applied to landfill systems, traditional designs are inherently affected by the increase of loads on the waste and reduction of waste capacity In landfill systems, these materials are commonly employed for rainwater or gas venting.

Solution: Under similar conditions, geocomposites can drain up to 40 times rainwater thana traditional 50-cm thick layer of aggregates. geocomposites in a landfill capping system prevent the saturation of the cover soils by collecting and draining away rainwater. This ensures the capping soil remains stable and also acts as a protective layer for the capping geomembrane.

The philosophy behind geocomposite materials is to combine the best features of different materials in such a way that specific applications are addressed in the optimal and at minimum cost. Thus, the benefit/cost is maximized.

Such geocomposites will generally be geosynthetic materials, but not always. In some cases it may be advantageous to use a nonsynthetic material with a

geosynthetic one for optimum performance and/or least cost such as geonet, geomembrane, geogrid or polymer- composites.

Gary R. Joachim, “Geocomposite container system” World Patent n° 2002052921A2, 2001; Müller, W. W.; Saathoff, F. (2015). ″Geosynthetics in geoenvironmental engineering". *Science and Technology of Advanced Materials*. 2015 **16** (3)

Landmine detector

Problem: Egypt is the leading country in the world with deployed mines accounting for 23 million followed by Iran with 16 million mines. The position of the third leading country with deployed mines is held by four nations namely Afghanistan, Angola, China, and with ten million mines each. Landmines cause irreversible damage to ecosystems, including prolonged direct damage to soil through shattering and displacement, destruction of soil structure, and increased vulnerability of soil to water and wind erosion. By degrading habitats, impacting population species, altering food's chain, and placing additional pressure over natural resources, landmines kill and maim numbers of specimens of wildlife and species worldwide. .

Solution: In 1874, electrical engineer Gustave Trouvé of Paris developed a device for locating and extracting metal objects such as bullets from human patients, the prototype of today’s metal detector. Inspired by Trouvé, Alexander Graham Bell developed a similar device to attempt to locate a bullet lodged in the chest of American President James Garfield in 1881; the metal detector worked correctly but the attempt was unsuccessful because the metal coil spring bed Garfield was lying on confused the detector. During the early years of World War II, Lieutenant Józef Stanisław Kosacki, a Polish officer attached to a unit stationed in St Andrews, Fife, Scotland, refined the design into a practical instrument, hundreds of which were deployed during World War II. With the invention and development of the transistor in the 1950s and 1960s, metal detector manufacturers and designers smaller, lighter machines with improved circuitry, running on small battery packs. One main manufacturer is Garrett Electronic of Garland, Texas, who pioneered the BFO (Beat Frequency Oscillator) machine.

In 2015, the FARC guerrilla and the Colombian government agreed on a comprehensive clearance. In collaboration with partners from South America, engineers at the German Ruhr-Universität Bochum and Technical University

Ilmenau are developing a new land mine clearance technology, based on ground penetrating radar. In the long run, they are aiming at creating a handheld device that will detect different types on varying terrain without fail and which can be used in the way as metal detectors. The engineers analysed the simulated radar signals to identify properties that are typical for mines, but are not generated by other objects, such as stones or shrapnel. This information is fed into the analysis of the gathered radar data; this is how they set up their system to perform an automated search for properties that are typical for mines. *(ruhr-uni-bochum.de)*

Even experimental, the MIDAS programme uses satellite technologies as an enabler for new services to demining operations safer, efficient, cheaper, auditable and autonomous.

:Latex glove surgical, sustainable

Problem:

Worldwide, over 80 million gloves been needed by COVID-19 health response teams each month, and the global medical gloves market is predicted to be worth $70billion by 2027 . Most of the gloves produced to satisfy this in demand are from petroleum-based nitrile rubber. However, most of them will end up in landfill and will remain there for about 100 years.

Currently a mannequin is used as a mould, dipped into a bath of natural latex rubber mixed with water which coats the ‘’ to produce the glove. However, significant wastage of both raw materials and energy occurs during the dipping method, the drying and curing procedure and in the energy required to support the multi-storey plant.

Solution:

Biodegradable surgical gloves

A team led by Krzysztof Koziol, Professor of Composites Engineering and Head of Enhanced Composites and Structures Centre at Cranfield University in partnership with Meditech Gloves in Negeri Sembilan, Malaysia, one of the leading manufacturers of high-quality examination and surgical gloves, shown how energy savings can be with the development of sustainable, biodegradable, protein-free, natural rubber gloves.

The natural rubber biodegrades 100 times faster synthetic rubber however, its use is limited due to skin allergies caused by the presence of proteins. A special formulation of natural rubber latex can remove this problem and reintroduce natural, sustainable raw latex to the industry on a mass scale.

The next phase of the Cranfield study will investigate how the natural latex raw material can be modified to rapidly enhance the biodegradability of natural rubber gloves. The university's PhD students who worked on the research regularly access the Meditech Gloves plant in Malaysia for rapid deployment of the findings from laboratory to the real world.

Laundry capsules mail and ecological

Problem: Laundry detergents come in plastic containers requiring the user to go and fetch them and then clothes that smell too much of laundry that was not dosed correctly

Solution: In March 2020, François Louart, originally from Pourville near Dieppe, launched his eco-responsible home laundry distribution business called Washaby. The eco-capsules come in Zero plastic packaging (recycled, recyclable and biodegradable) with mailbox delivery. Washaby is based in Catalonia, Spain because the raw materials are there: their packaging center is also in Catalonia, and the management centre is in Barcelona. Finally the preparation of orders is managed by a foundation that provides work and training to people with disabilities or at risk of social exclusion.

LAVO hydrogen battery

Problem:

Most hydrogen batteries up a lot of space.

Solution:

A fridge-sized residential hydrogen system

Francois Aguey-Zinsou, Chief Scientist and a team at the University of New South Wales Hydrogen Energy Research Centre, Australia developed a metal hydride battery which is about the size of a household fridge and can be hooked up to an existing array of solar panels. Inside it, electrolysers use that power to convert water into hydrogen and .

The start-up Lavo Green Energy System honours Antoine Lavoisier, the Parisian scientist who in 1743 named both hydrogen (H) and (O), and introduced new chemical nomenclature.

LAVO is developing a of lifestyle technology products, including a hydrogen-powered barbecue and e-bicycle. The company expects its initial customers to include homes and businesses on the edge of the national grid, such as mines and agribusinesses. One eco- is already a customer.

Gowings Bros, the investment company that evolved from the famous mens' clothing business, announced January 2021 it had signed-on as an investor and further committed to buying 200 of the LAVO power units for its properties around the country.

The LAVO system, which around $34,000, has a lifespan around three times current lithium batteries and should last users around 30 years. When the hydride is degraded it can be melted down and reused, giving the system significant environmental advantages over its competitors.

Lawns, biodiverse

Problem:

Every year across the USA, manicured lawns covering up to 50 million acres of ,consume nearly 3 trillion gallons of water a year, 200 million gallons of gas (for all that motor mowing), and 70 million pounds of pesticides. ... In fact, these lawns can do substantial harm to the environment and to both vertebrates and insects.

Solution:

The collective regeneration of grasslands in areas rich in biodiversity.

Lawns were a European invention, England to be precise, and they were the undertaking of the fabulously wealthy, seeking to bring the glade closer to home. Originally, they were cultivated with useful (though not necessarily used) plants like chamomile or thyme. However, the moved towards closely cropped , first maintained by grazing sheep then by men with scythes and finally, eventually, moving (in fast forward) to the suburban with his fossil fuel lawnmower, trimmers, and multitude of weapons against nature.

A growing number of homeowners are converting part or all of their lawns to a less thirsty form of landscape. These no-mow yards fall into four categories: 1) naturalized or unmowed turf that is left to grow wild; 2) low-growing turf that require little grooming (most are a blend of fescues); 3) native or naturalized landscapes where turf is replaced with native plants as well as noninvasive, climate-friendly that can thrive in local conditions; and 4) yards where edible plants—vegetables and fruit-bearing trees and shrubs—replace a portion of turf.

In Montreal, Canada, landscape gardeners Philippe Asselin, Emile Forest and Jonathan Lapalme created an ngo “Les Nouveaux Voisins” (= the new neighbours) to replace lawns with gardens favorable to biodiversity. They encourage individuals to cultures to accommodate plants, birds, insects, and other non-human neighbours. This in turn will reduce heat islands, increase carbon sequestration in soils as well as increased community resilience*(www.nouveauxvoisins.org)*

Organizations like the Surfriders Foundation, (www.surfrider.org) a national environmental group up of surfing aficionados, helped transform turf lawns in Southern California parks and homes into -friendly gardens, using succulents and other indigenous plants with hardscape materials like rocks and that increase filtration, conserve water, and reduce runoff.

Xeriscaping goes one step further by replacing grassy lawns with soil, rocks, mulch, and drought-tolerant native plant species. Trees such as myrtles and flowers such as daffodils are drought-tolerant plants. Native (warm-season) that been cultivated for turf lawns, such as buffalo and blue , can survive with a quarter of the water that bluegrass varieties need. The concept combining "landscape" with the Greek prefix *xero-*, from ξηρός (*xēros*), meaning dry, was coined and trademarked by Denver Water, the Colorado city of Denver's water

department, during a difficult drought period in the '70s and early '80s. *(www.denverwater.org)*

Leaf blower for controlled wildfire fighting

Problem: Global warming and droughts, wildfires across the world from Siberia to Australia, from to California.

Solution: For the creation of firebreaks, industrial standard leaf blowers are a powerful tool. Two people with leaf blowers can do job as ten people with traditional beaters, in a fraction of the time. The goal is to clear a swath to mineral soil that will not support fire spread.

The leaf blower was invented by Dom Quinto in the 1950s as a method of to spray chemicals in agricultural situations. The manufacturers of the device that Quinto invented saw that of their consumers where buying the machine and then removing the chemical dispersion unit, leaving just the blower.

the popular models are the gasoline-fuelled RedMax EB6200, the cord & Decker model BV6000 with an air velocity of 250 mph (400 kph), and a volumetric flow of 400 ft3. per minute (11.4 m^3/min) and the cordless Worx Turbine WG591 and Ego Power+ LB4801.

Another method is the **A**mphibious water bomber (see Solution N°)

Leather, animal-free

Problem: Not is the slaughter of millions of animals for meat considered very cruel, but also the secondary industry of tanning the hide

Solution: In recent years, when animal rights are something people are more aware of, animal-free leather innovations are being trialled. One of this is apple leather. The raw material grows in Southern Tirol over an area of around 4,500 ac (18,400 ha) where 60 million apple trees deliver the healthy fruit into the hands of 7,000 fruit farmers every year. Around 950,000 tons (860,000 tonnes) of apples are harvested a year – 10 % of the European apple harvest. Most of the apples end up in supermarkets, however are processed into juice or puree, with stalks, fibres and peel left as residue. This is known as apple pomace. Animals are pleased to the delicious waste, some of which is also incinerated to produce energy. A few years ago, Hannes Prath, founder of the company Frumat in the Italian town of Bolzano (Bozen), the industrial area of Florence, had the idea of producing imitation leather from apple waste. To do this, the fruit waste is dried and ground to a powder, which is applied to a tear-resistant cotton canvas with a biological plastics substitute. The solvent remaining on it is washed out; the residual elements fuse together at 130°C to the finished apple leather, which currently makes up 50 % of the material for ; for stability, the rest is made of biodegradable polyurethane (PU).

One of the companies to up this product was Nuuwaï (New Way) founded in Isernhagen Hamburg by a vegan called Svenja Detto who had seen saw a post on TV about it. This was not without reason: Svenja's father Gunnar Detto founded the handbag label 'diboni' six years before and was selling 1,000 of his own women's handbag designs a year. The appleskin are by a family-run concern in India. Customers think that apple leather looks very such as animal leather and genuine traditional imitation leather. The lining is of recycled plastic that has been fished out of the sea. For this Detto buys up remaining of ECOALF, which they no longer use. In this way they support the "Upcycling the " project and conserve resources. Because all used materials are free from animal derived ingredients nuuwaï is {PETA-Approved vegan}. The Nuuwaï , initially available in are now produced in light blue, pink, apricot and other colours. *(nuuwai.com)*

For Dr Carmen Hijos, discarded pineapple leaves are the key. Originally from Spain, Hijos was for the Design Centre Philippines leather export industry in the 1990s, but was shocked at the environmental impact of mass leather production and chemical tanning. Inspired by the abundance of natural resources, including the use of plant fibres in traditional weaving such as the delicate Tagalog garments, Hijos sought to create a new, non-woven textile that

could be commercially produced, provide positive social and economic impact and maintain a low environmental footprint throughout its life cycle. She then spent seven years developing the product through a PhD at the Royal College of Art in London, and joint collaborations with University in Wales, Northampton Leather Technology Center, Leitat Technological Centre in Spain, alongside NonWoven Philippines Inc. in Manila, and Bonditex S.A., a textile finishing company in Spain. In 2015 she presented Piñatex at the PhD graduate exhibition. To one square meter of Piñatex takes 460 leaves but there is no of raw material. Global pineapple production topped 28 million tons (25 million tonnes) in 2016, according to Statistica. Since its commercial launch in 2015, Piñatex faux leather has been used by about 500 manufacturers, including vegan sneakers sold by fashion house Hugo Boss, a jacket by H&M, by Altiir's for their biker-style jacket, by Somebody People for their barstools, by Apple as a strap for their watch and by Chanel for its luxury gold boater hat. Lucie Trejtnarová, a postgraduate student at the Faculty of Multimedia Communication, Tomas Bata University in Zlín (UTB), Czech Republic, and materials manufacturer Fillamentum developed the 3D printed shoe collection. The experimental sandal integrates 3D printed outsoles from TPU-based Flexfill 98A, Malai, also known as coconut leather, and Piñatex. *(ananas-.com)*

Another approach to leather handbags, pairs of shoes, smartphone hulls clothing and upholstery, but not using animals has been taken by Nawal Allaoui, a student at the Higher School of Textile and Clothing Industries (Esith) in Morocco. This was in social entrepreneurship in the coastal of Sidi Rahal with the wives of the fishermen who cleaned the fish and took away the spines of sea urchins. She observed how the skins, considered as waste, usually go to the trash to pile up in bins where they decompose in oily matter. After several tests in her room at the boarding school of Esith, Nawal was to concoct an innovative recipe for the tanning of fish skins, based on Moroccan products, such as henna.

In 2016, Nawal founded SeaSkin, sourcing raw fish skin (sole, whiting and salmon from fish restaurants and a fish fillet plant, before training six women in Sidi Rahal to peel the skin by removing the remaining flesh residues and rinsing the whole. The next day is devoted to vegetable tanning, Nawal bathes the skins by gradually incorporating the preparation from natural products. Finally, the skin will be ready to go into a dye bath to be customized according to the product. At the end of the chain, the final touch is to flatten and

dry the leather to create a luxury leather goods product. There is no fish smell because the oils, naturally present in the skins, are replaced by natural tanning or protective oils, so the object simply smells of leather. For the marketing of its products, Nawal sells online. *(industries.ma)*

In England, Lucy Hughes, a graduate of the product design program at the University of Sussex, has also developed a method of using fish waste, scales and skin, to a bioplastic called MarinaTex, which can biodegrade back into the soil in six weeks. Over 172,000 tons (156,000 tonnes) of fish waste produced annually by UK processing plants could be converted. Hughes was awarded the 2019 James Dyson Innovation Award. *(marinatex.co.uk)*

Near Biarritz, on the -Spanish border, Erik de Laurens and Edouard de Dreuzy developed *Scalite*, using salmon scales from the local fishing industry and sardine scales from Brittany. cleaned, crushed they are transformed into powder without any addition of chemical product. from this flour-like dust, Scalite with a marbled or homogeneous appearance is resistant to scratches and fire and can be worked like wood hence of great interest to architects and decorators. (*scale.vision.fr)*

"Vegan From… Apples: Meet Nuuwaï," *Style with a Smile*, April 20, 2019; Asmae Boukhems, "Nawal Allaoui. Une ingénieure innovatrice qui une nouvelle vie à la peau des poissons à "SeaSkin,"*industries.ma*, October 10, 2018; "Carmen Hijosa develops a sustainable textile of pineapple leaves' fibres as an alternative to leather," *Cartier Women's Initiative*, 2015 ; Carmen Hijosa, "Natural Nonwoven Materials," *US Patent 2013014951 2A1*, 13, 2013.

:Less Thirsty

Problem:

Traditional farming is heavily reliant on ready supplies of water and labour. Climate and urbanisation, however, threaten traditional paddy cultivation.

Solution:

In parts of Asia farmers are switching to direct seeded (DSR) as a sustainable alternative. This is grown in dry fields, so uses less water and requires less work. It also cuts out the greenhouse gases that bacteria in paddy fields produce.

A team led by plant development biologist Dr Smita Kurup at the Rothamstead Research in collaboration with the International Research Institute (IRRI), based in the Philippines, and Punjab Agricultural University, India, are using use cutting edge plant breeding technologies, field trials and an based system for measuring traits to accelerate the development of new "DSR adapted" varieties that can be grown with less water conventional puddled transplanted .

Kurup has already identified in the lab hitherto 'unknown' varieties suitable to DSR in terms of their seedling traits by screening several hundred varieties from the International Genebank at IRRI. As a next step, the is to use these lines to combine with current good yielding and disease resistant cultivars to generate new high-yielding "DSR adapted" varieties.

 developed, their field performance will be evaluated at multiple locations. Finally, the most promising breeding lines will be nominated for trails in Asia before releasing to farmers.

:Light displays

Problem:

Traditional fireworks create a fog of particulates, poisonous aerosols and heavy metals.

Solutions:

fireworks.

The Japanese solution of (mochi-gome) allows for far less smoke. The cares are prepared, toasted then broken apart before heating them again and making paste . Although this takes abit of effort, it produces the ultimate paste. If the adhesive strength is neither too weak nor too , a beautiful combustion will not be achieved

Thailand in the New Year 2021 with a 1.4 km display of 20,000 fireworks Bangkok's Chao Phraya riverfront as eco-friendly message of hope to the world

Drones were used in several cities to welcome in 2021. In London a 10-minute show used 300 which were flown around the Millenium Dome after the annual fireworks display at the London Eye was cancelled. It ended with the of a sea turtle and ended with Sir David Attenborough calling for people to work in 2021 to help our '' planet. In Scotland 150 drones were part of a three-part choreographed show called " Well" to say bye to 2020 and welcome

Three months' before, during the night of September 20, some 3,051 drones took to the skies above Zhuhai, Guangdong, China to break the record for the most Unmanned Aerial Vehicles (UAVs) airborne simultaneously. During this official challenge, the design executive team represented achievements of Chinese space science and technology in the night sky, such as the Tiangong-1, Beidou satellite system and China's space station.

The benchmark for this record was set by a 2,200 drone display in Russia on September 4, 2020. This broke the Guinness World Records title set by Intel Corporation (USA) with 2,066 in Folsom, California, USA on 15 July 2018.

Lift powered by wastewater

Problem: St Gervais les Bains is in the Haute-Savoie department in the Auvergne--Alpes region in south-eastern . At the foot of Mont Blanc, the mid-mountain village is best known for tourism, and has been a popular holiday destination since the early 1900s. To reach the thermal baths below and its activity center, including the high school, the thousands of tourists to a steeply sloping road for 4 km.

Solution: In to reduce individual motor transport and the carbon footprint, Mayor Marc Peillex wants to build a lift which will use water pressure to move the cabin up and down. Ballasts that will fill and empty will run the lift. It will be the town's wastewater that will be used and not spring water. The water lift is much less advanced than its big brother since it is still in the preliminary phase. *(To be updated)*

:Lithium-ion batteries, cobalt free

Problem: Lithium-ion batteries are essential to modern technology, powering cell phones, laptops, medical devices and even electric vehicles Lithium ion battery demand has grown from a production of 19GWh in 2010 to a production of 160GWh in 2019 from a capacity of 285GWh. In 2019, LG Chem had the most lithium battery production capacity at over 50 GWh. LG Chem pis increasing EV battery production capacity to as much as 110GWh by the end of 2020.

Cobalt is a scarce, , and lustrous mineral that is found in the negatively electrode—or cathode—of almost all lithium-ion batteries used today. It is expensive, heavy, and linked to unethical mining practices, wild price swings, and a tenuous global supply chain.

Solution: In July 2020, Arumugam Manthiram, a professor in the Walker Department of Mechanical Engineering and director of the Texas Materials Institute, Ph.D. student Steven Lee and Ph.D. graduate Wangda Li reported the results from tests using a new cathode chemistry that eliminates cobalt entirely without compromising performance.

The Texas trio used specialized techniques to mix the ingredients just so at the nanoscale. This involves pumping solutions containing 89% nickel, manganese, and aluminium ions into a reactor where they are mixed with another solution that combines with the metal ions. The result is a finely mixed powder of metal hydroxides that are baked with lithium hydroxide to create the

material used for the cathode, without reducing the lifetime or energy density and so is comparable to the current NMC (nickel-manganese- cobalt) or NCA (nickel-cobalt-aluminium) cells.

Although the battery has a slightly lower energy density typical cobalt batteries, it was able to operate at higher voltages and at similar chage rates . Even after 1,000 full -discharge cycles—the typical lifetime for a commercial battery—the experimental cell performed as well as comparable cells with cobalt cathodes.

Manthiram and his colleagues launched a spinout start-up, TexPower in Austin, to commercialize the material

Arumugam Manthiram, Abhay Gupta et al, "Designing Advanced Lithium−B*ased Batteries for Low−Temperature Conditions",* Advanced Energy Materials, 12 August 2020.

:Lithium extracted from geothermal waters

Problem:

Five times lithium is mined currently is to be necessary to meet global climate targets by 2050, according to the World .

Solution:

Lithium extracted from geothermal waters

In 1864, quantities of lithium were discovered in a hot spring is discovered nearly 450m (1,485ft) below ground in the Wheal Clifford, a copper in Cornwall. But 19th-Century England had little need for the element, and this 122C (252F) lithium-rich water continued boiling away in the dark for 150 years. Instead, Cornwall became world famous for its tin and copper mines.

In 2016 Cornish Lithium ltd was founded by mining engineer and businessman Jeremy Wrathall and a team of 10 full-time geoscientists led by Lucy to use modern extraction methods at the United Downs Geothermal Power site, the UK's first deep geothermal electricity plant. *(cornishlithium.com)*

The site, confirmed as having some of the world's highest of lithium in geothermal waters (260 milligrams per litre) would a tiny environmental footprint in comparison with conventional surface lithium mining, including very low carbon emissions.

The directors of Cornish Lithium secured agreements with various holders of mineral rights in Cornwall to explore for, and to commercially develop, lithium bearing hot spring brines throughout areas considered to be highly prospective. In August 2020, the project won £4m ($5.3m) backing from the UK government, allowing a pilot lithium extraction plant to be built in the next couple of years and move Cornish mining into the 21st century.

:li-glass battery

Problem: The li-ion battery is limited in the number of times it can be recharged 500 times.

Solution: In his nineties, John Goodenough, whilst one of the pioneers of the li-ion and the lithium phosphate battery, has been investigating another solution in the lithium-sodium glass battery.

Together with Maria Helena , a Portuguese physicist at the Cockrell School of Engineering, at the University of Texas, they developed a solid-state lithium rechargeable that uses a glass doped with alkali metals making it non flammable. Their prototype which offers three times' the energy density as li-ion, performs well in both hot and cold weather and can be /discharged up to 23,000 times, in minutes instead of hours.

In March 2020 the Canadian utility Hydro-Quebec announced that its research lab, comprising 120 people, would be preparing the battery for commercialisation, in collaboration with and the 97-year-old Goodenough who in 2019 was co-recipient of the Nobel Prize for chemistry. The utility announced that the battery would be ready in two years' time, before Goodenough's hundredth birthday. *(hydroquebec.com)*

, M.H.; Grundish, N.S.; Murchison, A.J.; Goodenough, J.B., "Alternative strategy for a rechargeable battery", *Energy & Environmental Science.* **10**: 331–3369 December 2016.

Liquid Clay

Problem: 30 million ac (12 million ha) of productive are lost every year due to desertification and drought. 2. By 2025, 1.8 billion people will suffer absolute water scarcity, and 2/3 of the world will experience water-stressed conditions. 3. Restoring the soils of degraded ecosystems has the potential to store up to 3 billion tons (2.7 billion tonnes) of CO_2 annually.

Solution: In 2005, Kristian P. Olesen, a veteran in the HVAC industry, based in Stavengar, Norway developed a mixture of clay and water called Liquid Clay. Sprinklers are used to spray the LNC 1.6 ft (0.5 m) into the , enabling the to hold water, and crops to be grown. The inorganic binder composition displays electric , precisely a homogenised dispersion of clay particle consisting substantially of single flakes of clay and air bubbles dispersed in a fluid. One major use of the binder composition is to reclaim arid and hyper-arid deserts and to prevent desertification and the movement and advancement of dunes, in other words stopping wind erosion efficiently. With this process any poor-quality sandy soil could be transformed into high-yield agricultural in seven hours. Olesen's vision and that of Desert Control, the firm he founded with Idlund is to " Earth Green Again".

In a field test using the world-patented LNC in the United Emirates, two areas were planted with a selection of crops: tomatoes, aubergines and . One was treated with LNC while a second control area was left untreated. While the untreated area used almost 4838 ft^3 (137 m^3). of water for irrigation, the one treated with LNC used just 2860 ft^3 (81 m^3), an enable saving of up to 52% of irrigation water and increase yields with less strain on scarce resources. Using LNC, deserts been planted with over ten thousand trees, wheatfields, pepper fields. Other successful tests took place in Pakistan and China.

Olesen proposes that the biomass produced from desert-grown plants could provide clean electricity to power the desalinisation plants from which water could be used to irrigate the green deserts. the awards received by Olesen and his son is the World Wildlife Foundation's acclamation of Desert Control as a Climate Solver/ *(desertcontrol.com)*

Kristian P. Olesen “Inorganic, electric binder composition, use thereof and method for the preparation of said binder composition,” NO20060203 2006.

Li-ion battery recycling

Problem: Since 2005, the commercialised li-ion battery has surged, starting with electronics and expanding into applications, including the growing electric and hybrid vehicle industry. As the popularity of electric vehicles starts to grow explosively, so does the pile of spent li-ion batteries that powered those cars. Industry analysts predict that by 2020, China will generate some 550,000 tons (500,000 tonnes) of used Li-ion batteries and that by 2030, the worldwide number will hit 2.2 million tons (2 million tonnes) per year. But the technologies to optimize recycling of these batteries not kept . If current trends for handling these spent batteries hold, most of those batteries may end up in landfills even though Li-ion batteries can be recycled.

Solution: In 2009, far-sightedly, the US Department of Energy DOE US$9.5 million to W. Novis Smith and Scott Swoffer at Toxco in California to build America’s first recycling facility for li-ion vehicle batteries. Toxco used the funds to expand an existing facility in Lancaster, Ohio, that already recycled the lead-acid and nickel-metal hydride batteries used in hybrid-electric vehicles. The new facility opened in 2015 and is currently in operation. It recycles a multitude of li-ion batteries, including those that have substituted cobalt for other minerals, including phosphate, manganese spinal, and nickel manganese. *(toxcommc.com)*

In 2018 China recycled around 67,000 tons (61,000 tonnes) of li-ion batteries 2018, or 69 % of all the available for recycling worldwide. The People’s Republic has benefited from around a decade of mobile manufacturing, which has enabled it to perfect li-ion battery recycling as part of a growing handset refurbishing industry. Hunan Brunp Recycling Technology, a subsidiary of li-ion battery leader CATL, recycled about 30,000 tons (27,000 tonnes) of batteries. Meanwhile, Quzhou Huayou Cobalt New Material has roughly 60,000 tons (40,000 tonnes) of li-ion battery recycling capacity a year and recycled around 10,000 tons (9.100 tonnes) in 2018. Recycling is also

carried out by Ganzhou Highpower Technology and Guangdong Guanghua Sci-Tech.

In 2018, researchers in the UK formed a consortium dedicated to improving Li-ion battery recycling, specifically from electric vehicles. Led by the University of Birmingham, the Reuse and Recycling of Li-ion Batteries (ReLiB) project brings together some 50 scientists and engineers at eight academic institutions, and it includes 14 industry partners. *(relib.org.uk)*

In February 2019, the United States Department of Energy (DOE) opened the ReCell Center a battery recycling research and development center at National Laboratory in Lemont, Illinois. The goal of the R&D facility is to reclaim and recycle materials such as cobalt and lithium from spent li-ion batteries. Launched with a US$15 million investment and headquartered at National Laboratory, ReCell includes some 50 researchers from ; the National Renewable Energy Laboratory (NREL); Oak National Laboratory () and several universities, including Worcester Polytechnic Institute (WPI) in Massachusetts, the University of California at San Diego and Michigan Technological University. Recycled materials from li-ion batteries can be reused in new batteries, reducing production by 10% to 30 %. This could help lower the overall cost of electric vehicle (EV) batteries closer to the DOE's goal of US$80 per kilowatt hour, says the agency. The ReCell Center is supported by the DOE with US$15 million in funding over three years, and its work will include development of test beds and a process scale-up facility at . *(recellcenter.org)*

The DOE also announced its US$5.5 million Li-ion Battery Recycling Prize. The prize encourages entrepreneurs to find innovative solutions to collecting, and transporting discarded li-ion batteries for eventual recycling. It will award cash prizes totaling US$5.5 million to contestants in three phases designed to accelerate the development of solutions from concept to prototype.

The ReCell collaborators also will use existing modeling and analysis tools to help industry determine how to optimize value. EverBatt, Argonne's closed-loop battery life-cycle model evaluates the techno-economic and environmental impacts of each of a battery's life, including recycling. NREL's supply chain analysis tool provides a birds-eye view of the interconnections between raw material availability, primary manufacture, recycling, and demand.

Worcester Polytechnic Institute is researching the effects of impurities on the cathode materials used to li-ion batteries. After 7 years' research, Yan , a

WPI William Smith Dean's Professor of Mechanical Engineering who developed a process for recycling li-ion batteries that can recover and reuse cathode materials regardless of their chemistry is leading the project. Yan founded Battery Resourcers in Worcester to demonstrate that the process can be scaled up to near-commercial capacity. *(wpi.edu)*

In Germany, Volkswagen started battery recycling in 2020 at Volkswagen Group's component plant in Salzgitter, with an initial capacity to recycle roughly 1,200 tons (1089 tonnes) of EV batteries per year, equal to the batteries from about 3,000 vehicles. The recycling of raw materials in Salzgitter is around 72%, which is already a lot higher the industry average. Using a special shredder, the individual battery parts can be ground up, the liquid electrolyte can be cleaned off, and the components separated into " powder." This contains the valuable raw materials cobalt, lithium, manganese, and nickel, which, while requiring further physical separation, are then ready for re-use in new batteries. In the term, Volkswagen wants to recycle about 97 % of all raw materials in the battery packs. In , Renault and Euro Dieuxe Industrie, a Veolia subsidiary, are employing a unique hydrometallurgical process that allows the recovery of precious metals such as cobalt and nickel contained in the batteries of electric vehicles, in to promote their re-use in various industrial applications or in chemistry for the manufacture of battery cells. *(volkswagen.ag.com)*

CSIRO's Australian Battery Recycling Initiative is preparing to tackle Australia's annual 3,600 tons (3300 tonnes) of li-ion battery waste. In September 2019 following Australian Prime Minister Scott Morrison's meeting with President Donald Trump, the CSIRO is joining ReCell Center's industrial advisory council to deepen collaboration on li-ion recycling.

Shuiyu, "E-vehicle batteries to be recycled in green push, " *China Daily* September 10, 2018; Tona Kunz, "DOE launches its first lithium-ion battery recycling R&D center: ReCell," *National Laboratory*, February 15, 2019; "VW releases battery recycling details," *electrive.com*, February 21, 2019; X. , "Hydrometallurgical process for the valorization of nickel ..." *University of* , March 29, 2018; "Australia to lead lithium-ion battery recycling ", *CSIRO*, July 17, 2018

Light-emitting diodes

Problem: Traditional incandescent light bulbs are harmful because of the traditional electricity they waste in producing heat, indirectly the cause of greater CO^2 emissions.

Solution: Light emitting diodes (LEDs) use at least 75% less energy, and last 25 times , incandescent lighting. LEDs are used in applications as diverse as aviation lighting, automotive headlamps, advertising, general lighting, traffic signals, camera flashes, lighted wallpaper and medical devices.

The invention of prototoype LEDs can be traced back to 1907 with big developments also in 1927, 1936 and 1939 but these were not taken up by industry. The first visible-light LEDs were developed for the market in 1962 by Nick Holonyak, Jr. while at, General Electric's research laboratory in Syracuse, New York. Holonyak patented a process for crystal alloys from which it was possible to make semi-conductors emit red light that was visible to the human eye. Earlier semi-conductors could emit invisible infrared light. They were of low intensity and limited to red often used as indicator lamps, replacing small incandescent bulbs, and in seven-segment displays. M. Craford, a former graduate student of Holonyak, invented the first yellow LED and improved the brightness of red and red- LEDs by a factor of ten in 1972. In 1976, T. P. Pearsall created the first high-brightness, high-efficiency green LEDs for optical fiber telecommunications by inventing new semiconductor materials specifically adapted to optical fiber transmission wavelengths. With green and blue LEDs in the 1990s, recent developments have produced high-output white light LEDs suitable for room and outdoor area lighting.

LEDs can have a relatively useful life. One report estimates 35,000 to 50,000 hours of useful life, though time to complete failure may be shorter or . However, in 2012, Celia Sánchez- and a team at Madrid University showed that blue LED light can irreparably damage the cells in the eye's retina.

On January 1, 2014, in keeping with a law passed by the US Congress in 2007, the old familiar tungsten-filament 40- and 60-watt incandescent light bulbs could no be manufactured in the U.S., because they did not meet federal energy-efficiency standards. Brazil and Venezuela started the phase-out in 2005, and the European Union, Switzerland, and Australia started to phase them out in 2009. Likewise, other nations are implementing new energy standards or

scheduled phase-outs: Argentina, and Russia in 2012, and the United States, Canada, Mexico, Malaysia and South Korea in 2014.

Yet during this very period, Celanovic, Principal Research Scientist Institute for Soldier Nanotechnology and a team at MIT were tweaking tweaked the traditional design and up with an incandescent light bulb that is several times energy efficient LEDs and fluorescent bulbs. They determined they could the filament with a special crystal structure inside the bulb's glass to "recycle" energy that is usually lost. The result, according to tests on the proof-of-concept design, is an incandescent bulb that emits particular wavelengths of light, rather like a gas mantle emitting white light when most materials at the temperature would glow while reaching efficiency levels up to 40 %. The new bulb is also vastly better at duplicating natural daylight modern energy efficient bulbs, so it could give the competition a real run for their money. The work was supported by the Army Research Office. *(isn.mit.edu)*

Celanovic et al. "Tailoring high-temperature radiation and the resurrection of the incandescent source," *Nature Nanotechnology* 11, 320–324 (2016); Celia Sánchez- et al "Effects of light-emitting diode radiations on human retinal pigment epithelial cells in vitro", *Photochemistry and Photobiology*, March-April 2013;89(2):468-73.

:Light-trapping in solar cells

Problem: The renewable energy sector is constantly looking for new ways to the light absorption of solar cells in lightweight materials that can be used in products from roof tiles to boat sails and camping equipment.

Solution:

A study, led by Christian Schuster from the Department of Physics at the University of York, England and conducted in partnership with NOVA University of Lisbon (CENIMAT-i3N) -- investigated how different surface designs impacted on the absorption of sunlight in solar cells, which put together form solar panels.

They found that a simple pattern checkerboard etching of solar cells can enhance the current generated by crystalline silicon (*c-Sy*) by as much as 125 % - to a solar cell absorb energy by trapping sunlight, while reflecting less away

from itself. The checkerboard pattern with randomised rotations of its reappearing units generations current any of the competing cells an generates about 125% by manufacturing with this checkerboard design the cost-effectiveness of resources used for cell fabrication could be 10-fold.

The study suggests the design principle could impact not in the solar cell or LED sector but also in applications such as acoustic noise shields, wind break panels, -skid surfaces, biosensing applications and atomic cooling.

Christian S. Schuster et al; “Light trapping in solar cells: simple design rules to maximise absoroption Vol7, Issue 10 (2020)

Liquid oil upcycled from plastic polymer

Problem: Plastic polymer trash uselessly and lethally fills a landfill unless it can be transformed into something useful.

Solution: Kenneth R. Poppelmeier and a team at Northwestern University in Illinois, US, collaborating with Aaron D. Sadow, a scientist in the Division of Chemical and Biological Sciences at Ames Laboratory, and Massimiliano Delferro, group leader of the Argonne National Laboratory's catalysis program, succeeded in developing a chemical technique which breaks down the bonds that make polyethylene - the plastic most commonly used to the ubiquitous carrier bag - so indestructible. The catalyst consists of platinum nanoparticles, just two nanometers in size, deposited perovskite nanocubes, which are about 50-60 nanometers in size. The team chose perovskite because it is stable under the high temperatures and pressures and an exceptionally good material for energy conversion. To deposit nanoparticles the nanocubes, the team used atomic layer deposition, a technique developed at that allows precise control of nanoparticles. Under moderate pressure and temperature, the catalyst cleaved plastic's carbon-carbon bond to produce high-quality liquid hydrocarbons. These liquids could be used in motor oil, lubricants or waxes or further processed to ingredients for detergents and cosmetics. This contrasts with commercially available catalysts, which generated lower quality products with short hydrocarbons, limiting the products' usefulness. In addition, the catalytic method produced far less waste in the process. Recycling methods that melt plastic or use conventional catalysts generate GHGs and by-products. Transforming that tide of plastic waste into something of higher value such as high-quality liquid products, such as lubricants and waxes, characterized by a narrow distribution of

oligomeric chains, is a promising business venture. It is called chemical recycling - and is distinct from purely mechanical recycling. *(chemgroups.northwestern.edu)*

Kenneth R. Poppelmeier et al. "Upcycling Single-Use Polyethylene into High-Quality Liquid Products," *ACS Cent. Sci,.*2019.

Liquid Sunshine

Solution:

On January 17th 2020, Can Li and a team of scientists led by the Dalian Institute of Chemical Physics (DICP) of the Chinese Academy of Sciences in Lanzhou, China began a -scale project demonstrating PV-powered production of hydrogen, which is then used to convert carbon dioxide into methanol.

The demonstration project based on the advanced technologies of electrocatalytic water splitting and CO2 hydrogenation was certified by China's Petroleum and Chemical Industry Federation and is expected to run for 10 months, with plans for expansion further down the .

The "Liquid Solar Fuel Production demonstration Project" combines a 10 MW PV array with an electrolyzer and equipment for CO_2 hydrogenation. The electrolyzers utilize an undisclosed catalyst developed at DICP, which it describes as a "low-cost and -lifetime electrocatalyst for alkaline water electrolysis." According to the institute, the facility currently has capacity to produce 1,000 cubic meters of hydrogen per hour and requires less 4.3 kWh of electricity per cubic meter.

Hydrogen is then used to convert CO_2 into methanol, driven by another catalyst, this time a mixed metal oxide. DICP reports that the demonstration facility currently has capacity to produce 1,000 tons of methanol per year, reaching 99.5% purity.

DICP plans to expand the scale from 1,000 ton-methanol/year to 10,000 ton-methanol per year, or even to 100,000 ton-methanol per year

:Litter picker tool

Problem:

The tools we use for tackling plastic pollution at the beachfront shouldn't be adding to the problem we're fighting.

Solution:

A litter picker using 100% recycled plastic from trawl fishing nets for the handle, trigger and jaw components

The original arm was developed by Benjamin Franklin in the 1780s to enable him to a book stacked on one of the highest shelves of his crowded library. It was simply a piece of wood with two "fingers" mounted on the end. By pulling on a cable, Franklin could the fingers together to grip the volume off a high shelf.

While litter pickers used by gardeners in public parks and gardens are as common as letterboxes, most of them are exclusively from raw materials such as plastic, rubber and aluminium.

British ecologist Harry Dennis of Waterhaul, Newquay, Cornwall who had already led campaigns to prevent sewage from discharged on beaches the South Coast felt that the tools for tackling "ghost gear" plastic pollution at the beachfront shouldn't be adding to the problem we're fighting. Waterhaul created a litter picker using 100% recycled plastic from local trawl fishing nets for the handle, trigger and jaw components. Developed with circular concepts in mind, theselitter pickers are rugged, repairable and created to be fully recycled cradle-to-cradle.

ALPAR (Alaskans for Litter Prevention and Recycling) based in Anchorage also developed that they call green garbage grabbers. They are easily from PVC pipe, recycled banding, duct and a rubber . A DIY video is available.

Looming Eyes Buoys (aka "Wall-E")

Problem:

More than 720,000 sea birds continue to die annually from getting caught in gillnets, vertical nets used in small-scale fisheries in many countries.

Solution:

A Looming Eyes Buoy (LEB) stops seabirds diving into gillnets, its appearance reminding one of Pixar's adorable waste collecting hero "Wall-E".

The device, resembling floating scarecrow, designed by Ben and Pete Kibel of Fishtek Marine, uses bright eyespots and looming movements to act as a natural deterrent.

To ensure that the buoy would elicit a strong evasive response by seabirds, the Kibels chose a looming eye design with a and white pattern to offer best contrast and visibility at distance. They designed a 150 mm wide target with a centre 'pupil' of 75 mm in diameter. These measurements are based on the visual acuity of Canada geese *Branta canadensis,* which have one of the lowest acuities measured in birds. They predicted that this design could be detected by a duck at a distance of 80 m during daylight, and at approximately 40 m during twilight.

This looming eye design was incorporated into a three-dimensional rotating device consisting of two panels simulating an eye pattern The opposite face of each panel exhibited an eye pattern of different size, in order to create the 'looming' effect when the panels rotate. Panels were assembled and shaped similar to a sinusoidal wind turbine in order to facilitate movement by the wind. Natural wind gusts induced unpredictable movements and speed rotations, which further intensify the likelihood of birds' behavioural responses and reduce chances of habituation

The prototype LEB was trialled by scientists from BirdLife International and the Estonian Ornithological Society in Küdema Bay, on the northern coast of the island of Saaremaa island, Estonia, on long-tailed ducks (*Clangula hyemalis).* After 250 hours of observation, the team found that it was able to stop local ducks congregating at a rate 20-30% within a 50 m radius of the LEB and that the presence of LEBs was the most important variable explaining this decline. This is more efficient than traditional fishing buoys intended for the same purpose.

Looop

Problem:

According to a waste statistics from Greenpeace in 2015, people in throw away 110,000 tonnes of textile products annually. these textiles wastes, there is a

substantial amount from blended materials. However, no commercially viable separation, , and recycling technologies are currently available for materials such as cotton and polyester blends.

Solution:

Looop recycling system

Looop is created by the non-profit H&M Foundation, together with research partner HKRITA (The Research Institute of Textiles and Apparel) and -based yarn spinner Novetex Textiles to develop practical solutions to recycle blended textiles into new fabrics and yarns. The objective of the collaboration is to facilitate the development of a closed loop textiles industry. The technology will be licensed widely to ensure broad market access and maximum impact.

H&M Foundation has installed a machine the size of a shipping container called Looop in its store in the Drottninggatan shopping district of Stockholm. It invites customers to a garment they're planning to discard—say, an old T-shirt or cotton dress—and watch it get broken down, then rewoven into a sweater, scarf, or baby blanket through the glass walls of the machine. The process takes about five hours, but when it's complete, the customer can pay $15 for the finished item.

H&M Group also recently announced that it has invested in Petri Alava's Finnish firm Infinited Fiber, which has found a way to liquefy bio-based fibers —such as cotton or viscose—then transform the fibers into a of fabrics—for instance, jersey and denim

Tomorrrow's solution: Automobile from recycled plastic: "Luca"

:"Luca"

Solution:

Lisa van Etten and a team of 22 students at the Technical University of Eindhoven taken 18 months to produce *Luca*, an electric concept car of flax and plastic waste.

The bright yellow, sporty two-seater can reach a top speed of 90 kilometres (56 miles) per hour and has a reach of 220 kilometres when fully ,

The is of flax and plastic waste. Flax has fibres that are enough to a chassis. The body, interior and windows are up of, other things, PET bottles, household waste and the type of hard plastic that is in toys or kitchen products. While the seat cushions consist of coconut and hairs, the yellow lacquer is a coloured foil, which is also easy to remove completely.

: Luminophores

Problem:

At night, sometimes it is difficult for cyclists to out an unlit track and indeed to differentiate it from pedestrian and motorised

Solution

Luminophore markings.

In 2014, based on an invention by two Australian brothers, Barry and Tony Rogers, Dutch artist Roosegaarde created a 600m luminous cycle for bikers and pedestrians. The contains thousands of twinkling coloured stones. The stones are by daylight and display fragments at night

Located between Nuenen and Eindhoven, part of the Van Gogh cycle interconnecting sites from the painter’s life, Roosegaarde called it the Starry Night path.

At the time, Roosegaarde’s pilot Smart Highway, named “Glowing Lines” – opened a stretch of N329 motorway in Oss where the photo-luminescent paint had been used to mark out the edges of the road. Developed with infrastructure firm Heijmans, the paint absorbs solar energy during the day then illuminates at night.

Meanwhile Smart Highway has developed to include interactive lighting and an induction priority for electric vehicles, using light, energy and road signs that automatically adapt to varying traffic conditions. The 'dynamic paint' used will respond to in temperature. Ice crystals will appear when road conditions are extra icy or slippery, for instance.

In 2016, TPA Quality Assurance laboratories in Pruszków in Poland, where research had been on for a time on colour and light-reflecting asphalt, and the European construction company Strabag created a new cycling in the town of Lidzbark Warminski, northern Poland composed of luminophores (lacquered luminescent aggregates) which glow blue at night in the town and improved bikers' safety. Beaming light for ten hours at a time, the luminophores can radiate different colours but the town chose blue to match the surrounding landscape

Maidenhair tree aka Gingko

Problem:

Researchers warn that pollution is accelerating the death of a wide of tree species with serious -term effects for biodiversity and carbon dioxide release trees, stunting their growth and making forests across the world and shorter.

Solution:

The gingko tree

Over the last 150 years, ginkgo, aptly named maidenhair tree for its ridged and fan shaped leaves, has found a place for itself city sidewalks throughout the world's temperate zones. It is tolerant of air pollution, which was probably the attribute that it so popular. It also tolerates compacted soil, acidic soil, salt, disease, wind, cold, drought, fire, and even nuclear.

In Hiroshima, Japan, six trees growing between 1–2 kilometres (0.62–1.24 mi) from the 1945 atom bomb explosion were the few living things in the area to survive the blast. Although almost all other plants (and animals) in the area were killed, the ginkgos, though charred, survived and were soon healthy again, other hibakujumoku (trees that survived the blast). The six trees are alive

As one example of forestry, due to the vaguely 'T' shape of its leaves, the ginkgo has been the symbol of Japan's capital city Tokyo since 1989. It can be found on the Tokyo Metro logo, and Tokyo parks are populated with them, such as Meiji-Jingu Gaien (明治神宮外苑), whose paths are lined with 150 ginkgos and their beautiful golden-yellow autumnal colour In the USA, The University of Virginia's Blandy Experimental Farm in , Clarke County, Virginia. is home to The Ginkgo , an arboretum with over 300 ginkgo trees.

Given that the Ginkgos are a living fossils, with the oldest living for over 1,000 years, with the earliest leaf fossils dating from 270 million years ago, they are in a unique position to help us learn what Earth was like millions of years ago and how today's sped-up climate might affect plant life in the near future. and what it might be like in the coming centuries

Mangrove reforestation

Problem: Senegal's forests faced multiple challenges. Severe droughts hit the country in the 1970s and '80s, and the boom in urbanization cleared thousands of ac of trees. Mangroves, one of the richest ecosystems in the world, been especially affected. Approximately 133,000 ac (54,000 ha) of mangroves in the regions of the Casamance Delta and Saloum, disappeared in Senegal between 1980 and 2005, according to a study by the United Nations' Food and Agriculture Organization. The study estimates that as of 2005, about 284,000 ac (115,000 ha) were left, mostly in the country's lush and tropical southern Casamance region.

Solution: Senegal is fighting back. It has planted 79 million mangrove trees, which will help protect vital arable , preserve aquatic habitats and absorb around 550,000 tons (500,000 tonnes) of carbon over 20 years. Since 2008, to help fight against mangrove degradation, Haidar el Ali, a Senegalese ecologist, through Océanium, helped by financial backing from both the Government and French water company Danone, and subsequently from the Paris-based Livelihoods Fund, organized 100,000 people from 350 villages to replant about 35,000 ac (14,000 ha) comprising 152 million mangrove buds in Casamance, and another 2,500 or so ac elsewhere in Senegal. One of the largest mangrove replanting efforts in the world this is now known as the Sengal Great Green Wall. After ten years, the national agency reports that it has planted 18 million trees on 99,000 ac (40,000 has) of restored .

The trees, which prosper in areas with low- soil, a dense of roots that appear to grow out of slow-moving waters. These intertwined clusters of roots

also provide a home for fish and other creatures seeking food and shelter from predators. The replanting has boosted depleted fish by producing up to 18,000 extra tons (16,000 tones) of fish annually, with shrimps, oysters, and molluscs that mangrove forests harbour. Nine market gardens are up and running, and three times as banks are keeping cattle fed in the season. Gazelles, jackals, desert tortoises and songbirds—not seen in the region for years—are returning.

In 2012 Haidar el Ali was appointed Minister of Ecology, becoming the Ministry of Fisheries the following year. He is also president of the Senegalese Green Party. But in May 2016, a piloted by the Oceanium team uncovered the site of illegal logging in the forest. Haidar El Ali announced that this looting, active since 2010, could turn the forest into desert within 2 years. In 2018, he planted propagules in Senegalese mangroves to revive plant outbreaks. The following year, he was sued for libel by the president of loggers Ablaye Sow for associating the killing of 13 people in the Baffa Bayotte forest with poor management by the logging company. *(au-senegal.com)*

Amanda Fortier, "How Haidar el Ali became one of Africa's best-known environmentalists." *The Christian Science Monitor*, October 20, 2016.

Moss

Solution:

Moss traps polluting micro-particles and certain volatile organic compounds such as ozone or benzene. It captures CO2. It is useful in offices where the indoor air is sometimes as polluted as the outside. In contact with natural vegetation, stress decreases, the sound is attenuated and open spaces can be partitioned. It provides humidity and freshness, and therefore reduces the use of air conditioning.

Josse Le Bilan and Arthur Lejeune, working with a team of bryologists founded PowerofMoss in Lille, northern France, using moss as an indoor wall covering. The moss used, grown in the regions of Mayenne and the Franco-German border. It is then given an oak frame from the Compiègne forest. Once indoors they have developed a unique irrigation system that will mist drops of the size of 1 to 5 micrometres, therefore tens, or even hundreds of times thinner than a hair, to irrigate without damaging the room. A specific low consumption horticultural

lamp is provided to activate photosynthesis. Without a root, it doesn't need any substrate to grow.

PowerofMoss plans to convert other people to this eco-interior décor. Having convinced both individuals and companies in the local Lille region, they are now starting to expand over the greater northern region, therefore towards Paris, Reims and Rouen.

Permaculture Arrays

Problem: As in much of the world, a lot of kelp and seaweed growing off the coast of Tasmania has died due to the rising sea temperatures. The University of Tasmania reports that roughly 95% of the kelp forests around Tasmania been lost over the past few years. This has led to the Australian Government listing them as an endangered community, the first of its kind in Australia.

Solution: In 2008, with two preeminent plankton experts, to manually restore overturning circulation in areas where it has stopped, von Herzen demonstrated the use of -driven pumps to up-well rich nutrients and grow plankton in a portion of the Pacific 60 mi (100 km) north of Hawaii. In just 57 hours after deployment, the system sparked plankton growth. Shortly thereafter, these blooms attracted various species of fish. Two weeks later, a 17-ft (5 m.) whale shark was circling the area feeding on plankton that had started to bloom. Herzen who has set up The Climate Foundation calls his floating platform system a Permaculture Array (MPA) with its ability to create forests of kelp and seaweed and to provide habitat for diverse fauna including invertebrates, and fish and birds. Climate Foundation was chosen out of a field of 220 organizations by Australia's Dept of Affairs and the Blue Economy Challenge to deploy a Permaculture Array in the Indian to validate the technical benefits. In this phase, they demonstrated the biological response of commercially relevant macroalgae to deep water upwelled to the surface. By October 2019, the first of CF's lab-bred kelp had been outplanted into the field, experimental arrays and aquaculture infrastructure in Storm Bay, Tasmania. The outplanting of these twines, seeded with microscopic juvenile kelp, was the first step in Herzen's research looking at cultivation of warm-tolerant kelp and restorative kelp aquaculture. This could then be scaled up to self-guided 250-ac (100 ha) Permaculture Arrays offshore. The kelp could be harvested to be used as biofuel, fertilizer, livestock feed, superfood and countless biomass applications and high-value extract. After high-value extraction at sea in the harvester bio-refinery, the

kelp could be sunk to deep anoxic environments, locking 90% of the sequestered carbon away for millennia. (see also **P**ermaculture). *(climatefoundation.org)*

von Herzen et al. "Assessing the Potential for Restoration and Permaculture of Tasmania's Kelp Forests" July 2018*;* von Herzen, "Structures and methods for simultaneously growing photosynthenic organisms and harvesting solar energy. Patent N°20190297789. October, 2019.

:Energy-saving ship propeller

Problem:

There are around 93,000 merchant ships, with 50,700 of them crisscrossing the at any one time. Their propulsion systems including their propellers, do not use energy efficiently**.**

Solution:

The 4-year LeanShips (Low Energy And Near to zero emissions Ships) project, funded by the European Union, ended in April 2019. It had carried out several demonstration actions that combine technologies for efficient and less polluting new or retrofitted vessels with end-user requirements.

The project's was to achieve CO_2 reduction of at least 25 %, estimated fuel savings of up to 25 %, and expected decrease of sulfur oxides, nitrogen oxides and particle matter air pollutants by up to 100 %. The markets covered by the LeanShips project include the small to mid-sized vessels for and maritime operations, and leisure and cruise ships.

One of the innovations was an energy-saving device (ESD), suitable for use by ships with controllable pitch propellers (CPPs) developed by Wärtsilä in association with the Netherlands-based Maritime Research Institute MARIN.

Called pre-swirl stator, the new technology has helped achieve 3.5 % fuel savings for ships with CPPs during sea trials. Also called EnergoFlow, the pre-

swirl stator guides one side of the stern flow in the opposite direction of the propeller rotation. Its multiple curved fins or stator blades minimise the viscous resistance while the connecting the fins at their tips decreases the peak stress of each fin.

The stator does not on its own energy or create a forward thrust, in fact it adds resistance; but its interaction with the propeller blade improves the propulsive efficiency and results in a power reduction. Due to its complex nature, the pre-swirl stator has been both successful and unsuccessful, depending on the application which has to be integrated with hull design to find an optimum stator configuration.

Tests of the pre-swirl stator were conducted with the ship *Portogallo*, a 540 ft (165 m) pure car and truck carrier by Italian shipping firm Grimaldi. It was introduced in 2017 at the Europort event in Rotterdam, the Netherlands. *(wartsila.com)*

Sunho Park et al., “Numerical Study of Pre-swirl Stator for Model and Full Scales”, August 2014; “Wärtsilä introduces an innovative pre-swirl stator to improve fuel efficiency.” *Wärtsilä Corporation*, 7 November 2017; H.J. Prins et al. “Green Retrofitting through Optimisation of Hull-propulsion Interaction – GRIP”, December 2019.

: Masking body odour: deodorant

Problem:

Antiperspirant deodorants contain aluminium-based compounds, preservative parabens, fragrance phthalates which can disrupt estrogen and androgens with carcinogenic effects.

Solution:

Sally R. Kim launched Wild in Portland, with a factory in Seoul, Korea, to produce a deodorant which is vegan-friendly, cruelty-free, dermatologically tested and free from artificial fragrance, parabens, aluminium and sulfates. Instead Wild has placed natural compostable refills like coconut, sunflower and shea into a plastic-free holder small enough for mail delivery.With over 100,000 armpits converted in the first 3 months since launch

in April 2020, Kim and her team continue to drive a sustainable revolution within personal allowing people to a small difference in reducing plastic waste whilst not having to sacrifice on product efficacy and style.

Maxime Debalt working for the Bleuvert family, based in Caumont-sur-Durance in the Vaucluse region of southeast France has produced Bôstick: a solid, natural, zero waste deodorant. The eight active ingredients of this deodorant are 100% natural and 72% of them are certified organic: organic coconut oil, organic shea butter, organic sunflower oil, organic Carnauba wax and natural perfumes that come from Grasse, these are the ingredients to which must be added diatomaceous earth which has an absorbing power.

For the applicator, Maxime wanted a practical and beautiful object. He drew several of them himself and then submitted them to Patrice, a woodturner who helped him improve the first prototypes. The applicator is therefore made of wood from sustainably managed French forests. Bôstick is therefore composed of a beech applicator, a cork pusher and a refill.

:Mater-Bi bioplastic

Problem:

Normally, plastic items can up to 1,000 years to decompose in landfills.

Solution:

Aliphatic-aromatic biodegradable polyester

One of the European pioneers of bio-plastic is Catia , a chemist from Novara, in the Piedmont region in northwest Italy.

In the 1980s, and a team at the Guido Donegani Institute, Ferruzzi-Montedison's Corporate Research Center, started up an ambitious project to develop chemicals with low environmental impact using raw materials of agricultural , so integrating chemistry, the environment and agriculture.

and a team set up Fertec research center where they Tomorrow'sed an enzymatic bacteria that makes goat cheese, cellulose to alcohol, and a fabulous -wrinkle material. They then investigated the potential of starch, wheat and potatoes. Novamont (Novara-Montedison) was created to commercialise their bio-plastic.

One of Fertec's earliest achievements was the creation of a biodegradable watch for Walt Disney. With Fertec incorporated with Novamont in 1991, production of the aliphatic-aromatic biodegradable polyester they tradenamed *Mater-Bi* (Materiale-) began at a new plant in Terni. worked as technical director, general and managing director at Novamont became the behind the transformation and of the company.

Before it was found that Mater-Bi presented properties and viscosity values that it suitable, after adjusting its molecular weight, for use in numerous practical applications such as films, injection molded products, extrusion coatings, fibers, foams, thermoformed products, extruded profiles and sheets, extrusion blow molding, injection blow molding, rotomolding, and stretch blow molding.

An initial production of 4,000 tons (3630 tonnes) per year, had doubled by 1997 and in 2001 had reached 16,000 tons (14,500 tonnes)per year. Products in Mater-Bi , cutlery, plates, glasses, toys, food trays, biodegradable mulch sheets are produced.

In Sardinia, the thistle is wild plant that grows in profusion and without fertilizer. Bastioli's team at Novamont realised that they could extract an oil that proved to be an excellent pesticide, and an effective lubricant for the maintenance of agricultural machinery.

Teaming up with partners in both Sardinia such as Versalis), the Matrica refinery and also Mater-, a joint venture with Genomatica in California began production of Mater-Bi from renewable sources and also creating sustainable rural regeneration. In 2012 the Novamont research center was expanded by

acquiring a medical biotechnology research center from Sigma-tau, redirecting its activities towards industrial biotechnology.

In 2019 a report about the biodegradability of compostable was published by the University of Pisa in the scientific journal *Ecological Indicators* in which is was found that Mater-Bi does not release persistent microplastics, as it is completely biodegradable within 20-30 days, as required by the OECD guidelines.

When exposed to micro-organisms, the material achieves high levels of biodegradation, substantially equal to those of paper, in a test period of less one year. Furthermore, the speed of biodegradation increases as the particle size decreases

 has been a member of important EU groups on climate , environment and renewable raw materials, such as the European Union Bioeconomy . Prime inventor of around 80 patent families in the sector of synthetic and natural polymers and transformation processes of renewable raw materials, she was awarded “European Inventor of the Year 2007” by the European Patent Office and the European Commission for her inventions related to starch-based bioplastics between 1991 and 2001.

She has become known as the Lady and the Wonder of the bioplastics industry. *(novamont.com)*

“The Handbook of Biodegradable Polymers”. Edited by Catia , Smithers Rapra, Shawbury, Shrewsbury, UK, 2nd edition, 2014.

:Eco-friendly mattress

Problem:

Most mattresses are with synthetic fibers or foam, which don't biodegrade. Cotton or wool stuffing can be processed with pesticides and other chemicals—some of them potentially carcinogenic.

Solution:

The eco-friendly mattress.

In September 2020, John Lewis Partnership, a of high-end department stores operating for almost one century throughout Great Britain, launched its first ever fully recyclable eco mattress. Their EcoMattress is handcrafted in a carbon-neutral factory in Yorkshire using chemical-free materials, 200 recycled plastic bottles, and layers of EcoFlex fibres (a soft polyester filling from 100 % recycled fibres).

The mattress, which can be fully recycled at the end of its life, also features a clever glue-free high density Cortec Quad pocket spring system, innovated by Harrison Spinks Springs of Leeds, UK. With a total of 750 pocket springs in the size mattress, it aims to provide balance during the night, while also reliving pressure and helping to keep your body weight evenly distributed.

:Cell-grown meat

Problem:

Apart from the destruction of forests to prairies for livestock, the latter's methane emissions contributing to GHGs, their intake of antibiotics and their traumatic electrocuted death prior to preparation as edible meat seen an exponential in the number of vegeterians and vegans worldwide. Vegetarianism categories were estimated in 2018 to be about 11% of the world population.

Solution:

Slaughter-free meat involves taking a sample of animal stem cells from a real cow, the building blocks of muscle and other and replicating them outside of the animal.

The cells are placed in petri dishes with amino acids and carbohydrates to help the muscle cells multiply and grow. The concept of cultured meat was popularized by Jason Matheny in the early 2000s after co-authoring a seminal paper on cultured meat production and creating New Harvest, the world's first non-profit organization dedicated to supporting in vitro meat research.

In August 2013, Mark Post, a Dutch pharmacologist and Professor of Vascular Physiology at the Netherlands' Maastricht University, was the first to showcase a proof-of-concept for cultured meat by creating the first burger patty grown directly from cells.

The burger was cooked by Chef Richard McGeown of Couch's Great House Restaurant, Polperro, Cornwall, and tasted by critics Hanni Rützler, a food researcher from the Future Food Studio and Josh Schonwald. To commercialize the product, Mark Post co-founded Mosa Meat, indicating that they planned to cultured meat to the market by 2021. *(mosameat.com).*

In 2015, Maastricht University hosted the first International Conference on Cultured Meat. As the field has grown, non-profit organizations such as New Harvest and The Good Food Institute begun hosting annual conferences to convene industry leaders, scientists, investors, and potential collaborators from parallel industries.

In 2018, a Dutch startup Meatable, consisting of Krijn de Nood, Luining, Ruud Out, Pederson, Mark Kotter and Apic others, reported that it had succeeded in growing meat using pluripotent stem cells from animals' umbilical cords.

Although such cells are reportedly difficult to work with, Meatable claimed to be to direct them to behave using their proprietary technique in to become muscle cells or fat cells as needed. The major advantage is that this technique bypasses fetal bovine serum, meaning that no animal has to be killed in to produce meat.

It is estimated there were about 30 cultured meat startups across the world. A Dutch House of Representatives Commission meeting discussed the importance and necessity of governmental support for researching, developing and introducing cultured meat in society, speaking to representatives of three universities, three startups and four civil interest groups on September 26, 2018. *(meatable.com)*

In California, Just is developing lab-grown chicken nuggets, while Finless Food has developed a lab-grown tuna and Memphis Meats, is on another cell-based product.

In Israel, in 2017 Professor Shulamit Levenberg from Technion University founded Aleph Farms in Rehovet, to commercialise the technique of growing bovine cells on a scaffold similar to growing human tissue implants.

A study by researchers at Oxford and the University of Amsterdam found that cultured meat was "potentially ... much efficient and environmentally-friendly", generating 4% GHG emissions, reducing the energy needs of meat generation by up to 45%, and requiring 2% of the that the global meat/livestock industry does.

In March 2019, the U.S. Department of Agriculture (USDA) and the U.S. Food and Administration (FDA) agreed on a framework to regulate laboratory grown meat. This deal takes lab meat one step closer to approved for commercial in the United States. Some lab meat producers expect this approval within the year, but some experts warn this process might take years.

During 2019, the nascent, laboratory-grown meat industry experienced fast development thanks to millions of dollars in capital investment. Estimates suggest these meats could reach a mass market by 2025,

The multi-billion dollar traditional meat-producing industry does not approve, warning that the energy and fossil fuel requirements of -scale cultured meat production may be environmentally destructive producing food off the .

In May 2019, the Alabama Senate passed a bill to ensure that laboratory-grown meat substitutes are not sold to Alabama consumers labeled as “meat.” There are over 20,000 cattle farms in the state of Alabama. Beef continues to be a favorite protein consumers across the world, with exports of American beef representing an US$8 billion industry .

Max Maxfield, “Sinking One’s Teeth into Artificial (Cultured) Meat,” *eeweb.com*, January 24, 2019; "Lab-Grown 'Mosa Meat' To Hit High-End Restaurants within 2 Years", *Green Matters*, 29, 2018; Jonathan Shieber, “Dutch startup Meatable is developing lab-grown pork and has $10 million in new financing to do it,” *techcrunch.com*, December 6, 2019; Brodwin, "An Israeli startup with ties to America's most popular hummus says it the world's first lab-grown — a holy for the industry", *Business Insider,* December 15, 2018; “USDA and FDA Announce a Formal Agreement to Regulate Cell-Cultured Food Products from Cell Lines of Livestock and Poultry,” *USDA*, March 17, 2019.

:MechanicalTree

Problem:

Natural trees and plants are limited in the quantity of CO2 they are to sequester.

Solution:

For two decades, Klaus S. Lackner (ex Los Alamos National Laboratory), and sustainability scientist, Allen Wright collaborated in a mission to create a machine that worked like a tree but was one thousand times efficient.

From 2000, Lackner and Wright, based at the Lenfest Center for Sustainable Energy at the Earth Institute and Faculty in the Earth and Environmental Engineering department at Columbia University in the City of New York worked with Mario Caceres and Christian Canonico of Influx Studio, set up the Treepod Initiative.

Their mission was to develop a faux tree, bio-mimicking the form of the blood tree *(Dracaena cinnabari)*,in view of its wide and umbrella style of tops that can support the bigger sized solar that power the tree. Treepod leaves would be of papery plastic coated in a resin containing sodium carbonate, to pull CO2 out of the air then stores it as a bicarbonate (baking soda) on the leaf.

To remove the carbon dioxide, the leaves are rinsed in water vapour and can dry naturally in the wind, soaking up carbon dioxide. Such leaves could be much closely spaced and overlapped – even configured in a honeycomb formation to them efficient.

Lackner calculated that the treepod could remove 1 of CO_2 per a day. Ten million of these trees could remove 3.6 billion tonnes of carbon dioxide a year – equivalent to about 10% of our global annual carbon dioxide emissions. Total emissions could be removed with 100 million treepods, 1,000 times that in real trees would be required to the effect.

In 2014 Klaus Lackner and Allen Wright moved from Columbia to the Center for Negative Carbon Emissions in the School of Sustainable Engineering, at Arizona State University. There they also co-founded Global Research Technologies (GRT)—in Tucson, Arizona where they demonstrated the moisture swing. (*sustainability.asu.edu*)

In February 2020, with ASU, Silicon Kingdom Holdings (SKH) in Dublin, Ireland agreed to build and deploy 12 clusters of treepods. Each cluster comprises 12 sorbent-filled columns and can remove one metric ton of CO_2 per day. SKH will deploy the technology in a pilot farm targeting 100 metric tons of CO_2 per.

The technology will then be deployed to -scale farms of up to 120,000 MechanicalTrees capturing some 4 million tons of CO2 annually and occupying a space of just 2 to 3 square kilometers (0.8 to 1.2 square miles) per farm. in multiple locations, each capable of removing 3.8 million metric tons annually..

The released gas is then collected, purified, processed used for other solutions as described elsewhere in 366solutions. *(mechanicaltrees.com)*

Allen Wright, Klaus Lackner, "Carbon Dioxide Sorbents and Strcutures, Methods of Use, and Methods of Making Thereof", *Patent N° 20180058008*, March 1, 2018; Klaus Lackner et al, "Sorbents for Direct Capture of CO2 from Ambient Air" August 2019; Allen Wright, Klaus Lackner et al. "Metal- framework-based sorbents and methods of synthesis thereof," Patent N°: 10413858, September 17, 2019

:Mechanochemical carbon capture

Problem: Carbon capture is in urgent need of every possible system -

Solution: Mechanochemistry using lysine

Mechanochemistry or mechanical chemistry is the coupling of mechanical and chemical phenomena on a molecular scale. It sometimes makes processes possible that are hard to do by traditional solution synthesis.

Thomas-Xavier Métro and team at the University of Montpellier, used mechanochemistry to reversibly capture carbon dioxide using lysine, an abundant solid amino acid. The process is simple and making it a promising new tool to capture carbon emissions.

Lysine was placed in a small reactor together with the milling balls and carbon dioxide under pressure. After five minutes, the contents of the reactor seemed unchanged, but the transformation was complete. The Montpellier researchers had a white powder, but lysine had reacted with the excess of CO_2 to form a new compound – a carbamate. This was confirmed using a combination of solution and solid-state NMR techniques.

Upscaling should be straightforward – industrial mills are already used by the cement, alloys and pharmaceutical industries. 'Indeed, there is potential for mechanochemical reactors to work at commercial scales and in continuous mode. Moreover, previous studies hint that energy consumption decreases as you scale-up some mechanochemical processes.

Abdal-Azim Al-Terkawi, Frédéric Lamaty and Thomas-Xavier Métro, "Efficient CO_2 Sequestration by a Solid–Gas Reaction Enabled by Mechanochemistry: The of l-Lysine," *ACS Sustainable Chem. Eng.* 2020,

: Cleaner metal-cutting fuel

Problem:

Annual emissions of acetylene gas as a metal cutting fuel run into millions of pounds, resulting in exposure to high concentrations of carbon monoxide and making it the most dangerous industrial gas in use today.

Solution:

Christopher Lynch and a team at Taronis Fuels Inc., located in Peoria, Arizona, USA, developed a safer solution called *MagneGas*. This is a synthetic gas comprised primarily of ionized hydrogen gas that is sold as an alternative product substitute for existing fossil fuel-based metal cutting fuels, such as acetylene and .

MagneGas is by running medical waste ethanol input through a Gasification Unit and by using submerged plasma arc technology to produce renewable gases. The gas comprises from 50-60% hydrogen, from 9-16% ethane, from 8-12% carbon monoxide, from 5-12% ethylene, from 3-8% methane, from 2-3% other gases, and from 1-2% carbon dioxide (all % Vol/Vol). This patented technology enables two end-use applications for renewable fuel production and water decontamination.

From 2018, after four years' work, Taronis presented a fourth-generation reactor in which a much larger area is exposed to the plasma arc. With a reduction of the amount of power required per cubic meter, it is to extract around 90% of the useful gas in the first pass through the plasma arc so that the feedstock needs to pass through the system or twice rather the six to eight times in the previous version.

In September 2020, Taronis was took part in the EarthX Climate Week virtual conference to present their environmentally responsible, hydrogen-based fuel products at a fraction of the cost of acetylene and propylene.

Christopher Lynch et al, "Apparatus for Flow-Through of Electric Arcs" **Patent:** 20150151269 and "Gas Production from an Oil Feedstock" (**Patent:** 20160017247), MagneGas Corporation.

:Metal framework (MOF) for carbon capture

Problem:

CO2 must be captured as swiftly and as efficiently as possible.

Solution:

Metal– frameworks (MOFs) are one class of crystalline adsorbent materials that are believed to be of potential in CO_2 capture applications because of their advantages such as ultrahigh porosity, boundless chemical tunability, and surface functionality over traditional porous zeolites and activated carbon.

Importantly, MOFs the largest surface areas of any known material: the size of two American football fields (115.2 ft²/ 5.4 m²)) in a single , offering plenty of space for “guest molecules” such as CO2 to get caught in millions of molecular . The “ZIF-8” MOF is already used to capture and store gases, and it is cheap and easy to synthesise.

MOFs are coming of age. Their numbers been mushrooming at an unprecedented since M. Yaghi, a Jordanian-American chemist uncovered their potential nearly 20 years before, and today the structures of over 6000 new MOFs are published each year.

Stuart James, chair of inorganic chemistry at Queen’s University Belfast in the UK and co-founder of MOF Technologies, secured US$ 87,500 to work 14 partners from 8 countries to develop and demonstrate the performance of MOF.

Christopher Wilmer, Assistant Professor of Chemical and Petroleum Engineering at the University of Pittsburgh's Swanson School of Engineering has collaborated with Jan Steckel, research scientist at the US Department of

Energy's National Energy Technology Laboratory, and Pittsburgh-based AECOM to develop a computational modeling method which may help to fast-track the identification and design of new carbon capture and materials such as MOF for use by the nation's coal-fired power plants.

Scientists at the U.S. Department of Energy's SLAC Laboratory and Stanford University taken the first images of CO_2 molecules captured within a MOF. The images, at the Stanford-SLAC Cryo-EM Facilities, show two configurations of the CO_2 molecule in its , in what scientists call a guest-host relationship; reveal that the expands slightly as the CO_2 enters; and zoom in on jagged edges where MOF particles may grow by adding *.(moftechnlogies.com)*

Researchers at the Institute for Integrated Cell-Material Sciences (iCeMS), Kyoto University, Japan, with colleagues at the University of Tokyo and Jiangsu Normal University in China created an MOF they call a porous coordination polymer (PCP).

It has an component with a propeller-like as molecular structure, and as CO2 molecules approach the structure, they and rearrange to permit CO2 trapping, resulting in slight to the molecular channels within the PCP. This allows it to act as molecular sieve that can recognize molecules by size and shape.

The PCP is also recyclable; the efficiency of the catalyst did not decrease even after 10 reaction cycles. After capturing the carbon, the converted material can be used to polyurethane, a material with a wide variety of applications including clothing, appliances, and packaging.

The researchers tested their material using X-ray structural analysis and found that it can selectively capture CO2 molecules with ten times efficiency other PCPs thus opening up an avenue for future research into carbon capture materials.*(icems.kyoto-u.ac.jp)*

Bio-mimicking the precise ion selective filtering capabilities of a living cell, researchers at Monash University, CSIRO, the University of Melbourne with The University of Texas at Austin, developed a synthetic MOF-based ion channel membrane that is precisely tuned, in both size and chemistry, to filter lithium ions in an ultra-fast, one-directional and highly selective .

This solution up the possibility to create a revolutionary filtering technology that could substantially the way in which lithium-from- extraction is undertaken. Energy Exploration Technologies, Inc. (EnergyX) in Newark, California has executed a worldwide exclusive license to commercialise the technology. *(monash.edu* and *energyx.com)*

Simon Weston and a team at ExxonMobil, collaborating with Jeffrey , UC Berkeley professor of chemistry and of chemical and biomolecular engineering and senior faculty scientist at Lawrence Berkeley Lab, and his group in UC Berkeley's Center for Gas Separations, developed a new material that could capture 90% of CO2 emitted from industrial sources using low-temperature steam, requiring less energy for the overall carbon capture process.

Laboratory tests indicate the patent-pending materials—tetraamine-functionalized metal frameworks—capture carbon dioxide emissions up to six times effectively conventional -based carbon capture technology. Using less energy to capture and remove carbon, the material has the potential to reduce the cost of the technology and eventually support commercial applications.

This is the result of eight years' R&D. Tetraamine molecules are added to a magnesium-based MOF to catalyze the formation of polymer chains of CO2 that could then be purged by flushing with a humid stream of carbon dioxide. By manipulating the structure of the metal framework material, the team of scientists and students demonstrated the ability to condense a surface area the size of a football field, into just one of mass—about the as a paperclip—that acts as a for CO2.

Additional research and development will be needed to progress this technology to a larger scale pilot and ultimately to industrial scale.

Hui and - Li, "Metal- Frameworks (MOFs) for CO_2 Capture", April 2014; Penyan Wu et al., "Carbon dioxide capture and efficient fixation in a dynamic porous coordination polymer," Nature

Communications 10(1):1-8 · September 2019; Jun Lu et al, "Efficient metal ion sieving in rectifying subnanochannels enabled by metal– frameworks," *Nature Materials*, March 9, 2020. Eugene J. Kim, Rebecca L. Siegelman, Henry Z. H. , Alexander C. , -Hoon Lee, Jeffrey D. Martell, Phillip J. Milner, Joseph M. Falkowski, Jeffrey B. Neaton, Jeffrey A. Reimer, Simon C. Weston, Jeffrey R. (2020) "Cooperative carbon capture and steam regeneration with tetraamine-appended metal– frameworks" *Science* 2020; ExxonMobil, UC Berkeley, Berkeley Lab develop new MOF for carbon capture and steam regeneration," *Green Car Congress*, 25 July 2020.

:Metal oxide microwave pulverisation of plastic

Problem

The uses which can be found for plastic waste , the better.

Solution:

A team of researchers from the UK, China and Saudi Arabia at the Edwards/ Xiao group at Oxford's Department of Inorganic Chemistry developed a method a remarkable process for converting plastic waste into hydrogen gas and carbon nanotubes.

The plastic is pulverized using microwaves with aluminium oxide and oxide serving as catalysts. The conversion process lasts 30 to 90 seconds resulting in the recovery of 97% of the hydrogen in the plastic.

Tomorrow's solution: A methane-reducing cow vaccine to reduce global gas emissions

:Methane-reducing cow vaccine

Problem:

A hefty of global GHG emissions come from the smelly bodily functions of livestock. Globally, livestock are responsible for burping (and a small amount from farting) the methane equivalent of 3.1 gigatonnes of carbon dioxide into the atmosphere annually, up to 14% of all greenhouse emissions from human activities.

Solution:

Methane-reducing cow vaccine

Sinead C. Leahy, a microbiologist leading a team at AgResearch Ltd, one of New Zealand's largest Crown Research Institutes, developed a vaccine against certain gut microbes that are responsible for producing methane as the animals digest their food, in an effort to allow us to continue eating meat and dairy products while lessening the impact the livestock industry has on the environment.

The methane produced by ruminants comes from some 3% of the vast number of microbes that live in the rumen, the first section of the gut. The guilty organisms belong to an ancient group called the archaea, and they are capable of living in environments where there is no . To weed out the bacteria responsible, however, Leahy and her colleagues had to find a way of reproducing the -free conditions of the rumen in their laboratory. Using DNA technology, they were then to sequence the genomes of some of the key species.

Given by injection, the vaccine is designed to stimulate the animals' output of -archaea antibodies in their saliva, which is then carried into the rumen as the animals swallow. AgResearch scientists identified five different animal-compounds that can reduce methane emissions from sheep and cattle by 30% to 90%. *(agresearch.co.nz)*

In the Netherlands, Stephane Duval and a team at DSM, developed a compound called enzyme inhibitor 3-nitrooxypropanol (NOP) which reduces livestock methane emissions by one-third. The compound has an effect similar to other compounds worked on by AgResearch, and the universities of and Auckland. *(dsm.com)*

Another option is to give cattle probiotics, or helpful bacteria, to aid their digestion. Elizabeth Latham, a former researcher at Texas A&M University and co-founder of Bezoar Laboratories, has been developing a probiotic to tackle methane from cattle and claims it can reduce emissions by 50%. *(bezoarlaboratories.com)*

After a three-year experiment with a group of 50 cows, Prof. Itzhak Mizrahi and a team at Ben-Gurion University (BGU) in southern Israel successfully manipulated cows' microbiome so preventing them from emitting methane. The microbiome is an underexplored area scientifically, yet it exerts great control over aspects of animal and human physical systems. Microbes begin to be introduced at birth and produce a unique microbiome which then evolves over time.

Mizrahi has also investigated the microbiome of fish and other species to prepare us for a world shaped by climate . Engineering healthier fish is especially important as the empty of fish and aquaculture becomes the major source of seafood.

Sinead C. Leahy et al, “Occurrence and expression of genes encoding methyl-compound production in rumen bacteria”, *resarchgate*, December 2019; Itzhak Mizrahi et al. “Stochasticity constrained by deterministic effects of diet and age drive rumen microbiome assembly dynamics,” *Nature Communications,* volume 11, Article number: 1904 (2020).

Low Carbon Cattle

Problem:

With 14% of greenhouse gases from livestock farming, and a dependence on Brazilian soybean meal, the carbon footprint of French milk is far from 'be negligible.

Solution:

Low carbon cattle

Commissioned by the Brittany Chamber of Agriculture and the Breeding Institute, since 2018, Pascal Le Coeur and an agricultural engineering team at the Trévarez experimental station in northern been developing the solution of a Prim'Holstein dairy herd of 120 “low carbon” cattle. Trévarez is just one of 8 experimental stations specializing in eco-friendlier dairy and beef production.

The Trévarez experimental farm has therefore implemented several actions aimed at reducing the carbon footprint of the dairy plant, while closely monitoring their economic impact. For herd management, the number of unproductive animals has been reduced as much as possible as well as their length of presence. The breeding seeks to reach an average age of first calving at 24 months, compared to 26 currently. To achieve this, they must heifers to calve as early as 22 months to compensate for later calving.

Trévarez works extensively on cattle fodder. It has logically banned soybean meal, whose cultivation accelerates deforestation in the Amazon, replacing it with rapeseed meal. Rapeseed is better, but you to it by truck, so the station is planning to use other protein crops grown on the spot such as faba

To act on gross emissions, Trévarez technicians also reduced chemical fertilizers, which emit nitrous oxide (N2O), in favor of fertilizers which are themselves spread “as close as possible to the ground, or even by injection into the soil ”, when the weather conditions prevent any ammonia volatilization. Added to this is crop rotation and reduced tillage, which are essential to preserve carbon.

Trévarez is not . Despite Brexit, in the UK, at a dairy farm across the border between Wales and Shropshire in the west of England run by Philip and Ben Davies, the cows spend all winter in the shed on rubber mats, and the flows down with gravity into a channel. The then gets pumped into the tower, where it is ready to be injected into the soil as fertiliser in spring and summer. Using this stored there is less need for synthetic fertilisers, reducing as well as the carbon footprint of fertilising the fields. Injecting in this way also reduces emissions of

ammonia, which can damage ecosystems and break down into nitrous oxides (a greenhouse gas)

:Methane Reprocessing

Problem:

Due to gas and oil explorations in the Arctic, melting permafrost is releasing sealed methane, formerly trapped in the form of gas hydrates; if these are not handled properly, the GHG effect of this is a lethal 25 times carbon dioxide.

Solutions:

Scientists from Skoltech University in Moscow Oblast Russia and Heriot-Watt University in Edinburgh Scotland looked at the gas hydrates, which are ice-like structures up of water and gas.

They found that they could inject hot waste flue gas, which is generated during fuel combustion from coal-powered plants, metal refineries and other furnaces that use fuel combustion into the gas hydrates. That starts a reaction where the methane is released and carbon dioxide replaces it and forms a new hydrate.

The researchers found they were to capture almost 82 % of the carbon dioxide contained in the flue gas As for the liberated methane, it can be used in a closed cycled where the gas powers an industrial plant and the flue gases are recycled to reduce emissions and to release methane for the plant to use. Evgeny Chuvilin, a leading research scientist at the Skoltech Center for Hydrocarbon Recovery (CHR) has stated "I would say our method offers a double dividend in terms of environmental safety." *(crei.skoltech.ru)*

To check out these methane leaks, GHGSat of Montreal, Canada has released a high-resolution map of methane in Earth's atmosphere. The company's first

satellite, launched in 2016, delivers 7.5 mi x 7.5 mi (12 km x 12 km) spot measurements of methane in the air. Features larger 50m across can be sensed. Subsequent satellites will a finer resolution of 82 ft (25m) per pixel. While GHGSat is focused on selling observations of methane, it believes it can also a very useful contribution to science with its planned free-to-use visualisation.

(ghgsat.com)

Evgeny Chuvilin et al, "An Experimental Investigation on the Kinetics of Integrated Methane Recovery and CO_2 Sequestration by Injection of Flue Gas into Permafrost Methane Hydrate Reservoirs," *Scientific Reports* Volume 9, Article number: 16206 (2019).

Tomorrow's solution: reducing methane by seaweed

:Methane, seaweed reduction system

Problem:

Developing vaccines to reduce the methane from ruminants may not be the path to follow.

Solution:

Scientists are to cultivate a specific type of red seaweed, *Asparagopsis taxiformis* which can dramatically reduce their burping and farting.

In 2015, Salwen, whose grandfather raised cattle and sheep when she was growing up in eastern Iowa, was interested in exploring themes of sustainable agriculture.

At Stanford University she read a little-known paper on the impacts of *Asparagopsis* on methane production authored by researchers at James Cook University in Australia and the government's research arm the Commonwealth Scientific and Industrial Research Organization. After enlisting experts to help her work through the technical aspects of the research, she was awestruck by the potential implications of the findings. She teamed up with Ermias Kebreab, at the Department of Animal Science at the University of California Davis.

They eventually found a supplier in Australia that was willing to some wild harvested seaweed, and later secured additional sources for roughly US$100 a kilogram of dried seaweed. To fund the effort, Salwen raised close to US$1 million from a number of different organizations, including the Schmidt Family Foundation, the David and Lucile Packard Foundation and the Foundation for Food and Agriculture Research. *(dci.stanford.edu)*

Jennifer Smith, a biologist at UC San Diego's Scripps Institution of Oceanography at La Jolla has also been attempting to maximise concentrations of bromoform, the compound that blocks the production of methane in cows, sheep, goats and other ruminant animals. Ongoing research at UC Davis, has found feeding dairy cows just a small amount of the seaweed can cut methane from the animals by 50%. *(scripps.ucsd.edu)*

Experts are currently debating in which to grow the seaweed. The practical considerations include not the cost of cultivation but its carbon footprint. If growing the seaweed and shipping it to farms generates considerable amounts of GHG, the process could cancel out the benefits of reducing methane.

Growing *Asparagopsis* as a sporophyte, for example, would likely require so in tanks of sterilized seawater to prevent contamination of the clingy plant material. That using some form of energy to pump in air and nitrogen. As a result, some businesses are focusing on growing the fleshy form of the plant in the .

In Australia, Josh Goldman and a team leading the Greener Grazing program at Australis Aquaculture are growing -farmed barramundi sea bass in Vietnam. The company also already grows a seaweed known as *Kappaphycus alvarezii*, a red algae used as a food additive to thicken or stabilize almond and coconut milk. Australis Aquaculture is planning to cultivate *Asparagopsis* using nets of "seeded " that float several ft. below the surface, with industrial-scale production by 2020. *(thebetterfish.com)*

Dr David Pacheco and AgResearch's Animal Nutrition & Physiology team, in Palmerston North, New Zealand been researching how , a leafy brassica crop can reduce emissions of urinary nitrogen and enteric methane from ruminants, sheep and dairy cows, by 25%

David Pacheco et al., "Can nitrous oxide emissions from soil be reduced by feeding lamps with fresh (Brassical napus L)," *Conference Paper ·26th Annual FLRC Workshop held at Massey University,* February 2013; Joshua Emerson Smith "The is on to cultivate a seaweed that slashes greenhouse emission from cows, other livestock" *The San Diego Union-Tribune* May 11, 2019.

Metropolis, sustainable

Problem:

For the world's most densely populated metropolis, the transition to 100% renewable energy is a major challenge.

Solution:

There are now 100 trailblazing cities mostly powered by clean energy. Not-for-profit environmental impact researcher CDP has reported that of the 570 plus global cities on their books, over 100 get at least 70% of their electricity from renewable sources such as hydro, geothermal, solar and wind.

The list includes cities such as Auckland (New Zealand); Nairobi (Kenya); Oslo (Norway); Seattle (USA) and Vancouver (Canada), and is double the 40 cities who reported that they were powered by at least 70% clean energy in 2015

Burlington, USA: Vermont's largest city now obtains 100% of its electricity from wind, solar, hydro, and biomass.

Since 2018, The City of London, otherwise known to the world of business as "The Square Mile" has taken recent steps to become a sustainable major city with a number of corporations adding solar panels to their buildings, with others investing in these alternative sources.

One example is adding a tax to disposable coffee cups, giving people an incentive to their reusable mugs to get their early caffeine. A temporary service

called “The Rubbish ” allowed people to pay with used recyclable plastic to receive coffee and vegan-friendly dishes.

In November 2020, to £3 million, the City of London Corporation announced its to buy half of the electricity powering the Corporation’s historic buildings such as the Guildhall buildings, the Barbican arts centre and Smithfield market from a subsidy-free solar farm in the south-west of England up of 95,000 new solar panels over the next 15 years.

Developed by French renewables company Voltalia, the South Farm Solar Park near Spetisbury, Dorset will a generating capacity of up to 40 megawatts (MW) and supply clean, renewable energy for around 12,120 homes a year.

The scheme would displace circa 17,200 tonnes of CO^2 that may otherwise be generated through the burning of traditional fossil fuels.

:Microbe extraction of valuable metals from e-waste

Problem:

the tons of e-waste around the world, there are several valuable metals to extract, including gold, silver and palladium.

Solution:

Mint Innovation set up Ollie (Wright) Crush of Auckland, New Zealand is developing and deploying biological approaches for recovering valuable metals from novel feedstocks, such as electronic waste

In their patented biorefining process, chemicals dissolve the powdered waste into a solution to which microbes are added. Gold atoms latch them by selective absorption. coated in gold, the microbes coated are filtered, producing a paste which is then refined back into solid recycled gold. Similar processes been developed for silver and palladium.

Mint Innovation and Remarkit Solutions, also of New Zealand, signed a deal to build a microbe extraction factory to build the factory and expand the company across the country, and then internationally. The scaled-up facility in Auckland will initially process up to 200 tonnes of old circuit boards per year.

:Microbial fungi and bacteria for CO2 capture.

Solution:

The Soil Carbon Co. of , New South Wales, Australia is developing a solution that allows plants to sequester way carbon they do naturally. On farms the East Coast of Australia, growers are testing out the solution of planting seeds coated in microbial fungi and bacteria that can help capture CO_2 from the air.

Farmers Mick Wettenhall & Guy Webb had been together for over a decade on ways of building their soil carbon with methods like reduced-till, mixed cover crops and experimenting with compost, when their heard how Peter A. McGee of Sydney University had been developing recalcitrant soil carbon using fungi. carbon in soils would not give agronomic benefits but creates an opportunity for farmers to a new commodity: sequestered carbon.

They called this *the Second Crop*. If it were to be used on farmland globally, they calculated it could sequester around 8.5 gigatons of carbon every year—or around a quarter of total CO2 emissions. It could also store that carbon for a time some “regenerative agriculture” techniques that also aim to capture carbon. The solution involves inoculating crops with symbiotic micro-organisms.

Not do these microbes improve the host plant’s fertility and protection against disease, but they also help the soil around the plant’s roots to store carbon effectively, leading to better quality soil for future planting. The “Second Crop” process also makes the soil healthier, so farmers should see better yields and be to use less fertilizer. It’s a relatively simple to ; farmers either buy microbe-coated seeds or coat their own seeds themselves, something that is commonly with other products.

In 2020 Soil Carbon Co raised A$10 million ($6.94 million) in seed funding in a round led by Horizons Ventures, the VC firm set up by billionaire tycoon Li Ka-shing. After finishing trials in both Australia and the USA, the Second Crop system will be launched commercially. Unlike other solutions such as carbon-capture machines, it can scale up almost immediately and does not require the acquisition of new equipment.

There are around one billion farmers around the world at the intersection of atmosphere and soil every day—and the infrastructure already in place.

P. A. McGee and T. T. Mukasa Mugerwa, “Potential effect of melanised endophytic fungi on levels of carbon within an Alfisol,” January 2016.

:Microfilter clothes washing devices

Problem:

700,000 plastic microfibres come off synthetic garments when they go into a machine. By coming off, these fibers pass through the filters of the washing machines, which are not equipped to retain these microparticles. Since wastewater treatment plants do not the capacity to filter them, they end up in sewage and, therefore, in the . These fibres finally finish their course in the of animals.

Solution:

Microfilter clothes-washing devices

In 2005, of Wexco Environmental Inc., Milaca, Minnesota developed the Filtrol 160 attachable filter which removes non-biodegradable materials and fibers, such as lint, hair, pet fur, , food and other debris, from a washing machine

discharge. Filtrols are now in use problem in thousands of homes, businesses, and residential properties across the USA. (*filtrol.net*)

In 2008, keen surfers, Alexander Nolte and Oliver Spies co-founded of LANGBRETT GmbH specializing in environmentally friendly surf, skate and outdoor apparel with retail stores in Berlin, Hamburg, Düsseldorf and Frankfurt.

Concerned with micro-particle pollution, they conceived of a plastic filter bag specially designed to retain these particles during a clothes wash. Nolte and Spies worked with German research institute Fraunhofer to test and vet the bag's design and material. They settled on polyamide, also known as nylon, that does not shed synthetic fibers easily. It is with a 50-micron mesh, a width that allows soapy water to enter the bag without allowing fibres to leave. They named their patented innovation the *Guppyfriend*.

Guppyfriend attracted the attention of Patagonia, the American clothing company, Greener Grazing program at Australis Aquaculture when word about the project reached Phil , managing director of Tin Shed Ventures, Patagonia's investment fund. Patagonia already had a relationship with LANGBRETT, which sells Patagonia clothing.

They received early prototypes of the bag and tested them with the UCSB researchers they had worked with on their fibre loss study. They confirmed that the bag trapped anywhere from 90-95% of fibres. When the bag is removed from the washer at the end of a cycle, the fiber – visible against the white mesh – can be removed by and disposed of. Tests show that the bag remains functional and intact after hundreds of washings.

Since then, Nolte and Spies are also on reducing microfiber losses before the fabric reaches the laundry room. They are with Deutsche Textilforschungszentrum, a German standards body, to create a metric that will show the and amount of fiber losses of a given textile. They hope clothing

designers will choose fabrics that aren't prone to shedding.
(en.guppyfriend.com)

In Ljubljana, Slovenia, a team led by Mojca Zupan and her engineer Hakim El Khiar developed the PlanetCare washing machine filter. PlanetCare filters are available worldwide from an online shop. Every user receives a filter, replacement cartridges, a hose, a mount, and a small counter of wash cycles.

After the initial installation, the user will need to replace a full cartridge after approximately 20 wash cycles. After installing the last new cartridge, they return the used cartridges to PlanetCare for recycling (cartridges come in a returnable box with prepaid) who will send you a new set. A commercial PlanetCare filter is designed for the service industry. Laundromats, hotels, hospitals, marinas: wherever washing machines operate 24 hours a day. This filter has been tested and approved by four renowned institutions: University of Slovenia, Consiglio Nazionale delle Ricerche (CNR), the Swedish Environmental Agency and a washing machine manufacturer. (*www.planetcare.org*)

As of January 1, 2025, based on a decree passed by the French Ministry of Ecological Transition, all new washing machines must be fitted with microplastic filters, while manufacturers would obtain an environmental bonus if they transitioned before 2025.

Oliver Spies, « Rückhaltemittel für kunststofffasern, » *WO2017121862A1*, July 20, 2017; Jonathan Fraenkel-Eidse, "Redefining retail: where customers become community," *Suston,* February 15, 2018. Margaret Rhodes, "Putting Your Washing Machine Into the Fight Against Plastic", *Bloomberg Green,* 2 octobre 2020.

:Microgroove Solar Film

Problem:

Today's solar technologies are either too expensive to deploy or their rigidity and weight makes them unsuitable for the job.

Solution:

In 2011, Alexander John Topping at Oxford University, developed a flexible and lightweight PV cell, thinner a human hair which has multiple vertical junctions

or multiple V-groove junctions formed in a semiconductor substrate. Topping realised that in using established production processes from other low-cost sectors (e.g. food packaging), the film would eliminate multiple manufacturing steps making its production significantly cheaper.

Together with Saul Joicey, he founded Big Solar Ltd. to commercialise the versatility of this PV film, suitable for nonload-bearing rooftops, building integration, transport, applications, off-grid projects and even power IoT sensors. With the solar film's efficiency increasing to 7%, the renamed Power Roll Ltd were soon to demonstrate 20cm² film samples *www.powerroll.solar*

As proof of concept, Power Roll Ltd, in partnership with The Energy Resources Institute (TERI) has installed an innovative solar mini-grid system to generate and store energy in rural villages located in Mukteshwar, in the Himalayas, India.

A modular system has been designed to meet the bespoke needs of each village. Applications include powering water pumps to support irrigation, lights to help students study at night and power to run phones enabling access to national and international knowledge and support networks.

It is also trialling novel approaches to mounting the solar film using wire tensioning systems, which allow the solar film to be quickly and easily moved to where it is most needed. The project is scheduled to run through to the end of 2021 and Power Roll will report on the outcomes in March 2022. Power Roll is also trialling their film to power off-an off-grid health centre in Zambia.

Alexander John Topping, "Optoelectronic device and method of producing the ", WO2014118545A1, August 8th 2014.

:Million-Mile Battery

Problem:

Most electric car batteries today already last 100,000 to 200,000 miles before needing replacement, though, while most gas-engine *cars* today last 150,000 miles before getting junked. A proportion of these batteries include cobalt, an expensive and precious material that is often mined by workers who are subject to poor pay and brutal conditions.

Solution:

Three companies developed a battery that can claim 1 million miles (1.6 million km) in total lifespan, last at least two decades in grid energy and give an electric vehicle an autonomy of 600 miles (1000 km).

Adam S. Kwiatkowski and a team at General Motors' Global Electric Propulsion Systems developed the Ultium -format pouch cell battery which follow a NCMA (nickel cobalt manganese aluminium) chemistry that was developed within GM and require fewer connectors and other parts to function.

Compared to existing NCM cells, the Ultium is lower in cobalt content but with aluminum added to the cathode structure for life. Zero-cobalt and zero-nickel cells are also tested, as well as with electrolyte additives and zeolite additives.

GM is on such advances as zero-cobalt electrodes, solid state electrolytes and ultra-fast charging. GM is aiming to up to a million electric vehicles per year by 2025, to be split between the U.S. and China. The new joint venture will supply U.S. vehicle production and could build up to 30 gigawatt-hours annually.

The second company is Tesla will soon introduce a lower-cost, -lasting "million mile" battery for its electric vehicles in China. The battery, also a pouch-cell design, is co-developed with Chinese battery Contemporary Amperex Technology Co. Ltd (CATL) with battery experts recruited by Tesla CEO Elon Musk, including Jeff Dahn at Dalhousie University, Nova Scotia, Canada.

The battery is expected to lower the cost per kilowatt hour (the unit of energy most commonly used to measure the capacity of the battery packs in modern electric vehicles) to under $100. By a coincidence, Tesla's Chinese battery cell provider CATL is also with GMs local partner SAIC (formerly known as Shanghai General Motors Company Ltd).

In Baoding in the Hebei Province of China, Svolt Energy Technology (the former battery business unit of Great Wall Motor Company) has produced a 24 GWh cobalt-free lithium-ion battery. By using single-crystal Co-free materials and stacking technology for cell design, plus the array-PACK design and the automotive- intelligent manufacturing process, Svolt has created a battery with a warranty of 15 years or 750,000 mi (1.2 million km) and an EV of almost 500 mi (800 km)

J.R. Dahn et al. "A Wide of Testing Results on an Excellent Lithium-Ion Cell Chemistry to be used as Benchmarks for New Battery Technologies," *J. Electrochem. Soc.* (2019), 166(13): A3031-A3044.

:Miscibility gap alloy

Problem:

As of 2019, there are an estimated 2,425 coal-fired power plants in the world, combining for an operating capacity of about 2,000 GW and roughly 15 billion tonnes of CO_2 emissions. Air pollution from coal-fired power plants is linked with asthma, , heart and ailments, neurological problems, acid , global warming, and other severe environmental and public health impacts.

Solution:

Miscibility gap alloy

In the next two decades, coal-fired power stations around the world will retire or be decommissioned, including in Australia. Between 2010 and 2018, Dr Heber Sugo, Professor Erich Kisi and Dylan Cuskelly of the University of Newcastle, Australia developed a new energy technology which could enable

refitted coal-fired power stations to run entirely emissions-free. (*newcastle.edu.au)*

The material, called miscibility gap alloy (MGA), stores energy in the form of heat. MGA is housed in small blocks of blended metals, which receive energy generated by renewables such as solar and wind. The energy can then be used as an alternative to coal to run steam turbines at coal-fired power stations, without producing emissions.

MGA blocks are 20cm x 20cm x 16cm. They essentially comprise a blend of metals – some that melt when heated, and others that do not. Stackable like Lego, they can be added or removed to meet demand. For coal stations to use this technology, the furnace and boiler must be removed and replaced by a unit containing MGA blocks.

The blocks do not just store energy – they heat water to create steam. In an old coal plant, this steam can be used to run turbines and generators to produce electricity, rather burning coal to produce the effect. MGA blocks are and non- – there is no risk of explosion or leakage, unlike some other fuels. The blocks can also be recycled.

They are expected to last 25-30 years, then can be easily separated into their individual materials – to be into new blocks, or recycled as raw materials for other uses.

The Australian team's additional research has shown that shown the blocks are one quarter the cost of a lithium battery of the size, yet produce the amount of energy. In 2019, the co-inventors formed a company, MGA Thermal, focussed on commercialising the technology and conducting real-world projects.

In July 2020, MGA Thermal received a A$495,000 from the federal Department of Industry, Innovation and Science, to retrofitting a functioning coal power plant in Newcastle, New South Wales with MGA .

Collaborating with a Swiss company, E2S Power AG, (www.ssa-power.com, this pilot plant is due to start manufacturing a commercial quantity of MGA blocks by the second half of 2021. The goal is to begin ally, at scale, for demonstration projects. If successful, they could allow coal-fired power plants to be used cleanly, and provide hope for the future of coal workers.

Erich Kisi, Heber Sugo and Dylan Cuskelly, "Alloys with inverse microstructures", European Patent P2912203A1 September 2015

:Modular houses from 100% recycled plastic

Problem:

There is a housing deficit of 160 million homes in Africa today, and it is forecasted to increase to 360 million by 2050. Traditional technology is and would too much time to build.

Solution:

Temperature-controlled Mobile Units

In partnership with UN Habitat program, Danish Architect Julien de Smedt, with Cato Lahti's start-up Othalo in Troms country, Norway developed a solution for building low-cost houses in sub-Saharan countries such as , Cameroon, and Uganda.

Lahti has been developing and testing the Othalo technologies in partnership with Sintef and UiT since 2014, and in 2019 the company was formally established and patents filed. These patents, including a load-bearing structure and a supportive and insulating structure: each house will be from 100% recycled plastic, with a 60 m2 Othalo house incorporating around eight tonnes of plastic waste.

It involves industrialized processes that, from pickers to fitters, creates up to 1600 jobs per one thousand 60sqm houses produced per year. 8100 metric tonnes of recycled plastic per production per year, it is a significant contributor to the plastic waste problem.

Othalo and De Smedt, envision the homes constructed from plastic that is collected from near the building sites. Just as cities are formed by buildings of wood, of concrete, clay, steel, they could very well contain a building constructed from plastic waste, as as it's in a and sustainable way.

Othalo expects to start mass-producing the houses in early 2022 and believes that the system will allow the millions of tonnes of plastic waste to become useful building material. With today's plastic waste, one billion houses could be built.

Cajsa Carlson,"Julien de Smedt designs of recycled-plastic houses", Dezeen, 16th October 2020.

:Molecular photoreactor

Problem:

To artificially capture CO_2, chemists developed ways to "scrub" it from air using chemicals that react very favourably with it. But even after it is captured, it is often difficult to release and use for artificial photosynthesis.

Solution :

A molecular photoreactor that captures CO_2 and converts it to fuels and useful chemicals.

The U.S. Department of Energy's (DOE) National Laboratory in Lemont, Illinois and SLAC (Stanford Linear Accelerator Center) at Menlo Park are developing artificial photosynthesis methods to enable direct air capture of CO_2 while expanding sources of energy through the conversion of CO_2 to fuels and other useful chemicals.

With $4.5 million funding over three years, Ksenija D. Glusac, a Serbian chemist with the Solar Energy Conversion group in the Chemical Sciences and Engineering division at , is leading Argonne's efforts as the principal investigator for the group.

Glusac and her team were able to use Argonne's Advanced Photon Source (APS), SLAC's Stanford Synchrotron Radiation Lightsource (SSRL) and SLAC's Linac Coherent Light Source (LCLS) — all are DOE Office of Science User Facilities — to collect X-ray absorption and scattering measurements to better understand the CO_2 capture and photo-conversion mechanisms.

The APS's high-energy storage ring generates ultrabright, hard X-ray beams for research in almost all scientific disciplines while SSRL provides electromagnetic radiation in the X-ray, ultraviolet, visible and infrared realms produced by electrons circulating in a storage . LCLS takes X-ray snapshots of atoms and

molecules at work, providing atomic resolution detail on ultrafast timescales to reveal fundamental processes in materials, technology and living things.

Glusac and her team have been taking measurements from samples of supramolecular structures called MOFs (metal- frameworks) that can absorb and harvest solar light and nodes that host two types of catalysts: reduction catalysts that can capture CO_2 from the air and reduce it to value-added chemicals and oxidation catalysts that can convert water to .

They are using Argonne's Laboratory Computing Resource Center to perform the computational investigations of CO_2 capture and conversion mechanisms.

:Molten salt system

Solution:

Ouarzazate Solar Power Station (OSPS), also called *Noor* Power Station (نور, Arabic for light) is a solar power complex located in the -Tafilalet region in Morocco, 6.2 mi (10 km) from Ouarzazate town, in Ghessat rural council area: The gateway to the Sahara Desert.

At 510 MW, it is the world's largest concentrated solar power plant. Unlike popular solar panels, which provide electricity when the sun is out, the *Noor* complex is a thermal solar plant.

Noor uses concentrated solar power (CSP) by heat, allowing it to continue to produce electricity for hours after sunset. Its 797 ft (243 m) tower, the tallest in Africa, houses molten salt which is melted to create energy. A cylinder full of salt is melted by the warmth from the mirrors during the day, and stays hot enough at night to provide up to three hours of power.

This system had been patented in 2009 by Jesús Maria Lata Pérez of Sener Ingenieria y Sistemas SA in Getxo, Basque Country, Spain. Its first commercial use was *Gemasolar*, located located within the city limits of Fuentes de Andalucía in the province of Seville, Spain. *Gemasolar* consists of a 75 ac (30.5

ha) solar heliostat aperture area with a power island and 2,650 heliostats, each with a 1,300 foot² (120 m²) aperture area and distributed in concentric around the 460 ft (140 m.)-high tower receiver. The total use of the Heliostats is 480 ac (195 has).

Managed by the Moroccan Agency for Sustainable Energy (MASEN) with ACWA power, *Noor* has been built in four overlapping phases.

Construction began in May 2013, *Noor I*, with an installed capacity of 160 MW. was connected to the Moroccan power grid on 5 February 2016. Using half a million mirrors, it covers 1,112 ac (450 ha) and is expected to deliver 370 GWh per year. The plant is a parabolic trough type with a molten salt for 3 hours of low-light producing capacity. The design uses wet cooling and the need to regularly clean the reflectors that the water use is high – 60 million ft³ (1.7 million m³) per year or 19.7 pints (4.6 liters) per kWh.

Water is double that of a wet-cooled coal power station and 23 times the water use per kWh of a dry cooled coal power station though life-cycle GHG emissions of solar thermal plants show that generating comparable energy from coal typically releases around 20 times carbon dioxide renewable sources. During 2017, *Noor I* produced monthly between 20 and 40 thousand MWH of electricity.

For the construction of *Noor II* and *Noor III*, Morocco called on the services of chief engineer Xinfeng and a team from Shandong Electric Power Construction Co., Ltd (SEPCO III) in China. Construction started in February 2016 and after 1,000 days and nights of hard work,

Noor II was commissioned in January 2018. It is a 200 MW CSP solar plant using parabolic troughs. It has a 7 hours capacity. It covers an area of 1,680 ac (680 has) and is expected to supply 600 GWh per year. It uses a dry cooling system to decrease water use.

Noor III is a 150 MW using a CSP tower mirror field with 7 hours energy , it covers an area of 1,359 ac (550 ha) and it is expected to supply 500 GW·h per year. At 150 MW, the Moroccan unit, 820 ft (243m) high, is the most powerful CSP tower unit built. In September 2018 it was synchronized to the power grid. In December *Noor III* completed a 10-day reliability test demonstrating that the project can provide continuous power even in the absence of sunlight. The model HE54 heliostat has 54 mirrors with a total reflective surface of 1,921 ft² (178.5 m²). The solar field has 7,400 of such mirrors.

Built by Chint of Hangzhou (China) and Sterling & Wilson of Mumbai (India), the 72 MW *Noor IV* is nearing completion.

completed the Noor Ouarzazate complex will cover an area the size of 3,500 football fields, it generates enough electricity 580 MW to power a city the size of , or twice the size of Marrakesh, protecting the Planet from over 838,000 tonnes (760,000 tonnes) of carbon emissions World financed construction with a US$400 million combined with US$ 216 million provided from the Clean Technology Fund. *(masen.ma)*

Thomas Bauer et al. “Overview of molten salt systems and material development for solar thermal power plants.” (Conference paper). World Renewable Energy Forum 2012.; “Moroccan Molten Salt Tower Project Clears Reliability Test.” *Power* 162(12) · December 2018.

:Molten Salt Reactor Ship

Problem:

Over the coming decades, as as 60,000 ships must transition from combustion of fossil fuels to zero-emission propulsion and reduce emissions by 50% of the 2008 total, before 2050. T

Solution:

MSRs (m-MSR)

Microsoft co-founder Bill Gates, Chairman of TerraPower nuclear tech company in Washington has linked up with Mikal Bøe's London-based Power, French nuclear materials handling specialist and American utilities firm Southern Company to develop Molten Salt Reactor (MSR) atomic technology in the USA with the potential for use in commercial shipping.

The team including Rob Corbin of TerraPower (terrapower.com) and Giulio Gennaro of Power (corepower.energy) has submitted its application to the US Department of Energy to part in cost- risk reduction awards under the Advanced Reactor Demonstration Program, in to build a prototype MSR as a proof-of-concept for a medium-scale commercial- reactor.

Their solution will be using a fluid fuel in the form of very hot fluoride or chloride salt typically composed of beryllium-fluoride (BeF2) and lithium-fluoride (LiF), infused with high-assay low-enriched uranium (**HALEU**), a 'hot' fissile material instead of solid fuel rods which are used in conventional pressurized water reactors (PWRs). They no moving parts, operate at very high temperatures under ambient pressure, and can be small enough to provide 'micro-grid-scale' electric power for energy-hungry assets, like ships. For this reason, they can be mass-manufactured to the cost of energy in with existing fuels.

MSRs are walk-away . The fuel salts for MSRs work at normal atmospheric pressure, so a breach of the reactor containment vessel would simply leak out the liquid fuel which would then solidify as it cooled.

Bjørn Højgaard, the CEO of ship -Eastern (angloeastern.com) has commented "I think that in 50 years nuclear molten-salt-reactors will be par for the course in the shipping industry, and we will look back at the current time and wonder why we dabbled in alternative pathways for greenhouse gas-free propulsion."

Ports will also be to use energy from ships installed with m-MSR to power equipment and machinery while the ship is at berth, through reverse cold ironing. Power generated by m-MSR will be cost competitive when compared to terrestrial energy sources available to the port.

:mottainai

Problem:

Japan is the second largest per-capita generator of single-use plastic waste in the world, producing the entire European Union.

Solution:

Mottainai (もったいない) is a centuries-old term of Japanese , deeply rooted in Buddhist origins which conveys a sense of regret over waste; the exclamation "Mottainai!" can translate as "What a waste!”

In November 2002, Hitoshi Chiba published an article in the English-language, Japan-based magazine *Look Japan* ran a cover story entitled "Restyling Japan: Revival of the 'Mottainai' Spirit".

He documented the motivation amongst volunteers in a "toy hospital" in Japan to "develop in children the habit of looking after their possessions", the re-emergence of repair shops specializing in repairing household appliances or children's clothes, the recycling of PET bottles and other materials, the collection of waste edible oil, and generally the efforts to stop the of throwing away everything that can no be used, i.e. the efforts of reviving "the spirit of *mottainai*".

Focussing on the essence of objects, it encourages people to look beyond our throwaway culture and value each item independently.

In 2005, Nobel prize-winning Warangi Maathai, the accomplished Kenyan political and environmental activist visited Japan and publically spoke of *mottainai*. Soon after, an ngo was set up and mottainai has since come to be thought of as an all-encompassing Japanese term for the four Rs: reduce, reuse, recycle and respect.

The year, Mariko Shinju's 'Mottainai ', published by Kodansha in Tokyo, brought the concept, not to Japanese children, but in 2018 was translated into Hindi and English. It is also known as "The Waste-Not--Not Grandmother."

The 2021 Olympic and Paralympic Games in Tokyo will beused to shine a spotlight on sustainability and, specifically, the *mottainai* version of it. Alongside renewable energy use, utilising existing stadiums and transport systems as well as carbon offsetting plans, there will be two highly visible symbols on display: ceremony podiums will be from recycled plastic gathered from across Japan.

All 5,000 medals will be from 100% recycled metals, carefully extracted from electronic devices donated by members of the public. By using personal items rather industrial or commercial sources, each and every donation allows the electronics' former owners to feel a sense of contribution to the medals and the event as a whole.

Chiba, Hitoshi, "Restyling Japan: Revival of the "Mottainai" Spirit", Look Japan, November 2002.

:Murals, pollution-eating

Problem:

Murals or wall paintings proliferate in big cities but are decorative.

Solution:

Pollution-eating paint

Since 2007, Massimo Bernardoni and Antonio Cianci of Airlite in Milan and London, developed *Sunlight Exterior* one of a of paint colours which contain

special compounds that absorb and eliminate pollutants in the air by 88%, similar to photosynthesis in plants. A study in Rome's Umberto tunnel found that after it was painted with a similar photocatalytic paint, nitrogen oxide levels were reduced by over 50%.

Sponsored by Veronica De Angelis, real estate entrepreneur and founder of Yourban2030, Milanese street artist Federico Massa (aka Iena Cruz) using the Airlite palette unveiled her work 'Hunting Pollution,' which spanned 1,000-square-metres, on the side of seven-story building in the capital. In , the Dutch street artist JDL (Judith de Leeuw) has painted another mural on a end of a building. Paying to the LGBTQ community by depicting a standing in of a mirror seeing her reflection as a man, the mural is absorbing the pollution generated by 52 cars every day.

Airlite is planning to focus on contracts and infrastructure projects like hospitals, schools, air quality in tunnels and the like.

:Multipurpose tent

Problem:

Since 2011, the Syrian Civil War created one of the most devastating humanitarian disasters in the world, with an estimated 13.5 million Syrians internally displaced or are refugees outside Syria, according to the United Nations. They are facing a need for shelter as are those displaced by climate and storms.

Solution:

Multi-purpose tent

In 2012, Abeer Seikaly, a Jordanian-Canadian architect and designer innovated a multi-purpose dual layer tent. Inspired by elements of nature such as skin and traditional cultural aspects such as weaving, nomadic life and tent dwellings, this weather proof, but lightweight and mobile fabric tent gives refugees shelter but also a chance to "weave their lives back together" and to their home wherever they are.

Her tent has the ability to close out the cold of winter and wet weather. It also up to allow cool air in and hot air out in summer. Rainwater is collected in the top of the tent and filters down the sides so the tent does not become flooded. The tent also has the ability to become a showering facility with water stored in pockets on the side and upwards via a thermo-siphoning system providing sanitation.

In 2013, Seikaly won the 2012 Lexus Design Award for her tent. By 2018 she was on a second mock-up with a to trial it on an expedition to the unforgiving Mount Everest summit. Invited by Jordanian mountaineer, Mostafa Salameh, who has climbed the seven summits, she joined a team of women for the trip.

In October 2019, at the Amman Design Week, Abeer Seikaly exhibited "Meeting Points, a reconfigurable tapestry of jute yarn, goat hair, and wood and steel connectors. The piece referenced Bedouin tent-making crafts and communal practices of weaving and construction. *(abeerseikaly.com)*

"Inspired by Syrian refugee crisis, weaved homes collect water and store solar energy", *Wisconsin Muslim Journal,* January 29, 2019.

:Musical culture and protection of plants - Genodics

Problem:

Plant growth is not favoured by light, water and fertiliser.

Solution:

Musical culture and protection of plants

In Africa, it was traditionally believed that singing to tomato plants them grow. In 1962, Dr. T. C. Singh, head of the Botany Department at India's Annamalia University, experimented with the effect of musical sounds on the growth of plants.

He found that balsam plants grew at a that accelerated by 20% in height and 72% in biomass when exposed to . He initially experimented with classical . Later, he experimented with (improvisations on a set of rhythms and notes) played on flute, violin, harmonium, *reena*, an Indian instrument and sholkas (Indian traditional ancient chants). He found similar effects.

At the time, Joël Sternheimer, a PhD in theoretical Physics first at the Univesity of Lyon, then at the University of Princeton, who also under the Evariste, used money from the of his records to research and Tomorrow's links between proteins, molecules for all living things, and into the effects of on plant growth.

In 1992, Sternheimer filed a European patent for the method for the regulation of protein biosynthesis, he called "genodics". He stated that the different levels of organization of matter (inert or living) are connected by "waves of scale" which ensure their coherence.

In the process of protein synthesis, amino acids emit quantum signal sequences that constitute a specific melody of each protein. The audible transpositions of these melodies can influence, in real time, via a form of resonance between successive frequencies, on the synthesis of the proteins.

The patent (N°20020177186) was in 2002 after ten years of scientific and legal controversy. To commercialise his solutions, Sternheimer set up Genodics I Paris and created musical sequences adapted to the cultivated plants and their pathologies as well as the device necessary for its broadcast in greenhouses or fields.

Because the sound treatment does not cure the plant definitively but stimulates the ways of resistances of the plant to the diseases, it must be permanent, even if a few minutes of daily may be enough. At the end of 2017, Genodics SAS carried out 600 annual applications of this process, in and neighboring countries, in market gardening, arboriculture, viticulture and on issues related to animal husbandry and oyster farming.

These included treating tomatoes against botrytis and endives against erwinia. *(genodics.com)*

J. Sternheimer, “ Musique des particules élémentaires,” *Comptes-rendus de l'Académie des Sciences*, tome 297, série 2, 829, December 12, 1983.

:Mushroom mycelium recycling technology

Problem:

Palm oil processing also gives to highly polluting waste-water, known as Palm Oil Mill Effluent, which is often discarded in disposal ponds, resulting in the leaching of contaminants that pollute the groundwater and soil, and in the release of methane gas into the atmosphere. The amount of palm oil waste produced by the palm oil plantation in South Sumatera is a staggering nine tons per hour.

Solution:

Mushroom mycelium technology

Co-founded by architects including Adi Reza Nugroho and Robbi Zidna Ilman, Mycotech, an Indonesian social entrepreneurship start-up based in Bandung, West Java, Indonesia is creating affordable, durable, recyclable and eco-friendly building materials out of agricultural waste such as Palm Oil Mill Effluent by applying mushroom mycelium technology.

Mycelium is the vegetative part of a fungus or fungus-like bacterial colony, consisting of a mass of branching, thread-like hyphae, or , branching filamentous structures. A common example of mycelium’s binding power is the way soybeans are ‘glued’ together in a of tempeh, a traditional Indonesian savory dish.

Mycotech had previously used woodchips or sawdust and sugarcane waste product to produce particle boards, producing upwards to 4,000 kilograms of particle board per month with the help of two mushroom farmer groups in Bandung, which consisted of 270 farmers, 64% of them women. Grown by local West Java farmers, most of whom are women, the fungi needs one week to grow and become harvest-ready.

But from September 2019, Mycotech its first shipment of entry doors for residential homes from recycled Palm Oil Mill Effluent to Australia.

The research on the use of palm oil production waste material and the subsequent fire testing of the end product were possible by funds from the Government of Australia through the Australia Awards Alumni Scheme, as well as from the DBS Foundation Social Enterprise Award 2017 and 2018.

As a building material, not only is Mycotech durable and flexible, it is reportedly fireproof and buoyant as well. Sturdy, lightweight products from , fibers can be formed into custom shapes, including panels and tiles, cabinetry, and interiors.

Led by researcher Erlambang Ajidarma, Myotech has now diversified to mycelium leather for wrist straps of their Pala X Mylea watch. Mychotech uses 45 liters of water and creates 0.7 kilograms of CO2 emissions, compared to 80,000 liters of water and 355,500 kilograms CO2 for cow leather. *(myci.bio)*

Jack Board,"The Bandung tech startup aiming to use mushrooms to help grow houses," *CNN International,* February 25, 2018.

:Sustainable or recycled musical instruments

Problem:

The metals used in brass and wind musical instruments are not biodegradable. Small pieces of metal, such as tin , will rust and flake into the atmosphere after about 100 years, but something as as an instrument takes much . While woodwind instruments almost brought their African blackWood or Mpingo forest source to extinction, spruce, maple, rainforest mahogany, ebony and rosewood trees used for guitars were cut down faster they could be replaced.

Solutions:

In 1996, Tanzanian botanist Sebastien Chuwa and US woodturner James Harris founded the African BlackWood Conservation Project, with students to plant hundreds of mpingo saplings to the forest.

Their campaign received little international attention until a BBC documentary, “The Tree of ” focussed world attention on the extinction risk. By 2004, Chuwa’s goal was achieved and 20,000 trees were planted in that year .

Also in 1996, Gibson, one of the world’s premier guitar brands, became the first in the industry to some of its instruments using wood certified as “sustainably harvested” by the non-profit Forest Stewardship Council (FSC).

In 2008 Gibson was joined by other guitar manufacturers Taylor, Fender, Martin, Guild, Walden and Yamaha to sign on as partners with Wood Coalition, a project of the leading environmental non-profit Greenpeace to promote in logging practices that would secure the longterm sustainability of tonewoods.

There are alternative solutions. In 2006, Favio Chávez, teacher, and Nicolás “Cola” Gómez, a rubbish picker, began to wonder if they could create instruments from garbage they found on the landfill in Cateura, a small town in Paraguay where residents suffer extreme poverty.

With the help of lutier Nicolás Gómez, Chàvez began to manufacture all kinds of instruments with which children could play.Their workshop became a place of musical refinement and experimentation. An oil drum was a good body for a cello; a bent kitchen fork for a violin tailpiece. The first few scratchy instruments were given to local kids for whom a new violin might cost a month of their parents’ .

Chávez began to his ensemble which he called La Orquesta de Instrumentos Reciclados de Cateura, or The Cateura Recycled Orchestra, formed by people from 11 to 25 years at risk of social exclusion. Since 2012 the orchestra has given concerts, not in South America, but all over the world.

In 2015 “Landfill Harmonic”, a film that follows their journey, won a special mention in the environment award at the prestigious Sheffield Doc/Fest. *(recycledorchestracateura.com)* The orchestra has now spawned copycats and is connected with similar groups who formed independently from Ecuador, Panama, Brazil and Burundi. In Mexico, the Orquestra Basura (Trash Orchestra) recorded albums and achieved minor celebrity status.

Another solution was found by Simon Lee of Burgos, Spain, originally as a sculptor who used these skills to work as a prop and model maker in the theatre, film and television industries.

After years of he decided to retrain as a guitar maker at Merton College London, but instead of using traditional tropical hardwoods materials, in 2008, he recycled. Lee’s Cyclotron guitars are made from recycled CDs, yoghurt pots and offcuts of industrial pipes. Though the neck is carvedn wood, Simon makes it a point to source materials locally where possible.

Art Mayer of Copper Guitars in Moscow, Russia has built the iCaster, a Tele-style guitar built from 107 Apple iPhone cases, gluing them together in a roughly four phones and then carving out the body, which also includes a recycled mahogany sustain .

Kevin Desmond, *Planet Savers, 301 Extraordinary Environmentalists* (Sheffield, UK: Greenleaf, 2008), 262; Simone Preuss, “Ten Guitars from Recycled Objects,” *recyclenation*, November 1, 2010; “The world sent them garbage, they sent back beauty,” *The Jupital*, December 18, 2013.

:Miyawaki Tiny forests

Problem:

Natural vegetation and green environments had disappeared rapidly from cities since World War II, replaced by concrete deserts with sparse, unnatural vegetation. Contemporary forests, created according to forestry principles, were neither the most resilient nor the best suited vegetation for the geobioclimatic conditions in Japan, neither are they the most suited to address climate .

Solution:

Miyawaki Tiny Forests

Akira Miyawaki, a professor of botany at the Department of Vegetation Science, Institute of Environmental Science & Technology, Yokohama Naional University realized that Japan's forests were not native 0.06% of contemporary Japanese forests were indigenous forests. He reasoned that densely packed native forests sited in schoolyards or alongside roads that fit into the size of a tennis court could all the benefits of a forest – climate cooling, lower flood risks, biodiversity, improved air quality, and physical and mental wellbeing – right into the heart of our cities and spaces.

With this method, the miniature forests would 10 times faster and become 30 times denser and 100 times biodiverse those planted by conventional methods. This result is achieved by planting saplings close together, three per square metre, using native varieties adapted to local conditions. A wide variety of species – ideally 30 or – are planted to recreate the layers of a natural forest.

In the early 1970s, Nippon Steel Corporation, who wanted to plant forests on embankments around its steelworks at Oita, became interested in his work after the death of previous conventional plantations and entrusted him with a first operation. The steel corporation was so pleased with the results that in the 18 years which followed, it planted forests with the Miyawaki method at sites of its steel mills in Nagoya, Sakai, Kamaishi, Futtu, Hikari, Muroran, and Yawata.

Since then, Miyawaki and his colleagues and partners successfully covered 1300 sites with multilayered protective Tiny Forests (Japanese : 小さな森 Chīsana mori), composed entirely of native species. The method has been tested successfully in almost all of Japan, Malaysia and elsewhere.

Nicolas de Brabandère, a Belgian naturalist and founder of Forests, began planting Miyawaki-style forests in 2016, organising volunteers and local authorities to plant 300 saplings on a grassy strip of near a road. Now his first forest is 3 metres tall, its floor a layer of humus. *(-forests.com)*

Akira Miyawaki et al.,"Towards Harmonious Green Environments in Japan and Other Countries", Department of Vegetation Science, Institute of Environmental Science & Technology, Yokohama National University No.194. January 1987.

:myclimate CO2 calculator

Problem:

How to calculate one's own carbon footprint.

Solution:

In 2002, Heuberger, Thomas Camerata and Patrick Bürgi at the Swiss Federal Institute of Technology Zurich founded myclimate as a non-profit climate protection organisation based in Switzerland to enable climate protection with economic mechanisms such as price-tagging carbon dioxide.

In 2006 they set up South Pole Group environmental enterprises to further that goal. Top-class customers been convinced about innovative climate protection, from reputable partners in the travel industry, to climate-neutral car travel with Mobility, to the CO2 compensation of the Football World Cup 2006.

Setting up The Climate Protection Partnership; myclimate is represented in nine countries through its partner organisations: Sweden, Norway, Luxembourg, Greece, the United Emirates, Japan, Germany Austria and India. The ngo also up with the carbon footprint calculator, enabling individuals to observe the emission they cause when driving a car, heating a house, cooking, celebrating or flying then to offset in myclimate carbon offset projects.

German airline Lufthansa, with myclimate team up with myclimate to analyse data from over 43,000 flights. On the of all these studies, myclimate then developed an algorithm that can calculate the CO_2 emissions generated by any air connection. The per-traveller calculations here even into account the passenger's class of travel.

This algorithm is also regularly updated with the latest flight data available, most recently in September 2018. *(co2.myclimate.org)*

Heuberger et al., "Evaluating projects that are potentially eligible for Clean Development Mechanism (CDM) funding in the South African context: A study to establish weighting values for sustainable development criteria." *Environment and Development Economic*s 10(05):631-649, October 2005.

:Quorn

Problem:

In the 1950s, forecasters predicted a worldwide of protein-rich foods within 30 years (that is, by the 1980s).

Solution: Mycoprotein is a form of single-cell protein, derived from fungi, especially as produced for human consumption.

It is to provide greater satiety traditional protein sources such as chicken, while also rich in protein and low in caloric content. Replacing two servings of meat protein with mycoprotein can result in a daily deficit of 80 kilocalories (330 kJ). It is rich in fiber and protein content, but very low in fat, making it a desirable food source for consumers trying to limit fat intake while participating in a high protein diet.

Since 1985 commercialised mycoprotein is by Quorn, based in Stokesley, North Yorkshire and sold primarily in Europe, but is available in 14 countries.

In most Quorn products, both as a cooking ingredient and as the meat substitute, the fungus culture is dried and mixed with egg albumen, which acts as a binder, and then is adjusted in texture and pressed into various forms.

In 2011, the first vegan Quorn product that uses potato protein as a binder instead of egg albumen was released as the Quorn Vegan Burger. *(quorn.co.uk)*

: Galvanized nails

Problem:

nails rust due to moisture and and can be the indirect cause of tetanus, often called lockjaw.

Solution:

Hot-dipped galvanized nails.

First commercialised in the 1830s, galvanizing is a sustainable solution from the very beginning and at every , considering that during the whole process there is no real raw materials loss.

All that is necessary are 1.7 mils minimum zinc coating thickness, evenly covering all nail surfaces from head to tip. Even ash residues get usually recovered and reused. Mattes get processed and used as “noble” additives for the rubber, pharmaceutical, cosmetics, electronic components and tyre manufacturing industries.

Galvanized steel has good impact and abrasion-resistance and a maintenance-free life of 50 years or . It can be recycled indefinitely has a low carbon footprint and requires minimal maintenance. Hot dip galvanizing is environmentally friendly as zinc is a natural and abundant mineral essential for life.

:NanoGraf silicon

Problem:

anxiety has often deterred potential purchasers of battery-electric automobiles

Solution

NanoGraf silicon

NanoGraf is an advanced battery material startup that has patented a new kind of graphene-wrapped silicon for lithium-ion batteries which leverages graphene to overcome traditional technical challenges with silicon. (An is the negatively-electrode in a lithium-ion battery.)

Developed since 2012 by a team led by Cary Hayner at Northwestern University and National Labs, this solution allows for powerful, -lasting batteries, for electric vehicles, and consumer electronics.

NanoGraf's patented silicon-graphene composite allows a lithium-ion battery to be 30% energy dense, and to run up to 30% . An electric automobile today can last about 350 miles (563 km) before needing to be recharged. With NanoGraf technology, that battery will power the car for 460 miles (740 km).

The U.S. Advanced Battery Consortium (USABC), which is a partnership between Fiat Chrysler, Ford, GM and the U.S. Dept. of Energy, has provided NanGraf headquartered in Chicago, with a manufacturing plant in Japan, and a satellite office in Silicon Valley, with $11.5 million in funding .

: Optical chip to predict and harness waves

Problem:

Catastrophic events such as tornadoes and tsunamis release an enormous amount of energy, but are notoriously difficult to predict.

Solution:

Andrea Fratalocchi, assistant professor in the Computer, Electrical and Mathematical Science and Engineering Division of Abdullah University of Science and Technology (KAUST), led a team of researchers from Saudi Arabia and three European universities and research centers to understand the dynamics of such destructive events and control the formation of waves (a photonic sea) in -optical chips, which can various technological applications.

A planar photonic crystal chip, fabricated at the University of St. Andrews and tested at the FOM institute AMOLF in the Amsterdam Science Park, was used to generate ultrafast (163 fs) and subwavelength (203 nm wide) nanoscale waves, proving that Fratalocchi's theory was correct.

The newly developed photonic chip offered an exceptional level of controllability over these events.

Fratalocchi and the team believe their solution could new perspectives in preventing their destructive appearance on scales, or using their unique power for ideating new applications at the nanoscale: "One of our key findings is that waves occur in a window where the losses of the system are optimum; not too

high and not too low. In a communication link, we could add a suitable loss mechanism, such as an absorber, which would increase the losses to the point where these events disappear." *www.kaust.edu.sa*

Liu, C., *et al* Triggering extreme events at the nanoscale in photonic seas. *Nature Physics* (2015).

:Nanosprings for breaking down microplastics

Problem:

Up to 14 million tons of plastic enters the annually, 40 percent of which is considered "single-use", which it goes into the water within the year that it was produced.Most plastics never fully break down; they just fragment into smaller pieces called microplastics (5 millimetres across or smaller). Microplastics been found in every corner of the globe, from the deepest part of the Mariana Trench to the top of the French Pyrenees.

Solution:

Nanosprings for breaking down microplastics

Xiaoguang and a team at the University of Adelaide South Australia found that nanotechnology could be a solution to our plastic problem. and a team of scientists created magnetic coils that will be used to break down microplastics using a chemical reaction. These tiny magnetic coils are coated with nitrogen and manganese, causing a chemical reaction with molecules. This reaction can break down microplastics, turning them into environmentally friendly salt compounds, carbon dioxide and water. In a new study published in the journal Matter, scientists describe a new type of nanotechnology that could help: tiny magnetic "-coils" that create chemical reactions in to break down microplastics in the . The process converts the plastic into carbon dioxide and water.

Xiaoguang et al, "Degradation of Cosmetic Microplastics via Functionalized Carbon Nanosprings" *Matter*, July 31, 2019

:Nanosensors to detect the presence of leaks

Problem:

The analysis and detection of GHG in environmental applications requires highly precise equipment.

Solution:

Nanosensors also various applications in the environmental field. The ability for nanosensors to measure air quality, particularly for pollutants, is a new approach to air sampling.

Nanosensors already been used to measure solar irradiance, aerosol cloud interactions, climate , and other biogeochemical cycles of East Asia and the Pacific region. Such instrumentation has been useful in tracking air pollution in Beijing during the summer Olympic Games.

Nanosensors also been used by an Israeli startup company that will monitor and analyze emissions from vehicle engines in to meet the ever increasing strict standards of American and European Environmental agencies.

Nanosensors will innovate the ways air and water quality is measured due to their size, quickness, and accuracy of measurements. An example of this is detecting mercury in any medium (such as air and water) through the use of dandelion like Au/polyaniline () nanoparticles in conjunction with surface-enhanced spectroscopy (SERS) nanosensors.

Another is their capacity to harness the in electrical conductivity that occurs when molecules bond to nanowires from semiconducting materials such as zinc oxide. One application is detecting excess levels of carbon monoxide.

The pioneer behind nanosensors is Wolter, whose research at IBM Sindelfingen (Germany) lead to technologies necessary for processing of silicon pulse monitoring (SPM) cantilever sensors.

In 1990 Dr. Wolter founded his own company called Nanoprobe. After further path-breaking developments, Nanoprobe became the first company worldwide to satisfy the emerging need for high quality atomic microscopy (AFM) sensors. The Nanoprobe AFM sensor with a tip radius of less 10 nm contributed to scientific breakthroughs.

These sensors are famous as 'Wolter'-tips honouring their inventor. In 1992/1993 Dr. Wolter not his to Ohlsson in the course of his marriage but also the of the company to Nanosensors. processing technologies were further developed to fulfil the demand of an ever growing SPM community.

In the 1990s Nanosensors achievements were honoured by various technology awards. In 1995 they received the "Dr.-Rudolf-Eberle Award", innovation award of the German State of Baden-Wurttemberg, (one of the high-tech centres in Germany, for exemplary achievements and in 2002, Nanosensors was intregrated into the Swiss-based NanoWorld AG. *(nanosensors.com)*

Wolter, "Praxisbeispiel: Agiles Qualitätsmanagement der Siemens AG – Wie wir künftig Qualität managen," August 2017.

:Single-walled and mass-produced nanotubes

Problem:

In 2014 Russia was responsible for 13.7 tons (11.86 tonnes) per capita of carbon emissions.

Solution:

Russian technology is making the production of single-walled carbon nanotubes almost 100-times cheaper. Experts believe this will help reduce carbon dioxide emissions in Russia by as much as 180 million tons (160 million tonnes) by 2030.

Nanotubes improve the qualities of 70 % of materials known to mankind; that is, they enhance a material's durability. This helps increase the lifetime of metals, rubber, other materials by two or three times. And since all sorts of items will last , there will be a significant reduction in energy spent for producing new materials, as well as less energy spent to recycle waste.

Mikhail Predtechensky, a member of the Russian Academy of Sciences, was the first scientist to discover a technology that can reduce the price of mass-produced single-walled nanotubes by 50 to 100-times.

In 2009, Predtechensky co-founded OCSiAl Technology (each letter in that word is the Chemical symbol for elements on the periodic table representing , Carbon, Silicon and Aluminium). The pilot industrial facility for single wall carbon nanotubes synthesis named *Graphetron 1.0* was installed in the Nanomodified Materials Centre at the Technopark of Novosibirsk Akademgorodok, in the R&D centre of OCSiAl.

Four years later, OCSiAl launched the world's largest industrial system for synthesizing single-walled *Graphetron 1.0* nanotubes called Tuball which is capable of producing11 tons per year (10 tonnes) SWCNT and is already building a plant in Luxembourg for a 55 tonnes per year (50) turn-key production of SWCNT. OCSiAl's process for producing SWCNT is protected by patents and patent applications in 50 countries, by a global holding company headquartered in Luxembourg, with offices in the USA, Russia, China, , South Korea and India. *(ocsial.com)*

This technology allows the synthesis of a wide of carbon nanomaterials. In the near future the company plans to establish in Novosibirsk a center for prototyping technologies based on single-layered carbon nanotubes to create rubber, composites, li-ion batteries, other materials.

Producers in more 30 countries buy nanotubes in Novosibirsk, including South Korea, Japan, the USA, Germany, and Israel. "The nanotubes' qualities are well-known across the world, yet perceive them as highly specialized additives, and so we are fighting this stereotype," said Kulgaeva.

In July 2019, Chinese companies Haiyi Scientific and Shenyang East Chemical Science Tech both won permission to mass-produce the OCSiAL Tuball Batts. With their combined production capacities, the partners anticipate manufacturing 7,000 tons of Tuball Batts for Chinese battery manufacturers whose is a 300 Wh/kg energy density.

In March 2019, a team of researchers at MIT created a new cathode for lithium battery cells which could allow for smaller and lighter lithium batteries. The team said an initial version of the battery, without optimization, achieved a gravimetric energy density of 360 Wh/kg, and volumetric energy density of 581 Wh/liter.

The researchers added that with further work and optimization they believed the battery could reach 400 Wh/kg and 700 Wh/liter – greatly increased from commercially available 260WH/kg li-ion batteries by several manufacturers in Japan, China and South Korea.

*"*OCSiAl launches carbon nanotube modifier product ". *CompositesWorld.com*, May 2014; Mikhail Predtechensky et al. “Effect of Carbon Nanotubes on the electrical properties of the polymeric composites,” 2019.

:National forests and preserves

Problem:

If left to their own, coal, oil and hydroelectric prospectors and property developers would totally destroy Nature and its flora and fauna.

Solution:

For over 150 years, the creation of parks has been one solution for protecting the Planet.

From the 1860s, John Muir, a Scottish-American naturalist, publicly campaigned to create a protected park in Yosemite until US President Abraham Lincoln signed an Act of Congress on 1 July 1864, ceding the Yosemite Valley and the Mariposa of sequoias (later becoming Yosemite National Park) to the state of California.

In the United States, the Forest Reserve Act of 1891 the President power to set aside forest reserves from the in the public domain. A series of 51 bird reserves, four preserves, and 150 National Forests were established by President Theodore Roosevelt from 1901 to 1909.The 1916 National Parks Act, included a 'use without impairment' clause.

In Europe, the first national parks were a set of nine parks in Sweden in 1909, followed by the Swiss National Park in 1914. Africa's first national park was established in 1925, an area centred on the Mountains hence the National Park).

In 1926, the government of South Africa designated Kruger National Park as the nation's first national park, Argentina became the third country in the Americas to create a national park system, with the creation of the Nahuel Huapi National Park in 1934. After World War II, national parks were founded all over the world. As of 2010 Europe had some 359 national parks.

According to an international organization, the International Union for Conservation of Nature (IUCN), and its World Commission on Protected Areas (WCPA), there are 6,555 protected national parks worldwide. The largest national park in the world meeting the IUCN definition is the Northeast Greenland National Park, which was established in 1974 and is 972,000 km2 (375,000 sq mi) in area.

"History of the National Parks", *Association of National Park Authorities*, April 21 2013.

:Natrium Reactor

Solution:

In August 2020, Microsoft co-founder Bill Gates presented his detailed on how to “address climate ”. One solution is a small yet advanced nuclear power station that will the ability to store electricity to supplement grids increasingly supplied by the intermittent sources like solar and wind energy.

Gates’s company TerraPower of Bellevue, Washington *(terrapower.com)*, is collaborating with GE Hitachi Nuclear Energy *(nuclear.gepower.com)* in Wilmington, North Carolina, to build the *Natrium*, a 345MWe cost-competitive sodium fast reactor (SFR) combined with a molten salt energy system. Sodium’s chemical element symbol is Na (from Latin "natrium").

Building on the technology used in solar thermal generation, *Natrium* energy and flexible power production will offer abundant clean energy in time to help meet climate goals. SFRs the potential to become an attractive energy source for countries interested in managing their nuclear supply and nuclear waste.

The Natrium technology’s novel architecture simplifies previous reactor types. Non-nuclear mechanical, electrical and other equipment will be housed in separate structures, reducing complexity and cost. The design is intended to permit significant cost savings by allowing major portions of the plant to be built to industrial standards. Improvements use fewer equipment interfaces and reduce the amount of nuclear- concrete by 80% compared to reactors.

Natrium reactors are designed to provide firm, flexible power that seamlessly integrates into power grids with high penetrations of renewables. For instance,

its innovative thermal has the potential to the system's output to 500MWe of power for five and a half hours when needed. This allows for a nuclear design that follows daily electric load and helps customers capitalize on peaking opportunities driven by renewable energy fluctuations.

According to TerraPower, Natrium technology will be available in the 2020s, making it one of the first commercial advanced nuclear technologies."

The development of the Natrium system demonstrates the benefits of modern virtual design and construction tools and has attracted the attention of numerous utilities through the U.S. Department of Energy's Advanced Reactor Demonstration Program. PacifiCorp, a subsidiary of Berkshire Hathaway Energy, Energy Northwest and Duke Energy expressed their support for the commercialization effort, which will provide energy and energy to the electrical grid.

TerraPower, LLC," Molten fuel reactor cooling and pump configurations" Patent *N° number: 10741293*, August 11, 2020

:Nature

Problem:

Fruit and veg on average travel by refrigerated air and transport between 2,400 and 4,800 kilometres from farm to market. The global transportation is the largest of humanity's carbon-emitting activities, and reducing the number of flights and truckloads of produce is a great place to start cutting the amount of CO2 entering the atmosphere.

Solution:

In 2016, Pascal Hardy, an engineer in agro-development had the intuition that growing towers could be used to set farms on the rooftops of cities and created Agripolis in Paris.

He started with the roof of Hall 6 at the six-storey Paris Exhibition Centre in the in the 15th arrondissement of the capital, designing the largest rooftop farm in the world, covering 3.4 acres, about the size of two soccer pitches. aeroponic or vertical growing techniques would be used to create fruits and vegetables without the use of pesticides, refrigerated trucks, chemical fertilizer, or even soil.

By 2019, “Nature ” (French for Nature) was supplying produce to local residents, including nearby hotels, catering halls, and . For a price of 15 euro, residents can a basket of produce online containing a bouquet of mint or , a head of lettuce, various sprouts, two bunches of radishes and one of chard, as well as a jar of jam or puree. Also available are 150 baskets of strawberries, as well as aubergines, tomatoes, and .

Accompanying the farm will be a new rooftop restaurant run by area group “Le Perchoir”.

When the Nature is finished, twenty gardeners will tend 30 different kinds of plants and harvest up to 2,200 lbs (1,000 kg) of perhaps 35 different kinds of fruits and vegetables every day.

Pascal Hardy is now planning similar projects in the suburbs of Paris and abroad.

:Nesting Boxes

Problem:

For example, the evaluation of threatened bird species in Finland was updated in 2015 under the coordination of the Finnish Environment Institute SYKE. The evaluation concluded that overall the populations of Finnish bird species are on the decline. The number of threatened bird species increased by 28 compared to the previous evaluation, while 21 new species were red-listed. The availability of suitable holes has greatly decreased in Finnish forests, and without access to a hole or a bird box birds simply fail to nest.

Solution:

A nest box can help prevent bird extinction. The species that use nest boxes and platforms are diverse. Many ses of owls, bats, , bluebirds, chickadees, American Kestrels, Purple Martins, and will use nest boxes of various sizes because they mimic cavity nests they would find in the wild.

In 1915, following publication of the US Department of Agriculture's "Farmer's Bulletin 609, "Bird Houses and How to Build Them", an estimated 50 million boxes were built.

Sixty years later, since January 1975, thanks to the initiative of Mary Marlar, the Northern Neck Audubon Society (NNAS) has been constructing and distributing bluebird nest boxes (also known as bluebird houses) to up for the loss of natural sites for blue birds depleted by logging and other development activities in the Virginian community.

Over ten years, NNAS has built and sold around 1,000 nesting boxes a year. *(northneckauduban.squarespace.com)*

In March 2015, the Finnish Broadcasting Company Yle launched the One Million Bird Boxes campaign, which is set to introduce one million new bird boxes to Finnish trees by the end of May 2017.

A million bird boxes would provide homes to ten million hatchlings, motivate people to do hundreds of thousands of outdoor treks and create a veritable symphony of congratulatory chirping to commemorate Finland's centenary. During the first few weeks after launch nearly 300,000 bird boxes already registered to the campaign with people from all over Finland taking the challenge to build bird boxes, from the capital Helsinki all the way to northernmost Lapland.

Over 40 bird boxes were in the garden of the President's official residence. cities also their citizens permission to bird boxes in parks and other city-recreational areas. The campaign proved successful with over 1.3 million nest boxes registered by May 21. *(yle.fi)*

In , winegrowers from the Clairette de Die appellation with the support of the Vercors Natural Park, built and installed 800 nest boxes on their 40 hectares of . The nesting birds fed on the insects in the vines eliminating the need for insecticide. *(clairette-de-die.com)*

:No dig gardening

Problem:

With market gardening, turning over the earth with a fork, hoe or machine enables weeds to grow and swamp the cropes

Solution:

In 1982, Charles Dowding, a vegetable grower in Shepton Mallet, Somerset, UK up with a different time-saving solution. No digging over would minimise the disturbance of the soil, so that the natural processes could be preserved.

This allows the natural organisms to thrive, increasing the soil's overall health and therefore that of his plants, enabling the buildup of beneficial rather harmful soil fungi. Moisture was also retained efficiently under mulch on the surface of earth, allowing slower percolation and less leaching of nutrients.

This approach is not new. Two pioneers of the method in the twentieth century included F. C. , Head Gardener at Levens Hall, South Westmorland, in the District of England, who the book "Is Digging Necessary?" in 1946 and a gardener from Middlecliffe in the UK, A. Guest, who in 1948 published the book "Gardening Without Digging".

Charles Dowding had soon created a a 6000m² market garden at his Homeacres farm, the first of four he would establish and run, in two countries and on a of soils, using this no dig approach. Using straw provided by his brother, a dairy farmer Dowding permanent pathways between beds. An annual dressing of compost improved soil structure, and is particularly worthwhile for growing an abundance of healthy vegetables to sell at the market.

The English farmer’s no-dig solution has become popular. He has written seven books on gardening organically and without digging, and gives regular talks and courses on the subject. These include videos to demonstrate and explain the

methods and virtues of how he and a growing number of gardeners time, for better results. The Royal Botanical Gardens at Kew went no dig in 2016 in their kitchen garden, and since 2018, no dig has arrived at the Royal Horticultural Society at Wisley where they demonstrate a of approaches.

(Network Observatory Environment Hive Monitoring Intelligence)

Problem:

Bee mortality and the fall in honey production

Solution:

A smart connected beehive

Farid Maniani and four partners in Illkirch Graffenstaden, near Strasbourg have started-up Tech4Gaia: “to conserve one billion bees” Noéhmi. (Network Observatory Environment Hive Monitoring Intelligence) is aimed at amateur and professional beekeepers, scientists and communities who carry out environmental programs thanks to the data collected on their territory, committed eco-citizens as well as companies in CSR (Corporate Social Responsibility) wishing to federate their teams around a common and meaningful project.

Noéhmie makes it possible to watch over our dear bees from a distance. Extinction today is a real threat for bees. Without disturbing the life of bees, Noéhmi’s sensors inside and outside the hive, enables watching over elements that are crucial for them, namely temperature, humidity; seeing if the honey production is consistent over a certain period. All of which gives indicators of the vitality of bee colonies on a well-determined ecosystem.

Noise Barriers to catch the sun’s energy

Problem:

Roadside noise barriers while also reducing the near-road air pollution concentration levels, by up to 50% compared to road values, enormous surface potential as well.

Solution:

Photovoltaic Noise Barriers (PVNB) are physical obstructions with photovoltaic panels designed to produce renewable energy and also to lower noise levels between noise sources and sensitive receptors, such as hospitals, schools and residential areas.

An efficient way of noise prevention by application of 2208 Kyocera photovoltaic modules was first demonstrated in 1989 the A13 motorway near Chur, Switzerland, stretching just under a kilometre. 20 years later, the system is in operation and delivers 100 MWh of electricity annually to the public grid.

Since then, PVNB systems been installed in Europe. In 1996 a PVNB consisting of 2,160 modules with module inverters was integrated into a noise barrier at the A9-motorway near Ouderkerk aan de Amstel (Amsterdam), the Netherlands.In 2009, 2.64 MW of PVNB were installed a motorway at Aschaffenbrg, Germany

According to Michael Debije at the Eindhoven University of Technology, using an innovative technology known as luminescent solar concentrators (LSC), PVNB can be multi-coloured and work under cloudy skies.

This year, the Dutch Government Solar Highways initiative includes deploying bifacial PVNBs the country's main roads. A first 400m solar array has been built the A50 near Uden, in the Netherlands' southern province of Noord-Brabant where the energy output will be measured during an 18-month test phase.

PVNBs are also evaluated in the USA's West Coast and in Singapore. In Australia, visitors to Victoria driving to Bendigo or Melbourne's international airport, are farewelled by a 500m PVNB.

Siddharth Wadhawan, Joshua Pearce "Power and energy potential of mass-scale photovoltaic noise barrier deployment: A study for the U.S", *HAL* April 28, 2019

:Nuclear fission power station, waste disposal

Problem:

Nuclear fission power stations efficiently and reliably provide quantities of electrical energy to national and international grids. As of 2014, the International Atomic Energy Agency reports there are 450 nuclear power reactors in operation in 31 countries.

Alongside serious accidents such as at Chernobyl in the and Fukushima, the radioactive effects of which caused sickness and even death of local inhabitants from , there is environmental damage from uranium mining, processing and transport, the risk of nuclear weapons proliferation or sabotage, and the unsolved problem of radioactive nuclear waste. Strontium-90 and cesium-137 half-lives of about 30 years (half the radioactivity will decay in 30 years). Plutonium-239 has a half-life of 24,000 years.

Solution:

Nuclear fission stations are now designed for a 40 to 60-year operating life. The Centurion Reactor is a future class of nuclear reactor that is designed to last 100 years. There currently are no Centurion Reactors operating in the world.

One of the major limiting wear factors is the deterioration of the reactor's pressure vessel under the action of neutron bombardment. However in 2018 Rosatom announced it had developed a thermal annealing technique for reactor pressure vessels which ameliorates radiation damage and extends service life by between 15 and 30 years.

Generation IV reactors (Gen IV) are a set of nuclear reactor designs currently researched for commercial applications by the Generation IV International Forum, a collaboration of 13 member nations, including the United States, Canada, Japan, China and the European Atomic Energy Community (Euratom).

In total, the forum's research and development work US$400 million dollars a year. Five of the six designs use hot gas, molten salt or liquid metal as a coolant. Most of them operate at very high temperatures, making it impractical to use water as a coolant.

The U.S. has an active in developing two out of the six Gen IV designs — the Very High Temperature Reactor (VHTR), although in October 2018, it was reported that successful air pressure tests had been completed on the first Gen IV high-temperature gas-cooled pebble-bed reactor at China Huaneng's Shidaowan site, Such reactors produce a higher volume of radioactive waste conventional reactors, although proponents of the design that the waste remains locked within the layers of ceramic and graphite that form the fuel pebbles.

However a serious number of Gen IV reactors will not be deployed until after 2025.

Thorium-based nuclear power generation is fueled primarily by the nuclear fission of the isotope uranium-233 produced from the fertile element thorium.

According to proponents, a thorium fuel cycle offers several potential advantages over a uranium fuel cycle, including much greater abundance of thorium on Earth, superior physical and nuclear fuel properties, and reduced nuclear waste production. Chinese scientists claim that hazardous waste will be a thousand times less with uranium. The radioactivity of the resulting waste also drops down to levels after just a one or a few hundred years, but as of 2019, there are no operational thorium reactors in the world.

In terms of disposal, high-level waste packed into boreholes drilled 3 mi. (5 km) deep in solid would generate so much heat that it would melt the surrounding rock, which would then engulf it. As the deadly waste cools, the rock would eventually re-solidify, encasing it: these are known as " coffins".

In Finland, from 1999, Posiva Oy, by the nuclear power plant operators Fortum and TVO, studied the geological disposal of spent nuclear fuel at four sites, Hästholmen in Loviisa, Kivetty in Äänekoski, Olkiluoto in Eurajoki and Romuvaara in Kuhmo, been studied in detail.

They chose Olkiluoto Island on the Bothnian coast of south-west Finland where they built a repository set 1,500 ft. (457 m.) down into 1.9-billion-year-old gneiss and bedrock. When the burial chambers of Onkalo are full with waste from the three nearby power stations of Olkiluoto, they will hold 6,500 tons (5,900 tonnes) of spent uranium.

Inside the copper canister is a cast- canister, which has been internally partitioned so that it resembles a tic-tac-toe board, with gaps for the squares. Into these gaps will be slid the zirconium alloy fuel rods containing the spent uranium pellets. Each canister will weigh around 25 tons (23 tonnes) when complete; each canister will be nested in a bed of water-absorbing bentonite clay, inside a cored-out tube of gneiss.

Critics do not believe that these risks can be reduced through new technology. *(posiva.fi)*

Ontario Power Generation in Canada has slowly headway for a to bury its nuclear waste in a deep underground repository next to the Bruce powerplant near Huron. OPG states the proximity to Huron is much distant when the waste is plunged into rock half a kilometer below the surface.

This is three times deeper the depth of the in sedimentary rock that is 450 million years old. The is to pack the bundles into carbon steel tubes coated in copper, 48 bundles per container. They look such as a big torpedoes. Each one will be packed snugly into what look like coffins of bentonite. *(opg.com)*

Giorgio Locatelli et al. "Generation IV nuclear reactors: Current status and future prospects," *Energy Policy. 61: 1503–1520*. October 1, 2013; Tom Clarke, “Nuclear waste could bury itself,” Nature, August 13, 2003; Corkill, "! Nuclear waste! Keep out — forever!" *Japan Times*, January 15, 2012; Eric Sorensen, “Canada’s nuclear waste to be buried in deep underground repository,” *Global News*, May 29, 2019.

:Nuclear fusion power station -Tokamak reactors

Problem:

The world’s 440 nuclear fission plants generate 10% of the world’s electrity while presenting the lethal menace of dealing with waste by transporting it to deep earth burial sites.

Solution:

Nuclear fusion is a reaction in which two lighter nuclei, typically isotopes of hydrogen, combine together under conditions of extreme pressure and temperature to form a heavier nucleus, releasing energy in the process. Fusion has been powering the sun and stars since their formation.

Unlike fission, fusion will a low burden of radioactive waste. The energy released during fusion in the sun makes all life on earth possible. The simplest way to replicate the primordial source of power on earth is via the fusion of deuterium and tritium.

Deuterium is found aplenty in water, enough to last for billions of years. Naturally occurring tritium is extremely , but it can be produced inside a reactor by neutron activation of lithium, found in brines, minerals and clays. Moreover, to run a 1,000 MW power plant with a fusion reactor, it is estimated that about 150kg of deuterium and three tonnes of lithium would be required per year, while the current fission reactors consume 25 to 30 tonnes of enriched uranium.

Fusion’s by-product is helium, which is an inert, non-, non-radioactive gas used to inflate balloons. In addition, a fusion power plant would not require transporting hazardous radioactive materials.

The 35-nation International Thermonuclear Experimental Reactor (ITER) including states from theEuropean Union, the USA, India, Japan, South Korea and Russia began construction at Cadarache in . It is the world’s largest fusion reactor, taking up equivalent to 60 football pitches.

Launched in 2006, ITER was beset with technical delays, labyrinthine decision-making and that soared from an initial estimate of five billion euros to around 20 billion euros.

In the chaos of the United Kingdom's leaving the European Union, or Brexit, there is now at least one certainty: As the UK's quest to produce clean energy from nuclear fusion by 2040, The Culham Centre for Fusion Energy Oxfordshire, UK but supported by the European Union will keep operating until the end of 2020, thanks to a €100 million infusion of EU funds.

The deal, agreed in April 2019, will enable the Joint European Torus (JET) to embark on a fusion campaign with a , tricky fuel that will help the way for its successor: the ITER fusion reactor under construction in .

The agreement comes as a relief to fusion researchers, who had feared JET would be shut down after Brexit. Now, they can go ahead with plans to gradually switch to a fuel mix of deuterium and tritium, both hydrogen isotopes. The latter is and hard to handle, but the will provide the most ITER-like dress rehearsal before the main event in 2025. The "D-T" reactions will ultimately power ITER and the commercial reactors that follow it.

Nuclear fusion is usually in hollow, donut-shaped reactors called tokamaks, which are filled with of plasma as hot as the Sun. Soviet scientists coined the term as a shortening of the Russian for “toroidal magnetic confinement.”

The is perfectly descriptive. A tokamak is a torus—the math term for a donut. But this takes tremendous effort to maintain the intense pressures and temperatures required for an "artificial star" here on Earth. Eruptions called edge-localized modes (ELMs) been damaging the walls of reactors, making them less secure and requiring the replacement of parts far too regularly.

The problem was that the plasma used is inherently unstable, and eruptions can damage the reactors containing it. Recently, physicists from the Princeton Plasma Physics Laboratory (PPPL) found that creating a series of small ELMs could prevent larger, damaging from occurring.

These smaller eruptions could be triggered by injecting of beryllium, measuring about 1.5 mm into the boiling plasma at regular intervals. Following computer simulations, the team ran physical experiments in the DIII-D, a tokamak reactor housed in the National Fusion Facility in San Diego prior to testing the technique out on other tokamaks, such as the Joint European Torus (JET).

The next breakthrough when scientists developed a new superconducting material, essentially a steel coated with yttrium-barium-copper oxide (YBCO) enabling smaller and powerful magnets. This in turn lowers the energy required to get the fusion reacton off the ground. With 18 nobium-in superconducting magnets (aka torroidal-field coils) installed, 150 million degrees celius was finally in sight

November 2019 saw the completion of the seven-storey Tokamak Building, after six million work hours, performed by approximately 850 workers since 2010. Some 105,000 tonnes of concrete, reinforced by approximately 20,000 tonnes of steel rebar, had into the building's construction.

Transport of component parts was been a major undertaking. The PF6 (the second-smallest of the six coils that circle the vacuum vessel) weighing 396 tonnes and measuring 40 ft. (12 m.) , 36 ft. (11 m.) wide and a little 13 ft. (4

m.) high, was in China under an agreement signed between the Institute of Plasma Physics of the Chinese Academy of Sciences (ASIPP) and the procuring party, the European Agency.

Transported by ship, having arrived at Fosses-sur-Mer, the port of Marseilles, for this "highly exceptional load" (HEL) to reach the ITER site, approximately 2,220 cubic yards (1,700 cubic m.) of roadside rock and trees had to be removed. This is just one of approximately 100 components for the magnet feeder system, adding up to 1,600 tonnes of equipment in all and measuring from 100 to 160 ft. (30 to 50 m.) in length.

other components to be delivered was the 18 m., or 60 ft. (18 m.), tall 1000-“Central Solenoid,” the superconducting electromagnet that stands the central axis of the tokamak, sometimes referred to as “the beating heart of ITER,” under manufacture by General Atomics in Poway, California, near San Diego.

This 1,000-metric-ton solenoid will 5.5 gigajoules of stored energy to enable 100-million-degree-Celsius plasmas within carefully defined magnetic fields. In some locations, there will be 10 mm of space—the width of a pencil—between the massive central solenoid and a 45 foot (13 m.) tall "D"-shaped toroidal field magnet.

Despite the delay caused by the COVID-19 lockdown, the project began its five-year assembly phase in July 2020, launched by the French president, Emmanuel Macron alongside senior figures from ITER members, the EU, UK, China, India, Japan, Korea, Russia and the US. Trials were due to begin in 2021 and if successful, regular power supply will be in 2025. *(iter.org)*

Meanwhile, by November 2019, following delivery of the coil system, the Southwestern Institute of Physics (SWIP) under the China National Nuclear Corporation (CNNC) completed the construction of *HL-2M*, the Experimental

Advanced Superconducting Tokamak (EAST) at a research centre in Chengdu, the capital city of southwest China's Sichuan province.

人造太阳 (Rénzào tàiyáng = artificial sun), expected to generate plasmas hotter 200 million°C should also be operational in 2020. *(cnnc.com.cn)*

On November 24th 2020, The Korea Superconducting Tokamak Advanced Research (KSTAR), a superconducting fusion device also known as the artificial sun, set the new world record as it succeeded in maintaining the high temperature plasma for 20 seconds with an ion temperature over 100 million degrees Celsius (retention time: about 1.5 seconds) the temperature as the of the Sun—its hottest part. In a continuing research program with the Seoul National University (SNU) and Columbia University of the United States, KSTAR aims to continuously operate high-temperature plasma over the 100-million-degree for 300 seconds by 2025.

On Aug. 8, 2021, an experiment at Lawrence Livermore National Laboratory's (LLNL's) National Ignition Facility (NIF) made a significant step toward ignition, when a laser light was focused onto a target the size of a BB which resulted in "a hot-spot the diameter of a human hair, generating more than 10 quadrillion watts of fusion power for 100 trillionths of a second, achieving a yield of more than 1.3 megajoules (MJ). This advancement puts researchers at the threshold of fusion ignition, an important goal of the NIF, and opens access to a new experimental regime.

" Wins Nuclear Fusion Plant," *Deutsche Welle*, 28, 2005; Lev Grossman, "A Star is ", *Time Magazine*, November 2, 2015, p.29; Robert Lunsford et al. « Supplemental ELM control in ITER through beryllium injection" *Nuclear Materials and Energy* Volume 19, May 2019, 34-41;*"*Q4-23: Begin installation of central solenoid,*" iter,* July 27 2019.

:Nurseries to protect baby fish

Problem :

According to a study by WWF, fish could completely disappeared from the world by 2050. The urbanization of the seas with the construction and extension of ports is a devastating factor.

Solution:

Harbour nurseries to protect baby fish

In 2003, biologist Gilles Lecaillon of Montpellier, patented a solution to preserve the smallest fish in the post-larva state with artificial nurseries he called Biohuts. Sixteen years later, Lecaillon's firm Ecocean had equipped the pontoons, on the protective dikes of twenty-five Mediterranean ports with 3,000 such Biohuts.

A Biohut consists of a steel mesh , with three compartments. The middle is filled with empty oyster shells which are the refuge for aquatic species. There are, for example, sars, wolves and mullets or pipefish (fish close to seahorses) but also a whole vagile fauna (2) up of sea urchins, crabs, shrimps and scallops

these fish grown to the size that allows them to become predators themselves and less of targets for the people of the seas, they naturally leave this habitat and gradually disperse into the depths of the .

Thus protected, a wide variety of fish live use Biohuts. In the Mediterranean, brown groupers, scorpion fish, eels, red mullet and sea bream are gradually dispersing in the depths of the sea. Ports in Brittany will soon be equipped and the company is on the verge of convincing ports to adopt the system.

Gilles Lecaillon « Ensemble modulaires pour alevins et autres organismes aquatiques », World Patent N°2014195658A2, December 11, 2014; Gilles Lecaillon, "Postlarval Fish Capture and Culture for Restoring Fisheries", book: Innovative Methods of Ecosystem Restoration (pp.179-188) December 2012

:Nylon from landfill waste

Problem:

Luxury-car interiors usually feature hardwoods and animal-sourced leather

Solution:

The British automaker Jaguar Rover (JLR) is using Econyl nylon by nylon manufacturer Aquafil in Ljubljana, Slovenia, employing depolymerisation from recycled industrial plastic, clothing offcuts, and fishing nets, to develop high-quality interiors such as floor mats and trim pieces from and landfill waste.

: Ocean Clean-up machine

Problem:

An estimated 8.8 million tons (8 million tonnes) of plastic waste finds its way into our every year, and that burden is expected to grow. The Great Pacific Garbage Patch, which is located between California and Hawaii is the area where plastic rubbish accumulates because of currents, known as gyres which act such as a vortex pulling waste into a central channel. It is around three times the size of Spain.

Solution: A floating barrier that collects debris as the system is pushed by wind, waves and current, and slowed down by a sea anchor.

The Ocean Cleanup was founded in 2013 by Slat, of Croatian , living in the Netherlands. In 2011, at age 16, Slat across plastic fish while diving in Greece. He decided to devote a high school project to deeper investigation into plastic pollution and why it was considered impossible to clean up.

He later up with the idea to build a passive system, using the circulating currents to his advantage, which he presented at a TEDx talk in Delft in 2012. He founded the non-profit Ocean Cleanup in 2013, and shortly after, his TEDx talk went viral after shared on several news sites.

After foundation, The Ocean Cleanup managed to US$2.2 million through a crowdfunding campaign with the help of 38,000 donors from 160 countries. In 2014, the Ocean Cleanup published a 528- feasibility study.

As a planet-protecting solution, the prototype consisted of 2000 ft (600 m.) , U-shaped floating cylinder with a 9ft (2.74 m) skirt beneath which moves with the current capturing plastic as it goes. It is attached to a central platform shaped

like a manta ray for stability. The barriers would direct the floating plastic to the central platform, which would remove the plastic from the water.

The refuse is then picked up by boat every few months and taken to for processing and recycling. In 2014, the design was revised, replacing the central platform with a tower detached from the floating barriers. This platform would collect the plastic using a conveyor belt.

On 22, 2016, The Ocean Cleanup deployed a 330 ft (100 m.)- barrier segment in the North Sea, 14.2 mi. (23 km) off the coast of The Netherlands. It was the first time the design was put to the test in waters and the tests conducted valuable insights to the engineering team. Making modifications on a small scale structure 10 mi. offshore is relatively easy. In contrast, making corrections on a scale structure 1,609 km (1,000 mi.) offshore would be an entirely different challenge, at a different cost.

The test indicated that conventional oil containment booms could not endure the harsh environments the system would . They the floater material to a hard-walled HDPE pipe, which is flexible enough to follow the waves, and rigid enough to maintain its U-shape. prototypes were deployed to test component endurance.

On September 9, 2018, *System 001* (nicknamed *Wilson* in reference to the floating soccer ball in the 2000 film *Cast Away)* deployed from San Francisco. The ship *Maersk Launcher* towed the system to a position 286 mi (440 km) off the coast, where it was put through a series of sea trials. When the tests were complete, it was towed to the Great Pacific Garbage Patch for real-world duty.

Research by the foundation found that, at its peak, the patch contains around 330lbs (150 kg.) of plastic per square mile, reducing to 33lbs (15 kg.) at the outer edges. *Wilson* arrived on October 16, 2018, and was deployed in operational configuration. *System 001* encountered difficulties retaining the

plastic collected. The system collected debris, but soon lost it because the barrier traveled too slowly.

In November, the project attempted to widen the mouth of the U by 195-230 ft. (60-70m.) but failed. A 60-foot chunk of the Cleanup device, deployed with much fanfare in the Great Pacific Garbage Patch in October, has broken off and the entire plastic collection system will now be towed back to port for an overhaul and upgrade. The break was discovered on Dec. 29 during a routine inspection by the cleanup system's crew. A 60-foot (18 m.) end section of the 2,000-foot (600 m.) boom that corrals the plastic had detached

Shortly thereafter, the rig began its journey to Hawaii for inspection and repair. During the two months of operation, the system had captured some 4,400 lb. (2,000 kg.) of plastic. In mid-January 2019, *Wilson* completed its 800 mi (1,290 km.) journey and arrived in Hilo Bay, Hawaii. Ocean Cleanup anticipates the repaired system back in action by summer.

In July 2019, the improved *System 001B* its size reduced by a factor of 3, returned towards the GPGP Vortex. A string of inflatable buoys had been attached across the system's opening to add to the windage of the system and pull it through the water faster. If that failed, the team would hoist a parachute to the opening.

Measuring 65 ft (20 m.) across, to serve as an anchor of sorts, slowing the system down so that it travels at around the speed as the water. It has also reduced the size of the barrier by a factor of three and taken a modular approach to its construction, allowing the team to deploy the system faster and certain alterations without towing it back to shore.

In October, Slat tweeted that *System 001B* had successfully captured and retained debris.

Alongside a picture of the collected rubbish, which includes a car wheel, Slat : "Our cleanup system is now finally catching plastic, from one-ton ghost nets to tiny microplastics! Also, anyone missing a wheel?" The plastic gathered was brought to shore in December for recycling.

The project believes there may be a premium market for items that been using plastic reclaimed from the . "I think in a few years' time when we the full-scale fleet out there, it should be possible to cover the operational cost of the cleanup operation using the plastic harvested," Slat said.

In February 2020, the Globus Family of Brands, which includes Globus, Cosmos, Monograms, and Avalon, launched a new promotion in hopes of supporting The Cleanup. Globus is making a donation to The Cleanup every time a client opts for e-docs, rather paper documents, when booking a trip.

For inshore cleaning, The Ocean Cleanup presented its latest invention in Rotterdam, Netherlands, a solar-electric trash-collecting called *The Interceptor*. The Interceptor aims to collect low-hanging fruit, plastic trash, as it down the world's most polluted rivers before reaching the sea.

When the vessel is anchored to the riverbed, a floating arm extends into the river's current to catch plastic and direct it into the *Interceptor*'s maw, where it is hauled from the water and put into dumpsters, which can be removed for recycling.

Four Interceptors already been built, and two are operational, one on the River that flows through Kuala Lumpur, Malaysia, and one on the Cengkareng , which flows through Jakarta, Indonesia. The other two are destined for Vietnam and the Dominican Republic.

Outfitted with li-ion batteries and an array of solar panels, Interceptors can operate day or night, without producing noise or pollution. The organization estimates that a single *Interceptor* could remove as much as 110,000 lb (50,000 kg) of plastic trash a day from a polluted river, and claims that because the arm will not completely the river, it will not impede boat traffic or local wildlife. The idea is to implement the Interceptor as a scalable solution that can be mass-produced to meet needs around the world.

By placing *Interceptors* in 1,000 strategic locations in rivers around the world, the Ocean Cleanup claimed it could halt 80% of plastic from entering the in five years' time.

On October 25th 2020 Ocean Cleanup launched its first "Great Pacific Garbage Patch" product, The Cleanup sunglasses from the recycled plastic, designed in California by Yves Behar, in Italy by Safilo. Recycled plastic was also used for the sunglasses' is from the HDPE floater of System 001 (aka Wilson), and the carrying pouch is from recycled PET bottles.

With a similar approach, Marcella Hansch, an architectural student of Aachen, Germany, has invented "Pacific Garbage Screening", a floating platform with a distinctive design that makes it possible to filter plastic particles out of the water from both and rivers.

The platform is an anchored object, so it has no drive and needs no fuel, and works like an inverted sedimentation . Its architectural form calms down the currents and then because of the calming and the low density of plastics, the plastic particles float to the surface. There is no need for filter systems such as nets. This fish and other life will not be harmed.

For this design, Hansch not received the "25 Women Award - Women, whose inventions our lives" from the magazine *Edition F* but also the German Federal Ecodesign Award in the category Talent. The Pacific Garbage Screening ngo has funding from both Swiss luxury watch manufacturer and German sanitary fittings manufacturer so that together with an interdisciplinary team of natural

scientists, engineers and biologists, the architect is on the creation of the platform to be implemented within the next five years. *(theoceancleanup.com)*

In the closed sea which is the Mediterranan, swelling with 600,000 tons of plastic every year. Co-founded by Pierre- Giudicelli, the Vivu association based at Pinu on the island of Corsica has organized the CorSeaCare 2.0 mission to inform the public about the harmful effects of single-use plastic and to clean up the coastline using a low-tech system that allows used plastic to be recycled. This includes members out the beaches or in their , catamarans and kayaks, and picking up plastic waste. (-*vivu.org*)

Slat et al. "How the Can Clean Themselves: A Feasibility Study" *Independently published book*, 2014; Laurent C. M. Lebreton, Julia Reisser & Sainte-, "Modelling Floating Plastic , Transport and Accumulation in the World's ," *Conference Paper, Association for the Sciences of Limnology and Oceanography*, March 2017; Laurent Lebreton and Anthony Andrady, "Future Scenarios of Global Plastic Waste Generation and Disposal," *Nature, Palgrave Communications*, January 2019. Marcella Hansch et al."Reinigung der Meere von Plastik mit Pacific Garbage Screening." *Wasser und Abfall* 19(9):58-59 · September 2017.

:Zero emission liner and container ship

Problem:

The Naturschutzbund Deutschland (NABU), a German non-governmental organisation has estimated that the average fuel of an ocean liner is 150 tons (136 tonnes) of fuel a day, releasing as much particulate matter into the air as about 1 million fossil fuel automobiles each day. All of the vessels are powered by heavy fuel oil, a sludgy tar - like fuel that produces noxious fumes when burned that can harm not passengers of the cruise, but all those in the vicinity of the ship, while greatly accelerating climate . With an estimated total number of about 23 million cruise ship passengers in 2015, it can be estimated that the average cruise ship passenger emits 0.83 tonnes of carbon dioxide-equivalent for their cruise. The study from the EU based non-profit Transport & Environment, which advocates for cleaner of transportation in Europe, says that the 203 cruise ships that operated in European waters in 2017 emitted a combined total of

62,000 tons (56,000 tonnes) of sulfur oxides (SOx), which form airborne gases known to cause and acid resulting in 50,000 premature deaths and over US$ 63.5 billion per year. *(nabu.de)*

Solution:

Soot filters would help to capture some of the particulates that are released when the diesel engines burn fuel, thereby preventing them from escaping into the atmosphere and would at least marginally improve the environmental impact of their massive fuel combustion.

In 2014, Haldor Topsoe A/S of Denmark and its Italian partner Ecospray Technologies S.r.l. launched a groundbreaking catalytic process technology called ECO-Jet that can significantly reduce harmful emissions from vessels. It was tested on a cruise ship, the M/S *Queen Victoria*, in close collaboration with the vessel's , Carnival Corporation, one of the world's largest cruise companies.

installed aboard a ship that uses heavy fuel oil, the process eliminates up to 95% of soot emissions while also removing poisonous hydrocarbons and a wide of heavy metals including vanadium, , nickel, silicon and sodium. Furthermore, the ECO-Jet technology can be combined with a so-called scrubber process that removes sulfur. *(ecospray.eu)*

In partnership with leading cruise lines, Norwegian technology suppliers now developed a concept for zero-emission cruising**.** The concept has been developed in cooperation with Eker Design, cruise giants Carnival Corporation and Royal Caribbean Cruises Ltd, technology suppliers in the industry cluster NCE Maritime CleanTech and various interest organisations.

The concept launched is in high demand by an industry that is hard to meet the IMO's of a 50% cut in emissions by 2050 and zero-emission requirements in Norwegian tourist fjords from 2026. The development work has been supported by Norwegian foundation DOGA.

The participants in the development of the concept are: Eker Design, Carnival Corporation, Royal Caribbean Cruises Ltd, Bergen harbour, Scanship, Wärtsilä, Corvus Energy, Teknotherm, DNV GL, Hydro, ETA Energi, , Hardcruise, Blueday, BKK, Solbære, Hyon, , Østensjø, GAC Norway, Yxney Maritime, Prototech, , NCL, Bellona and NCE Fjord Tourism Norway. *(ekerdesign.com)*

US-listed Star Bulk Carriers has begun installing exhaust gas cleaning units on 100 vessels — almost all of its fleet — to meet new environmental rules that are set to the industry.

One of Star Bulk's biggest ships, the 1000 ft x 164 ft (300m × 50 m) *Star Leo* — has recently had a scrubber installed. It does 90-day journeys from Brazil to China carrying ore, the raw material used to steel. The bulk carrier goes around the of Good Hope, then the Strait of Malacca to ports on the east coast of China — the most polluted superhighways in the world. *(starbulk.com)*

In November 2019, Hurtigruten of Norway launched their 450-passenger *Roald Amundsen,* as the world's first hybrid diesel-electric cruise ship.

She is equipped with two lithium-ion battery packs that complement its four low-emission Rolls engines that use low-sulfur diesel. The batteries provide the necessary energy to meet peaks in demand without having to start another engine and reduce both fuel consumption and CO2 emissions by 20%.

Hurtigruten was also the first cruise to stop using single-use plastic, so guests will find , refillable amenity bottles in the bathrooms and aluminum water bottles to on excursions; the hairdryer and laundry bag found in guest rooms, meanwhile, are using upcycled hotel linens.

One of the company's creative initiatives resulted in the uniforms in the street food-inspired restaurant Fredheim: the blue shirts worn by the waiters are made

of 54 % recycled plastic, sourced from fishermen who plucked it from the waters around Spain and Portugal.

Hurtigruten has plans to update its entire expedition fleet with the clean, stylish design and sustainability features seen throughout the *MS Roald Amundsen* by the end of 2021, so guests will eventually be to choose from ten hybrid-powered ships for adventures throughout the world. *(global.hurtigruten.com)*

M/S *Viking Glory* will be one of the most eco-efficient passenger ships in the world when it goes into service in 2021. Powered by six Wärtsilä 31DF dual-fuel engines, it will run on sulfur-free liquefied natural gas, while also having the capability to run on biogas, minimizing its carbon footprint.

electric ships are already a reality and their technology should be used for cruise liners as well. A. P. Moller-Maersk Group (Maersk)'s *Triple E*, the world's biggest ship, is hybrid-electric.

Triple E stands for Economy of scale, Energy efficiency, and Environmentally improved. The twenty- Triple E fleet, each measuring 1,312 ft (400 m.) LOA, and capable of transporting over 18,000 TEU containers, has been built by Daewoo Shipbuilding and Engineering (DSME) of Seoul, South Korea. They are powered by two 32-MW (43,000 hp) ultra- stroke two-stroke MAN diesel engines, driving two propellers at a design speed of 19 knots (22 mph/ 35 kph).

Three 3 MW Siemens Shaft Generator Motors (SGM), enabled by Waste Heat Recovery System (WHR), act as a variable consumer or power generation units. these mega-hips is *Maersk Mette*, run entirely on cooking oil-based biofuel, part of a collaboration with Heineken, Phillips, Shell, Unilever, DSM and FrieslandCampina. Maersk has unilaterally pledged to achieve net zero emissions throughout its operations by 2050. *(maersk.com)*

In May 2020, the *Zhongtiandianyun 001,* a battery-electric ship with a load capacity of 1,100 tons (1,000 tonnes) was successfully tested on the River section in Changzhou, east China's Jiangsu Province. The vessel, powered by a lithium-ion battery system and supercapacitors, has an energy capacity of 1,458 kWh, and can cruise 30 mi (50 km) after it is for 2.5 hours.

A Swedish consortium including the KTH Royal Institute of Technology in Stockholm, maritime consultancy SSPA, and lead by ship designers Wallenius has developed the wind Powered Car Carrier, or *wPCC* for short.

on the rig development and control at KTH is Ulysse Dhomé, already with experience of the autonomous sailing Maribot . A 7m demonstrator is already trialled. This transatlantic wPCC is capable of carrying up to 7,000 vehicles at a time and reduces emissions for the crossing by 90% compared to traditional ships. It is believed that the wPCC will be ready for its maiden sailing by 2024.

Since 2019, DecarbonICE, a consortium of leading ship companies, has teamed up with the Maritime Development Centre to develop an on-board carbon capture and solution. In the process, the CO2 and other greenhouse gases in the ship exhaust are captured on board in a cryogenic process and turned into dry ice.

Proven offshore technology is then applied during normal ship operations to transport the dry ice into the seafloor sediments. Here the CO2 will be safely and permanently stored as liquid CO2 and CO2 hydrate.

A new study, carried out for campaign groups Seas at Risk and Transport & Environment recommends that the reduction in the speeds of such ships could further reduce GHG emissions. A 20% reduction would cut GHGs but also curb pollutants that damage human health such as carbon and nitrogen oxides. This speed limit would cut underwater noise by 66% and reduce the chances of whale collisions by 78%.

Josh Gabbatiss, “Cruise ships using ‘dirtiest of all fuels’ must be banned in European ports, says environmental group,” *independent*, August 22, 2018; Peter Tubaas, “ New concept guides the way to emission-free cruises,” *NCE Maritime CleanTech*, April 11, 2019; Kevin Desmond, *Electric and Ships: A History*, (Jefferson, NC: McFarland, 2017). p. 219.

: OTEC

Problem:

The cover a little 70 % of the Earth’s surface: this makes them the world’s largest solar energy collector and energy system. On an average day, 23 million mi.² (60 million km²) of tropical seas absorb an amount of solar radiation equal in heat content to about 250 billion barrels of oil. If less one-tenth of one % of this stored solar energy could be converted into electric power, it would supply 20 times the total amount of electricity consumed in the United States on any given day.

Solution: OTEC (Thermal Energy Conversion) is a form of Solar Thermal Energy technology that essentially uses the as a solar collector. OTEC takes advantage of the small temperature differential that exists between the warm surface of the sea and the cooler water at the bottom.

In deep waters in excess of 3280 ft (1000 m) this difference is as much as 20°C. In 1881, Jacques d'Arsonval, a French physicist, proposed tapping the thermal energy of the .

D'Arsonval's student, Georges Claude, built the first OTEC plant, in Matanzas, Cuba in 1930. The system generated 22 kW of electricity with a low-pressure turbine. The plant was later destroyed in a storm.

His idea called for a closed-cycle system.Thanks too recent technological advances in heat exchangers, D'Arsonval's concept was demonstrated in 1979, when a small plant mounted on a off Hawaii (Mini-OTEC) produced 50 kW of gross power, with a net output of 18 kW. Subsequently, a 100 kW gross power, -based plant was operated in the island nation of Nauru by a consortium of Japanese companies.

The economics of energy production today delayed the financing of a permanent, continuously operating OTEC plant. However, OTEC is very promising as an alternative energy resource for tropical island communities that rely heavily on imported fuel.

OTEC plants in these markets could provide islanders with much-needed power, as well as desalinated water and a variety of mariculture products. One of the disadvantages of -based OTEC plants is the need for a 1.86 mi (3 km.) cold water pipe to transport the volumes of deep seawater required from a depth of about 3,280 ft. (1,000 m).

Currently the world's operating OTEC plant is in Japan, overseen by Saga University. Japan is a major contributor to the development of OTEC technology. Beginning in 1970 the Tokyo Electric Power Company successfully built and deployed a 100 kW closed-cycle OTEC plant on the island of Nauru.

The plant became operational on October 14, 1981, producing about 120 kW of electricity; 90 kW was used to power the plant and the remaining electricity was used to power a school and other places. This set a world record for power output from an OTEC system where the power was sent to a real (as opposed to an experimental) power grid. *(ioes.saga-u.ac.jp)*

1981 also saw a major development in OTEC technology when Russian engineer, Dr. Alexander Kalina, used a mixture of ammonia and water to

produce electricity. This new ammonia-water mixture greatly improved the efficiency of the power cycle.

In 1994 Saga University designed and constructed a 4.5 kW plant for the purpose of testing a newly invented Uehara cycle, also named after its inventor Haruo Uehara. This cycle included absorption and extraction processes that allow this system to outperform the Kalina cycle by 1-2 %. Currently, the Institute of Energy, Saga University, is the leader in OTEC power plant research and also focuses on of the technology's secondary benefits. The laboratory located at lmari bay area, some 50km to the north from the administrative office in Saga City, functions as our study center of fundamental and practical aspects of OTEC technology.

The Thermal Energy Corporation with offices in Pennsylvania, Virginia, Hawaii, The Bahamas, and Cayman Islands been preparing clean hydrothermal energy plants worldwide using the proven technologies of Thermal Energy Conversion (OTEC) and Seawater Air Conditioning (SWAC).

Since 1988, OTE has established a noteworthy pipeline of projects with a signed energy services agreement (ESA), four signed memoranda of understanding (MoU) and proposals to the United States Department of Agriculture (USDA) and United States Department of Defense (USDoD).

In 2017, new power cycle utilising a combination of thermal energy and geothermal waste energy, called a GeOTEC (Geo- Thermal Energy Conversion) power cycle/plant. The potential geothermal waste heat, which exists in the form of raw hot natural gas would be continuously pumped from a shallow water Malaysia-Thailand Joint Authority (MTJA) gas production platform, and the supply data is estimated based on the output of the platform.

A thermodynamic model derived from an energy balance calculation is used to simulate the proposed GeOTEC cycle with Matlab. With higher superheated ammonia temperature, GeOTEC power plant efficiency increases, while the net

power output decreases. A maximum net power produced by the proposed GeOTEC is 32.593 MW.

L.A. Vega, Ph.D., Hawaii, USA " Thermal Energy Conversion (OTEC)" 1999; Yoshitaka Matsuda et al. "Construction of a Model for Power Generation of OTEC Plant Using Uehara Cycle Based on Experimental *Data Journal of Science and Engineering,* February 15, 2018.

:Ocean-cleaning bathing suit

Problem:

Holidaymakers swimming in lakes and oceans often encounter oily pollution about they can do very little.

Solution: the Spongesuit

In 2015 Mihri and Cengiz Ozkan, both professors at the University of California Riverside, collaborating with Eray/Carbajo, an architecture and design studio based in New York and Istanbul, developed Spongesuit, made from heated sugar, that leaches oily pollution out of water. As the user swims along, they clean the ocean. They originally envisioned the material not as a bathing suit, but as a way to clean up large-scale oil spills in the ocean. The SpongeSuit is built from two components – a net-like exterior shell made from 3D-printed plastic that flexes to fit the body and a filler made from Sponge. The Sponge portion of the design is intended to collect 25 times its own weight in oil. When it's heated up to 1000°C, it releases its absorbed gunk. The material can be re-used up to 20 times. Users can replace their old Sponge pad in the bathing suit for a fresh one. The SpongeSuit was prominently featured in the 2018 Philadelphia Eagles football team Swimsuit Calendar, with Snow Feng, a four-year veteran of the squad, modeling it on the front cover.

:Ocean microplastic sensor

Problem:

More than 250 metric tons of microplastic are estimated to be floating in the world's oceans. By 2050, it is estimated that there will be more plastic in the ocean than fish. Studies suggest that 99.8% of oceanic plastic sinks below the ocean's surface where they can affect coral reefs and feeding grounds. But the

cost to take a research vessel out to study those particles and their dispersion patterns can be astronomical up to ,$10,000 per day — with a winch and a crane to move a sampler into the water.

Solution:

In 2015, Ethan Edson, a student working at Mark Patterson's Field Robotics Laboratory, Northeastern University of Massachusetts, who had also spent a semester at sea using Neuston Nets, developed the "MantaRay," a sensor that could autonomously collect and quantify microplastics in marine environments. The was trialled in Boston Harbour.

In 2017, Edson teamed up with Dean Wenham, a drug developer and biopharma entrepreneur to a create a start up Ocean Diagnostics Inc (ODI) Victoria, British Columbia. By 2021, ODI brought out their portable commercial version *Ascension* weighs approximately 8 kg. (18 lbs) and can reach 200 metres from the side of a small boat, including a two-person canoe., It includes a battery that lasts between one and 1.5 hours and seven filter channels. It is good for a depth of 400 metres and comes with a 200-metre tether.

In order to determine long-term effects of microplastics on ecosystems, food chains, and human health, scientists are working towards gaining a better understanding of how microplastics affect fish populations. Using their knowledge of how fish eat plankton, they can better understand the levels of microplastics fish ingest and how many particles fish are eating in different areas. Less expensive device such as *Ascension* will enable them to carry out more fruitful researches.

Oceanix

Problem:

By 2030, approximately 60 % of the world's population will live in cities that are exposed to economic, social, and environmental pressures.
Further, approximately 90 % of the largest global cities are vulnerable to rising sea levels. By 2050, out of the world's 22 megacities with a population of 10 million, 15 are located the coasts.

Solution:

In 2019, UN-Habitat New Agenda with non-profit unveiled designs to build a floating city at sea that would house 10,000 people, be fully autonomous and could withstand Category 5 hurricanes.

Based in , is the brainchild of Marc Collins Chen, a Tahitian entrepreneur and former politician, who served as the Minister of Tourism of the Pacific nation of French Polynesia. In January 2017, this nation looking for a potential lifeline as AGW takes hold, in had become the first country to sign an agreement to deploy the floating islands off its coast. Low-lying, small islands of the Pacific are disproportionately at risk of losing as sea level climbs by an expected 10 in. to 32 in. (26-82 cm) by the 21st century.

Also on the team are Bjarke Ingels Group (BIG) in Denmark and MIT's Center for Engineering. City would measure 185 ac (75 ha) spread over floating platforms. The idea is that the floating hexagonal platforms would be prefabricated on and grouped into clusters of six to create a "village" of up to 1,650 residents.

A total of six villages would then be grouped together around a central harbour. All buildings would be kept between 4 and 7 seven stories-high to ensure a low center of gravity and mitigate the effects of high winds. They would also be from sustainable materials such as bamboo and feature flat roofs to aid shading and offer space for solar panels. There would be a focus on farming too, both on and, below sea level, floating reefs, seaweed, oysters, mussel, scallop and clam farming.

Residents would get around on electric vehicles. The structure itself will be moored to the bottom of the and will rely entirely on the concept of so-called " farming", which growing food under the surface of the water. For example, cells under the platforms could collect mussels, squid and other types of seafood. Aquaponics systems will use fish waste to help fertilize plants while vertical farms will generate year-round production.

Both technologies could help the city self-sufficient to food during a hurricane or other natural disaster. Either cars or vehicles with harmful emissions will be forbidden. Even garbage trucks will not be provided - trash pneumatic tubes will be installed. They will transport the waste to a station where they could be identified and redirected. The city will also a water system that extracts clean water from the air. *(.org)*

Currently there is a technology to build the first green floating city for people to live sustainably on the . Singapore is cooperating with Norway on ambitious floating projects. In Europe, Norway is putting the weight of its state- enterprise Equinor (formerly Statoil) into exploring this new space and building strategic alliances. Norway is conducting workshops on floating cities.

The Netherlands, in cooperation with the United Nations, recently announced the creation of the Global Center on Adaptation to be housed in floating offices in Rotterdam. This center will be led by several luminaries, including former UN Secretary-General Ban Ki-Moon, business leader Bill Gates and CEO of the World Kristalina Georgieva.

Damian Holmes, “BIG and Partners unveils City,” *worldlandscapearchitect.com*, 3, 2019; Laurence Brahm, “New technologies and frontiers: Sustainable floating cities for China's coastlines and BRI,” *China Daily*, April 3, 2019.

:Offshore computer server

Problem:

Cooling is one of the biggest of running a data center and keeping computers from overheating, particularly on a scale.

Solution:

Microsoft’s Project involves lowering a hyperscale data center down to the cold depths of the sea and pumping cold seawater through to keep it cool;

From 2015, Phase 1 of Microsoft's project saw a 10 ft (3 m) prototype submerged off the coast of California for 105 days, which proved the feasibility of the concept. Phase 2 was designed to test if the idea was practical in a logistical, environmental and economic sense.

Microsoft partnered with a French manufacturing company called Naval Group, which designed the watertight cylindrical shell and adapted a commonly-used submarine cooling system to work with the data center. Positioned offshore from the new facility, known as the Northern Isles data center sits 117 ft (36 m) below the waves, and measures 40 ft (12 m) . It houses 12 racks with 864 servers and 27.6 petabytes (27,600 terabytes) of , enough to store at least 5 million copies of *Finding Nemo*.

To cool them, seawater is piped through the radiators on the backs of the server racks, before being released back out into the sea . The centre is connected to the world through a fibre cable and gets most of its power from the nearby Islands. Interestingly, 100 % of the region's energy already comes from renewable sources, thanks to wind turbines, solar panels and other experimental sources such as tidal turbines and energy converters.

The eventual goal of Project is to these underwater data centers be completely self-sustained, powered entirely through offshore wind, or tidal generators. In so, they could essentially be submerged near any coastal city where they are needed, and supply faster internet and cloud services. This phase of Project will see the team monitoring the Northern Isles data center for the next 12 months, keeping watch over its performance, power consumption, sound, humidity and temperature.

This version is designed to work continuously down there for up to five years without needing maintenance. Project has been criticized because, using the as a heat exchange to reduce energy used to cool data centres, could be construed as conflicting with environmental objectives, particularly as the global energy consumption of data centres is due to expand from its current 3% to about 14% by 2050. Other companies also built facilities in cold locations such as the Arctic Circle or beneath the fjords of Norway. *(natwick.research.microsoft.com)*

Kevin Simon, "Project -Microsoft's Self-sufficient Underwater Datacenters." *ResearchGate*, 2018.

:Offshore floating wind farm

Problem:

Towards the end of 2019 there were 5,000 offshore wind turbines in 110 parks with a total power output of 22.1 Gigawatts. Fixed to the seabed, these turbines are limited to shallow waters. Yet close to 80% of the world's offshore wind resource potential is in waters deeper 60 metres, too deep for the foundations, but where winds are and consistent.

Solution:

Floating offshore wind turbines.

Norway In 2009, Norway's Statoil (now Equinor) launched *Hywind*, the world's first operational deep-water floating -capacity wind turbine. The 120 metres (390 ft) tall tower with a 2.3 MWh turbine was towed 10 kilometres (6.2 mi) offshore into the Amoy Fjord in 220 metres (720 ft) deep water off Stavanger, Norway for a two-year test run.

In October 2020, Norway-based OIM Wind, together with its financial partners, has signed an EPC contract with the CIMC Yantai Raffles Offshore shipyard in China and its Swedish subsidiary Basstech for the construction of an installation vessel capable of installing next-generation XXL offshore wind turbines, including full height towers that reach 130 metres.

The vessel, currently referred to as *BT-220IU Wind Installation Unit,* will enter into service by the end of 2022 and will be operated by Norwegian company OSM Maritime. It is LNG-powered, battery-backed up, and for 15+ MW wind turbines. It will feature a Huisman heavy lift with a lifting capacity of 2,600 tonnes. The will a main hook height of 165 metres above deck and 195 metres above sea level, even at the vessel's maximum operational water depth of 67 metres.

Scotland: Following proof that the suction anchor system worked, Equinor and Masdar launched the world's first floating wind turbine farm, at a depth of 100 metres and situated 29 kilometres (18 mi) off Peterhead, Scotland. The farm has five 6 MW *Hywind* floating turbines with a total capacity of 30 MW.

Work is now underway for the 88MW Hywind Tampen floating wind farm will comprise 11 Siemens Gamesa 8MW wind turbines supported by the Hywind technology developed by Equinor and expected to come online in 2022. commissioned, the wind farm is projected to cover a third of the total energy needs of two oil and gas platforms, Gullfaks and Snorre, with wind power instead of gas.

Floatgen is the floating wind turbine in today. It is situated off the Mediterranean coast of Le Croisic, one of the largest wind resources in Europe, The venture is a joint venture of Ideol, Bouygues Travaux Publics, Centrale Nantes engineering school, RSK Group, Zabala, the University of Stuttgart, and Fraunhofer IWES. The anchorage system, developed by Ideol is a -shaped floating foundation based on a central opening system and called a Damping PooAbove this a Vestas V80 turbine is mounted. After two years of trial, in February 2020, **Floatgen** produced 9 GWh of electricity

Italy Milan-based Ichnusa Wind Power srl has applied with the Port Authority of Cagliari for a 30-year concession to build and operate an export cable connection for Sardegna Sud Occidentale a floating wind farm off the west coast of Sardinia**.** Some 35 kilometres off the coast of the San Pietro island, it will comprise 42 wind turbines measuring 265 meters each, on a sea surface of 49 thousand square meters. Instead of the conventional three-bladed turbines, the Ichnusa solution uses a single-bladed , scalable rotor, to adjust its to the wind currents of up to 70 m/s. The planned capacity is 12 MW each for a total of 504 MW.

Portugal In October 2011, Principle Power installed their 2 MW WindFloat turbine 5 kilometers off the Portuguese Atlantic coast where, during the next five years, it encountered 17-metre heights and 111km/h winds, but generated 17GWh of electricity.

Based on this, in January 2020, Principle Power is preparing a the world's first semi-submersible floating wind farm for operation 20km off the coast of Viana do Castelo, Portugal. The wind farm is developed by the Windplus consortium

that includes EDP Renewables (54.4%), Repsol (19.4%), Engie (25%) and Principle Power (1.2%).

Japan

The Fukushima floating offshore wind farm demonstration project (Fukushima FORWARD) serves as a symbol of Fukushima's recovery from the nuclear disaster caused by the earthquake and tsunami in 2011.

The phased development of the project includes the installation of three floating wind turbines and a substation at approximately 23km off the Fukushima coast.

The project is sponsored by Japan's Ministry of Economy, and Industry (METI).The Fukushima *Offshore* Wind Consortium comprises ten companies, namely Marubeni, the project integrator, University of Tokyo, Mitsubishi Corporation, Mitsubishi Heavy Industries, Japan United, Mitsui Engineering & Shipbuilding, Nippon Steel & Sumitomo Metal Corporation, Hitachi, Furukawa Electric, Shimizu, and Mizuho Information & Research.

The first phase of the project consisted of a 2MW compact semi-sub floating wind turbine, the world's first 66kV floating power sub-station and undersea cables. The turbine has a rotor diameter of 80m and a hub height of 65m above sea level (asl) and is placed on a floater called Fukushima MIRAI. A downwind-type blade, located leeward, was used for the project in to the most of the upward wind blowing from the surface of the sea.

One Hundred Million Farmers

Problem:

The Planet must transition towards net-zero, nature-positive food systems by 2030

Solution:

Disruptive Agricultural Technology

100 Million Farmers is a multi-stakeholder platform catalysing action such as mainstreaming regenerative and climate-smart agricultural practices, which are at the centre of this process. This can also create additional co-benefits, such as increased socioeconomic resilience, improved livelihoods and enhanced soil and water health. The cumulation of these benefits, described as a “carbon+” approach, would ensure the health of both people and the planet. This not only gives incentives to 100 million farmers to adopt regenerative and climate-smart practices, but it also empowers 1 billion consumers to demand and support this type of agricultural production.

100 Million Farmers is anchored in regional and national ‘lighthouse’ projects. Each lighthouse is led by a regional multi-stakeholder coalition, with solutions tailored to local food systems and the natural ecosystems they depend on. The effort builds on the ambition of various leadership groups, within and beyond the World Economic Forum and will seek to align, scale and amplify a broad base of efforts. One lighthouse is the European Carbon+ Farming Coalition: BASF, Bayer, COPA-COGECA, CropIn, European Conservation Agriculture Federation (ECAF), European Institute of Innovation & Technology (EIT) Food, HERO, Planet Labs, Syngenta, Swiss Re, University of Glasgow, Yara, Zurich and the World Economic Forum.

Another is Kenya, where fourteen agri-tech innovations have been funded by the World Bank to form a One Million Farmer platform lighthouse. The initiative aims to create a platform that leverages disruptive agricultural technologies to reach one million farmers and enhance their productivity, profitability and resilience for feeding the nation. The initiative works with support from Ministry of Agriculture, Livestock, Fisheries and Irrigation (MoALFI) and the counties to ensure its success. In addition, Microsoft, through its *4Afrika Initiative*, has pledged support to the One Million Farmers Platform, by providing technical and business support to the 14 Kenyan innovators selected to build technology solutions for the platform.

: Organic Fertilizer

Problem:

Fertilizing the soil with chemical agents is highly controversial and it has been proven that major problems are caused for the environment. One problem is the loss of nutrients when spreading liquid effluents. EU ammonia emissions are the cause of an estimated 80.000 premature deaths per year

Solution:

In 2007, the Danish government stated that agriculture had to reduce its ammonia losses further to conserve and protect sensitive nature. From this process a legislation proposal where founded, that all grass fields had to be injected or acidified. Two years later, Morten Toft of Vejen, South West Jutland, Denmark, founder of BioCover A/S developed the sustainable SyreN process for the use of organic fertilizers. This unique process converts harmful ammonia into ammonium during use, reduces ammonia emissions by 70% and increases the volume of plant nitrogen to about 50 kg per hectare. Finding that the pH of the effluent affects its composition, BioCover has designed a tool that automatically regulates this parameter during spreading. On the nitrogen cycle, acidity pushes the ammonium / ammonia balance towards the least volatile and mobile ion in the soil, ammonium, which is also available to plants. Biocover is aiming for a pH of 6.4".

: juice bar – circular economy

Problem:

Machines for making fresh juice, usually throw away the peel.

Solution: the Circular Juice Bar

Carlo Ratti Associati in Turin and energy company Eni created “Feel the Peel”, a Circular Juice bar which supplies freshly squeezed juice in a 3D printed bioplastic cup from the peel.

The prototype machine is 3.1 meters tall and has a circular dome which holds 1,500 . When you an juice, an slides down, is cut in half, and juiced. The peel is then dropped into a container at the bottom of the machine and the leftover rinds are dried and milled to “*dust*“. This is then mixed with PLA pellets to create a material ready for 3D printing into a cup. The 3D printer – presumably provided by Wasp, whose logo is emblazoned on the side of the unit – resides in the middle of the juice bar.

Visitors can watch as their cup is created and then filled with juice. After the drink is finished, the cup can be recycled. It could potentially be broken down and re- into another cup to keep the circular economy . In October 2019, the Circular Juice Bar was trialled at the Singularity University Summit in Milan, Italy.

:Owantshoozi

Problem:

Making objects using raw materials and then transporting them draws on the Planet’s resources.

Solution:

Settled in the heart of their native village of Ordiarp, Juana Etcheberry (with an MA Masters degree from the Ecole de la Chambre Syndicale de la Couture Parisienne) and her brother Ddiddue Etcheberry (with a BA with the Prize of Authenticity at the Design Academy of Eindhoven caps with materials from local waste reception centres where they had noticed that 20% of plastic waste is recycled, the rest is destined for landfill.

With a population of 530, Ordiap (near Mauléon) is a commune in the Pyrénées-Atlantiques department in south-western France .

For their unique caps and bracelets, the Etcheberrys use clamps from used plastic containers, flower pots, buckets, basins or watering . The crown is of various flexible materials depending on the raw material recovered, such as leather, rubber , inner tubes, wool blanket, cotton canvas. paraglider sails or old household linen; some are screen printed or braided

In 2020, at the 35th Hyères fashion festival, the Etcheberry's enterprise Owantshoozi was awarded two prizes for fashion accessories: le Prix Hermès and the Prix Chanel

:Oyster shells, recycled

Problem :

Oysters are delicious, but eaten, their thousands of shells need to be recycled

Solutions:

In 1988, the Saundier family of Périgny, Charente-Maritime, west founded Ovive SA. to collect, crush and calibrate dried oyster shells from local oyster farmers to transform them into food supplements for the animal industry, poultry industry, aquarists, but also landscaping and public works.

Ovive enjoys the proximity of the largest oyster center in Europe: the Marennes-Oléron , and is located less 200 km from the oyster basins of Arcachon in the south and Vendée in the north. It is in this privileged geographical context that the OVIVE company draws its raw material.

From 1989 to 1994, Ovive's raw materials and their compounds were approved for use in farming by the Nature & Progrès association, and checked by the ECOCERT organization. Since 1994 and the establishment of European standards, OVIVE has complied with EEC regulation n ° 2092/91, concerning agricultural production methods

Member of the Poitou-Charentes Pole of ECO-INDUSTRIES, Ovive is also a stakeholder in the BIOTOP network: a voluntary initiative by around fifty companies from the La Rochelle Agglomeration Community, to improve their professional practices with regard to the objectives of Sustainable Development taking in the reduction of industrial waste, circular and local economy, travel management,control of energy consumption and social responsibility

Ovive now produces 50% of its electricity from the 740 m2 of photovoltaic panels installed on its new building. It was voted best company in 2018 for CSR during the "Stars & Métiers" competition organized jointly by the Chamber of Trades and Crafts of Charente-Maritime, and the Banque Populaire Center Atlantique.

: Paper from fallen leaves

Problem:

Traditionally, paper has been made from trees, with little interest shown in the leaves shed by deciduous trees every autumn.

Solution:

Valentyn Frechka was a high school student living in rural Ukraine, Russia when he began a science project to turn fallen leaves from trees and plants into paper. Success led to his starting up the Re-Leaf Paper concern at the Zhytomyr Cardboard Factory in Zhytomyr, Ukraine producing paper bags and packaging. In October 2020, Re-leaf Paper produced its first batch of solid paper, made from leaves collected in large bags in Kyiv and other cities. It is planning to go into commercial production.

Personal Carbon Allowances (PCA)

Solution:

Prof. Yael Parag, vice dean of the School of Sustainability at Herzliya’s Interdisciplinary Center in Israel and Tina Fawcett of Oxford University propose a solution which would enlist households, responsible for 40% of carbon emissions — in climate crisis fight

Tradeable personal carbon allowances could significantly cut global warming gas emissions and help nations to reach their zero carbon goals. Each adult citizen in a country would receive a standard carbon emissions "budget," which would reduce over time in line with national targets. Under one possible model, credits would be deducted for journeys in private cars and by plane, home and water heating and electricity use. The individual's use would be registered every time a car was filled with fuel or a bill was paid to a utility.

Tools to help householders monitor their carbon emissions could include online applications, LED displays on electrical appliances showing how many units of carbon are being emitted, and tracking of behavioral choices combined with anti-carbon waste recommendations gathered via artificial intelligence and machine learning.

Just as companies already trade carbon emissions credits — today, policymakers focus on carbon producers rather than end-users — individuals who have used up their points would be able to buy more from people who have points to spare.

Acceptance of such a system will depend on the increasing concern of the citizen for the future of their Planet and the part each one can play….

Yael Parag and Tina Fawcett, "Personal carbon trading: a review of research evidence and real-world experience of a radical idea" *Energy and Emission Control Technologies* October 2014(2):23-32

:Plastic pick-up barrier, camera-equipped

In 2019, Ichthion, based in Staines, Middlesex a British-Ecuadorian start-up born out of the laboratories of Imperial College London in opened offices in Ecuador to start the installation and operation of their *Azure* system in the Portoviejo River to prevent plastic pollution from reaching the famously biodiverse Galapagos Islands. This was funded by the Benioff Ocean Initiative and the Coca-Cola Foundation to the tune of $1 million.

Azure's solution, developed by Eugenio Welker, which also uses a barrier to direct waste onto conveyor belts, which run along the riverbank, and deposit it into receptacles, is also equipped with cameras that snap images of the waste, and then use algorithms to identify the plastic by type. That will help authorities understand how best to reduce waste at source. Azure is currently at pilot scale, but once up and running, it's expected to capture 80 tonnes of waste per day.

Plastic-recycling machine, low cost

Problem:

For the most part, recycling machines are large and occupy big buildings.

Solution:

Samuel Le Bihan and Christofer Costes of Nice, France have invented the Earthwake Chrysalis, a machine to recycle plastic waste into fuel, in a small, mobile format, and at an affordable price. Their Chrysalis machine uses the pyrolysis process of flameless combustion at very high temperatures (about 450 °) to melt and dissolve plastic molecules. After distillation, they are recovered as petrol, diesel or gas. Low-tech, mobile and self-sufficient, Chrysalis uses the gas it produces to power itself. As one example, the houshold garbage trucks of the small French town of Puget-Théniers run on Chrysalis fuel.

:Plastic to oil converter

Problem:

To convert plastic waste into fuel usually requires transporting the raw material to a fairly sizeable factory.

Solution:

Akinori Ito wanted to the process of plastic recycling accessible, so that less landfill would be required -- an increasing problem in his densely-populated native Japan. So he invented a tabletop -type machine (called Be-h), household appliance which converts plastic into fuel.

To operate, users put their plastic trash in a bucket, then screw on a lid. The temperature inside rises, slowly melting the plastic, which becomes a liquid and then a gas. The gas passes through a tube into a container filled with water, where it cools and forms oil again. That oil can then be burned as-is or further separated into gasoline, diesel and kerosene. A kilogram of plastic turns into about a litre of oil.

In 2011, Akinori set up the Blest Corporation Ltd. to commercialise his solution which he called the Be-h. (*blest.co.jp)*. Initially it retailed for approximately

$10,000, and Ito was planning to the price down as the system became popular. There was also a Small-scale system (with a max. capacity of 200kg/hr and a Big-scale system with two models (one with a max. capacity of 1000kg/ 24h and the other with a max. capacity of 2000kg/24h).

Yoshiko Shimo, Akinori Ito, Hitoshi Itagaki, Yasuo Ishikawa, "Liquefying apparatus," *Blest Co., Ltd*. Patent n°: 8187428 May 29, 2012

:Post wildfire reforestation

Problem:

Whilst hundreds of thousands of hectares will need to be reforested after 2021's global wildfires, this must be done so that the same disaster does not occur again, especially in areas where wildfire wipes out entire stands and the seed source necessary to forests' natural regrowth.

Solution:

According to silviculturalists worldwide, when reforesting burned areas, avoid planting sites that are dominated by the old straight-line monoculture pine and shrub species that will soon reoccupy the site from developing root sprouts. Instead, replace them with new methods emphasizing variety of both spacing and species-diverse mixes of native tree saplings. The more biodiverse an ecosystem, the quicker it tends to bounce back after a threat. For inaccessible and very steep terrains where seed sources are gone, the "founder stand", based on Latin American practice, involves a small grove, planted and left to grow and seed over time. And ensure the creation of fire breaks to halt future wildfires.

:Olive Oil plastic

Problem:

According to Spanish research institute Aimplas, Spain is the world's major olive oil producer and hence produces significant waste during the stoning process. At present, the generated waste is incinerated for power generation.

Solution:

The Spanish research institute Aimplas has collaborated with Olivarera de los Pedroches (OLIPE) to develop an olive-based plastic for packaging that contains products with olive oil.

Both organisations been on a project called GO-OLIVA to use olive waste to new material. Their solution is a new biodegradable, compostable and plastic compound material, dubbed Oliplast, by using materials from renewable sources such as filler or reinforcement from olive oil and thermoplastic material.

Extrusion and injection moulding technology will be used to process Oliplast for the manufacturing of new products such as trays and plates to hold bottles.

Oliplast can also be used for the production of caps for packaging containers for cosmetic creams with olive oil.

According to Aimplas, work to includes selecting raw materials and developing an olive that can be used to produce the new material.

The partnership will conduct a behavioural study to validate the material for transformation processes. In addition, they will conduct an environmental study to determine the compostability of the material.

GO-OLIVA project, which has a total budget of €340,million, has secured a for €316, million. A total of 80% of this is co-funded by the European Agricultural Fund for Rural Development (EAFRD) and the rest by the Spanish government.

:Olivine Sequestration of CO2

Solution:

The green mineral Olivine (/ˈɒlɪˌviːn/), a magnesium silicate with the formula $(Mg^{2+}, Fe^{2+})_2SiO$ has been mined for almost one hundred years in places such

as Nordall in Norway. Natural weathering is how earth removes CO_2 from the atmosphere in the first place and it has been this for billions of years.

Project Vesta, set up as a nonprofit back in 2019, wants to accelerate this process by taking olivine from below the surface directly to the coastal areas to green beaches. The waves will break down the mineral and speed up the removal of CO_2 from both the atmosphere and the . olivine is in its carbon-capturing sandy state, it could be scattered in streets, green strips near roads and industrial sites, parks, gardens, beaches, and in the sandpits of schools.

Vesta co-founder Pol Koops of Geleen, Apeldoorn Area, the Netherlands, having authored numerous papers related to olivine weathering and is an expert in the field of olivine dissolution kinetics has founded Green Minerals to explore industrial and commercial uses for olivine. An enhanced mineral weather trial is currently underway alongside the shoreline of an undisclosed island in the Caribbean. *(projetcvesta.org)*

Francesco Montserrat, Pol Knops et al., “Olivine Dissolution in Seawater: Implications for CO2 Sequestration through Enhanced Weathering in Coastal Environments,” *Environ Sci Technol.* 2017 Apr 4; 51(7): 3960–3972.

faecal to water OmniProcessor

Problem:

Sewage sludge is the residual, semi-solid material that is produced as a by-product during sewage treatment of industrial or municipal wastewater. The sludge will become putrescent in a short time anaerobic bacteria over, and must be removed from the sedimentation before this happens Environmental issues related to the recycling of wet sewage sludge on include the risk of nutrient leaching, impacts on soil biodiversity and GHG emissions. According to a report released by the World Health Organization and Unicef in 2013, data collected two years earlier showed that 2.5 billion people worldwide lacked "improved sanitation facilities".

Solution: Funded by the Bill & Melinda Gates Foundation, Seattle-based engineering firm Janicki Bioenergy developed the Processor which the wet sewage sludge to generate water vapour that is cleaned and turned into purified water, the leftover dry sewage is then burned to create a little bit of ash and lots of steam which is used to drive a generator. For use in developing countries, one of the OmniProcessor's main treatment aims is pathogen removal to stop the spread of disease from fecal sludge.

The term OmniProcessor was created by staff of the Water, Sanitation, Hygiene Program at the Bill & Melinda Gates Foundation in 2012. Peter Janicki presented in 2014 a prototype using combustion. In a video, Janicki is shown Bill Gates a glass of water processed by the machine. The US$100 prototype model can produce 2,853 gallons (10,800 liters) of drinking water per day and 100 kW net electricity.

A larger model under development, the S200, is designed to handle the waste from 100,000 people, produce 22,700 gallons (86,000 liters) of drinking water per day and 250 kW net output electricity. These systems are designed to provide a "self-sustaining bioenergy" process.

A pilot project of Janicki Bioenergy's processor was installed in Dakar, Senegal, in 2015 and can now treat the fecal sludge of 50,000-100,000 people. In 2018 Sedron Technologies, Sedro-Woolley, Washington, formerly Janicki Bioenergy received a license to commercialise its patented Processor. *(gatesnotes.com)*

Katariina Kemppainen, "Ethanol and biogas production from waste fibre and fibre sludge – The FibreEtOH concept." *Biomass and Bioenergy* 46:60-98 · November 2012.

:OEOO (One Earth – One Ocean)

Problem:

After fishing plastic waste out of the , it normally has to be shipped back to port and on to a recycling plant.

Solution:

Günter is a passionate sailor. On his cruises , the Munich-based IT entrepreneur came across ever increasing amounts of plastic waste. He decided to put his IT company to rest and to deal intensively with solving the global plastic waste problem.

In 2011 with Dr. Harald , Erich Groever, Lennart Rölz, founded the environmental organization One Earth - One (OEOO). In 2013, One Earth – One Ocean e.V. was awarded the prestigious GreenTec Award 2013, Europe's largest environmental and business award, for its concept of " litter cleanup".www.oneearth-oneocean.com

Since then, from its Kiel and Hamburg bases, OEOO has been developing various types of ships to collect plastic waste from the sea: Since 2012, five 5m x 2 m *SeeHamsters* developed by OEOO been sailing in rivers and port areas. These are equipped with a collapsible safety net or safety harness to collect plastic waste from inland waters.

The *SeeKuh*, a plastic collecting ship measuring 12m × 10 m, has also been in use since 2016. It is used collect the plastic debris and the plastic that is floating up to 4 meters under the surface in coastal regions and estuaries of the Sea and in .

In 2018 OEOO became an official partner of the UN Environment #CleanSeas campaign. During the past two years, OEOO has been developing the *SeeElefant*, (= Elephant Seal) a container ship that is designed to take on board the rubbish collected by the hamsters and cows and process, sort, process and, other things, reprocess it into oil using the system technology integrated in the ship. Over the past few years OEOO has carried out a feasibility study for this largest ship model; the pilot system is scheduled to start in 2021.

In the future, this vessel will press the finds into single-variety plastic balls that can be processed into new products on shore . For the *SeeElefant*, OEOO received the Federal Ecodesign Award in the “Concept” category in 2019.

With the second generation of the *SeeKuh*, which is currently under construction, the garbage will be divided into recyclable and non-recyclable materials. such as algae and mussels are sorted out and returned to the sea. So far, the recycling garbage has been given unsorted to local recycling companies.

OEOO’s vision is to establish as systems of collection vehicles and processing vessels as possible, preferably in of each river mouth. Because when no

rubbish ends up in the sea, it helps a lot. it's drifted into the sea, it's actually too
.

Dominik Huter, “Plastic pollution in the . An agent-based model of the garbage collecting ship Seacow”, November 2017.

:Online platform for threatened species

Problem:

As plants head towards extinction, the best tracking methods will those that rest.

Solution:

Following his quest for the Canberra Spider Orchids, in 2014 Aaron Clausen, Managing Director at 3am IT in Canberra set up NatureMapr, an innovative cloud software platform that is helping to track plants throughout Australia, especially those which may be extinct.

The platform is even used by the ACT (Australian Capital Territory) government conservation officers, local councils, biodiversity experts and environmental groups across Australia and throughout the world.

For example, NatureMapr is the recording platform and database used by the Atlas of Life, an ongoing citizen-science project. It was originally the initiative of a small group of dedicated people who, in 2011, recognised the biological importance of the far south coastal region of NSW. They sought to encourage the documentation of the area’s biodiversity, building a community-based resource and network of contributors.

The *Atlas of Life* encompasses the coast and hinterlands of the south-eastern corner of Australia, from the Great Dividing in the west, to the coast of New South Wales and eastern Victoria; from just north of Narooma in the north, to

beyond Mallacoota in the south. The region corresponds to the ‘South East Corner Bioregion' recognised under the IBRA environmental planning framework adopted by Australian governments.

As a result of such workflow, NatureMapr database now has around 1.2 million sightings – the vast majority of those sightings been confirmed and identified by experts. If you are located in one of the NatureMapr areas, Apple’s free NatureMapr application is a great tool to explore biodiversity!

At3amIT is also used by the Department of Infrastructure, Regional Development and Cities to provide software analysis; and configuration and development services supporting the introduction of a new system to track projects.*(naturemapr.org)*

“NatureMapr network wins national Banksia award,” *Local Services South East*, December 2018.

: architecture

Problem:

Building often involves the -distance transportation of building materials which plunder resources such as forest and beaches

Solution: American architect Lloyd Wright believed that architecture should be intimately connected to the on which it was built. When he added a studio to his home in Oak Park, Illinois in 1898, he built an interior passageway around a beloved willow tree and allowed it to grow into the house.

From 1935 to 1939, Lloyd Wright designed a home for Edgar J Kaufmann in Mill run, Pennsylvania. “Fallingwater” was built into a natural rock outcrop above a pristine waterfall, Lloyd Wright had the stones lifted out of the riverbed to create the interior floor, using the largest rock as a hearthstone for the living-room fireplace.

For other houses he designed, the building materials were often limited to those found in the immediate area – if the earth yielded clay, if the ground was rocky and natural wood from nearby trees for buildings in forested regions. He called his approach " architecture."

In August 1972, as a V.I.P. for the Non-Aligned Ministers Conference, it was decided to build a conical building next to the Le Meridien Pegasus Hotel. Erected by a team of about sixty Wai-Wai Amerindians, one of the nine indigenous tribes of Guyana, it was fashioned like the Wai-Wai benabs or shelters which are found deep in Guyana's interior.

A circular area of the , about 26.8 metres in diameter was cleared of and excavated, the soil levelled and compacted to a smooth hard finish by the Wai Wai who stomped the ground, feet unshod, moving rhythmically forward, backward and round and round as in a sort of tribal . was then placed over the area and a concrete foundation slab; complete with holes for the insertion of the poles was laid to protect the structure from dampness, given the nature of the shallow water table of the coastal soils.

The 55 feet (16.78 meters) high structure was from thatched allibanna and manicole palm leaves, and wallaba lashed together with mukru, turu and nibbi vines. No nails were used. Occupying an area of 460 m², it is the largest structure of its kind in Guyana. Called the Umana Yana, a Wai Wai word meaning "meeting place of the people", it remains in constant use as an exhibition and conference centre.

:-inorganic hybrid material for separating CO^2

Problem:

Removing CO_2 from gas mixtures without chemically binding CO_2.

Solution:

Chemists at the Inorganic Chemistry I research group of the University of Bayreuth in northern Bavaria, Germany developed a material that could well an important contribution to climate protection and sustainable industrial production. With this material, the greenhouse gas carbon dioxide (CO_2) can be specifically separated from industrial waste gases, natural gas, or biogas, and thereby available for recycling. The separation process is both energy efficient and cost-effective. In the journal *Cell Reports Physical Science* the researchers present the structure and function of the material.

(ac1.uni-bayreuth.de)

The chemical is clay minerals consisting of hundreds of individual glass platelets. These are one nanometre each, and precisely one above the other. Between the individual glass plates there are molecules that act as spacers. Their shape and chemical properties been selected so that the spaces created are optimally tailored to accumulate CO_2.

Martin Rieß, Siegel, Jürgen Senker, Josef Breu, “Diammonium-Pillared ‚MOPS with Dynamic CO2 Selectivity”. *Cell Reports Physical Science*, 2020

:Customized packaging machine

Problem:

Over ten years, online orders account for nearly 39 million tons (35.4 million tonnes) of cardboard. Despite the use of biodegradable loosefill or void fill, objects are packed very inefficiently, leading to waste.

Solution: Stéphane Birebent, mechatronics engineer and a team at D.S.Smith Packaging Systems plc’s plant in Dijon, in the Côte-d'Or region of developed an end-of- packaging machine that can customise cardboard boxes for specific objects.

The Combi 150R machine incorporates an oblique mandrel machine, a packing station and a closing system. The volume of the is from flat cardboard cuttings that follow the shape of the mandrel. A fourth module, available as an option, is provided for inserting tabs. Over 1,000 cardboard cases can be packed every hour. For this innovation, DS Smith (Dijon) was awarded with an Oscar for packaging in 2017. *(dssmith.com)*

"DS Smith Launches Combi 150R for Efficiency and Waste Reduction," *Packaging Europe* April 26, 2017.

:Algae-based paint

Problem:

VOC from solvent and paint emissions contribute to harmful formation and peroxyacetyl nitrate. The VOC content of paint and the CO_2 emitted during manufacture are key contributors to air pollution.

Solution:

In 2008, Lionel Bouillon, keen to revive the family business of Félor in Brittany, inspired by algae-based shampoo, began to research the possibility of using algae to create a of eco-friendly colours.

He consulted both Yves Rocher's research team who were making algae-based cosmetics, the Rennes National School of Chemistry (ENSCR) and the Center for the Study of Algae Recovery (Ceva) so that the project would be collaborative and local.

By 2012, the prototype ecological paint composition they had obtained comprised a of algae with one or alga having mineral structure. This involved their preparing the paint composition by making a gel comprising water, thickening extracts and optionally additives, dispersing the algae and optionally the pigment in a mixer, and adding a binder and/or a resin or casein or its derivative, and adjusting the viscosity.

Having obtained a patent, , located in Vern-sur-Seiche, a few kilometres from Rennes, in Ille-et-Vilaine, launched its first with storytale names: *Nantes Berlingot*, *Brioche with pralines*, *Southwest cherry jam*, *View of the Erquy* and *Stroll in the Camargue*.

Containing less 1 of VOC per litre, with 0 odor, 0 solvent and 0 emissiviions, hospitals, communities or companies were seduced, such as the headquarters of Delta , the Hennessy cellar LVMH group or Rennes metropolis to renovate its nurseries.

Spotted by the DIY chain Mr. Bricolage, paint was soon distributed at Leroy Merlin, Théolaur and Biocoop. Exported to Switzerland, Belgium and the Netherlands, aimed for worldwide distribution. On Wednesday, December 13,

2017, in the framework of the COP 23, received the *My Positive Impact* trophy. *(peinture-.fr)*

Nicole Conquer, "Cop 23. récompensée pour sa peinture à d'algues," *Ouest-,* December 13, 2017.

:Palm Oil synthetic

Problem:

Conflict palm oil, used in shampoos, soaps, detergents and lipsticks, to food products like packaged bread, biscuits, margarine, ice cream and chocolate, is also responsible for the rapid deforestation of some of the world's most biodiverse forests, destroying the habitat of already endangered species like the orangutan, pygmy elephant and Sumatran rhino.

Solution:

Synthetic palm oil

C16 Biosceiences Technology Inc. was started up in 2017 by David Heller, Andrew Shumaker and Shara of New York to advance their solution which uses microbiology to brew sustainable alternatives to palm oil which is nearly chemically and functionally identical to palm oil and no requires deforestation or inhumane labour practices.

Technically, they developed microorganisms and methods for producing lipids by co-culturing a photosynthetic microorganism with a heterotrophic microorganism to produce a culture medium having a titer of lipids.

Earlier in 2020, C16 Biosciences received a $20m (£15m) investment from Breakthrough Energy Ventures, a fund backed by Bill Gates and the likes of Amazon's Jeff Bezos, Michael Bloomberg and Virgin's Richard .

C16 Biosciences is not the organisation looking to come up with a synthetic alternative. Researchers lead by Chris Chuck are on something similar at the UK's University of Bath, England

In Hayward, California, Lisa Dyson and John Reed at Kiverdi developed and pateneded PALM+, a synthetic palm oil from CO^2 fermentation, based on NASA research in the 1960s/ Kiverdi says its process requires 1/10,000th the space to produce the amount of oil. They also applied their solution to produce MicroFeed, a protein-rich meal that can be fed to fish in aquaculture.

Indonesia's Golden Agri-Resources, one of the world's largest privately- palm oil plantation companies is focused on improving its yield per hectare with new variants of its natural oil palm trees such as the *Dami Mas*, cloned and genetically mapped, as well as their *Eka 1 and Eka 2*, planting materials created through cloning and tissue culture process at their SMART Biotechnology Centre in Sentul, Indonesia.

recyclable pantyhose

Problem:

A pair of women's tights (pantyhose) does not resist six uses. The 104 million pairs of tights in thrown away each year equal to the weight of the Eiffel Tower or 7, 300 tonnes of garbage..

Solutions:

Lætitia Paput and Aurore Jacques of the Bordeaux suburb of Blanquefort, decided to pantyhose in a fiber recycled from plastic waste from the textile industry which were previously buried or burned. They also created bins specifically from thrown-away tights.

They called their start-up REV, the first three letters of the French words "rêver, révolutionner et revivre" (= dream, revolutionise and recycle). Rêver because it is a childlike dream to create this of textile; revolutionise eco-fashion with pretty and comfortable products and recycle materials.

To finance their first pairs of tights, Paput and Jacques launched a fundraising campaign on the Ulule platform. In a few hours they had reached 440% of their goal. *(rev-society.com)*

In Stockholm, Sweden, Nadja Forsberg and Linn Frisinger started up "Swedish Stockings" to a luxury of pantyhose from recycled nylon and natural fibers, at a plant in Italy which uses sustainable practices like eco-friendly dyes, post-dyeing water treatments, and solar power.

From a fashion perspective, there are classic opaque panty hose, Astrid fishnets, and leopard tights, and pointelle socks, other styles. Committed to a circular fashion industry, Swedish Stockings also provide two recycling centres to which you can post your old nylons for recycling, and they will accept any . Send a minimum of 3 old pairs at , and they will send you a discount code for your next purchase.

Considering whether there is a second life for old tights, Forsberg and Frisinger, teamed up with Gustaf Westman to combine recycled tights and recycled fiberglass and them into a limited edition collection of marble-look tables durable enough to be used both indoors and outdoors.

Each table (depending on its size) contains between 80 and 350 pairs of tights that been diverted from landfills through their recycling program. *(swedishstockings.com)*

Emily Farra "Meet the Women Behind Swedish Stockings, the First-Ever Sustainable Hosiery ," *Vogue,* November 8, 2017.

:Paper Bottles, plastic free

Problem:

The current of demand for glass is unsustainable. Globally, the world is using up 50 billion tonnes of every year, which is twice the amount that our rivers can replenish in the time . Commonly harvested from seabeds and riverbeds, the demand for is disrupting ecosystems and microorganisms that depend upon it for survival, and leaving coastal communities vulnerable to flooding caused by erosion as well.

Solution:

Paper-based spirits bottle.

In Spring 2021, the British multinational beverage alcohol company , whose portfolio includes Smirnoff, Guinness and Johnnie Walker, debuted the world's first paper-based spirits bottle, produced by Pulpex Ltd., originally developed by Lextar for Hercules, Inc. of Wilmington, Delaware. The bottle, which is fully recyclable, is using sustainably sourced wood pulp and contains no plastic.

This solution has been taken up with one size and variant of Johnnie Walker, the famous of Scotch whisky, expanding its partnerships later this year. unveiled an impressive list of multinationals backing the technology, including Unilever and PepsiCo, who are expected to launch their own paper bottles soon after.

Meanwhile, Martin Myerscough, inventor and co-founder of Frugalpac of Ipswich, Suffolk, England has also launched a paper bottle, based on the already proven technology which produced the Frugal Carton and then the Frugal Cup, the world's first -away coffee cup.

Frugal Bottle is from 94% recycled paper with a food- liner to hold the or spirit. At just 83g it is five times lighter a normal glass bottle It's easy to recycle again – simply separate the liner from the paper bottle and put them in your different recycling bins. As the Frugal Bottle is from recycled paper, it allows for 360-degree branding across the bottle and it can be produced in the heart of any bottling facility.

The first to go on in the Frugal Bottle is from the award-winning Italian vineyard Cantina Goccia with its 3Q, an unwooded Sangiovese red with a hint of Merlot and Cabernet Sauvignon.

:Paper machine for recycling and upcycling

Problem:

There is a considerable carbon footprint attached to the paper shredding process, which generally involves secure and expensive transport to dedicated offsite shredding facilities.

Solution: In 2010, Yamagami and Ken Ikuma at the Seiko Epson Corporation at Suwa, Nagano, Japan, famous for its printing machines, invented a machine which would enable organisations such as government offices and banks to directly recycle and upcycled paper in their own building.

The Epson PaperLab a-8000 is a combination of shredder and paper-making machine. A company dumps its waste paper into the machine, which then defibrates the paper and shoots the with a jet stream of air to eliminate ink from the shredded bits. Liquid binders are then added to reassemble the fibers into recycled sheets.

A high-pressured process can then perform custom size, thickness, color and even scented alterations to any individual sheet of paper. While the PaperLab machine is by no —it measures 9 ft. by 4 ft.(2.7 x 1.2 m) —it can produce 14 sheets of paper every minute: 6,720 sheets in a regular eight-hour workday.

Epson expects that their PaperLab will create an office 'eco-system' that reduces CO_2 emissions, increases savings on collection, disposal and logistics, ensures secure disposal of confidential documents and saves water, which is used in volumes in traditional recycling processes. *(global.epson.com)*

"World's First Dry Process Office Papermaking System Comes to Europe," *Epson*, March 20, .2017; Yamagami and Ken Ikuma, "Paper recycling device and paper recycling method Patent N° 9636847 *Seiko Epson Corporation* May 2, 2017.

: Paper from fallen leaves

Problem:

Traditionally, paper has been made from trees, with little interest shown in the leaves shed by deciduous trees every autumn.

Solution:

Valentyn Frechka was a high school student living in rural Ukraine, Russia when he began a science project to turn fallen leaves from trees and plants into paper. Success led to his starting up the Re-Leaf Paper concern at the Zhytomyr Cardboard Factory in Zhytomyr, Ukraine producing paper bags and packaging. In October 2020, Re-leaf Paper produced its first batch of solid paper, made

from leaves collected in large bags in Kyiv and other cities. It is planning to go into commercial production.

:Paper-shredding machine

Problem:

According to *Recycle Now* the USA gets through 13.8 million tons (12.5 million tonnes) of paper every year, with around 24 trees used to 1 ton of paper.

Solution:

Even though the first material that was universally termed as "paper" did not emerge until 200 B.C., the idea of reusing writing canvas can be traced back to the First Egyptian Dynasty. Scribes would erase old papyrus documents in to something to write new documents on. Clearly, this was not strictly a paper recycling technique, but the principal concept was there as they were making an effort to reuse materials for writing.

Before the industrialisation of paper production the most common fiber source was recycled fibers from used textiles, called . The were from hemp, linen and cotton. A process for removing printing inks from recycled paper was invented by German jurist Justus Claproth in 1774. Today this method is called de-inking. It was not until the introduction of wood pulp in 1843 that paper production was no dependent on recycled materials from ragpickers.

As the amount of paper accumulated, a way had to be found to dispose of it. In 1909, Abbot A. Low of Piercefield, New York took out a patent for a paper

shredder. Thirty years later, *Adolf* of Balingen manufactured the first paper shredder, inspired by a pasta maker. Some believe that the device was to shred Herr Ehinger's -Nazi propaganda.

As the economy recovered following World War 2 and the United States experienced meteoric growth during the 1940s and 1950s, paper recycling fell by the wayside. Despite this, continued to manufacture his paper shredder and in 1959, the was eventually replaced with an electric motor and units were sold to the government and financial institutions.

It was not until 1988 when the California Government lead the by resolving to purchase paper that was at least 50% recycled and 10% post-consumer waste, that this issue back to the forefront. Every other state in the union followed suit and by 1993, they had all adopted similar policies. Shredders became commonplace. After this , paper was recycled then was buried in landfills.

However, the massive switch to computers has not necessarily reduced paper in the 21st century. The Worldwatch Institute pointed out in 2009 that, "The average web user prints 28 daily". Output such as this results in 115 billion sheets of paper used annually for personal computers.

To reduce this, 225 million people use Evernote, based in Redwood City, California as their archive for all their notes and documents, but others opt to use a cloud service such as Dropbox, Google Drive, or Microsoft OneDrive.

John Woestendiek, ″The Compleat History of Shredding,″ *The Baltimore Sun,*. February 10, 2002; SiNing "Oxford's New SCRIBZEE App Extends the Life of Handwritten Notes," *evernote,* March 1, 2017; Zainab Hasnain "How to use Evernote to your life," *The Verge*, September 6, 2017,

:Parabolic photovoltaic-thermal trough

Problem:

In 1882, the French engineer Abel Pifre used a solar concentrator to power a Maroni press which printed up to 500 examples per hour of a little journal called "Soleil-Journal"

Solution:

Parabolic photovoltaic-thermal trough

Greenetica of Pordenone, north-east Italy revived and improved a system for concentrating sunlight using a parabolic trough capable of producing both electricity and heat.

Their *eos1* has been designed for the production of 6,000 kWh of electricity and 20,000 kWh of heat a year. The reflector ensures maximum reliability in terms of reflectance, uniformity and accuracy of sunlight concentration. This allows the user to advantage of the benefits of the receiving bar, which employs triple-junction, solar cells derived from aerospace.

The heat/ electricity system features four parabolic trough mirrors that concentrate solar radiation on a linear receiver. The receiver includes two photovoltaic-thermal modules, each with a length of 1.2 meters.

Each photovoltaic-thermal is equipped with Azure Space's multi-junction solar cells based on indium gallium phosphide (InGaP), gallium arsenide (GaAs), and germanium (Ge), which are soldered a ceramic substrate, which is linked to an active cooling system with an aluminum roll-bond heat exchanger and a closed loop to pump water as a coolant. They are said to exhibit a very limited dependence of efficiency on the operating temperature and can work with maximum efficiency at 80 C.

Greenetica Distribution plans to commercialize for both residential and -scale industrial applications. A thermal system should launch within a year. The heat/ electricity combination system should be launched in 2022.

Michele Luca Giacalone, Antonio Sichirollo and Perenthaler, "Solar apparatus for concurrent heat and power-generation", EP2297530B1 2014.

:Passive Downdraught Evaporative Cooling (PDEC)

Problem:

Leaking CFC and HCFC-based air conditioners contribute to GHG and depletion.

Solution:

Eastern architecture as an alternative to air conditioning. Chimney-like towers, (Persian: بادگیر *bâdgir*: *bâd* "wind" + *gir* "catcher") have been used for centuries to deliver passive cooling in arid desert regions.

Their function is to catch cooler breeze that prevail at a higher level above the ground and to direct it into the interior of the buildings. During archaeological investigations conducted by Masouda in the 1970s, the first historical evidence of windcatcher was found in the site of Tappeh Chackmaq near the city of Shahrood, which dates back to 4000 BC.

A painting depicting such a device has been found at the Pharaonic house of Neb-Ammun, Egypt, which dates from the 19th Dynasty, c. 1300 BC (British Museum), while similar edifices can be found in Hyderabad, southern Pakistan.

traditional water reservoirs (*ab anbars*) are built with windcatchers that are capable of water at near freezing temperatures during summer months. The evaporative cooling effect is strongest in the driest climates, such as on the Iranian plateau, leading to the ubiquitous use of windcatchers in drier areas such as Kerman, Kashan, Sirjan, Nain, Bam and Yazd, the latter known as the “City of Windcatchers”.

The modernisation of windcatcher’s efficiency was proved in 1997 by Nimish Patel and Parul Zaveri of Abhikram Architects designed the 1 million ft² (93,000m2) Torrent Research Centre for Torrent Pharmaceuticals Ltd. in Ahmedabad, India. It is a complex of windcatchers saved around 200 tonnes of air conditioning load.

The Kensington cricket ground in Barbados (2007) and the Saint-Étienne Métropole's Zénith (2008) with their aluminum windcatcher rooves both use this method. Since 2004, over 7000 X-Air windcatchers been installed by Monodraught Ltd. of High Wycombe on public buildings across the UK.

In 2019, Kerim Miskavi of Istanbul created a 21 ft (6.5 m.) tall windcatcher out of 450 layers of recycled corrugated cardboard with 22 ft² (2m²) blocks held together by steel rods which run from top to bottom. Miskavi Architecture Studio (MAS) collaborated with cardboard recycler Kaplamin Ambalaj in Turkey. It was exhibited at Dubai. *(mas-arch.com)*

Chris Soelberg; and Julie Rich, "Sustainable Construction Methods Using Ancient *BAD GIR* (Wind Catcher) Technology." *Construction Research Congress*, 2014.

:Passive House

Problem:

During the past 120 years, those installing electricity to heat and light buildings and homes usually little thought to lowering consumption and improving energy efficiency.

Solution:

In 1987, Bo Adamson of the Swedish State Council for Building Research went out to southern China to assist in the improvement of comfort in unheated homes which he referred to as "passive houses".

He observed how traditional houses in the People's Republic, like those in or on the coast of Portugal had been sensibly constructed so that neither additional heating nor cooling was required.

The following year, inspired by Bo Adamson, Wolfgang Feist began to explore how modern buildings could be designed in a sustainable, energy efficient way. with architects Bott, Ridder und Westermeyer, by 1991 Feist had built the first terraced Passivhaus residence in Darmstadt-Kranichstein, its measured annual energy consumption would consistently amount to less 15 kWh per square metre of living space, year after year.

The year, Stephen D. Heckeroth of Albion, California, designed the 3,000 ft² (280 m²) Caspar Point home, located in northern California on a rugged point of jutting out into the Pacific. It incorporates southern exposure, sun spaces, thermal mass, insulating envelope, earth coupling, and thermosiphon solar-heated water for hot water and radiant floors. Heckeroth went on to design and build over 20 such passive solar homes.

Meanwhile, further passive houses were built in Stuttgart (1993), Naumburg, Hesse, Wiesbaden, and Cologne (1997) and The Passivhaus Institute was founded in Darmstadt, Germany so a group could develop a building program.

This included the production of the innovative components that had been used, notably the windows and the high-efficiency ventilation systems, and roof insulation, with space heating at 90% less that required for a conventional new building at the time. In terms of heating oil, Passive House buildings use less 1.5 litres per m² of living space per year. An addition in fireproof external wooden cladding.

Products, which had been developed for the Passivhaus standard were further commercialised during and following the European Union sponsored CEPHEUS project, which proved the concept in five European countries in the winter of

2000–2001. The first to be certified was built in 2006 near Bemidji, Minnesota in Camp Waldsee of the German Concordia Language Villages. *(passivehouse.com)*

In the United States, in 1993, the Green Building Council (USGBC) was co-founded by Mike Italiano, David Gottfried and Rick Fedrizzi to promote sustainability in building design, construction, and operation; its membership has grown to 13,000. The year, the Leadership in Energy and Environmental Design (LEED) certification program, providing third-party verification of green buildings was spearheaded by Natural Resources Defense Council (NRDC) senior scientist Robert K. Watson.

It has been developed to a comprehensive system of nine interrelated systems covering all aspects of the development and construction process. The concept of passive design was taken up by Katrin Klingenberg in 2003 when she built a passive home prototype named "The Smith House" in Urbana, Illinois. From here, she and builder Mike Kernagis co-founded the e-cological Construction Laboratory (e-colab) in 2004 to further explore the feasibility of affordable passive design.

This eventually lead to the inception of the Passive House Institute United States (PHIUS) in 2007. The first US passive retrofit project, the remodelled craftsman O'Neill house in Sonoma, California was certified in July 2010. Since then, the PHIUS has released their PHIUS + 2015 Building Standard and has certified over 1,200 projects and 1.1 million ft² (100,000 m²) across the United States.

By 2008, estimates of the number of Passivhaus buildings around the world from 15,000 to 20,000 structures. As of August 2010, there were approximately 25,000 such certified structures of all types in Europe. The vast majority of passive structures been built in German-speaking countries and Scandinavia. By 2016, the number of Passive Houses in use worldwide had tripled to over 60,000.

The Passive House Standard is a sustainable construction standard, and the Resolution of the European Parliament of January 31, 2008 calls for its implementation by all member states by 2021.

In August 2019 Canadian company Henson Developments released plans to build the world's tallest Passive House in Vancouver's West End neighborhood. The 60-story undulating tower was formed to break away from traditional Passive House design approaches. Rick Gregory, Vice-President of Henson Developments, said that, "There is a certain look that Passive House generally yields, and we're trying to move away from that to it much attractive to other people to the approach." *(hensondevelopments.com)*

Wolfgang Walter Josef Feist, "The world's first Passive House, Darmstadt-Kranichstein, Germany." October 2014; Eric Baldwin, "World's Tallest Passive House Skyscraper Designed for Vancouver," *archdaily.com,* August 28, 2019.

:Patch- burning for forest protection

Problem:

As of 9 March 2020, bushfires in Australia had burned an estimated 18.6 million hectares (46 million acres; 186,000 square kilometres; 72,000 square miles), destroyed over 5,900 buildings (including 2,779 homes) and killed at least 34 people. In August and September 2020, 7,000 fires destroyed 1.4 million acres of California's forests burned across California, compared to 4,292 fires burning 56,000 acres across the state in the previous year. Tens of thousands of firefighters from across California and states from as far away as Kansas were enlisted to help contain the blazes.

Solution:

In North and South America, in Venezuala, South Africa and Australia, indigenous tribes traditionally set thousands of fires each year so creating firebreaks or fireroads that last for several years and can potentially keep destructive wildfires in check.

For example, in the first year the Pemón (Pemong) of the Venezuelan Guayana uplands (Sabana) burn a small area of savannah near the forest. The second year they look for another area, and so on until they form a patchwork that has a different history of burning. Mistakenly they were labelled “Pemones los quemones” (crudely translated as “Pemón the pyromaniacs”). In Australia, the Aborigines used to go walkabout and use fire- farming or cultural burning.

Catherine Parr and Bruce Brockett,“Patch- burning: A new paradigm for savanna fire management in protected areas?” *Koedoe - African Protected Area Conservation and Science 42(2)* February 1999. Stewart, O.C., *Forgotten fires: Native Americans and the transient wilderness.:* University of Oklahoma Press. (2002).

:Pavements for carbon capture

Problem:

As pedestrians walk on a walkway, instead of wasting good energy, the pressure could be used to electromagnetic induction creating kinetic energy which can then be used to power devices.

Solution:

Jose Luis Moracho Amigot and Moracho Jimenez direct PVT (Pavimentos de Tudela) in Navarra, Spain, a company with 30 years of experience specializing in the manufacture of non-slip outdoor pavements.

In 2009, they adapted the system developed by Italcementi of Italy, to manufacture paving stones whose photosynthetic, concrete-titanium dioxide composition would enable them to absorb particulate matter, nitrogen oxides (NOx) and volatile compounds (VOC), and render them harmless.

Their patented product, *ecoGranic*, bio-mimics the performance of chlorophyll in plants. A top layer comprises oxide additives titanium incorporating a catalyst that is activated by sunlight, which then converts pollution that go with the nitrates and carbonates and the wind until it reaches where vegetation is removed. The lower layet consists of recycled materials.

ISO trials at prestigious laboratory of the Dutch Twente University, and field studies carried out at different sites, showed *ecoGranic*'s decontaminating efficiency at up to 56% of nitrous oxide degradation.

A sidewalk the size of a soccer field with *ecoGranic* would eliminate pollution from approximately 4,000 vehicles. Following the success of three streets repaved with ecoGranic in Spain's capital, Madrid, Plaza de la Cruz, an entire 10,800 ft² (1,000 m²) square in La Rioja, was repaved with ecoGranic, following by another square in Santander.

The technology soon spread to dozens of cities across Spain. The Navarra company currently has two plants, one located in Tudela and another in Cabanillas with a production capacity of 54,000 ft² (5,000 m2) per day. While PVT has signed with China to supply their *ecoGranic* decontaminating pavement, its co-inventor José Luis Moracho is on a version.

Meanhile Aira has produced a bicycle and a scooter which, by carrying the PVT ecoGranic tile vertically below its handlebars can absorb CO_2 as it moves . *(pvt.es)*

Alba,"EcoGranic: latest generation ecological floor tiles," *Capital*, 6, 2010; James , "A Delivery Service That's Kind on the Environment!" *Design,* April 5, 2019.

:Peat alternative

Problem:

The intensive mining of peat has adverse effects on the climate, and destroys valuable ecosystems of birds, plants and insects that rely on them. If all the peat was removed and burned this would quickly release a volume of CO^2 into the atmosphere and contribute to the greenhouse effect.

Solution:

From 2000, Simon Bland, a fifth generation farmer at Dalefoot Farm, Heltondale, near Penrith from the heart of the English District and his wife Barker an Environmental Scientist brought their creative thinking together in their search for diversification.

Looking through old gardening books that talked of wool's natural ability to hold water, they Tomorrow'sed the wool was used to grow rhubarb in Yorkshire. Bland & Barker then a *peat-free* potting compost, from and sheep's wool with natural water retention and slow release nitrogen.

Sheep's wool has a high level of nitrogen that works as a slow release fertiliser and has good water retention. gives a high level of natural potash essential for fruiting and flowering, also it has a wide of naturally occurring elements for good plant health.

Dalefoot Farm's sustainable Wool Compost , which is now widely used by gardeners across the UK, boasts wool from their own flock.
(dalefootcomposts.co.uk)

:Perfume with a cyber message

Problem:

While marketing "sexy" perfumes it is easy to their effect on the Environment

Solution:

 Katzarov is a multi-award technologist, responsible for digital transformation and IoT at Henkel Beauty with over 15 years in the beauty technology industry. In 2020, he set up Look Labs in Düsseldorf, Germany to produce *Cyber EDP (Eau de Parfum),* the first unisex fragrance with sustainable printed electronics and a clear environmentally friendly message.

Not is Cyber EDP fragrant. Woody notes of cedarwood and sandalwood associated with intense lemon and fresh tangerine evoke the fever of a spirited city atmosphere. At its heart it has top signature notes that reminisce of the lilies of the valley and from , perfume mecca.

Not are the label, cap and outer packaging sustainable, and the perfume bottle refillable. The design and functionality of the label is to attention to the

immediate climate crisis and environmental issues. Whenever the user presses the power button on the label, the CYBER lights up in red. The universal recycling and earth symbols that reminding him or her that we should protect our planet and be conscious of our environment

:Permaculture

Problem:

Agriculture exploits and often drains major water systems, ditching use waste and impoverishing or poisoning the soil.

Solution:

In the 1970s Bruce Charles "Bill" Mollison and David Holmgren at the University of Tasmania, Australia jointly evolved a holistic framework for a sustainable agricultural system based on a multi-crop of perennial trees, shrubs, herbs (vegetables and weeds), fungi, and root systems for which they coined the word permaculture (permanent agriculture).

In 1987, Mollison taught the first permaculture course that was offered in India.

By 2011, there had been over 300,000 graduates practicing and teaching throughout the world. According to Scott Pittman, the director of the National Permaculture Institute, approximately 100,000 to 150,000 students completed the certificate course with around 50,000 students from the United States.

There is a wide body of literature confirming success stories of permaculture being implemented around the globe. According to Appleseed Permaculture, over 1,000,000 people are now certified in permaculture in 140 countries with 4,000 projects on the ground.

The Worldwide Permaculture Network has published an extensive database on which to understand better what projects exist. The site allows you to search for projects based on keywords, climate , and types of projects to better filter your results.

Currently, the site features 1,957 permaculture projects around the globe. As one example In Ecuador, the Third Millenium Alliance planted over 20,000 trees

and developed an experimental fruit tree orchard with over 50 species of food trees, a vegetable garden, and a tree nursery. Permaculture can also work in a small private garden. *(tmalliance.org)*

Bill Mollison and David Holmgren, *Permaculture One: A Perennial Agriculture for Human Settlements,* with David Holmgren. (Melbourne, Australia: Transworld Publishers, 1978) : *Permaculture Two: Practical Design for Town and Country in Permanent Agriculture* (Tasmania, Australia: Tagari Publications, 1979). Williams, "Gaia's Garden: A Guide to Home-Scale Permaculture," *Whole Earth*, 2001.

:PBR aka photobioreactor

Problem:

With fossil fuel running out, one solution is fast-growing microalgae which can be cultivated in a closed photobioreactor to produce fuels such as biodiesel and bioethanol, to generate animal feed, or to reduce pollutants such as NO_x and CO_2 in flue gases of power plants; biofuel for transport, but also for bioplastics and for biofood.

Solution:

A photobioreactor (PBR) is a bioreactor that utilizes a light source to cultivate phototrophic micro or macro algae micro-organisms. Mounted vertically, horizontally, or at an , a PBR is not space saving but allows meticulous control growth parameters and better control of culture environment such as carbon dioxide.

Like all prototypes, the first PBRs met with problems.

In the mid 1980s, Richard J. Radmer at the Martek Corporation in Maryland developed a model for use by astronauts. At the time John Pirt at Queen Elizabeth College, University of London, took out a patent which lead to the creation of Photo Bioreactors Ltd. in 1985. In 1990 a plant constructed in Murcia (Spain) comprising 165 ft (50 m.) polyethylene tubes connected to

vertical manifolds up a total of 410,000 ft. (125,000 m) of tubing went into operation.

Rapid material degradation under sunlight, unavoidable tube wall growth, inadequate degassing and insufficient temperature control led to poor growth of the algae, biofouling and heavy contamination, resulting in permanent shutdown of the plant in September 1991.

Three types of algae photobioreactors, plate, tubular and bubble-column reactor been developed, but the determining factor is the unifying parameter – the available intensity of sunlight energy.

Algae can produce amounts of -3 fatty acids, an important dietary supplement. This it could be a sustainable, vegetarian source of -3, which is otherwise available from eating fish or unappetising cod liver tablets. generally, algae are excellent sources of vitamins, minerals and proteins, with species such as *Chlorella* and *Spirulina* commonly consumed for their health benefits.

iWi is a nutrition company that algae farms in Houston, Texas and New Mexico. Founded by Miguel Calatayud, the project has been developed by microbiologist Rebecca White. iWi's two farms host 48 shallow blue-green ponds, each about the size of a football field. They harvest the algae and turn it into algae oil, which is sold as supplements called AlmegaPL. Algae are also added to meat products, such as pasties, steaks, frankfurters and sausages, as well as to fish, fish products, and oils, to improve their quality. *(iwilife.com)*

Another useful product that can be from algae is bioplastic. Regular plastic is a product of fossil fuels and takes an extremely time to break down, which makes it very environmentally unfriendly. Bioplastic from algae can be produced with low carbon emissions, or even in a way that absorbs emissions. Their use could help prevent the build up of plastic in the environment.

the manufacturers of algae biofuel: Algenol, Blue Marble Production, Solazyme, Sapphire Energy, Culture Biosystems, Oils, Proviron, Genifuels, Algae Systems, Solix Biofuels, Reliance Life Sciences.

Stanley John Pirt, "Bioreactor system", *WO199302241 8A1*, November 11, 1993; Lynn Brezosky "Remote Texas algae farm grows a food for the future," *Houston Chronicle*, 27, 2018.

:Pedelec, electric-assisted bicycle

Problem:

The millions of tons of CO_2 hourly produced by diesel/gasoline engined transport needs to be reduced.

Solution:

Whilst millions of people pedal bicycles, some wish for a little power. The electrically assisted bicycle meets this requirement and there are at least 40 million such e-two wheelers in use around the Planet. Manufacturers include A2B Bicycles, Airwheel, Beistegui Hermanos, GI Flybike, Gocycle, Italjet, Mahindra GenZe, Pedego Electric Bikes, F-wheel DYU, Fuji-Ta, Pinnacle, Riese und Müller, Solex, Superpedestrian, SwagCycle alongside innumerable Chinese and Taiwanese manufacturers.

Commercially manufactured e-bicycles been in use since the early 1990s, although the arrival of the - li-ion battery from 2007 increased the popularity of the pedelec. The choice from the simple street scooter to the muscular 2kW models where riders must show a number plate and are advised to wear a helmet.

Since the COVID19 pandemic, given the need for social distancing, the use of pedelecs has been encouraged by Governments and Municipalities.

Kevin Desmond, *Electric Motorcycles and Bicycyles: A History Including Scooters, Tricycles, Segways and Monocycles.* (Jefferson, NC: McFarland, 2019).

:Pellet stove

Problem:

Heating homes with coal or oil is inefficient.

Solution:

During the Depression of the 1930s, the Presto-Log was invented reusing scrap sawdust from the Potlatch mill in Lewiston, Idaho for is in oil drum stoves.

Following the Oil Crisis of the 1970s with residential use of woodstoves growing rapidly and causing days of high smog, adverse health reports triggered legislation in Washington and . Jerry Whitfield of Shaw Island, an aviation engineer from Washington, and Joe , who ran a family- heating company in , were each experimenting which burned sawdust-based pellets resembling rabbit food.

Although the stoves looked like traditional wood stoves, they worked very differently. Run by electricity, the pellet stoves utilized a motor-driven to deliver a specific amount of pellets from the hopper to a fire pot, where a fan aided combustion and blew the warm air from the stove. Out of this “collision of events” the pellet stove was .

Whitfield, who had learned about pellet technology in Europe, started on the first project in his garage. He even paid a local university to test it. He introduced his first stove at the Wood Heating Alliance show in , Nevada in 1984. At the end of the four-day show he had orders for 1,000 stoves and the company he founded, Pyro Industries were eventually manufacturing up to 150 stoves a day during peak production.

Joe developed the pellet grill in 1985 and patented it in 1986. The Fiber Fuels Institute was set up, later becoming the Pellet Fuels Institute (PFI) was established and during the past 25 years, the North American wood-pellet industry has grown from a few small outfits to well over 100 companies that produce 1.8 million tons of pellets per year.

Pellet boilers are used in central heating systems for heat requirements (heating load) from 3.9 kW to 1 MW or . Steven J. Walker of New England Wood Pellet, the largest manufacturer of wood pellet fuel in the north-eastern US, pioneered a bulk delivery system modelled on agriculture and the heating-oil industry.

Led by Fuentes Renovables de Energia SA (FRESA), a 40-MW biomass plant is in operation in Gobernator, the Argentine province of Corrientes. With a turbogenerator, boiler, biomass silo, transformer station and auxiliary equipment, the FRESA plant will produce electricity from chips, sawdust, and eucalyptus bark and biomass from dry wood and forest materials that currently do not industrial use.

Its electricity will account for 10%-15% of the total consumption of the Corrientes province.*(fresa.com.ar)*

Desmond 37 should go here

In 2020 Group and Mitsubishi Heavy Industries Engineering, Ltd., part of Mitsubishi Heavy Industries Group (MHI) began to collaborate on a new bioenergy with carbon capture and (BECCS) pilot project at Power Station's CCUS Incubation Area, in Selby, Nork Yorkshire.

Britain's biggest carbon emitter, had already abandoned coal and converted four of its furnaces converted four of its furnaces for biomass, *using compressed wood pellets* produced from sustainably managed forests located in Louisiana, Mississippi and Arkansas.

With C-Capture, a University of Leeds spin-off, Biomass began BECCS trials in 2018. Two of Mitsubishi's proprietary solvents will be tested. One is already in use at 13 commercial plants, including Petra Nova in Texas, the world's largest post combustion carbon capture facility. There it captures 1.4 million tonnes of CO_2 a year. The second is a newly developed solvent.

If successful, the Yorkshire generator hopes massively scaled up kit and associated infrastructure can help enable its ambition of carbon negative by 2030.

Because of their small size and composition, food- pellets burn cleanly, producing a light smoky flavour. Wood pellet varieties include oak, maple, apple, acacia, alder, mesquite, cherry, maple, hickory, and pecan. The amount of CO_2 emitted during the burning process is equivalent to the amount absorbed during the growth of the trees.

John Dieckmann, "Warming Up To Pellet Stoves," *Ashrae Journal,* 52(3), March 2010; Augusto Uasuf and Gero Becker, "Wood pellets production and energy consumption under different framework conditions in Northeast Argentina," *Biomass and Bioenergy* 35(3):1357-1366, March 2011; Steven J. Walker, "Pellet mill," *US Patent 9132399B2*, August 23, 2012.

: Penitentiaries with pv arrays

Problem:

Penitentiaries, prisons and jails cover areas, requiring electricity for their inmates or visitors.

Solution:

Solar panels on the roof or on the ground.

A solar farm called Bardzour (Créole for “breaking dawn) was established by Akuo Energy in 2014 on the no-man’s land of a Port penitentiary centre located to the west of the French island of La Réunion. With total power of 9MWp, the project incorporates 8.4MWp of ground-based panels supplying over 4,000 islanders’ households. This includes 0.6MWp installed on 6,000m_2 of Agrinergie® greenhouses for permaculture market gardening, horticulture and beekeeping.

Bardzour has been involved in an ambitious prisoner rehabilitation program: during the construction phase, 15,000 hours were dedicated to retraining, giving prisoners nearing the end of their sentences skills in the construction of photovoltaic units.

USA

For over one hundred years, Rikers Island, off New York City was a penal colony of trash brought in on from Manhattan to build out the island to accommodate a massive jail complex. Pockets of methane created by decomposing garbage routinely burst, shaking the island and endangering anyone around.

After decades of lawsuits and controversy and a concerted campaign by former inmates and activists, the New York City Council finally voted to close down Rikers Island’s jail facilities. In 2019, it was found that although covering the island with solar panels would generate enough electricity for about 12,000 homes — the number of people who live on a single city in dense parts of the city, transforming it into a renewable energy powerhouse would focus on the relatively small island’s capacity for power to send to the electrical grid when demand rises;

Although the penitentiary on the island of Alcatraz in the middle of San Francisco Bay closed in 1963, a recent 280 kW solar photovoltaic installation on the roof of the island’s main cell house provides roughly 66% of the island’s electricity needs, including a booming tourism. The solar array operates in combination with an extensive battery system to maximize solar electricity generation and .

Solar panels have been set up at numerous prisons throughout Colorado, including the San Carlos prison in Pueblo, the Colorado Territorial prison, the

East Canon Prison Complex in Canon City, as well as the Arkansas Valley prison in Ordway. This new renewable energy project is predicted to save state taxpayers $475,000 in electricity during the course of the next 20 years by generating enough electricity to power the equivalent of 80 homes. A fuel cell plant next to Florida's jail generates 8 million kilowatts hourly which covers 50% of the *jail's energy*. *Solar panels* that were placed on the rooftop of the *jail* cover the other 50% of their *energy* needs

South Africa

Robben Island, where Nelson Mandela spent 17 years in prison has been equipped with a solar farm by Town-based firm Sola Future Energy to use photovoltaic modules in a bid to reduce the island's dependency on expensive fossil fuels. The PV farm consists of 1,960 Canadian solar modules and has the capacity of generating over 650 kilowatt hour power supply and almost one million kilowatt hours of electricity annually, reducing the island's reliance on the existing diesel-powered system.

Taiwan: Pingtung Jail's roof has been equipped by its inmates with solar panels providing 1.8 megawatts, enough to supply power to 639 average Taiwanese households for a year.

:Peppermint tea for fart reduction

Problem:

Collectively the world population of almost 8 billion releases about 73 metric tons of methane and 1000 metric tons of CO_2 into the atmosphere by farting just 14 times a day. This is equivalent to roughly 1,000 people flying from New York to Los Angeles, daily.

Solution:

Peppermint tea ***(****Mentha piperita*), is a most pleasant solution for reducing flatulence. In 2014, world production of peppermint was 92,296 tonnes, 92% of which is produced by Morocco renowned for its traditional tea drinking ceremony using organically grown leaves.

There are other solutions. Eat slowly and mindfully. Cut back on gas-producing foods and gaseous drinks, indulging in a lower fibre diet. Eat less meat so reducing the requirement for methane-producing cattle. Try drinking a glass of water about 30 minutes before a meal to help your stomach digest better.

Activated charcoal is a powder from char, coconut shells, peat, petroleum coke, coal, olive pits or sawdust. you activated charcoal (via liquid or pill) in moderation, it attaches to fluid in your gut, potentially reducing gas and bloating and creating firmer stools.

:Pesticide eco-friendly

Problem:

Chemical pesticides, such as neonicotinoids, produced from chemical alteration can contaminate soil, water, turf, and other vegetation. In addition to killing insects or weeds, pesticides can be to a host of other organisms including, humans, birds, fish, beneficial insects such as bees, and non- plants. Examples of acute health effects include stinging eyes, rashes, blisters, blindness, nausea, dizziness, diarrhea and death.

Solution:

Nanopesticides offer hope of a environmentally-friendly approach.

Nanopesticides are plant protection products where nanotechnology is employed to enhance the efficacy or reduce the environmental footprint of a pesticide active ingredient. It is such a solution that, in the European Union, silicon dioxide (SiO2) is the active substance with an approval for use as a nanomaterial in biocidal products.

Bacterial leaf blight of rice caused by *Xanthomonas* pv. (*Xoo*) is a major disease of , leading to reduction in production by 10–50%. In to control this disease, various chemical bactericides have been used. Wide and prolonged

application of chemical bactericides resulted in the resistant strain of *Xoo* that was isolated from .

To address this problem, Chinese researchers at both the College of Materials and Energy, South China Agricultural University, Guangzhou and the College of Agriculture, Shihezi University, Xinjiang were searching for an environmentally friendly alternative to the commonly used chemical bactericides.

They found that silicon dioxide nanospheres loaded with silver nanoparticles (SiO_2-Ag) can be prepared by using husk as material precursor. The results of the antibacterial tests showed that SiO_2-Ag composites displayed antibacterial activity against *Xoo.*

technology can also be used to create e-friendly fertilisers. In 2019, Researchers at Egypt's National Research Centre in Cairo produced a -fertiliser from banana peels. They used potassium hydroxide as the extracting agent at optimum operating conditions (solid to liquid 1:2, temperature 100 °C, and cooking time 30 min).

The product was applied in agriculture of two crops, tomato and fenugreek *(Trigonella foenum-graecum)*. Their findings revealed that germination percentage increased with increasing dose of banana peel extract for both crops. For tomato crop, the germination percentage was increased from 14% (control without) to 97% after 7 days of plantation. Also, the was noticed for fenugreek crop, the germination percentage was enhanced from 25% (control without) to 93.14%.

H S Hussein et al. « Preparation of -fertilizer blend from banana peels", *Bulletin of the National Research Centre* volume 43, Article number: 26 (2019).

:Photocatalyst sheet

Problem:

Harvesting solar energy to convert carbon dioxide into fuel is a promising way to reduce carbon emissions and transition away from fossil fuels. However, it is challenging to produce these clean fuels without unwanted by-products, in addition, of gaseous fuels and separation of by-products can be complicated

Solution:

Dr Qian Wang, a researcher at the Department of Chemistry, Cambridge University originally from Jiangxi province has collaborated with artificial photosynthesis expert Erwin Reisner, to develop a standalone biomimicry device that converts sunlight, carbon dioxide and water into a carbon-neutral fuel, without requiring any additional components or electricity.

The 20cm² test unit called a photocatalyst sheet is up of cost-effective semiconductor powders and uses light as its energy source, prompting a reaction that produces formic acid, a fuel that can be used directly or converted into clean-burning hydrogen. The wireless device could be scaled up to several m² and used on energy 'farms' similar to solar farms, producing clean fuel using sunlight and water. In addition, the formic acid can be accumulated in solution, and be chemically converted into different types of fuel.

Qian Wang et al. 'Molecularly engineered photocatalyst sheet for scalable solar production from carbon dioxide and water.' Nature Energy (2020).

:Photonic Smart Coating

Problem:

What to do with the wasted visible light of photovoltaic panels and them efficient?

Solution:

Indian- Nishikant Sonwalkar (MIT alumni) and a team at the University of Massachusetts-, USA, developed a coating applied under any type of pv from cadmium telluride to perovskite reacts to incoming photons and shapes the outgoing photons to maximize their amenability to optoelectronic devices, such as solar cells.

Its multiple -optical layers selectively downshift ultraviolet photons into the infrared, creating a quantum match and generating a higher number of electrons.

The photonic smart coating (PSC) increases the efficiency of existing solar panels by 5% taking a solar cell with efficiency of 22% to operate at 27% efficiency%, which corresponds to an increase of approximately 15-20% in power output. In addition to increasing output, and unlike conventional

antireflection (AR) coatings. It also decreases the levelized cost of energy (LCOE) by producing power per . PSC can be applied to other opto-electronic devices and architectural glass.

To commercialise *Power2Peer*, Sonwalkar founded SunDensity. In September 2020 SunDensity took Top Prize of $1 million at the Luminate NY Program's Innovation Finals Competition sufficient funding to set up a factory in Rochester.

Nishikant Sonwalkar also a pioneer of -materials, blockchain, and -computer interface(BCI) for - adaptive learning, founded the LearnQuest Academy of Indian and is himself an accomplished percussionist in the Indian tradition.

:Self-switched PV motor

Problem:

Nearly all PV motors require intermediary component parts.

Solution:

Alain Coty, an aerospace electro-technical engineer of Auxerre, in Burgundy, has developed an electric motor technology that converts solar energy directly into mechanical rotation, without the need for batteries or power electronics.

To manufacture and market it, in 2017 Coty teamed up with his family to found a startup called SAUREA (Solar-Autnomous-Reliable-Application). The Cotys humorously nickname their 27.5 in (70 cm) disc-shaped motor which resembles a flying saucer an *ITO* (Unidentified Turning Object) as opposed to a UFO!

The robust 130 watt engine enables it to drive both agricultural irrigation pumps and building ventilation turbines for up to 20 years without the need for maintenance.

Loïc Quéval, Alain Coty, Lionel Vido, Raimund Gottkehaskamp, Bernard Multon, "A Switched Reluctance Motor Drive using Photovoltaic Transistors: Principle, Prototype, Experimental and Numerical Results," *IEEE Transactions on Industry Applications, Institute of Electrical and Electronics Engineers, 2017.* hal-01533800; Benedict O'Donnell, "French start-up launches solar engine," *PV Magazine*, September 10, 2019.

:PV paint

Problem:

Installing solar panels is an expensive, laborious process, a fact that keeps homeowners from making the switch.

Solution:

PV (Photovoltaic) paint could be applied to any surface that will capture energy from the sun and transform it into electricity.

The most common type of PV paint uses colloidal quantum dots. These are semiconductor crystals that are already used in solar panels, as well as LEDs and computers. The University of Toronto created an iteration of solar paint wherein they sprayed these dots atom by atom a backing. This backing could then be rolled up, sent to the place where it is to be installed, and then applied like wallpaper.

At the University of Buffalo, in 2013, researchers announced that they had progress using plasmonic-enhanced materials. The team noted, however, that the thin nature of paint makes absorbing as much light difficult.

Four years later a research team led by Torben Daeneke at the Royal Melbourne Institute of Technology demonstrated solar paint that splits water particles to harness the hydrogen. Wai-Lun , an associate professor of physics and astronomy at the University of Kansas has been with other researchers to explore how to use semiconductors to produce PV solar cells. The best method to commercialise the right formulae for PV paint has to be found. *(physics.ku.edu)*

Shaheer Ahmed and Ataur Rahman, “The efficiency of thin film PV paint: A brief review,” April 2019.

:Physee windows

Problem:

Traditionally windows are used to see out of, to let light in and to keep out the cold., but their efficiency and versatility can always been increased.

Solution:

Willem Kesteloo and Ferdinand Grappherhaus Jr., graduates at the Department of Radiation, Science and Technology at the Delft University of Technology on Luminescent Solar Concentrators led by Erik van de Kolk, began to research energy generation from a building's windows in imitation of human skin, of how hot or cold it is and responding accordingly.

They started Physee in 2014 to commercialise their patented PowerWindow, transparent double- or triple- units with their embedded luminescent solar concentrator, installed at an , converting sunlight into green electricity. This window is as transparent as a normal window, but it yields 10 watt-peak of sustainable electricity per square metre.

Two years later, Physee won the Postcode Lottery Green Challenge and presented the award and US$ 55,000 prize by Her Majesty Queen Màxima. Thanks to proof-of-concept funding, with input from Arjen Jellema, PHYSEE was to further develop SmartSkin which continuously measures the light intensity, temperature and air quality and simultaneously generate electricity.

They can up to 30% on a building's energy consumption by controlling the air-conditioning or the sun blind systems, for example.

Measuring 323 ft.² (30 m.²) in 2018, the first installation of Physee's innovative windows was in Eindhoven, in the south of the Netherlands at the headquarters of Rabobank, the nation's biggest . Employees plug their smartphones into the windows using USB ports connected to their batteries.

The second installation was for the headquarters of the Amsterdam-based charity the Postcode Lottery. Physee has worked on its first -scale project: a 19,000 ft² (1,800 m²) installation in a , newly built residential complex in Amsterdam, the Bold Tower as well as Grafton Palace, Pharos, in the etc . In 2019, following trials, Pilkington Nederland provided Physee with a 10-year guarantee on their PowerWindows.

Physee has raised US$ 1.6 million in funding to accelerate the development and of smart, energy generating windows. The money was collected by a specifically assembled Clean-Tech Real Estate Consortium that consists of van der Vorm (Vorm Ontwikkeling), Coen van Oostrom (Edge Technologies), Job Dura (Dura Vermeer Group), the Van Veggel Family (Timeless Investments), and tech company builder and serial investor Dinko Valerio (CRXL).

Physee is using the money to scale-up the production of its products and to further develop currently patented lab-scale technologies. Next to that the investment will enable the company to expand in European and overseas cities. In this way, the company aims to contribute to the United Nations' Sustainable Development Goals for carbon neutral cities. *(physee.eu)*

Ramzy Alghamedi et al, "Spectrally-selective all-inorganic scattering luminophores for solar energy-harvesting clear glass windows," *Scientific Reports,* October 4, 2014.

:Plant meat

Problem:

All agricultural practices been found to a variety of effects on the environment. Some of the environmental effects that been associated with meat production are pollution through fossil fuel , animal methane, effluent waste, and water and consumption. Dairy cows and their consume amounts of water and produce GHG emissions which contribute to climate

Solution:

Since Donald Watson of Leicester, England founded the Vegan Society ("the beginning and end of 'vegetarian'") for those no eating meat, the population of vegans has risen from 150,000 in 2014 to 600,000 by 2019.

Nearly all UK supermarkets sell plant-based vegan food such as the Linda McCartney or Quorn A new report by a global management consulting firm A.J. Kearney predicts that 40 % of the meat we eat by 2040 will come from animals, 35 % will come from lab-grown meat (see entry), and the other 25 % will be sourced from plant-based alternatives.

Beyond Meat is a producer of plant-based meat substitutes founded in 2009 by Ethan Brown in El Segundo, California, U.S. The company's initial products became available across the United States in 2013. Designed to simulate chicken, beef, and pork sausage, they are now found in over 58,000 grocery stores, restaurants, hotels, universities and beyond.

According to Beyond Meat's website, ingredients for its plant-based patties include water, pea protein isolate, expeller-pressed canola oil, refined coconut oil, protein and other natural flavors, including apple extract and beet juice extract (for color).

According to a study commissioned by Beyond Meat with the Center for Sustainable Systems at the University of Michigan, a plant-based burger generates 90% less GHG emissions, requires 45% less energy, has 99% less

impact on water scarcity, and 93% less impact on use a 0.25 lb (0.11 kg) of traditional U.S. beef. *(beyondmeat.com)*

Nova Meat of Barcelona, Spain has developed a way to 3D-print plant-based derived from peas, , seaweed and other ingredients. The ingredients are laid down as a criss-cross of filaments, which imitate the intracellular proteins in muscle cells. This strategy allows us to define the resulting texture in terms of chewiness and tensile and compression resistance, and to mimic the taste and nutritional properties of a variety of meat and seafood, as well as their appearance. *(novameat.com)*

In August 2018, IKE, the Dutch-based Swedish multinational group that designs and sells ready-to-assemble furniture, introduced a vegetarian version of its hot dog which it sold 10 million of in its first year. In 2019, IKEA had sold over 1 billion traditional meatballs so decided to launch its plant-based "meatball" (aka Plant Balls), created with ingredients that include yellow pea protein, , potatoes, onion and apple.

Designed to look and taste as close as possible to the original meatballs, they are also created from sustainable sources. IKEA’s Plant Balls became available in its 290 European stores starting in 2021.

In 2019, award-winning film directors James Cameron (“Titanic” and “Avatar”) and Sir Peter Jackson (Hobbit) launched PBT, to produce plant-based meat, cheese, and dairy products in a bid to help New Zealand’s struggling farming industry.

Some of it will be grown in a lab, using animal cells, while other products that taste and smell like meat will be from plant protein, based on plants such as alfalfa. Cameron, a vegan since 2012 and his wife, Suzy Amis-Cameron, founder of MUSE, the first K-12 vegan school in the United States, own 2,500 ac (1,000 ha) of farmland in the Wairarapa.

The pair also run Verdient Foods, a company that will a pea- and pulse-processing facility in Canada to support the booming plant-based meat industry. vegan food is served to the film crew on the set of his four upcoming sequels to "Avatar" which are slated for release in 2020, 2021, 2024, and 2025.

In December 2020, Eat Just, founded by Josh Tetrick and Josh Balk to lab-grown chicken meat gained regulatory approval from the Singapore Food Agency (SFA), a world first. Eat Just's new GOOD Meat through partnerships with local manufacturers and go on to restaurants before it is available to consumers.

Climax Foods, a Californian data science company, founded by astrophysicist Oliver Zahn, co-founder and former sales and operation executive of JUST Inc Caroline Love, and the chemist and Stanford graduate Pavel Aronov, will be using machine intelligence tools that are expected to up faster and intelligent paths to produce such items vegan cheese.

Rahim Kanani, "The Future of Meat is Meatless, Just as Tasty, And About to the World," Forbes, 3, 2014; Jehan Casinader, "Sir Peter Jackson and James Cameron team up to promote meatless future," *stuff,* 16 2019.; "Climax Foods, founded by Astrophysicist and a Former JUST Exec, Raises $7.5 Million to "Out-Compete" Animal Products", *vegconomist*, September 3, 2020.

:Plant pots, biodegradable and compostable

Problem:

Unlike terracotta flower pots, plastic flower pots are very slow to biodegrade.

Solution:

Eva and Domen Štraser and Herlah of Evergreen d.o.o in Mislinja, Slovenia found a way to convert vegetables waste (peas, etc) to bioplastic flower pots, which after planting in the ground become fertilizer and ideal protection against parasites. *(bioplastic pot.com)*

The non-marketable by-products of legume production are ground and soluble with a buffer solution. The fibrous fraction can be used for composite materials, while the proteins are into bioplastic. LEGUVAL, a European Union-funded consortium of plastics makers and processors followed Evergreen's solution. *(leguval.eu)*

:PlantVillage Nuru

Problem:

Fall Armyworm, a new and fast-spreading crop pest, first appeared in West Africa in 2016, and then rapidly spread across all countries in sub-Saharan Africa in 2017, infecting millions of ha. of maize, and threatening the food security of 300 million people.

Solution :

In 2018, the United Nations' Food and Agriculture Organization and Pennsylvania State University with their PlantVillage app, joined forces to develop and launch an innovative, talking app - Nuru - to help African farmers recognize *Fall Armyworm*, in sub-Saharan Africa, so that they can immediate steps to destroy it and curb its spread.

African farmers might heard about *Fall Armyworm* but are seeing it for the first time, and are often unable to recognize it or unsure of what they are facing. With the new application, they can hold the next to an infested plant, and Nuru can immediately confirm if *Fall Armyworm* has caused the damage.

Nuru is an app that uses cutting-edge technologies involving machine learning and artificial intelligence. It inside a standard Android and can work also offline so farmers can use it whenever they it. It complements FAO's recently launched *Fall Armyworm* Monitoring and Early Warning System (FAMEWS) mobile app, which builds knowledge on how and where the pest spreads, and what makes it less damaging.

In addition to English, Nuru will be to speak to farmers in their own language, Swahili, French and Twi and will be learning new languages all the time. As an assistant, Nuru has learned to diagnose not *Fall Armyworm* but also multiple diseases in Cassava, infections in African Maize, potato disease and wheat disease as well as spotted lanternfly pests in Pennsylvania.
(plantvillage.psu.edu)

Similar plant disease diagnostic and monitoring apps include Plantix, developed by PEAT in Berlin, Germany, downloaded by almost 10 million users globally with about 85 % in India for cotton plants.

plantvillage.psu.edu; Pennsylvania State University, "New AI app predicts climate stress for farmers in Africa," *phys.org,* September 3, 2019.

:Plantable paper

Problem:

In , about 3 billion newspapers and magazines are printed every year. Newspapers are often left on the subway, or put on the top of a pile of other newspapers, or used as garden mulch. Glossy coloured paper can two to three months to decompose.

Solution: In 1997, Heidi Reimer and her mother Mary, a teacher in Winnipeg, Manitoba, Canada started up Botanical PaperWorks (later the Seed Paper Company) to manufacture plantable paper.

This included plantable paper products such as wedding invitations, seal and send wedding invitations, eco-friendly wedding favours, memorial products, baby shower invitations and so much . Plantable paper is a biodegradable eco-paper that is with post-consumer materials (no trees harmed for this paper!) and embedded with seeds. When the paper is planted in a pot of soil, the seeds grow and the paper composts away. All that is left behind is flowers, herbs or vegetables, and no waste.

They even published a book “Three Hundred Paper-Making Recipes” used in 35 countries around the world.

In 2016 a Japanese designer named Yoshinaka Ono went one further when he invented a special 100% biodegradable “green” paper that contains plant seeds.

The concept was adopted by *The Mainichi Shinbun* **(**毎 日 新聞**)**, a daily newspaper created in 1872 known for its stance on the environment. *Mainichi* printed a special 100% biodegradable "green” issue. The *“Green Newspaper”* was published for "Greenery Day" on May 4, 2016.

Most of the articles were about major environmental issues. But most importantly, the newspaper was designed to be reused. It was printed with plant-based ink – acting as fertilizer - on recycled paper, dotted with flower seeds (poppies, roses, daisies, etc.). After reading it, the reader just had to crumble the paper which was composed of a mixture of recycled paper, seeds, , water, flowers such as daisies, poppies or roses and vegetable ink. Then disperse it in freshly worked soil. With regular watering and a few weeks of waiting, it produced pretty flowers.

With a circulation of 4.6 million country-wide, the special 5 million copy edition was a real success – numbers of flowers making Japan greener and cleaner. This version of the newspaper was a one-off but at least, it intrigued an Japanese population keen on reconnecting with nature and made them think about their daily use of paper.

:Pencils

Problem:

Pencil shavings may be biodegradable, but those with various species of cedar degrade slower other types of wood. Their graphite will decompose in 100 to 200 hundred years or if it is compacted tightly in the landfill. Mechanical pencils can be reused indefinitely, but are usually not recyclable because they are of plastic.

Solution:

The wooden pencils that are best for the environment are those that are out of recycled material such as paper or with wood from lumber companies that try to

minimize the impact of logging on the eco-system. Unlike mechanical pencils, such wooden pencils quickly degrade.

In 2012, Mario Bollini and a team of six others at the Massachusetts Institute of Technology were assigned to come up with a sustainable commercial product. They up with a pencil (of sustainable wood, with clay and graphite at its) featuring a dissolvable capsule of seeds in place of an eraser. The pencil could be planted to grow flowers, herbs and vegetables.

The pencil acquired the Sprout, and with two other team members — Ben Peters and Lauren Herney — Bollini founded a product development company called democratech and started a Kickstarter campaign to launch Sprout as its first product.

That campaign caught the attention of Michael Stausholm and Jonathan Løw who founded SproutWorld in Europe to commercialize the pencil. In 2015, the company sold 1.7 million pencils and drew in about $2 million in revenues and since then, 25 mio Sprout pencils sold in +80 countries to companies and consumers.

About three quarters of SproutWorld's customers are corporations (like Ikea, PepsiCo and of America) who the pencils monogrammed with their logos.

:Plastic bag re-usable

Problem:

Paper and cotton are much for the planet plastic . Paper requires trees felled, cotton growing and both a lot of water.

Solution: In 1959, Sten Gustaf Thulin, sales at Celloplast in Norrköping, Sweden specialized in package design and experimented with different materials to hold, ship, and preserve consumer goods. It must be and lightweight so lasting for , enabling people to use it over and over again, repairing it if necessary.

of of polyethylene with special handles and high carrying capacity, with a patent awarded, in 1961 production began of what to be known as the T-shirt bag. The plastic bag became a great commercial success for Celloplast AB, and by the end of the 1960s about 600 million plastic were produced a year, and by the beginning of the 1970s production had increased to about 760 million annually.

By 1979, plastic accounted for 80 per cent of Europe's bag market. In 1982, two of the biggest supermarket chains in the US – Safeway and – switched to plastic .

Thulin, who always kept a plastic bag in his pocket in of need, never envisaged that humans would end up throwing his plastic away. Currently, the majority of plastic are not recycled and end up in landfill or polluting the environment where they up to 1,000 years to degrade.

But his reasoning remains. Paper carrier used energy to and water, are a heavier to transport in bulk. Cotton to be re-used 131 times to get the environmental impact as a plastic bag which gets recycled.

Use a plastic bag you already own and keep using it again and again. It is even better if it is of from swiftly biodegradable materials.

Sten Gustaf Thulin, "Bag with handle of weldable plastic material." US3180557A (1963); Utaraitė, "Apparently, Plastic Were Invented To The Planet, But Then We Got Lazy" *BoredPanda,* August 2019.

:Plastic bottle cutter

Problem:

What to do with plastic bottles in the home

Solution:

Plastic Bottle Cutter

In 2016, two Russians, Pavel et Ian Polianskii living in Versailles, developed the Plastic Bottle Cutter, a cutting tool, which after removing the bottom of an empty bottle, can shred the rest of the plastic into skinny strands of plastic . The device consists of a wooden handle, razor blade, and a cutting guide and can be used in any home or office.

The product first appeared on Kickstarter on February 23, 2016. With no moving parts and a simple design, this handy handheld device seemed to explode in popularity nearly overnight. By the end of March the product had gained nearly 7,000 backers and a pledge total now passing $350,000; far the original goal of $9,945. PBC became 8th most funded project from , top150 most funded design projects of KickStarter, 4.195% funded!

The Plastic Bottle Cutter can be ordered on but users should consider how to ultimately recycle the twine they produce from it.

:Plastic-free aisles in supermarkets

Problem:

According to the *Checking Out on Plastics* report by the Environmental Investigation Agency and Greenpeace UK, .Britain's top 10 supermarkets are flooding the planet with 810,000 tonnes of single-use plastic every year, according to a major new report. This is in addition to over 1.1 billion single-use , 958 million “ for life” and 1.2 billion plastic for fruit and vegetables, which supermarkets produce annually. Seven of those supermarkets are putting into circulation around 59 billion pieces of plastic packaging a year – roughly 2,000 pieces for every household in the country.

Solution:

In 2016, Sutherland and Frederikke Magnussen launched *A Plastic Planet*, coming up with one solution of a plastic free aisle in supermarkets. In February 2018, the world’s first plastic-free supermarket aisle opened in Amsterdam. Ekoplaza, a Dutch chain, where around 700 products at its pilot launch and

everything was packaged, just in glass, metal, cardboard or a compostable, plant-based biofilm.

Sutherland and her team at *A Plastic Planet* been collaboratively with industry, retailers, Governments, legislators and the UN to accelerate the of at all levels creating the Plastic Free Trust Mark for brands, with over 1,000 already certified, and the Industry Commitment Mark ‘ Towards Plastic Free’.

A Plastic Planet also became a key founding partner in the Plastic Health Coalition, bringing together the world’s scientists, doctors to irrefutably the impact of plastic toxicity on human health.

In January 2019, Thornton’s Budgens supermarket in Belsize Park, North London introduced dedicated plastic-free zones featuring 1,700 plastic-free products. Customers can pick up everything from fresh fruit and vegetables, bread and cheese, to wild meat, including squirrel and wild boar, all free from plastic packaging. Plastic-free materials are used instead, including beech wood nets, pulp, paper, metal, glass, cellulose and carton board.

In 2020, A Plastic Planet and packaging companies Reelbrands and Transcend Packaging together to develop the world’s first compostable, plastic-free PPE (personal protective equipment) in clear plastic-free REELshield visors in a bid to assist the fight against coronavirus polluting the environment.

From 2020, collaborating with Loop, a "zero waste shopping platform", Tesco, the British supermarket chain is trialling a scheme in the UK where online shoppers will get products in reusable packaging. The trial covers 150 items, which will be delivered in reusable containers for which consumers pay a deposit.

After using the products, which include Heinz Tomato Ketchup, Persil washing liquid, Coca-Cola, and Danone yoghurt, customers ask for DPD (Dynamic Parcel Distribution) to come and pick up the empties in the bag.

Based at the European Science Park in Scotland, a team led by Karen Scofield Seal, at Oceanium Ltd is investigating the potential of seaweed to provide a - term response to the demand for - packaging as well as sustainably-sourced plant-based food sources. Their solution is a circular life-cycle bio packaging material, *Oceanware* designed to be disposed of with food waste and ultimately used for compost for soil health or anaerobic digestion for energy.

Harry Cockburn, "Supermarkets flooding Britain with 59 billion pieces of plastic packaging a year, major study reveals", *The Independent*, November 15, 2018; Luke Andrews,"World's first' plastic-free coronavirus visor that can be composted in your garden goes on at 50p per mask," *mailonline*, 2, 2020.

:Plastic from waste CO_2

Problem:

Once captured, CO_2 must be recycled.

Solution:

Phil De Luna and a team at the University of Toronto, Canada found a way to recycle waste CO_2 back into ethylene, the raw material used to the most commonly used plastic, polyethylene.

The team used a technique involving X-ray spectroscopy and computer modelling techniques at the Canadian Light Source (CLS) facility at the University of Saskatchewan – analysing matter with electromagnetic radiation to identify their key catalyst.

And it was thanks to a new piece of equipment developed by CLS senior scientist Tom Regier that the researchers were to study both the shape and the chemical environment of the catalyst in real time. The researchers worked out

how to control the reaction so that ethylene production was maximised, while waste products such as methane were kept to a minimum.

Armed with this new knowledge and a suitable carbon capture technology, we could potentially remove CO_2 from the atmosphere while producing plastics in an environmentally friendly way at the time. Further research is required to refine the technique, but we now one of the building blocks

For his breakthrough in 2019, De Luna was named in the 2019 Forbes Top 30 under 30 Energy List. *(mse.utoronto.ca)*

Phil De Luna et al., "Catalyst electro-redeposition controls morphology and oxidation state for selective carbon dioxide reduction" *Nature Catalysis* volume 1, pages103–110 (2018).

:PlasticPatrol

Solution: After she had through radiotherapy for thyroid in 2013, Lizzie Carr, 25 years' old, went to the Isles of Scilly and Tomorrow'sed paddleboarding as a low-impact way of exercising. She wanted to continue she returned home to London – but gliding up and down Regent's Canal she became of the city's plastic pollution problem.

In May 2016, solo and unsupported. Lizzie became the first person in history to paddle board the entire length of Britain's waterways, 400 miles from Godalming to the District to find evidence of plastic pollution. She loaded all of her food and camping gear the of her board, paddled 10 hours per day and slept in her tent alongside the waterway each night.

Over 22 days she took 3,000 photos and in each there were hundreds of pieces of rubbish. Although she got carpal tunnel syndrome from gripping the paddle every day, her social media began to grow and she had started to awareness. She later logged her photo locations on an interactive map, which she developed into the Plastic Patrol app. Plastic Patrol has evolved organically into a global movement, as 100,000 pieces of plastic waste been logged from 44 countries.

In 2017 Lizzie was the first to paddleboard solo across the English Channel. In 2018 she was the first person the paddle board the 170 mile entire length of the Hudson River in America, from Albany to New York City. UFlex and Plastic Patrol, then screened a short documentary “The Hudson Project” at the Club in New York City.

In 2020, Plastic Patrol, released a report that reveals the extent of single-use litter across the UK, utilising community volunteering and technology to collect data on single-use litter.

Researchers from the University of Glasgow and University of Nottingham concluded that 64,913 pieces of litter recorded in the Plastic Patrol app by volunteers up and down the country over a nine-month period from 5th April 2019 to 31st December 2019.

In 2020 Lizzie Carr was awarded both the Prime Minister’s “Point of Light” and the ‘Inspiration of the Year’ Award at the “Stylist Magazine” awards. *(plasticpatrol.co.uk)*

:Plaxx plastic-recycled oil

Problem: Incineration of plastic waste is not energy efficient.

Solution: Since 2011, Adrian Griffiths of Recycling Technologies, Swindon, United Kingdom has been perfecting a machine to break down MPW (mixed plastic waste), a variety of plastic products including cling and electronics, and turn them into Plaxx™, a valuable hydrocarbon product usable materials or energy-producing oil.

The RT7000, a thermal cracker, heats up the waste to 500° C, melting the debris into a vapor. It is then cooled to create one of three different materials: a fuel that can be sold to petrochemical companies, a wax-such as substance that is

similar to what ship engines burn or a brown wax that can be used for shoe polish or cosmetics.

Using Plaxx® as feedstock for new polymers allows plastics circularity. In 2019 Tesco, the UK's leading retailer began to trial RT7000 units in ten of its stores. Modular, they can be moved around.

From 2020, international energy company Total, Recycling Technologies, and global brands Nestlé and Mars joined forces to develop an "innovative" industrial chemical recycling industry in . Recycling Technologies, with a production capacity of 200 unts per year, plans to install 1,700 units and reach 7 million tpy capacity by 2027.

In January 2020, Nestlé announced that it would cut in other parts of its business to buy 2 million tonnes of recycled plastic between now and 2025. This should enable the food to meet its goal of reducing its use of virgin plastics by a third. *(recyclingtechnologies.co.uk)*

Adrian Edward Griffiths, "Process and Apparatus for Treating Waste comprising mixed plastic waste. *Patent 20150376508*, December 31, 2015; "New Factory Facility and Headquarters to Triple Europe's Waste Plastic Recycling Capacity," November 16, 2018; Dickinson, "New 'all-plastic' recycling facility in the pipeline for Swindon," *resource*, January 7, 2019.

:Platform for Science-based Solutions

Problem:

In September 2019, the Intergovernmental on Climate (IPCC) launched the Special Report on the and Cryosphere in a Changing Climate (SROCC). This Report revealed that impacts are already significant and will be increasingly dangerous if the world does not urgently mitigation and adaptation actions.

Solution:

On November 4, 2019 during the Conference of the Parties to the UNFCCC (COP25) in Madrid, Spain, Carolina Schmidt, both conference President and Minister of Environment of Chile, launched The Platform of Science-based Solutions.

Its goal is "to enhance the sharing of knowledge created by various actors in the and climate community to advance -climate action".

The most specific aim of the new platform is “to encourage the incorporation of the in climate strategies (Nationally Determined Contributions, National Adaptation Plans, Adaptation Communications, and National Policy Frameworks). Supporters include the Foundation of Prince Albert II of Monaco. A number of solutions can be found elsewhere in this book (regrowth, Fish Farm offshore, Cleanup, liners with Zero Emission, etc.)

Tarun Gopalakrishnan, “Climate Emergency CoP 25: New platform linking and climate launched in Madrid,” *DownToEarth,* December 4, 2019.

:Pleistocene Park

Problem:

It is thought that permafrost thawing during the coming decades will exacerbate GHG by releasing methane and other hydrocarbons. This will also could cause erosion because permafrost lends stability to barren Arctic slopes.

Solution:

In “Pleistocene Park” in Cherskii, Arctic Siberia, northeast Russia, herbivores been imported to help most of the world's remaining permafrost.

During the winter, as their heavy hooves trample the snow, this helps the extremely cold outdoor air reach the permafrost, preventing it from melting. If 10 thousand years ago declining animal density for an extended period of time allowed grasslands to vanish, then artificially introducing herbivores to the Arctic and maintaining their existence will promote grasslands establishment and allow revival of a sustainable high productive ecosystem.

In the grazing ecosystems, herbivore is quickly returned back to the system. This allows grazing ecosystems to produce much higher harvest and maintain much higher density of animals comparing with any modern Arctic ecosystem

Since 1988, a father and son team Sergey Aphanasievich and Nikita Zimov been developing Pleistocene Park in the Northeast Scientific Station. Fencing off an area of 62 mi^2 (160 $km^{2)}$, the Russian geophysicists brought in 70

herbivores thousands of miles by truck and boat. These are up of American and European bison, reindeer, moose, muskox and Yakutian horses.

In 2007 a 250 ft (35m) high flux tower was erected in the park which constantly monitors the levels of methane, carbon dioxide, water vapor and energy (temperature) in the park's atmosphere. Scientists at Hamburg University, Germany looked at what would happen if the Zimov solution were applied to the entire Arctic Circle.

They found that under a scenario where greenhouse gas emissions remain unchecked (RCP 8.5), permafrost temperatures would be expected to increase 3.8°C. But that number could be reduced 44 percent to 2.1°C if the area were repopulated with herbivores. That, the study suggests, would be enough to 80 percent of the world's permafrost could be preserved until 2100 with animal intervention.

Merritt R. Turetsky, "Permafrost collapse is accelerating carbon release", *Nature*, April 30, 2019. N° 569 (7754): 32–34; Nikita and Sergey Zimov et al., “Protection of Permafrost Soils from Thawing by Increasing Herbivore Density” *Scientific Reports* 17 March 2020 volume 10, Article number: 4170.

:Plogging

Problem: Could jogging be just a way of keeping fit?

Solution:

In 2016, after moving to Stockholm from a small ski-community in northern Sweden, Erik Ahlström became frustrated with the amount of litter he saw while riding his bike to work every day. The debris could remain in the road for several weeks without anyone picking it up, so Erik started picking it up.

It felt good in his heart to clean up even a small place. Searching for a word to describe what he was , Erik combined the Swedish word: plocka upp (pick up) with jogging and up with “plogging”. Before other people were joining Ahlström, and plogging , with groups of couple coming together to run and pick up trash, became official events across Sweden.

The official on- Plogga movement, the Swedish eco-fitness was with 1 million hits on social media with international plogging groups starting up in at least 50 countries and hundreds of locations worldwide. This included a catchphrase Pick’n Jog – Be a hero”

While most of the initial growth was in Europe, plogging groups can now be found as far away as Ecuador and Thailand, a global reach that has far exceeded the initial expectations of the movement’s founder. In Sweden there are 200 events to . One idea has suggested making “plogging” an Olympic Sport.

In the early 2000s most Gujarat State Road Transport Corporation buses had a poster on the back with a portrait of Narendra Modi (who was then the chief minister of Gujarat) and slogan "Clean Gujarat", while inside each bus was a that said "Throw Rubbish Outside". Since Modi became Prime Minister of India, public places in India (railway stations for example) become much tidier and cleaner.

In October 2019 Prime Minister Modi, in Mamallapuram, for an informal summit with Chinese President Xi Jinping, released a three-minute video on Twitter in which he was seen plogging and the people to follow suit.

In February 2018, Couderc and Nil Hoppenot, in their thirties left Portugal in February 2018 and arrived in Istanbul in March 2020. They walked 10,000 km, crossed 19 countries in southern Europe, using small paths. In their backpacks which weighed on average 20kg, and Nil always had a place for the environment. They collected up to 1kg of waste found the way that they selectively disposed of when they could. It was the effort they wanted to for the planet. They wanted to show that everyone on their big or small hikes can do the

Others prefer to walk instead of jogging.

In November 2018, French youtubers Mcfly and Carlito organized and filmed CleanWalk, picking up plastic while for walks in the streets of Paris. Viewed almost 3 million times, it had a knock-on effect. In March 2019, Elsa a second year student at the Doctrine high school in Strasbourg, organised a GreenWalk around her French city. On December 15, 2020 a hundred " vests" responded and a dozen Belgian personalities participated in the first Greenwalk in Belgium. Armed with litter picker and trash provided by Bruxelles-Propreté, the 150 participants traveled 1.7 km and collected 550 kilos of waste

Klein, Allison, "Plogging' is the Swedish fitness for people who to the planet. It's making its way to the U.S.," *The Washington Post,* February 23, 2018; “Plogging: The eco-friendly workout that’s sweeping the globe,” *unep.org.*

Pods for coffee

Problem:

When Éric , an aerodynamics engineer from the French-speaking Swiss canton of Vaud first created a system for putting coffee into single-serve aluminium capsules or pods, he little dreamed of the environmental risk they posed.

Machines that depend on hard-to-recycle pods, such as Nespresso and Keurig systems, are awful for the environment can create unnecessary landfill waste. Of the 39,000 capsules produced worldwide *every minute*, 29,000 of them end up in landfills. Nespresso almost enough coffee pods to circle the world 26 times.

Solution:

1991 saw *Nespresso* launch the world's first capsule recycling system in Switzerland. By 2015 they had reached 86% global recycling capacity, achieved with the help of some 14,000 dedicated capsule collection points operational around the world (additional to over 80'000 UPS points in the US and over 6'000 Green Dot collection points in 3 countries).

Nespresso are expanding their capacity to collect used aluminium capsules to 100% wherever the company does business, thereby increasing recycling . Further to this, each time it makes environmental sense, they will recycle used *Nespresso* capsules collected by the company, reusing them as new capsules. Another key part of this vision is for 100% of our virgin aluminium capsules to be produced with material compliant with the new Aluminium Stewardship Initiative standard, currently developed within a multi-stakeholder program led by the IUCN.

Nespresso is not the firm with a conscience. In 2017, regarding his creation of the Keurig machine and its plastic pod, inventor John Sylvan stated, "I feel bad sometimes that I ever did it." *Glorybrew* is a Miami (Florida) based coffee and the innovator of the 100% compostable, single-serve, BPI and Rainforest Alliance Certified coffee pods for Keurig machines. The is using coffee chaff and the filter with renewable bio-based materials. These K-Cup pods have been proven to completely break down in about 8 weeks, becoming clean soil that can be added back into the ecosystem.

Even though Keurig has a goal to all pods recyclable by 2021, (57 billion, or so, sold pods away) *Glorybrew* pods will remain the greener choice both now and then. This breakdown occurs in Industrial Composting Facilities, as there is not currently a certification for backyard composting.

CBD produces 95% , *Hemp You Can Feel Coffee*, based on some of the highest quality ingredients available in the marketplace: hemp extracts, non-GMO starches from vegetables, honey from farms, and amounts of vegetable and coconut oils. No chemicals, surfactants, or artificial processes are added to their infusions. Their hemp extract infusions are based on BeeFuse Technology patented biomimicry composition, which is part of PhytoPharma International Ltd, was invented by B. Simon in Israel. CBD's packaging of the coffee pod and the lid are 100% compostable within 120 days of discarded.

:Poetry

Problem:

Sometimes is not enough to us up.

Solution:

Poetry

When in the early 1800s the English poet William Blake saw the pollution caused by the nearby Albion coal-fired stream-powered flour mill, he included these verses in one of his poems.

And was Jerusalem builded here,
 these dark Satanic Mills?

I will not cease from Mental Fight,
Nor shall my Sword sleep in my :
Till we built Jerusalem,
In England's green & pleasant .

 others followed him

In his15-stanza poem " of the Road, first published in 1856, American poet Walt Whitman, famous for his work "Leaves of " writes

Now I see the secret of the making of the best persons,

It is to grow in the air and to eat and sleep with the earth.

Tom Paxton an American folk -songwriter "Whose Garden Was This?" for the first Earth Day in 1970. It was originally recorded on the album "6", and was later covered by John Denver and was the first in a of that Denver recorded about the environment.

In 2018, Amanda , National Youth Poet Laureate of the United States and declaimed "Earthrise" for The Climate Reality Project about the climate emergency and the action we must to end it. She also read out "The Hill We Climb" at the inauguration of President Jo Biden in January 2021.

:Poultry farm, free- and solar powered

Problem:

Traditional poultry farms can use almost four times as much energy per live weight poultry (20 to 83 kWh/1000lb) to power lighting, ventilators, heaters, coolers and automated feed lines.

Solution:

Based in Mogumber, Western Australia, Western Riverlands Poultry, the nation's largest free- chicken farm occupying 42 free- sheds and about 10 million birds are turned over each year, is leading the transition to clean energy with one of the largest Agricultural Solar PV projects in Western Australia.

With the support of $1.3 million in state government funding, Western Riverlands AAM has added 1.4 megawatts of Solar Choice PV panels to the farm sheds and installed five Tesla batteries.

Solar Choice's engineering team analysed 30-minute interval data to understand energy consumption through bird cycles and weather seasons, and to design the optimal Solar PV system to maximise economic return and carbon offsets.

Through a National Solar Tender process, Solar Choice was to help the Mogumber Poultry Farm beat the current market price for solar by over 10%, while delivering a high quality solution which surpasses industry standards for warranties and performance guarantees.

The 340kW Solar PV system utilises Fronius Inverter technology and Solar Panels with both roof-mounted and ground-mounted arrays.

Construction of the new installation by Santrev – a leader in poultry shed construction reached completion in 2019.

During its lifetime the project will prevent over 17,000 tonnes of carbon emissions and over $1.5million in energy .

West Riverland is also turning straw and from chicken sheds into profitable compost. After a few months of monitoring and turning, the raw material is converted into a nutrient-rich compost which is then available for purchase. 50,000 cubic metres of soiled straw and comes out of the sheds each year. One

South Australian winemaker Michael Bruer has been spreading the compost at two of the family's vineyards.

AAM believes the Riverlands sustainable model can be rolled out to all areas of agriculture.

Power over Ethernet (PoE) lighting

Problem:

The efficient the light bulb, the less energy it will need.

Solution:

Energy-efficiency has driven the evolution of the light bulb, but the next iteration of the light bulb will launch it into the Era of the Internet of Things (IoT).

As LED lights slowly replace compact fluorescent lights (CFL's) due to greater energy-efficiency, businesses been exploring the profitability of replacing LED lights' electrical power source with an alternate but common power source found in the networking world — Power over Ethernet (PoE).. Following pioneering work by Cisco Systems of San Jose, California, there are several common techniques for transmitting power over Ethernet cabling. Three of them been standardized by IEEE 802.3 since 2003.

A Light over Ethernet (LoE) LED system is powered by Ethernet and 100% IP based. This makes the system (i.e. each luminaire individually) computer controllable, so that can be implemented quickly and easily without opening suspended ceilings. The luminaires are furthermore equipped with Philips' 'coded-light' system allowing for a highly precise localisation via smartphone down to 8 in (20 cm) accuracy, much precise known WiFi or beacon systems.

One of the digital buildings using the PoE is *The Edge*, a 430,000 ft² (40,000m²) office building in the Zuidas business district in Amsterdam. It was designed for

the global financial firm and main tenant, Deloitte. The project aimed to consolidate Deloitte's employees from multiple buildings throughout the city into a single environment, and to create a 'smart building' to act as a catalyst for Deloitte's transition into the digital age.

Around 6,000 of these luminaires were placed in *The Edge* with every second luminaire equipped with an additional multi-sensor to detect movement, light, infrared and temperature. The Philips LoE LED system was used in all office spaces to reduce the energy requirement by around 50% compared to conventional TL-5 Lighting. Via the LoE system daily building use can be monitored.

The Edge's orientation is based on the path of the sun. The atrium bathes the building in northern daylight while the solar panels on the southern facade shield the workspaces from the sun. The roof and the south-facing facade incorporate the largest array of PV panels of any European office building, and an aquifer thermal energy system provides all of the energy required for heating and cooling. A heat-pump was applied to this system significantly increases efficiency.

The Edge uses about 70% less energy most buildings but is not glass- on all sides – the southern, eastern and western sides smaller window openings to reduce heat gain, and openable windows.

Chien- Yeh, "Real-time white-light phosphor-LED visible light communication (VLC) with compact size." *Express* 21(22):26192-7 · November 2013.

Electric-engined powerboat

Problem:

Emissions from gasoline outboard engines, above and below the water are harmful to aquatic flora and fauna.

Solution:

Zero-emission outboard engines been around for over a century, but until recently they were low-powered which that gasoline outboards by big firms such as Mercury and OMC dominated the market.

This did not deter Marshall “Duffy” Duffield of Newport Beach, California, from manufacturing a total over 14,000 battery-electric dayboats during the period 1970 to the present day, 3,500 sold in Newport Harbor

In 2015, Torqeedo of Starnberg, Germany who had built up a of electric outboards, added the Deep Blue Hybrid, the world's first high-performance saildrive system from serial production. In 2012 Robert Venture Capital GmbH, acquired a minority stake in the Starnberg firm. The move was as part of a round of financing that Torqeedo undertook in preparation for further growth and the development of new innovative products.

The R&D team, led by propulsion specialist Jens Biebach, formerly of Dresden Technical University, and Marc Hartmeyer, now up with a 325V DC high- Deep Blue system with an unprecedented power output of 33 kW (40 hp) or 66 kW (80 hp). Deep Blue works with two generators, delivering 20kWk with a top speed of 15.5 mph (25 kph).

On 20 of that year, 13 top journalists from German mass media plus the chief editors of leading European boat magazines gathered for the first “Electric Days” at Starnberg near Munich. Motor manufacturer Torqeedo had teamed up with the four shipyards Nimbus (Sweden), Frauscher (Austria), Designboats (Switzerland) and Kaiser (Germany) to present the future and present of electric boating with seven on the water during two days of test drives.

The 36 ft (11 m) *Nimbus 305* Coupé ePower is fitted with twin 80 hp Deep Blue Hybrid motors fed by banks of automotive lithium batteries providing energy for propulsion of the 72 ton (6.5) boat and 50 kWh of electric power including auxiliary equipment on board. A cruising of up to 20 nautical mi. is possible without using a generator, which is always available for extended .

Torqeedo has stepped up the Deep Blue power output to 100 kW, using two BMW technology (i3-type) batteries with an energy density of 40 kWh. *(torqeedo.com)*

Another electric power boat is by EVOY in Norway, who drivetrains for boat systems at 74-671 kW, 100-900hp, for new and used fast planing from 20 to 30ft (6 to 9 m.). In July 2019, *Evoy I*, a 28ft (8.6 m.) Polarcircle 860 workboat, was timed at a speed of 50 knots across Ranafjorden.

In 2021, some 40 electric , in length from 6ft to 80 ft (2 –25 m), including those described above, will parade the Canal, Venice, Italy as part of that canal city's program to transition its 1,800- fleet to zero-electric propulsion by 2028.

Torqeedo.com website; Patent N° 9718526 "Boat with high- system," Jens Biebach, Philipp Krieger, Marc Hartmeyer, *Torqeedo GmbH* (2017).

:PowerCone

Problem:

Root leakage is a problem that occurs at the center of wind turbines. Around the hub, an area of low pressure develops and no power is produced. This is in contrast to the high-pressure area around the rest of the blades, which creates a pressure differential. This sucks additional power away from the blades and creates unnecessary turbulence. When it comes to the annual energy production (AEP) for a wind turbine, the industry says that gains of more than 1 to 2 percent was thought impossible.

Solution:

Ryan Church of Toronto, describing himself as a bioneer or biomimetic innovator, and founder of Biome Renewables has innovated the PowerCone, a turbine retrofit that channels incoming wind onto the blades to address root

leakage. The result is not just more power, but power from a place where no bigger blade or smarter software can find it.

The PowerCone attaches directly to the hub of a wind turbine and co-rotates with the rotor, helping it to capture more of the wind that's already blowing. It redistributes wind to enhance the performance of existing turbines, lowering cut-in speeds, increasing torque and ultimately making the turbine more effective and efficient. It does this because the PowerCone mimics the coning angle of the maple seed. The coning angle is the angle at which a maple seed falls as it moves through the air, following the path of least resistance.

The PowerCone also mimics a kingfisher beak, which allows the bird to dive into the water while barely making a splash. This is due to the way the bird pushes fluid around its beak as it enters the water. The PowerCone draws on these principles, directing wind from the root to outer spans of the blade and channeling it smoothly onto its surface.

PowerCone test results at TUDelft, and more than 25,000 person hours of R&D have shown increases in annual energy production of up to 13%. DNV Turbine Engineering has also indicated reduced loads on system-critical components.

Global engineering technologies company, Renishaw, collaborated with the Nova Scotia Community College (NSCC) in Canada, to produce two ocean turbine parts using additive manufacturing (AM) for industrial design firm Biome Renewables. The prototype was then installed this summer at the Skyway8 wind farm northeast of Toronto, in partnership with Capstone Power. Leading independent entities, such as DNV-GL, Power Factors and NREL assessed the technology. In April 2020, Biome Renewables presented PowerCone to investors and industry representatives at the Virtual Industry Growth Forum (IGF).

The PowerCone could be fitted to 98% of all installed turbines around the world.

:"Precious Plastic" recycling machine

Problem:

The recovery and recycling of plastic does not always need to be carried out in commercial factories.

Solution:

Hakkens takes a different approach to Planet-Protecting by placing his solutions on- -source.

From 2009, studying at the Design Academy of Eindhoven, Hakkens, 20, published his first video “Rubble Floor” showing viewers how to re-use rubble to from a building site to new paths.

“Wind Oil” followed, showing how to a wind-powered oil press, Playful Paper and Breaksoap. In 2013 Hakkens, having graduated cum laude, launched Phonebloks, a modular smartphone designed to limit the amount of electronic waste produced.

In its successful , Google and Motorola announced the launch of a similar project, known as Ara, which eventually to nothing After exceeding his goal of 900,000 supporters on Thunder clap by October 2013, Hakkens launched Precious Plastic, a small-scale factory that allows people to recycle plastic for themselves: a shredder turns plastic waste into small flakes, which are melted and then reconditioned using presses and molds.

“Precious Plastic” has been picked up by hundreds of people around the world that built the machines and started recycling plastic waste.

Hakkens and Precious Plastic entered the third of the project - the community, estimated to be around 40,000 people. those 40,000, some volunteered to go from Iceland or Mexico to the Netherlands to help Hakkens develop his concept. An interactive world map has been developed to identify members of the community and the workspaces that been established all over the world.

The Precious Plastic website also has a "Forum" section where "builders" can chat, and a marketplace, the "Bazaar" where people can buy and sell the products they , buy parts to machines.

From Chile to Japan and from Kenya to the 200 people work in some 80 Precious Plastic workspaces. The offices are from materials, affordable, easy to find and to build. Some people jewelry, plates, smartphone covers, even beams for use in building, one Spaniard has a chlorine water filter.

In October 2019 Hakkens launched Precious Plastic Version 4 to build an army to fight plastic waste.*(davehakkens.nl)*

davehakkens.nl ; Matthieu , " Hakkens and how to do your own plastic recycling," *LivingCircular* December, 18, 2017. *map.preciousplastic.com*; Baart, Ruben, "Designer Hakkens is putting plastic waste to better use," *nextnature.net,* November 11, 2016.

:Precision farming machines

Problem:

Despite a century of horrific wars and some significant international plagues, human populations managed to grow 400 % during the 20th century. Today's world population is 7.6 billion, and the United Nations (New York), projects that another billion will be added by 2030, another by 2050, and that by 2100, the world population will be 11.2 billion. The food they will eat will need to be farmed as efficiently and as sustainably as possible. This involves the smart use of a matrix of electrical agricultural machines.

Solution: The most important tool is the crop yield monitor whereby each and every farmer can connect via a GPS system to inspect, in real time, the precise state of his soil, his crops, his orchards and his forests, square inch by square inch (cm^2 x cm^2).

He thus knows exactly where and when to deploy exact doses of pesticides, fertilizers and water. This deployment can be carried out with laser-like as precision by an autonomous electric vehicle, be it a tractor, or one or small-sized AI agbots, and/ or . Other precision vehicles are then deployed to plant, to pollinate and to harvest.

In 2010, S. Muhammad Umair and Rasyidi Usman from the National University of Science and Technology in Pakistan proposed to create an automated micro irrigation system using Artificial Neural Network based controller. The input parameters such as air temperature, soil moisture, radiations and humidity are modelled. Then using an appropriate method, ecological conditions, evapotranspiration and type of crop, the amount of water needed for irrigation is estimated and then associated results are simulated.

John Deere's Automated Electric Tractor has been developed by a team including Steve P. Robisky, Strategic Planning of "Farm of the Future" and Troy K Maddox, Senior Designer UX/ID., the modified John Deere *6210R* tractor uses a robot arm to pay out and retract its GridCON, a 1 km onboard extension cord from the machine to the field perimeter, which provides up to 400hp (300kW) of power in total.

Pairing autonomous grooming with the extension cord has the potential to lower the capital cost of purchasing the vehicle by removing the batteries. At the time, the autonomous capability of the vehicle ensures that it will not run over its own power cord and reduces wear and tear on the cord itself. Compared to battery-powered equivalents, the prototype delivers around 50% lower machine and operating . *(deere.com)*

Perhaps most revolutionary of all is AGCO and Fendt's FutureFarm Project *Xaver*, using Mobile Agricultural Robot Swarms (MARS). The use of a number of small, identical robots operating in a swarm enables smooth running of the job, even in the event of the failure of a single unit. The Mother Ship arrives and the small agbots disembark to carry out their tasks. *(agcocorp.com)*

In 2014, Green Robot Machinery Ltd. in Bangalore, India was founded by Manohar Sambandam and Neeraj Bhardwaj. When Sambandam chose to turn entrepreneur at the age of 50, he had it all figured out. With a Masters in Electronics & Communication from the Indian Institute of Science, and having worked for 25 years in the semi-conductor industry at Texas Instruments, Athena and Broadcom.

He also 12 ac (5 ha) of and cultivates paddy, cotton and legumes. He is an active participant in various cotton farmers' guilds and is sought after for his views and advises to leverage technology in farm.

He teamed up with his friend and former colleague at Texas Instruments, Neeraj Bhardwaj to develop the GRoboMac which harvests primarily cotton but also horticulture crops such as egg plant, and capsicum. The of the robot has been designed in such a way that its computerized vision detects and locates the precise 3D coordinates of the bloomed cotton from the images of the cotton plant. A arm uses these coordinates to pick the cotton and the arm, then uses a vacuum for precision picking of cotton and avoids picking any other contaminant.

In 2016, Green Robot Machinery was awarded the Qualcomm Design in India prize. The cotton harvesting machine has been field tested and became available commercially from 2019. *(grobomac.com)*

Kevin Desmond, *Electric Machines in Agriculture: Origins, Developments and Applications,* New Delhi, India, NIPA, 2020.

:Precision planting robots

Problem:

To ensure maximum yield, a copy producing plant must be tended and cared for with as much attention as it they were a human /

Solution: precision plant AI robots

England

Ben Scott-Robinson ane Joe Allnutt, founded the Small Robot Company in Portsmouth, to develop *Rachel*, a four-wheel monitoring robot 50 x 60 x 40 cm (20 x 24 x 16 in), weighs around five kilos (11 pounds) with a bright 3D-printed body and beefy all-terrain wheels, whose task is to obtain a plant-by-plant view of the fields, which enables digitisation.

Rachel is quite small and is fitted with cameras. It backwards and forwards, over plots of and collects data about the plants present. *Rachel* was renamed *Tom*.

*Tom (*ex-*Rachel)* is part of Small Robot's "Farming as a Service" (FaaS), a new way to grow crops. The idea of FaaS is that the farmer does not actually buy a robot, but contracts in the service, paying a per area. FaaS uses *Wilma*, a data and management system that sits in the Cloud draws all the information from *Tom* the scout, combines it with weather data, crop and field history, plugs into pathogen-monitoring and similar services, and delivers direction to *Dick* to carry out remedial work based on this plant-level data.

Dick then accurately targets weeds for micro-spraying and mechanical weeding, then also delivers fertiliser directly to soil around roots, instead of wasteful blanket spraying, and uses laser or micro-spray chemicals to kill weeds. *Harry* will plant seeds in the ground, at a uniform spacing and depth, allowing them to grow effectively, eliminating the need for tractors to plough furrows.

The disruptive of the Small Robot Company is to own and administer a nationwide fleet of *Toms, Dicks* and *Harrys*, ensuring they are all running effectively and carrying out any maintenance, upgrades or replacements required.

USA

Elliott at Google's Alphabet X Company has unveiled Project Mineral involving prototype robots that can inspect individual plants one by one in a field and then give it exactly the nutrition it requires to help farms improved crop yields. The plant buggy has checked out strawberry fields in California and soybean fields in Illinois, counting and classifying every berry and every , including plant height, leaf area and fruit size.

Troy Fiechter of in West Lafayette Indiana, has developed SmartCore an autonomous soil sampling vehicle that uses to gather samples with a consistent depth, and with proximity repeatability to ensure accurate sampling year after year. It operates at a 202-hectare (500-) capacity without stopping and can hold up to 200 samples.

The SmartCore uses a Bobcat tracked skid steer chassis as the , and a hydraulic-powered bit is used to collect samples. The bit is configured so that no soil can escape the , ensuring each sample is pure and accurate. The extraction arm is rotationally received on a housing and movable to an inverted position for depositing the quantity of extracted soil into a packaging assembly for collection, labelling and of the individual samples.

While the machine is autonomous, an operator helps up a field and evaluates potential trouble sites, such as ditches or other obstacles. While the SmartCore gathers soil, a employee can package soil samples for delivery to a soil lab of the farmers' choice. Covering 324 hectares (800 acres) per day, SmartCore autonomously sampled 8,094 hectares (20,000 acres) during the autumn of 2018.

:Prefabricated Plastic Road

Problem:

Bottles close to 500 years to decompose in landfills, and some **plastic** items last almost twice as unless they can be recycled

Solution:

Recycle plastic into repaved roads

In 2001, Rajagopalan Vasudevan, an Indian chemistry professor, recognised plastic's binding qualities and pioneered a plastic-bitumen road-laying technique across India. He thought up the idea of shredding plastic waste, mixing it with bitumen and using the polymerized mix in road construction.

Since 2010, Somers Weaver and a team at TechniSoil in Redding, California been developing this solution to repair Los Angeles roads. With their G5 binder, they can recycle 100% of the existing road in place, and approximately 150,000 plastic bottles per mile. The end result is a completely new category of plastic pavement that lasts at least 2 - 3 times traditional asphalt pavement. The company collaborated with the University of Nevada, .

Using a modification of a Cold In-Place Recycling process, the equipment mills the existing roadway, crushes and sizes the RAP (Reclaimed Asphalt Pavement), and mixes the RAP with the G5 Binder. The recycled mixture is immediately paved back the road and compacted with a vibratory roller. Traffic can return within hours.

While in Los Angeles, the Bureau of Street Services, or StreetsLA, has tested samples TechniSoil in parking lots and smaller streets in Oroville, other cities and states such as Texas, and Colorado expressed interest in TechniSoil's pavement technology,

TechniSoil uses approximately 2,300kg of recycled PET plastic per 1.5km two-way road, which equates to around 395,000 plastic bottles, but CEO Weaver hopes to double this content by 2022.

Besides TechniSoil, there is Dow Chemical, which has worked with local governments across Indonesia, India, and Thailand since 2017; and Scottish company MacRebur, which makes road products that replace part of the bitumen with waste plastic crumbs.

In The Netherlands, Wavin, a Dutch maker of plastic pipes, has announced that after 18 months of testing, including the construction of two 30m- PlasticRoad roads in Zwolle and Giethoorn to the east of Amsterdam, it will begin production of its modular plastic road technology early 2021.

The test roads were fitted with sensors to monitor how well they dealt with heavy vehicles such as garbage trucks and other heavy traffic.

Somers Weaver, “Polyurethane based roadway ”, Technisoil Industrial LLC, Patent number: 9957670 of Patent: May 1, 2018; *Subramanian, Sribala (30 2016). "Plastic roads: India's radical to bury its garbage beneath the streets". The Guardian*. 21 August 2018.

:Aluminium-air primary battery

Problem:

Secondary batteries require recharging which can from ten minutes to over an hour. They also require the setting up or a geographic infrastructure of charging points.

Solution: In 2009, after a decade of research, British engineer and former Royal Navy officer Trevor Jackson set up a company called iCanique to promote a primary aluminum-air battery composed of a half-cell of the fuel-cell type and of a half-cell of the primary-cell type with one metallic and one gaseous electrode.

This electro-couple not it a 1,500 mile (2400 km) but also a 90-second swap system. Instead of a vast network of charging points, all that is necessary are stores where the cassette cells can be swapped, just as people already swap gas bottles.

Despite support from the Technology Developer Accelerator Programme (TDAP), part of a 10-year program to U.K. a world-leader in low-carbon propulsion technology, Jackson had to resistance to his innovation from the lead-acid and the lithium-ion battery lobbies.

Undeterred, in 2013 he created another company Métalectrique Aerosystems Ltd (MAL) in Tavistock, Devon, south-west England. In October 2019 MAL signed a multi-million-pound deal to start manufacturing the MAAPS-2 (Métalectrique

Advanced Aluminium Power System) can battery lasting between 2.6 and 11 times an incumbent lithium primary battery, on a scale in the UK.

Austin Electric, an engineering firm based in Essex, which the rights to use the old Austin Motor Company logo, plans to put thousands of them into both electric Asian electric ‘tuk-tuks’, pedalectric bikes and then as kits to convert ordinary petrol and diesel cars into hybrids, by fitting them with aluminium-air cells and electric motors on the rear wheels.

The system is suitable for other applications like . (metalectrique.com)

A similar solution has been developed by Michael F. Levy and a team at AAQIUS, headquartered in Switzerland with their STOR-H canister exchange system, using hydrogen as its energy.

These are used on Sneaker e-tricycles developed by Cycleurope. Exchangeable in a few seconds, they give a of about 50 km, with a life of 15 years. In 2018 Aaqius unveiled their STOR-H distributor at the World future Energy Summit. 21 In October 2019, STOR-H obtained le Solar Impulse Efficient Solution Label. (aaquis.com)

Meanwhile, during 2020, the Big Four motorcycle manufacturers in Japan, Honda, Yamaha, Kawasaki, and Suzuki been at Osaka University to develop a shared swappable secondary battery. The “e-Yan Osaka” trial, been putting battery packs and electric bikes and scooters from all four manufacturers to the test with battery-swap stations installed on campus as well as at convenience stores in the area. They been following Honda’s lead with the swappable battery packs from Honda’s PCX and Benly electric scooters

The point of the trial is to demonstrate that instead of putting in battery packs, such as in the Harley-Davidson Livewire or Zero SR/S electric motorcycles, and having to it at home or at work, the solution is to simply swap out the power pack.

-Baptiste Dementhon, Michael Francis Levy, “Gas unit and associated structure and system,” Patent number: 10502367, Filed: August 9, 2013 of Patent: December 10, 2019;

Trevor Jackson, “An aluminium-air cell, an aluminium-air battery and a motor unit comprising an electric motor and an aluminium-air battery,” WO2016178017A1, 2016.

:Printing ink cartridges and toners

Problem:

It’s been estimated that over 350 million ink cartridges in North America end up in landfills every year while in the UK, 45 million non-biodegradable ink cartridges are thrown away. Some of the plastics used in the manufacturing process can up to 1,000 years to fully decompose. During this time, chemicals spread into the soil and pollute the environment.

Solution:

An independent study by sustainability company Best Foot Foreward, concluded that the ink cartridge re-manufacturing process saves on average, 2.5kg of CO_2 per cartridge compared to the production of a new cartridge.

The study goes on to say, “the carbon footprint of a remanufactured cartridge is approximately 2.8 kg, which is 2 kg (46%) lower that for a new cartridge.” Since 1996, Clover Technologies Group at Hoffman Estates, Marseilles, Ilinois has been recuperating, recycling and remanufacturing printer cartridges, printer parts, mobile phones, and other small electronics. Clover’s system “collecture” is widely known and recognised throughout the DACH region (D - Germany, A - Austria, CH - Switzerland), but is also operational in the United Kingdom and other European points.

This program is dedicated to creating innovative environmental solutions that will businesses and private communities cleaner and better places. With

collecture programs, companies can recycle office electronic waste in a simple and secure way. *(cloverimaging.com)*

Clover Imaging Group partnered with PrintReleaf to empower our customers to certifiably reduce the environmental impact of printing by planting trees across a global network of reforestation projects. For every 8,333 printed, PrintReleaf plants a tree in a forest of your choice: 653,000 trees been planted since 2015.

Printerre EA (enterprise adapté) was founded in 2012 by Laurent Berthuel in Cherisy, a commune in the Eure-et-Loir department in northern , to recondition printers, maintain printing systems and sell computer consumables and printers.

Employing 80% of disabled workers, Printerre is proud of their " in " operation, based in a former television plant. Recognised by Eco Ecologic pour the collection and selection of professional cartridges, Printerre reconditions 100,000 cartridges and toners per year with 31 available brands. (*printerre.fr*)

"Toner Refills at Cartridge World – Comparative Carbon Footprints," *Best Foot Forward Ltd*. March 2008.

PLANET

:"Proton", single-cell protein from CO2

Problem:

Currently we struggle to feed our current global population and unless we drastically the way we produce our food, this problem will get . Most animal feed protein sources are imported from overseas, making the UK dependent on complicated and supply chains. This is a particular problem with protein.

Solution: In July 2018, Peter and Robert Mansfield, based in Nottingham, England, founded Deep Branch Biotechnology to develop their solution of using of microbes to convert CO_2 directly from industrial emissions into high-value

products, specifically a totally novel, new type of high value single-cell protein animal feed, or SCP, called *Proton.*

Deep Branch's logo is "Transforming the polluters of today into the producers of Tomorrow."

The first sustainable protein product coming out of the company is Autotrofish, nutritionally tailored for aquaculture, making it a sustainable alternative to fishmeal. It is from single cell protein generated from captured emissions.

The company is also on developing single cell protein for monogastrics—that is, animals with single-chambered stomachs, like humans, , dogs and pigs, cats, horses and rabbits—and ruminants, which multi-chambered stomachs, such as cattle, antelopes, sheep and goats.

In July 2020, with financial support from the government in the form of £3 million funding from Innovate UK, Deep Branch set up REACT-FIRST to contribute to meeting the UK's Net Zero climate commitment as well as to the circular economy. It involves ten industry and academic partners, which all a commitment to tackling the global climate crisis and the goal of achieving neutral/negative carbon emissions.

The members of the REACT-FIRST consortium are: – the UK's largest single site renewable electricity generator and pioneer of Bioenergy with Carbon Capture and (BECCS); BioMar – one of the world's largest aquafeed producers; AB Agri – a global agri-food business and leading producer of monogastric feed; Sainsbury's – recognised as world's best sustainable seafood retailer in 2017; Scottish Aquaculture Innovation Centre (SAIC) - a network of 100+ key stakeholders from the aquaculture industry; Synthetic Biology Research Centre, University of Nottingham (SBRC Nottingham) – the world-leading gas fermentation research group; The Institute of Aquaculture, University of Stirling – the UK's leading aquaculture research centre; Nottingham University, School

of Animal Rural and Environmental Sciences – experts in assessing sustainable poultry production; and Innogen, University of Edinburgh – experts in value chain integration and responsible innovation. *(deepbranchbio.com)*

Robert Mansfield, Peter et al., "Hydrogen oxidising bacteria for production of single-cell protein and other food and feed ingredients," Engineering Biology IEE, May 4,2020

:PV-SÜD

Problem:

It would incredibly to equip the unused surfaces of the hundreds and thousands of highways and motorways with resistant solar panelled roads, subject to damage

Solution: The Austrian Institute of Technology, Martin Heinrich, supervisor of the solar module product team Fraunhofer Solar Energy Systems (ISE) in Germany (www.ise.fraunhofer.de), and Forster Industrietechnik in Switzerland with interest from the German Federal Ministry of Transport Switzerland's Federal Roads Office is to develop a solar canopy system. It is called the PV-SÜD initiative.

A trial demonstration section will be built in Southern Germany, including the 1-year testing at the section 20-40m from the exit and entrance, where they will not study the power generation volume, but also observe on water , snow and wind resistance, stability, and resistance to vehicle collision, since equipment maintenance and traffic security are the largest challenge subsequent to the completion of engineering.

Naturally, traffic safety is another unique concern, and efficient maintenance would be important to making it cost competitive. In addition to the double use of space, the scientists expect other positive outcomes, including the protection of road surfaces from precipitation and overheating. Such a system can also help reduce noise pollution.

The theory is basically attainable, as Germany has a 13,000km highway network, and if a standard 4- highway measures 24m in width is established with solar panels that are capable of 180W/m^2, the total solar capacity can reach to 56GW, which exceeds the accumulated installed capacity of 49GW in

Germany during 2019. Looking at the power consumption demand from Germany in 2019, the solar highway will satisfy 9% of power consumption in the country, equalling approximately 1/3 of household power consumption.

The Directorate-General for Public Works and Water Management is also considering to install solar panels on the A37 motorway in Drenthe that are expected to be 40km, and 3 km^2 (approx. 300 hectares) in total area. The solar panels will not be laid on the road, but on the refuge islands and enclosures between roads, and will arrive at 140MW in total installed capacity.

:Quantum computer

Problem:

Data centers are the most energy-intensive systems on the planet, representing approximately 10% of global electricity generation. China is home to the most energy-intensive supercomputer in the world, the Tianhe-2 in Guangzhou. This machine uses about 18 MWs of power, and is expected to be succeeded by the exascale Tianhe-3, which will further increase this extraordinary level of energy consumption. For reference, the average hydroelectric dam in the US produces approximately 36 MWs of power.

Solution:

Most quantum processors use cryogenic refrigerators to operate, and can reach about 15 millikelvin, which is colder interstellar space. At this low temperature, the processor is superconducting, which that it can conduct electricity with virtually no resistance.

As a result, this processor uses almost no power and generates almost no heat, so the power of a quantum computer, or the amount of energy it consumes, is just a fraction of a classical computer’s.

In 2019, IBM unveiled its first commercial quantum computer, the IBM Q System One, designed by UK-based Map Project Office and Universal Design Studio and manufactured by Goppion. *(ibm.com)*

Several months later, Google claimed that *Sycamore*, its quantum computer, which contains 54 superconducting quantum bits, or qubits, had performed a task in 200 seconds that the fastest supercomputer would taken 10,000 years to complete, in other words, it has attained quantum supremacy. While there was some quibbling over its achievement, but experts said it was a big moment. *(googleblog.com)*

Meanwhile in Canada, the British Columbia government invested US$2 million in Burnaby-based D-, through the province's Innovative Clean Energy fund, and Sustainable Technologies Development Canada the company US$10 million to continue developing quantum computers, on the that they could energy and help solve climate .*(dwavesys.com)*

In November 2019, IONQ partnered with Microsoft to create Azure Quantum, a full-, cloud ecosystem that will IONQ's quantum computers, based on trapped ions, commercially available via the cloud. IONQ has received US$55M from Samsung, Mubadala, Amazon and NEA and built the largest programmable quantum computer to .. *(ionq.com)*

In 2020, Honeywell announced that it had developed the world's fast quantum calculator, at least twice as powerful as existing computers from Google and IBM. The device, stored in a 140 m² secure warehouse in Boulder, Colorado, consists of a stainless steel chamber the size of a basketball, cooled by liquid helium to a temperature just above absolute zero (temperature at which atoms stop vibrating).

In this chamber, the ytterbium isolated atoms floating above the computer chip are targeted by lasers to perform calculations. Honeywell plans to multiply the volume of its quantum calculator by ten every year over the next five years, eventually reaching a quantum volume of 640,000, speeding up the research for solutions to global warming and virus vaccines.*(honeywell.com)*

In August 2020,Amazon Web Services (AWS) announced its quantum computing development environment Amazon Braket has entered general availability.The service acts as a testbed for quantum algorithms, allowing customers to build and troubleshoot their programs on simulated quantum computers that run on AWS resources. -tuned, businesses can then use Amazon Braket to run algorithms on a selection of quantum hardware based on different technologies, from companies including D-, IonQ and Rigetti.

Quantum computers also a vital part to play in 4IR (see entry). The White House Office of Science and Technology Policy has launched the National Quantum Coordination Office, while the US National Institute of Standards and Technology is investing US $400m over five years into a Quantum Information Science Research and Education Program.

"Future developments in high-performance scientific computing," *Ethics and Information Technology,*May 201 7; Mary K. Pratt, "Quantum information science continues to advance with federal efforts," *techtarget.com*, February 28, 2020.

:" for Water"

Problem:

Some planet-protecting solutions are unique marathon ambassadors which inspire others to find solutions.

Solutions:

In 2004, Raphaël Domjan of Lausanne, Switzerland had the idea of circumnavigating the world at speed in a boat uniquely powered by solar energy so as to demonstrate the potential of sustainable energy. Between 2010 and 2014, the 101ft (31m) MS *Tûranor PlanetSolar*, her deck covered by 5,780 ft² (537 meters²) of solar panels at 93 kW, she cruised at an average 7.5 knots (14 kph) around the of our Planet.

From 2015, having been transformed into a laboratory to present on board plastic waste-upcycling solution demonstrators, the renamed *for Water*, again embarked on a five-year program (2017-2021), serving as an as educational platform, itinerant laboratory and demonstration of support for the promotion of Clean-tech innovations.

These include her 25 hydrogen tanks at 350 bars, two 30 kW fuel cells of, two 5 kW electrolysers complete the 5,330 ft² (500 m²) of solar panels and the 4 li-ion batteries (754 kWh). The whole hydrogen system allows of 2800 kWh so gaining up to 6 days of autonomy, with a mass balance that is very advantageous: the hydrogen is 10 times lighter the in battery. *(raceforwater.org)*

Simon Bernard of Marseilles, former container and cruise liner merchant officer, having witnessed the extent of plastic pollution poisoning , ecosystems, and mankind, started up the Plastic Odyssey Expedition. The *Victor-Hensen*, an 80 ft (25 m) former oceanographic vessel has been refitted to use pyrolysis to convert salvaged plastic waste into 8 to 10 gallons (30 to 40 li.) of green fuel per hour.

From 2021 and for the next three years, *Plastic Odyssey* is circumnavigating the Planet to promote plastic recycling and reduction, sailing the most polluted coasts (Africa, South America, and South-East Asia) to build at each stopover small modular recycling plants that will meet different needs. *Plastic Odyssey* is sponsored by the Occitania Region in Provence, Clarins, Matmut, Crédit Agricole and Veolia. Simon Bernard and his team are developing low-tech and -source technologies to valorize plastic waste. Blueprints will be available online so that everyone can free access to them. *(plasticodyssey.com)*

In 2016, 23 students at Eindhoven University of Technology (TU/e), the Netherlands, an 80-day, 14,300 mi (23,000 km.) round-the-world journey on two self-built electric motorbikes.

They called their mounts STORM . They designed and built special li-ion battery packs giving a promising of 236 mi. (380 km.) between ; each

honeycomb-shaped modular pack comprised 24 separate cartridges shaped into the body of the motorcycle and lays on 28.5 kWh of energy. It was possible to a full battery pack within seven minutes.

Despite some minor setbacks, the team had taken it in turns to through 16 countries, visited 65 cities covering a total of close to 14,300 miles (23,000 km.) The publicity generated inspired others.

Between 2015 and 2016, the world watched while Bertrand Piccard and Borschberg of Switzerland flew around the world in *Solar Impulse 2.* With a length of 73.5 ft (22.4 m.) and a wingspan of 236 ft (71.9 m), and a weight of 5,000 lb (2,268 kg), the solar-electric airplane carried 17,248 monocrystalline silicon solar cells, 135µ and mounted on the wings, fuselage and horizontal tail .

They completed 23 days of flight and 26,744 mi. (43,041 km). Taking it in turns, they travelled in a 17-leg journey, with 4 continents, 3 seas, and 2 crossed, proving that clean technologies can achieve the impossible.

In November 2016, the Solar Impulse Foundation launched the World Alliance for Clean Technologies during COP22 at Marrakech, as a legacy to the first ever solar flight around the world. Its goal is to federate the main actors in the field of clean technologies, in to create synergies, promote profitable solutions to the world's most pressing environmental and health challenges, and give credible advice to governments.

With a of 1,000 solutions, by May 2020 the portfolio had reached 419 solutions, with 25 from the United States, all third-party validated for both profitability and environmental protection. *(solarimpulse.com)*

Between 2016 and 2019, Wiebe Wakker of the Netherlands across 33 countries, including Turkey, , India, Myanmar, Malaysia and Indonesia, with the determined by the offers he received on his website totalling 59,000 mi. (95,000 km.) in his electric Volkswagen Mark V Golf Wagon *The Blue Bandit.* On his arrival in Sydney, Australia, Wakker was escorted into Sydney by a fleet of nearly 50 electric vehicles. His event became worldwide news.

Although such vehicles can be criticised as expensive one-offs, they may inspire people to do their little bit.

Kevin Desmond, *Electric and Ships: A History* (Jefferson, NC: McFarland, 2017).

Kevin Desmond, *Electric Airplanes and : A History* (Jefferson, NC: McFarland, 2018)

Kevin Desmond, *Electric Motorcycles and Bicycyles: A History Including Scooters, Tricycles, Segways and Monocycles* (Jefferson, NC: McFarland, 2019).

Kevin Desmond, *Electric Buses: A History Including Minivans and Taxis* (Jefferson, NC: McFarland, 2019).

: to Zero.

Problem:

The urgent challenge of achieving carbon neutrality must be coordinated globally

Solution:

At the UNSG's Climate Action Summit 2019, Sebastián Piñera, President of Chile, launched " to Zero," a UNFCCC campaign to build momentum for a shift towards a decarbonised economy ahead of COP26 the UN Climate Conference scheduled in Glasgow in November, 2021.

To , 120 countries, 449 cities, 21 regions, 992 businesses, 38 of the biggest investors and 505 universities are collaborating to achieve net zero carbon emissions by 2050 at the latest. They include Business Ambition for 1.5C – Our Future, Carbon Neutrality Coalition, The Climate Pledge, World Economic Forum, World Business Council for Sustainable Development, and .

:Zero emission yacht

Problem:

Since the 1890s, sailing yachts nearly always had an auxiliary fossil fuel engine on board or outboard for moving when the sails were lowered and for generating electricity in the cabin.

Solution: In 2017, 29 sailing set off on the November 6, each of them with just one person aboard. They embarked on the Vendee Globe Challenge, a non-stop solo three month journey around the world. All of them had diesel generators on board, with one exception: Conrad Colman's boat *Foresight Natural Energy* used solely hydro, solar and wind energy.

Solar panels integrated on the mainsail and on the cockpit roof - provided by French company SolarClothSystem produced up to 350 watts, a hydro generator which generated power from the motion through the water - provided by Finnish Company Volt. The power was stored in li-ion batteries, provided by Dutch Company SuperB with capacity the equivalent of half a Tesla In this way all onboard electrical equipment was sustainable. Colman completed the circumnavigation.

Soon after, IMOCA (International Monohull Class Association) which manages the class of 60-foot (18.28 m.) monohulls, required members to support the No Plastic Challenge , a national campaign aims to fight against plastic pollution, encouraging everyone to cut the production and consumption of this non-biodegradable product.

Belonging to the IMOCA class, *Malizia II* is equipped with a one-design keel and mast (identical materials, forms and suppliers). With the Monaco Yacht

Club, the Malizia team launched a project entitled "My Challenge", aimed at "promoting the protection of the , the training of people and the scientific study of the seabed during navigations."

Malizia II is equipped with solar panels and underwater turbines to generate the electricity that feeds the instruments. navigation, the autopilot, watermakers and a laboratory to test the CO_2 level of the waters.

It seemed appropriate that when the world famous Swedish environmental activist Greta Thunberg chose to cross the Atlantic in a yacht rather an airplane and attend the UN climate summit in New York*, Malizia II* was chosen. Also on board were the skipper Hermann, Pierre Casiraghi, second son of Her Royal Highness the Princess of Hanover, vice-president of the Monaco Yacht Club, Svante Thunberg, the father of Greta Thunberg and the documentary film maker director Nathan Grossman.

A small gas stove to heat the water needed for freeze-dried vegan food was the consumer of fossil energy. The toilet was a blue plastic bucket with degradable bio bag that can be thrown overboard. The boat cast off on August 15 and arrived in New York.

After the summit, accompanied by her father, Greta travelled by and bus to the annual UN climate conference in Chile with stops in Canada, Mexico and other countries. *(team-malizia.com)*

During the 2020, Vendée Globe round the world , Hermann sailed *Malizia II* he carried an sensor onboard to monitor water temperature, carbon dioxide and pH levels in the Southern to gather data for scientists examining climate .

Another initiative has been by the The Zer°emission team sailing a modern TP52-class sailing boat in major events during 2019 and 2020. Together,

industrial technology company Wärtsilä and the Zer°emission team are to inspire sailors, , other organisations, and host cities to join the quest for cleaner . The joint goal was to awareness about sea pollution and offer a platform for discussion.

From prototypes, zero emission yachts should become the norm.

"The Whys and Watts of Conrad Colman 100% Natural Energy," *vendeeglobe.org*, October 29, 2016; "First major solo challenge for Malizia II- Yacht Club de Monaco," *yacht-club-monaco.mc,* November 2, 2018; "Wärtsilä supports Zer◦emission project in against sea pollution," *Wärtsilä Corporation News*, May 14, 2019.

:Radiative passive cooling system

Problem:

With the melting of Arctic ice and mountain glaciers which had previously reflected back solar heat and maintained global cooling, alternatives must be found, particularly for the air conditioning of buildings which traditionally use chemicals and electricity.

Solution:

Qiaoqiang Gan, Electrical Engineering Associate Professor at the University at Buffalo School of Engineering and Applied Sciences, with staff from Abdullah's Saudi Arabian University has developed an air conditioning system using a unique plastic on a roof that allows heat to pass back into the sky.

The ideal material for radiant cooling is such as a mirror or white paint. They will scatter or reflect most of the solar light. Therefore, the solar light will not heat the object. Then it's easier to cool it down. *Newtact* system, beyond simple white paint, consists of an inexpensive polymer/aluminium film that is installed inside a box at the bottom of a specially designed solar "shelter."

Taken together, the shelter-and-box system the engineers designed measures about 18 in. tall (45.72 cm), 10 in. (25. cm) wide and 10 in. (25.4 cm). As a

commercially viable alternative, the researchers fabricated their thermal emitter from polydimethylsiloxane (PDMS) and either silver or aluminium.

The PDMS film absorbs heat from the environment and then transmits the heat to cool down its surroundings. The metal reflects the solar light to prevent the transmission of sunlight to materials under the emitter, such as a roof. The film helps keep its surroundings cool by absorbing heat from the air inside the box and transmitting that energy into outer space. The shelter serves a dual purpose, helping to incoming sunlight, while also beaming thermal radiation emitted from the film into the sky.

Outdoor experiments performed in Buffalo, NY, to test the device provided cooling of up to 9 °C. To cool a building, numerous units of the system would need to be installed to cover its roof. *(kaust.edu.sa)*

America

 in Stanford University, Shanhui Fan, Eli A; Goldstein, and Aaswath Pattabhi also developed a flat rectangular metal covered in a sheet of the material: a high-tech film which reflects the light and heat of the sun so effectively that the temperature beneath the film can drop 5 to 10° C (9 to 18° F) lower the air around it.

A system of pipes behind the RC is exposed to that colder temperature, cooling the fluid inside before it is sent out to current-day refrigeration systems. efficient any vapour-compression based cooling system, the can also prevent the emissions of CO_2 and other harmful greenhouse gases. It can be roof-mounted as a simple add-on to new and existing cooling systems

To commercialise their innovation, Fan, Goldstein and started up a company, SkyCool Systems in Davis, California. As a pilot study, they installed an array of RC panels on the roof a supermarket as a subcooler and were pleased to observe a 10% to 15% efficiency improvement , although subcooling could be as much as 20°F (11°C) below the outlet of the condenser. Other studies followed….<<<

Lyu Zhou, Haomin , Jianwei , Matthew , Zhou, Edgars Stegenburgs, Nan , Chen Xu, Tien Ng, Zongfu Yu, Boon Ooi & Qiaoqiang Gan. “A polydimethylsiloxane-coated metal structure for all-day radiative cooling.” *Nature Sustainability*, 2019. Zhen Chen, Linxiao Zhu, Aaswath , Eli A. Goldstein, Shanhui Fan “Ultrahigh-performance radiative cooler” Patent number: 10508838 Leland Stanford Junior University December 2019.

:Rainforest protection by communities

Problem:

The research initiative Global Forest Watch found that since 2010, nearly 11 million acres of primary forest — the oldest, densest and most ecologically significant kind — been lost in the Congo to logging, agriculture, mining and oil drilling. That's roughly triple what was lost in the previous decade.

Solution:

Community forest management.

A community forest offers the local community value and benefits from the , access and rights to the forest resources, and participation in management decisions. ... Community forests are permanently protected and typically by a local government or community-based non-profit, such as a trust, often stemming rampant logging that has led to shortages of firewood and fodder.

Second to the Amazon, the Congo river spans six central African countries: Cameroon, the Central African Republic, the Democratic Republic of Congo, Gabon, Equatorial Guinea and the Republic of Congo. It is known as "Africa's " because it the world's second largest tropical forest. It covers an area of around 3 million square kilometres – almost the size of India.

In February 2016, the Democratic Republic of Congo (DRC) passed community forest legislation in what is arguably the most ground-breaking legal development related to Congo rainforests in recent years.

The DRC is home to the second largest and most intact area of contiguous rainforest in the world, and now over 75 million hectares of forest (three times the size of the UK) could be available to local communities, who can manage their natural resources according to their own customs and needs, so alleviateiing poverty, improving rural livelihoods and reducing deforestation in the Congo

To realise, a vibrant consortium of partners was created and led by the International Institute for Environment and Development (IIED). The

consortium included Client Earth, Fern, Forest Peoples Programme, Rainforest Foundation UK, Tropenbos International, and Well Grounded.

By 2020, 70 communities had been allocated a total of 3.5 million acres. The 300 people of Nkala, for example, received 12,000 acres in 2018 which would be closely monitored and documented for lesson learning and sharing of experiences

There a growing number of Community Forest programs including Peru (Nii Kaniti Amazon Forest) Kathmandu (Thokarpa Community Forest, Sindhupalchok), Golden in British Columbia, etc.

Raised-up Houses in Bangladesh

Problem:

Bangladesh's low elevation, high population density and inadequate infrastructure it exceptionally vulnerable to sea level , monsoons, storms, cyclones, drought, erosion, landslides, flooding and salinization which are already displacing numbers of people. Especially vulnerable are people living on the charlands –the banks lying in the rivers where floods wash away lands, houses and their vital assets.

Solution:

Raised wall or concrete plinths for houses.

The international relief cooperative is collaborating with Bangledesh to build new houses upon raised, -walled plinths to elevate them above flood level, with deeply embedded precast concrete columns for added strength. With the area also to cyclones, the roof and superstructure are designed to resist the high winds.

of concrete pillars and treated bamboo poles strengthened with metal tie rods to hold the wall firm and , since the year 2004, almost 120,000 such houses been constructed in clusters on raised to 60 centimetres above the highest known flood level so water cannot reach the plinth in normal floods.

Treated jute woven mat partitions increase durability. The structure, with woven bamboo walls, can be dismantled in the of a forecast severe flood, and moved

for re-erection on a new site or restoration after floodwaters subside Jute panels resilient walls that cost very little yet are and easy to replace. A staircase-like structure (*ghat*) around the cluster is developed. These *ghats* enable villagers to grow to prevent soil erosion and also to sow water vegetables and other crops

Major districts where the programme has been implemented are Kurigram, Tangail, Jamalpur, Rangpur, Lamonirhat, Sirajganj, Nilphamari, Bogra, Gaibandha and Pabna.

:Rammed earth building

Problem:

Within three years (2011-2014) China consumed cement the USA during the last century. Most of those people living now in concrete housing blocks were living in houses of natural materials. This happens all over the world. Alternatives are needed to reduce CO2 emissions.

At the age of 19 Anna Heringer lived in Bangladesh for almost a year, where she had the chance to learn from the NGO Dipshikha about sustainable development work.

In 2005, she tried to this philosophy into the field of architecture. Together with Eike Roswag and a team of Bangladeshi and German craftsmen, Heringer realized the Meti School in Rudrapur, Bangladesh, a community centre in Bangladesh designed by German architect Anna Heringer has won the second edition of the prestigious Obel Award.

Named *Anandaloy*, which place of deep joy in the local dialect, the building contains a therapy centre for people with disabilities on the ground floor with a women-led textile workshop above it.

Heringer used rammed earth, with mud from local ponds, for the structural elements. These include the walls and a that wraps around the building, which was designed to the community centre inclusive. Bamboo from a local forest was used to create a veranda around the building and for its ceilings and roof. The natural materials that at the end of the building's life it can decompose.

I`m not aiming for an eternal architecture, for buildings that are standing forever; this reality does not exist and we should admit it. I try to generate buildings that, one day, can go back into their natural site, if they are no needed.

A house built of earth can last for a time, if maintained and it can be turned into a garden

The building was named the second winner of the Obel Award, which is presented annually by the Henrik Obel Foundation to honour "recent and outstanding architectural contributions to human development all over the world".

There are other locally sourced rammed earth homes. “Adanado” in the San Luis Valley of southern Colorado designed and built by Johanna Barrett and her husband Sid. Located at an altitude of 7,600 feet in one of the highest alpine valleys in the world, Barrett's rammed earth home is entirely off-grid. It is 100 % powered by solar panels. And, even though winter temperatures can plunge to 50 degrees below zero, an evacuated tube solar hot water collector system heats their hot water.

:Recycling old clothes

Problem:

The second dirtiest industry after oil, the fashion sector whose production often exploits workers operating in inhumane conditions in Asia, and which has a high price tag for the planet when it comes to discarding these garments, destined for dumping or burning.

Solution:

Recycling old clothes and

Since the mid-19th century and particularly since World War II, , in Tuscany, Italy built its on *cenciaolis* or recycling used clothes into “regenerated carded wool”, a longstanding circular economy solution which puts recycling and saving of dyes and of water first

With woollen arriving in compressed into bales from all over the world, around 7,000 small textile businesses are each specialising in one part of the textile manufacturing process whether it’s spinning, warping, weaving, dyeing, finishing, printing, or designing.

Every six months the companies develop 2,000 new yarns, 60,000 new textile designs and hundreds of new fabric collections. Zara, H&M, Banana Republic and Armani are some of those businesses that used recycled fabrics from in its collections.

For example, Comistra, a 100-year-old company, by Fabrizio and Cinzia Tesi produces fabrics containing 90 percent recycled textiles. 2018, Tesi also started making clothes in collaboration with the Brunelleschi Institute of Art, based on the principles of eco-design. These garments are designed to be easily repaired and regenerated, with cotton seams, non- colors and natural fabrics, and without thermo adhesives or synthetic materials, which can compromise recycling.

Tesi is also president of A.S.T.R.I, the Italian Association of Recycled Textiles, founded in 2018 to promote Italian excellence and Prato's nearly two centuries of transforming textile waste, especially wool, into resources These include the Valfilo spinning mill, which produces carded yarn from recycled materials; the Intespra wool mill, which manufactures fabrics; the Manifattura Maiano, which processes textile waste to obtain insulation for sustainable construction; and startups such as Rifò, founded last year by Niccolò Cipriani, producing scarves and hats from recycled wool.

With this industry requiring around 93 billion cubic metres of water a year, since1981, has come up with a secondary innovative solution in for its waste water purification: Through its 5 different biological plants, including an incineration plant and a photovoltaic system for its biggest plant, GIDA (= Gestione impianti di depurazione acque) manages all the wastewater from both industry and the public including the harnessing of the energy potential of sludge resulting from treatment, and finally This amounts to up to 50 million cubic metres of liquid a year, or the equivalent of 20 000 Olympic swimming pools. Approximately 11% of it goes back to the textile industry through the industrial water aqueduct. At the time the benefit is substantial: 4.5 million cubic metres remain in the natural water system.

:Enzyme-based recyclable plastic

Problem: Current plastics recycling processes are primarily thermo-mechanical which limits their recyclability.

Solution:

In 2012, - Desrousseaux, a researcher in specialized enzyme technology, brought together a team including Alain Marty of the French National Institute for Agricultural Research (INRA) to investigate using enzymatic technologies for the recovery of plastic waste.

Research in this area was influenced by the Tomorrow'sy in 2016 of plastic-eating bugs at a Japanese dump. The bacterium had naturally evolved to eat plastic, and scientists worked to identify the key enzyme which existed in the bacterium, allowing it to break down plastic.

Within the framework of the Thanaplast consortium, they innovated an enzymatic technology enabling the specific de-polymerization of a single polymer (e.g. PET) contained in the various plastics to be recycled. The PET is placed in a bioreactor, where water and enzymes are added to the waste, which is then heated and churned. At the end of this , the monomer or monomers resulting from the de-polymerization process are purified, with the objective to re-polymerize them, thus enabling a recycling process to infinity.

A company called Carbios was set up at the Biopôle Clermont-Limagne ("Chemical Valley") in Saint-Beauzire in the Puy-de-Dôme department in Auvergne in central . In February 2019, after nine years' R&D in collaboration with Toulouse Biotechnology Institute (TBI), Carbios achieved a world first by converting PET plastic waste into its constituents at 98% in just 10 hours; a technology applicable to all kinds of PET bottles (clear, colored, opaque, complex).

32 patents were taken out worldwide, 13 of which are related to the bio-recycling technology. Carbios created the Carbiolice joint venture, in partnership with Limagrain Céréales Ingrédients and the SPI fund operated by Bpifrance. This company will produce the enzymatic .

In 2019, Carbolice was awarded the EuropaBio Prize for innovation. L'Oréal, the world's largest cosmetics company and Carbios signed an agreement to jointly found a consortium for the bio-recycling of plastic on industrial scale. An industrial demonstrator at Saint-Fons, south of Lyon, was scheduled to go into operation in 2021.

By 2025, L'Oreal is planning that 50% of the plastic used in their packaging will be recycled or bio-sourced. Nestlé Waters, Pepsico and Suntory Europe (-Schweppes) joined a consortium with Carbios. *(carbios.fr)*

By linking two separate enzymes, scientists at the University of Portsmouth, UK engineered a new super-enzyme which gets to work six times faster, with the capacity to allow mixed-fabric clothing to be recycled.

Sophie Duquesne, Alain Marty et al, "Developing cellulolytic Yarrowia lipolytica as a platform for the production of valuable products in consolidated bioprocessing of cellulose," May 2018; V. Tournier et al, "An engineered PET-depolymerase to break down and recycle plastic bottles", *Nature* 580, pages216–219 (2020).

: Recycling stands for disposable paper cups

Problem:

Each year, some 2.5 billion single use cups are thrown away in the UK. Of these 7 million coffees are sold in paper cups in the UK every single day which works out at 5,000 every minute.

Solution:

Recycling stands for disposable paper cups

Based in Leeds, West Yorkshire, Waste & Recycling started in November 2010. The company was started by Harvey and Fraser Mills with the aim to offer a competitive and flexible waste management service with an emphasis on making recycling easy.

Initially in partnership with Co2 Sense, the company received EU funding to help purchase our first vehicle and we continued to grow ever since.

Following further investment in 2013, currently operate a fleet of specialist collection vehicles. They use the latest logistics packages and waste management software to ensure all vehicles are run as efficiently as possible.

At the LNER (London North Eastern Railways) stations such as York to it easier for customers to recycle their cups, innovated a simple recycling stand. gathered by Recycling for and baling, the cups are transported to a specialist paperille where the polythene liner is stripped from the outside paper fibres which then both are upcycled.

:Recycling workshops

Problem :

One can no over-consume raw materials

Solution :

Recycling workshops

There are currently 90 “recycleries” recycling centers in . An organizing entity which sets up a collection of reusable materials, then provides for their “upclcyling”, or in other words , repair, transformation and resale, these structures generally combine a professional integration component with their activity, as well as a public awareness component and promotion of re-employment.

One of these "La Matière" was founded in 2014 by Julien Duranceau and Pierre-Hugo Barbançon in in Périgny near La Rochelle, western . They collect different materials (wood, leather, advertising tarpaulins, sheets, paint, ...) in different forms (scrap, scraps, remains, downgraded, old furniture, ...) from individuals, local companies (eg: TEKABOIS, manufacturer and importer of wood) or public structures (eg CYCLAD, mixed union in of waste management in the north-east of Charente-Maritime).

Part of this material is reused in the manufacture of products and space planning, and can also be sold by weight in their Périgny workshop to members of their association (individuals or professionals). Nothing is lost, everything can be recreated and everything is transformed.

The team at "La Matière" helps people to design and manufacture a piece of furniture. But they can also be or less do-it-yourselfers, the right tools or not and their will then be simply to provide them with the advice, materials or tools they need. But Duranceau and Barbançon also work with organizations - associations, communities, companies - which call on the to design a project or a space.

Potato peel and beer transformed into fertilizer

Problem:

Potato peel and brewery sediment usually end up as waste.

Solution:

Peter J. Hammond and a team at CCm in Oxford with the Viridor Technology Centre in Somerset developed a technology which, taking CO_2 captured from beer fermentation in a brewery, is then mixed with potato waste and turned into a fertiliser formula developed after years of agricultural trials at the Royal Agricultural University & Velcourt.

Creating fertiliser normally produces high CO2 emissions. PepsiCo- Walkers Crisps firm by setting up the CCm anaerobic digester, which feeds potato waste to bacteria to produce useful methane technology at its Leicester factory will slash CO_2 emissions from its manufacturing process by 70%. The resulting fertilizer will then be spread on UK fields to feed the following year's potato

crop, starting in 2022. In short, 6,500 tonnes of waste anaerobic digestate can be converted into approx. 13,000 tonnes of high- compound fertiliser

The CCm technology falls into the industrial category of Carbon Capture and (CCU) as opposed to CCS Carbon Capture and .

:Recreational power plant

Problem:

Proximity to power plants isn't typically a selling point for neighbourhoods,

Solution:

Recreational power plant

With Copenhagen's commitment to carbon-neutral by 2025, the team of architects and engineers at Bjarke Ingels Group has completed the "cleanest waste-to-energy power plant in the world" Their design for the 41,0000-square-metre plant won an international competition in 2011, with the building breaking ground two years later and the power station officially online in March 2017

CopenHill, also known as Resource Centre, replaces a 50-year old waste-to-energy plant with one that incinerates trash, then uses catalytic filtration to remove pollutants from the resulting smoke. It converts 440,000 tons of garbage annually enough to provide over 30,000 homes with electricity and 72,000 homes with heating in an area spread across five municipalities including Copenhagen.

But this is not all. CopenHill, "the epicentre for mountain sport, comprises an artificial ski slope that is all year round. Operated in partnership with Snowminds Ski School, a glass elevator ferries skiers and snowboards to the top; and at 85 m the world's tallest climbing wall, designed by walltopia; and a 490-metre- hiking and running trail within a rooftop bar and a "lush" garden.

a month CopneHill a new freestyle event Friday Night Freestyle. Everyone is welcome - skiers, snowboarders, rookies and pros! The event starts at 5pm where there will be a freestyle session on the slope. The Middelgrunden wind farm can be seen in the distance.

This "garden" is designed by collaborators SLA Architects, and is hoped to created a "vibrant green pocket" in the city for birds, bees and flowers, while absorbing heat, remove harmful air particles and minimise storm water runoff.

Due to its location on the industrial waterfront of CopenHill is also the ground level site for the site for extreme sports from wakeboarding to go-kart

It is hoped the building will help Copenhagen meet its goal of becoming the world's first carbon-neutral city by 2025.

Riccardo Bianchini,"Genius or Gimmick? Bjarke Ingels' ski-slope-topped power station in Copenhagen", inexhibit, October30th 2019

:Reforestation sponsored by search engine

Problem: Reforestation money.

Solution: With the 50th anniversary of Earth Day fast approaching in 2020, Earth Day Network is launching a series of major campaigns to catalyze and channel global collaboration for the health of our planet, Trees for the Earth was the first of these campaigns.

Launched in 2016, its goal is to plant 7.8 billion trees worldwide by 2021, one for every person projected to be on Earth. This could cut carbon dioxide in the atmosphere by up to 25 %, to levels last seen almost a century ago.

Ecosia, a popular internet search engine has brought in enough revenues to enable it to plant 70 million trees. This equates to the removal of 2.5 million tonnes of CO_2 from the atmosphere.

The search engine is planting a tree every second in Kenya, Brazil, Indonesia, Spain, Tanzania, Madagascar, Colombia, Peru, Senegal, Burkina Faso, Haiti,

Morocco, Ethiopia, Uganda, and Nicaragua with the profits it makes from advertisements on its search engine.

Ecosia has partnered with , Microsoft's search engine, to get results for users, but receives a majority portion of any revenues. After covering its internal , everything left goes towards planting trees; Ecosia, founded by Christian Kroll, is a non-profit organization.

The startup, which began operations in 2009, has grown exponentially, with people using Ecosia in 183 countries, but particularly in its home country of Germany. As consumer concern about climate increases, the company is on track to reach 100 million trees planted by the end of 2019, thanks to its users. It is targeting planting one trillion trees, equivalent to 10% of the world's annual military spending. *(ecosia.org)*

: Refrigeration trucks, solar-powered

Problem:

The transporting of tons of food to local supermarkets are normally cooled by diesel fuel. Idling diesel tractors burn about a gallon of fuel every hour while releasing more than 22 pounds of carbon dioxide into the atmosphere. Approximately 50,000 new diesel-powered refrigerated trailers are sold annually in the U.S.A.

Solution:

Solar-powered refrigeration trucks.

In July 2021 XL Fleet Corp. announced a battery and power electronics development and supply agreement and an investment in eNow, Inc.of Providence, Rhode Island, a provider of solar and battery power systems including lift gates, in-cab air conditioning, refrigeration and lighting to enable

fully-electric Transport Refrigeration Units (eTRUs) for Class 8 commercial trailers.

XL Fleet is supplying battery and power electronics systems for the first 1,000 units of eNow's new electrified refrigerated trailer solutions, as innovated by Robert W. Doane, also respected for his solar solutions on trucks, trailers, and trains to supplement electrical energy and reduce reliance on fossil fuels.

Primary applications are for medium and heavy-duty trucks, commercial buses, school buses, and emergency vehicles. Power needs for these vehicles include HVAC and hotel loads, liftgates, refrigeration, telematics, and emergency lighting. eNow solar system sizes range from 25-watts (for telematics, security, and safety systems) to 6,000 watts (for eNow solar-electric trailer refrigeration systems).

:Regolith aka Moon rock

Problem:

For four decades, human space exploration has been limited to missions to the International Space Station, an orbiting outpost about 220 miles above Earth. The focus in the coming years will be on building a new station in orbit around the moon that will serve as a stopping point for humans to establish a presence on the lunar surface, and possibly as a from which to launch outward can mars.

Solution: Regolith or moon rock.

In the 1990s, Derek , Tom Farthing and Chen at the Univesity of Cambridge developed and patented a technology for reducing metal oxide to metalin a molten salt. It became known as the -Farthing-Chen (FFC) Process

Thirty years later, Beth Lomax at the School of Chemistry of the University of Glasgow, Scotland has developed a method of extracting and metallic powders such as aluminium and from regolith or moon rock, ie "lunar in-situ resource utilisation (ISRU)". Samples returned from the lunar surface confirm that lunar regolith is up of 40-45 % by weight, its single most abundant element.

Using the lunar regolith simulant JSC-2A, Lomax tested the low temperature/ low energy electrolysis developed by start-up called Metalysis, based in Rotherham, England to commercialise the process. An initial proof of concept

study on regolith-like material resulted in a metallic powder and . 96% of the was successfully extracted, alongside the mixed metal alloy product for in-situ manufacturing. The method reportedly requires inexpensive components and generates no by-products. Funding is by the European Space Agency.

At Metalysis, produced by the process was an unwanted by-product and is instead released as carbon dioxide and carbon monoxide, which the reactors were not designed to withstand gas itself.

So iin 2020, a prototype plant has been set up in the Materials and Electrical Components Laboratory of the European Space Research and Technology Centre, , based in Noordwijk in the Netherlands where becomes available to measure

If the process works well enough, it will the way for extraction facilities on the moon that will produce and valuable materials on the surface instead of having to transport them to space at enormous expense. The could be used as propellant or life support on space missions, while the mixed metal alloy could be used for manufacturing on the lunar surface.

The ultimate aim would be to design a 'pilot plant' that could operate sustainably on the Moon, with the first technology demonstration targeted for the mid-2020s. The project, dubbed "a gas station on the moon", would enable travel beyond to Mars and other destinations.

Restoration Hydro Turbine

Problem:

Hydroelectric turbines are used to produce renewable energy, but they come with risks to wildlife, particularly salmon and other fish that need to use the waterways. The fish can get sucking into the spinning blades of the turbines. To prevent this typically requires the turbines to have much larger, widely-spaced blades – which is more expensive to build and generally can't be used in smaller dams.

Solution:

Restoration Hydro Turbines

Developed by Abraham D Schneider and his sister Gia of Natel Energy, Alameda, California, the Restoration Hydro Turbine (RHT) has an inner

diameter of only 1 to 3 metres and uses fish-friendly blades with a blunt, slanting edge. The design deflects the fish around the blades, reducing direct strike impacts. They also do not require the use of fish-proof screens, which can slow the flow of water and reduce the effectiveness of the turbines.

RHTs can be installed in a range of settings, including retrofits of existing small hydro plants (for low-cost compliance with environmental requirements or to improve output of old units), at existing non-power dams, in irrigation canals, on dam removal projects combined with new hydro, and in run-of-river new stream reach developments.

The blades are optimized for low head—between 2 meters (m) and 10 m (about 6.5 ft to 33 ft)—eliminating the need for fine fish screens, thus increasing total plant efficiency while reducing both upfront, and operations and maintenance costs. The thick, slanted blades deflect fish

3. Rainbow trout were

In a recent test of the new turbines, scientists found that a group of 60 rainbow trout, tagged and equipped with self-inflating balloons and miniature radio transponders to enable recapture after passing through hydro turbines during testing, all made it safely through the turbines alive and uninjured. making them useful in different settings.

Natel’s fish-friendly turbines are just one of a number of innovations designed to make renewable energy easier and safer for people and animals.

:Religion

Problem:

According to the Pew Research Center's 2012 global study of 230 countries and territories, 84% of the world's population are affiliated with a religion. Some believe that as prophesies in holy scriptures predicted the end time, they are powerless and so do nothing.

Solution:

Alongside atheists, people a religious belief that they a vital part to play in protecting our Planet.

In 2007, when Indonesia hosted the annual UN Climate Summit in Bali, ten Indonesian religious leaders from six religious groups presented an interfaith statement on the responsibility of religious groups to address climate . In 2014, Indonesia's top Islamic clerical body the Ulema Council issued a religious fatwa against the illegal hunting and in endangered animals in the country, which the WWF hailed as the world's first. The country of 250 million people is the world's most populous Muslim nation.

In September 2012 Ecumenical Patriarch Bartholomew I of Constantinople, the spiritual leader of the world's Orthodox Christians published a strongly worded encyclical calling on all Orthodox Christians to repent "for our sinfulness" in not enough to protect the Planet. Biodiversity, "the work of divine wisdom," was not to humanity to abuse it, he ; human dominion over the earth does not the right to greedily acquire and destroy its resources.

He singled out "the powerful of this world," saying they need a new mind-set to stop destroying the planet for profit or short-term interest. Bartholomew's seat, established 1,700 years ago, holds primacy the world's 300 million Orthodox Christians.

Two years later, in 2015, Pope Francis, the head of the Catholic Church and sovereign of the Vatican City State published his Laudato si' (Italian "Praise Be To You"): the encyclical has the subtitle "one for our common home". In it, the pope critiques consumerism and irresponsible development, laments environmental degradation and AGW, and calls all people of the world to "swift and unified global action."

The title of the social encyclical is an Umbrian phrase from Saint Francis of Assisi's 13th-century "Canticle of the Sun" (also called the Canticle of the

Creatures), a poem and prayer in which God is praised for the creation of the different creatures and aspects of the Earth. Speaking at the press conference were Turkson, Schellnhuber, and John Zizioulas (the metropolitan of Pergamon, representing the Orthodox Church).

The Vatican then released the document in Italian, German, English, Spanish, French, Polish, Portuguese and Arabic, alongside the original Latin. The encyclical would been communicated to the estimated 1.2 billion Catholics in the world, according to Vatican figures.

Three days before the encyclical was released, the 14th Dalai Lama issued a Twitter message stating: "Since climate and the global economy now affect us all, we to develop a sense of the oneness of humanity." The Dalai Lama is a spiritual head in the Buddhist religion, practiced by an estimated 535 million in the world.

Two days before the encyclical was released, Archbishop of Canterbury Justin Welby, head of the Anglican Communion, issued a "Green Declaration" (also signed by the Methodist Conference as well as representatives of the Catholic Church in England and Wales and the British Muslim, Sikh and Jewish communities) urging a transition to a low-carbon economy and fasting and prayer for success at the December 2015 United Nations Climate Conference in Paris.

In March 2020, The Church of England's Synod voted to achieve year-on-year carbon reductions, pulling their zero emission back from 2045 to 2030.

In August 2015, the Islamic Climate Symposium adopted the Islamic Declaration on Global Climate . Current estimates put the number of Muslims in the world at around 1.8 billion. Hundreds of Qur'an verses support the protection of the environment. Islamic organizations promote the relation between Islam and sustainability.

Islam also approaches the environment from a stewardship perspective. The earth is God’s creation, and as humans, we been entrusted to preserve it as we found. The responsibility of humanity is to protect and ensure the unity (Tawheed) of the God’s creation. Moreover, Islam prohibits the excessive consumption of resources the planet provides to the humanity. Qur’an mentions wasteful consumption (Isrāf) as the thirty-second greatest sin.

As of 2018, the world's Jewish Population, those identifying as Jews above all else, was 14.6 million. Jewish tradition teaches us to for our planet in to preserve that which God has created. Psalm 24 notes, "The earth is the Lord's and the fullness thereof," a dramatic assertion of God's ownership of the . It follows, then, that any act that damages our earth is an offense against the property of God. The Jewish concept of *bal tashchit*, "do not destroy," forbids needless destruction.

According to an internet survey, Hinduism has over 1.08 billion adherents worldwide Hinduism is a religion deeply rooted in nature. The sacred text (Vedas, Upanishads, Bhagavad Gita, Epics) has references of divinity related to nature, such as rivers, mountains, trees, animals, and the earth. To protect them, Hinduism encourages environmental protection and there are organizations who promote sustainable development and support the protection of the environment through awareness campaigns and actions.

Marlise Simons, “Orthodox Leader Deepens Progressive Stance on Environment,” *The New York Times*, December 3, 2012; Jim Yardley and Laurie Goodstein, "Pope Francis, in Sweeping Encyclical, Calls for Swift Action on Climate ," *The New York Times*, 18, 2015; Steve Doughty, “Greener thou! Welby trumps Pope in climate crusade by releasing statement on issue saying it has hurt the poor of the world,” *The Daily Mail*, 17, 2015.

Repair robot for wind turbines

Problem:

As the offshore wind industry enters a rapid phase of growth, with hundreds and thousands of units operating on and offshore, with faster tip speeds and sea

conditions combining to create significant damage to blades over time, the challenges to keeping turbines spinning and optimised grow with it.

Solution:

A maintenance robot capable of inspecting wind turbine blades for cracks and other damage, transmitting the data back to shore and resurfacing the blades.

In 2014, whilst as a turbine blade engineer, Chris Cieslak, became convinced that advanced could transform operations at offshore wind farms, reducing and maximising asset lifetimes. By 2017 Cieslak had developed a six-legged version of the robot, capable of adapting to various forms for grip and movement. He called it BladeBUG.

In 2019 BladeBUG was awarded further funding from Innovate UK for the next phase of Technologies for Extreme and Challenging Environments

In October 2020, the BladeBUG robot was tested in real-world conditions, having previously been demonstrated on the vertical training tower at ORE Catapult’s National Renewable Energy Centre in Blyth. The walk has proven the six-legged robot's ability to carry out lengthy deployments.

The demonstration saw the robot a 50-metre walk on a vertically-positioned blade of a 7WM offshore wind turbine at Levenmouth. The trial showed the BladeBUG's 'perfect' vacuum-packed feet adherence to the turbine blades in offshore conditions, as well as its ability to navigate the curves of the blade, and transmit blade scans and a video feed to the technicians onshore.

BladeBUG is said to represent cost reductions of as much as 30% on lifetime blade maintenance undertaken by -access technicians. ORE Catapult has forecasted that for next-generation turbines, these savings could reach up to 50%.

BladeBUG is a key part of the £4.2 million (€4.68 million) MIMRee project, the goal of which is to develop a fully autonomous inspect-and-repair system for offshore wind farms. The robot will work together with an autonomous vessel and a team of , using a arm to clean and resurface damaged blades. The final MIMRee tech trials are scheduled to place in mid-2021.

:Resurrection plants

Problem:

Drought is the greatest threat to world agriculture. Due to global warming, increased and extended droughts are predicted in Africa (*inter alia*), presenting a threat to food security. Current crops do not tolerate much water loss, survival contingent on mechanisms that retain water (technically drought resistance) which fail under severe drought

Solution:

Resurrection plants (RPs)

Jill M. Farrant, a professor of molecular and cell biology at the Plant Strees Lab of the University of Town (UCT) in South Africa, researches the remarkable (and little known) world of resurrection plants. These are plants that can survive extreme drought, “resurrecting” when moistened or irrigated.

For her researches in the field of plant responses to water deficit stress (drought/desiccation tolerance), involving multiple genes, the products of which interact in complex ways to facilitate subcellular and thus tissue survival of water deficit, Farrant received international recognition for her research. She was the African/ States recipient of the 2012 L'Oreal-UNESCO Award for Women in Science. She has published 216 articles on the subject.

Farrant investigated the potential of turning *eragrostis tef*, an annual , into just such a crop. Eragrostis tef seeds are a high-protein staple food in Ethiopia, and it is closely related to a drought-resistant resurrection .

Her recent research, with colleague Bentley, has been into the resurrection plant *Myrothamnus flabellifolia* is distributed throughout southern Africa and is vicariantly separated between arid Namibia and the comparatively South Africa where it is subjected to contrasting climate regime.

Its leaves and stems are commonly used as tea and spices. Leaves can used to lotion. is used by traditional village medicine men in Africa. Its uses include the

treatment of: coughs, influenza, mastitis, backache, kidney disorders, hemorrhoids, and abdominal pains.

Farrant and Bentley's findings suggest that -term, rather short-term, environmental conditions warrant -scale reprogramming of the metabolome in M. flabellifolia, and that the climate conditions in the arid region of the species' necessitate the production of particular phenolic metabolites

According to Farrant, "In the way that humans bred plant species together over the centuries to create , maize and wheat, so too can we breed desiccation-tolerant, drought-resistant crops. Resurrection plants may be a solution for a small amount of crops that are to help with food security. People are thinking about aeroponics, hydroponics, eating insects, eating all sorts of other foods.

:Retrofitting vehicles to electric propulsion

Problem:

According to Oliver Wyman of Lux Research electric vehicles are 45% expensive to build their internal combustion engined equivalents.

Solution:

During the 1980s, individuals retrofitted their gasoline automobiles to electric propulsion despite held back by batteries with feeble autonomy. In 1966, Daniel Theobald Cambridge, Massachusetts bought a 1966 VW camper off Craigslist, converted it to electric power in an afternoon and started re-engineering the vehicle for solar power.

them was Holmquist of Errington, a small Vancouver Island community in British Columbia, Canada. In 1995 Holmquist set up Canadian Electric Vehicles (CEV) with the initial focus to provide the designs and parts for converting gas vehicles to non-polluting electric.

In 2000 Canadian Electric Vehicles was approached by Los Angeles airport to design and build an electric powered aircraft refueling truck. Over 70 of these three ton trucks been converted and are in use at airports in in US, Dubai, Puerto Rico, Australia and in 2009 England. In 2012, CEV innovated a kit to

convert Ford fleet vehicles to electric which was received by both municipal and private fleet operators in BC.

Today, across the border, there are some thirteen Electric Vehicle Conversion Companies

Across the Atlantic, in Newton, mid-Wales, Richard “Moggy” and Graham Swann e-retrofit models from the 1960s or 1970s including the iconic VW Beetle and its derivatives

Since 1954, it had been impossible to a car engine in , even to put an electric, batteries and thus drive every day with much less pollution. But on April 6th 2020, the French government published a ministerial decree that creates a legal framework for electric car conversions. ICE cars, buses, and trucks over five years old, and two and three-wheelers over three years old can now be retrofitted with an electric powertrain

This was largely due to lobbying by Retrofuture of Paris, who “electrified” such vehicles an Austin Mini, a Peugeot 504 or a Jaguar XJ. With batteries today, but with hydrogen tomorrow, Marc Tison and Arnaud Pigounides are accompanying the revolution in ecological and economic mobility.

Reusable PPE

Problem:

According to figures from the World Health Organization (WHO) in the first six months of the COVID-19 pandemic, 400 thousand tons of medical waste were produced. Many hundreds of intensive care teams have been using as many as four Personal Protective Equipment PPE gowns per day, all of which end up in landfills, incinerators and waterways.

Solution:

In 2020, Tamara Chayo Romo, a Chemical Engineering student at the Faculty of Chemical Sciences, La Salle University, Mexico, Alix Pérez Saavedra from the Bachelor of Communication Sciences at the Mexican Faculty of Architecture, Design and Communication (FAMADYC), Natalia Orozco Fernández from Universidad Panamericana Guadalajara, and Ana Fernanda Villarreal Molín from Tecnológico de Monterrey developed a sustainable suit to protect health

professionals treating COVID-19 patients at a time when PPE was in short supply.

MEDU's 83% Cotton 17% Polyurethane PPE, is made of a fabric that has not been used in the health sector, but is often used in the coating of bacteriological and viral research laboratories. It can be worn all day and washed 50 times without losing its protective properties — meaning each garment saves 200 plastic items from landfills and incinerators. MEDU's garments are embedded with QR monitoring technology which informs health workers, via a smartphone app, how many times an item has been machine-washed. After 50 wears, the PPE is returned to MEDU which disinfects it and converts it into cotton scrubs and bags for packaging its products. Such reusable medical apparel could slash hospital PPE spending by 90%.

The MEDU project became one of the finalists in the 2020 edition of the Santander Award for Business Innovation 2020, in the Prototype category, chosen from more than 1,200 projects. , which encourages young entrepreneurs from all over Mexico. In addition, the project could be presented at the United Nations Climate Change Conference in 2021.

REV

Kjell Røkke, a Norwegian billionaire businessman who became a billionaire from oil and over-fishing, has another solution. In 2017, he created REV to ensure 'One Healthy ' and commissioned a ship of the . At 183 metres (600 ft) in length and at 17,440 gross tons, she is the longest motor yacht in the world. Her TIER III hybrid propulsion allows a full-electric mode at eleven knots when required. Her total operating is 21,000 nautical miles.

Apart from research labs, sonar systems, and a remote-operated robot capable of diving to depths of up to 20,000 feet to plot garbage patches, assess fish and test water acidity levels, *REV* is also fitted with booms which, encountering a garbage patch, can scoop up to 5 tons a day of plastic which a hi-tech incinerator melts down and converts into thermal power for the ship's systems

:Reverse fuel cell

Solution:

A University of Toronto engineering team, headed by Professor Ted Sargent, announced the development of an electrolyzer that can valuable chemicals from captured CO_2 and clean electricity at 10 times the speed of existing electrolyzers.

The device is similar to a fuel cell except running in reverse. In a fuel cell, hydrogen and combine on the surface of a catalyst, releasing electrons. In the electrolyzer, the electricity drives the reaction, transforming the hydrogen ions in water and CO_2 into another carbon-based molecule like ethylene.

The U of T research team' electrolyzer design speeds up the process by pairing a copper-based catalyst composed of small particles embedded in a layer of Nafion, an ion-conducing polymer commonly used in fuel cells.

In their experiments, they Tomorrow'sed that a certain arrangement of Nafion can facilitate the transport of gases such as CO_2. The next step will be to the catalyst's durability so it lasts for thousands of hours rather its current 10 hour lifespan. In addition, team members will also work on optimizing the system to product other carbon-based products like ethanol.

Tyler Irving, "Reverse fuel cell" converts waste carbon to valuable products at record ," *University of Toronto Engineering News*, February 6, 2020.

:Reversible pumped systems

Solution:

A reversible pumped hydroelectric power plant works like an enormous rechargeable battery. Its reversible turbines use cheap electricity during the night to pump water to an upper reservoir, in readiness for charging the turbines to meet peak demand the following day.

There are nearly 300 pumped projects in the world, and 40 in the United States.

The first use of pumped- in the United States was in 1930 by the Connecticut Electric and Power Company, using the 11 mi (17.7 km) Candlewood , a reservoir located near New Milford, Connecticut, pumping water from the Housatonic River to the reservoir 230 ft. (70 m) above.

Its Chief Engineer, Paul Heslop described his design "The statement that a hydro-electric plant can pump its own water supply sounds absurd on the of it, yet this is virtually what happens in the of our the Rocky River Hydro Plant. " The technology pioneered at the Rocky River project using reversible pumps that also act as generators was not widely used in other U.S. projects until the 1950s and 1960s.

Another RPSS, the Cruachan Power Station, located in Argyll and Bute, Scotland which takes water between Cruachan Reservoir to Loch Awe, a height difference of 1,299 ft (396 m.) has a capacity of 7.1 GWh. It was the brainchild of Sir Edward McColl, a Dumbarton- engineer and pioneer of hydro power while the civil engineering design of the scheme was carried out by James Williamson & Partners of Glasgow, and the main project contractors were William Tawse of Aberdeen and Edmund Nuttall of Camberley. Consulting electrical engineers were Merz & McLellan of Newcastle on .

Construction began in 1959 to coincide with the Hunterston A nuclear power station in Ayrshire. models of the turbines were built and work tests were carried out on completed alternators before delivered to the site. At the peak of

the construction, there were around 4,000 people on the project. It was opened Queen Elizabeth II on 15 October 1965 and is in service.

Over in the USA, the Bath County Pumped Station was built for the Virginia Electric and Power Company (VEPCO) between March 1977 and December 1985 The station consists of two reservoirs separated by about 1,260 ft. (380 m) in elevation. It is the largest pumped- power station in the world with a maximum generation capacity of 3,003 MW, when all six generators are operating at full power. National Public called the station "The World's Biggest Battery."

Pumped hydroelectric (PHS) is by far the largest and most cost-effective form of energy today. In 2009, world pumped generating capacity was 104 GW, while other sources claim 127 GW, which comprises the vast majority of all types of utility electric . While the facility in Bath County is the largest now, a 4,000 MW project at Revelstoke in British Columbia has been proposed.

In 2017 the largest pumped in Europe was the Cortes-La Muela hydroelectric project in Spain, at 1,762MW. The largest in China was the Cuntangkou Pumped Hydro Power Station in Sichuan, at 2,000MW. The Snowy Hydro 2.0 pumped project in Australia completed a feasibility study in 2017 that proposed to expand the existing network of hydropower dams to provide up to 6,000 MW of generating capacity. It would become the world's largest hydropower scheme with pumped . It has yet to be built.

"A Ten-Mile Battery," *Popular Science*, July 1930, p. 60; “Cruachan Power Station: Site Information" *(PDF)*. *Scottish Power.* April 26, 2014; "Pumped in Bath County," *www.virginiaplaces.org.* November 28, 2017; “Snowy 2.0 Hydropower Project, New South Wales,” *Power Technology*, 2019.

:Rewilding

Problem:

The accumulation of dykes, dams and territorial walls, the artificial management of wildlife populations, the unsustainable management of forests and the exponential increase in the disappearance of flora and fauna requires global countermeasures.

Solution:

Rewilding, -scale wilderness recovery allows natural processes and native wildlife to flourish.

It was first promoted by “Earth First!” founder Foreman in his book on rewilding North America, then by Michael Soulé and Reed Noss in their landmark 1998 *Wild Earth* article “Rewilding and Biodiversity”, where they proposed a scientific argument for restoring big wilderness based on the regulatory roles of predators.

A controversial 2005 editorial in *Nature*, signed by a number of conservation biologists, took up the argument, urging that elephants, lions, and cheetahs could be reintroduced in protected areas in the Great Plains. During the past decade, rewilding has become a principal method for designing, connecting, and restoring protected areas, the ultimate weapon in the fight against fragmentation.

Perhaps the most famous – and controversial – of rewilding is Yellowstone National Park’s thriving wolf population. Eleven packs and 108 wolves were reported, as of 2016, while there were before the 1995 reintroduction of 14 Canadian wolves. The project was sparked by rampant elk overpopulation. In South Korea, when DNA tests revealed that the extinct, near-mythical, tiger was the species as the Siberian tiger, South Korea the decision to them back. A “tiger forest” opened on May 3, 2018 which will contribute towards WWF’s aim of having 6,000 tigers in the wild, globally, by 2022.

Purchasing tracts of in Chile and Argentina, former clothing tycoons Doug and Kristine Tompkins led a quarter century- effort to reintroduce threatened and locally extinct species to the wilds of South America. These from anteaters and jaguars in northern Argentina to Darwin’s rhea, a species of native to southern Patagonia. Native guanaco herds flourished from an unsustainable population of several hundred to an estimated 3,000. There are positive examples of rewilding.

“Rewilding success stories,” *The Guardian*, 3, 2018.

:Right to Repair

Problem:

In 1924, Alfred P. Sloan Jr of General Motors, Detroit thought up the idea of planned or built-in obsolescence, designing an automobile with an artificially limited useful life, so that it becomes obsolete (i.e., unfashionable, or no functional) after a certain period of time. This has contributed to the exponential in harmful waste and landfills.

Solution:

Repairing broken objects, the ' in time' notion has been current in English for a very time and is first recorded in Thomas Fuller's *Gnomologia, Adagies and Proverbs, Wise Sentences and Witty Sayings, Ancient and Modern, and British*, 1732.

In his childhood, this website co-creator was one of millions who learned how to use a screwdriver and a from the Meccano model construction system. In 1960, cultural critic Packard published *The Waste Makers*, arguing against planned obsolescence for two reasons: -lasting, repairable products advantages for the environment: maximising our use of the precious materials already in everyday products would reduce the depletion of natural resources; and for society: Easily repairable goods could also be sold on the second market at low prices, especially to low-income groups.

To on the “Planned Obsolescence industry”, in 2003 Kyle Wiens launched a website out of his Cal Poly college dorm room he called iFixit, an electronics repair information and parts site, which has published repair manuals for every Apple product in the last two decades.

Millions of people are using those manuals to repair their iPhones and MacBooks, saving money and making their gadgets last Apple's engineers imagined possible. Added to this, since Martine Postma of Amsterdam opened the first DIY Repair in 2009, there are now over 1,500 in 33 countries, where people can learn to repair things. *(repaircafe.org)*

This is the with the London-based Restart Parties movement. In 2015 Gay Gordon- founded The Digital Right to Repair Coalition, renamed The Repair Association, an alliance of independent repair shops for articles from cell phones to tractors and mainframes, that supports right-to-repair legislation. *(repair.org)*

Governments around the world are now legislating that new appliances put on the market will to be designed to allowed the replacement of key parts using commonly available tools, without causing permanent damage to the appliance. As of 2021, the EU has legislated the right to repair electronics equipment.

Manufacturers are adapting. One example, Microsoft's new Surface Pro X is a noticeably repairable device. iFixit's assessment of the Surface Pro X reveals that access to the SSD is via a SIM--style eject mechanism, so the can it out with a paper clip. In other words, it is completely user-replaceable, without having to it to a repair centre because everything is baked in. *(ifixit.com)*

When a customer begins to spot wear and tear on a puffer jacket or fleece vest by Patagonia, they can it back to a Patagonia store to it repaired. If they do not use the item much anymore, they can give it back to Patagonia, who will refurbish it and sell it on " Wear", a marketplace of second- products that launched in 2017.

The takes -out, damaged goods and transforms them into entirely new, one-of-a-kind products at a workshop in Los Angeles. Each item in the ReCrafted collection is up of between three and six pieces of used clothing.

Kelli van der Waals, "In het Repair van Martine Postma wordt gemoedelijk gerecyclet," *Vrij Nederland,* September 9, 2015; Nick Whigham, “Why can't we repair our own iPhones, Apple?,” *Daily Mercury,* February 10, 2017; Dan Grabham “Could Microsoft's new Surface Pro X usher in a new generation of repairable devices?,” *pocket-lint.com*, November 8, 2019.

:RIKR backpack

Problem:

There is so much plastic waste recuperated from landfills, waterways and that as ways as possible must be found to recycle it profitably.

Solution:

Backpacks from recycled plastic.

Sisters Georgia, Nina and Sophia Scott a lifetime of travel experience, and lived and worked all over the world. Georgia and Sophia a decade of experience with their documentary film company GroundTruth Productions, across Africa, Asia, Europe and the Middle East put them in direct contact with a of extreme environments – from drought in East Africa to conflict in the Middle East. These experiences sparked their drive to create a company that could effect positive, meaningful .

In 2017, with a specialist textile mill in Taiwan, the Scott sisters developed a high-performance GT-RK-001 textile from 100% recycled PET, using plastic waste collected from landfill sites, waterways and worldwide.

With a 600 denier ballistic yarn structure for premium strength combining three layers of recycled synthetic fibres, a unique triangular ripstop weave, and a water-repellant TPU coating, it offers unparalleled durability and resistance to the elements.

Groundtruth created the RIKR backpack (equivalent to 120 recycled plastic bottles), following with other items from laptop to key chains, all of which respond to the demands of a new era of global travel.

with bluesign®-approved manufacturers, Groundtruth has also partnered with REDD+ Conservation Company Wildlife Works to guarantee emission-free production and offset the carbon footprint of the company’s travel emissions.

Polar explorer Rob , the first person to walk to both Poles, has been putting the RIKR backpack to the test in the South Pole Energy Challenge where it must survive in conditions of -40C. takes great and caution when choosing his expedition equipment as at times it can life or death.

:Photovoltaic road surfacing

Problem: Perhaps the most common and useful characteristic for roadways around the world is the enormity of their surface area. Roadways which could generate electricity for even a fraction of the day, could contribute to local power demands.

Solution:

In 2014, Colas, a world leader in transport infrastructure teamed up with the INES (French National Institute for Solar Energy) to install 710 ft² (66m²) of solar road which they called *Wattway* on a carpool area in Narbonne (Highway A9, exit 38). The goal of the installation is to provide a clean energy, stored and then used to power roadside equipment locally (here, the light for the pedestrian path).

Wattway's panels are thin polycrystalline solar cells, and each module is composed of 28 cells. Even after embedded in resin, the cells are thin enough that they won't peel off the road during normal expansion and contraction.

The next pilot test was undertaken in a small town with a 1-km stretch of solar pavement. This one section produced enough power to light the village's street lamps and cater to its 3,400 residents. In fact, 215 ft² (20 m²) of these panels can supply the electricity requirements of a single home. In 2019 Wattway presented their product at the "francophone village" at CES Las Vegas 2019 and 80 startups and companies, Wattway won the silver Smart City award as well as the second " Jury Prize". *(wattwaybycolas.com)*

In December 2017, China opened its 0.6 mi (1km) solar highway in the Shandong province's capital Jinan, south of Beijing. It spans 63,234 ft² (5,875 m²) and is capable of generating up to 1GWh every year – enough to power 800 homes. However, the Chinese government plans to use the electricity created by its solar highway to power street lights, billboards and CCTV cameras, as well as to heat the roads surface to melt any snow that gathers on it.

In its first 14 weeks in operation, the road generated 96 megawatt-hours of energy. completed, the road will be to use the sun to generate electricity, which will be transmitted into the grid. Its peak power generating capacity is 817.2 kilowatts, over a designed service life of 20 years.

Funded by Qilu Transportation Development Group and built by Pavenergy, the Chinese solar road was developed by chief engineer Hongchao at Tongji University's College of Transportation Engineering. *(tjjt.tongji.edu.cn)*

Solar roads can also provide energy to electric vehicles. ElectReon Wireless in Israel has developed a dynamic wireless power (DWPT), which enables energy exchange between all vehicles moving the road. This technology combined with a renewable source (such as solar panels) could provide a nearly endless power supply to various EVs.

It is capable of both powering vehicles without a battery and charging a battery connected to the vehicle. A major advantage of this technology is the high efficiency and safety: DWPT operates with 88% efficiency and has no safety concerns for surrounding wildlife or human users. The system began trial testing in March 2016 in Tel Aviv.

Additional tests are up-coming, with a public transportation use- and a commercial development installation. A trial section laid down on a coastal of Bett Yanai, Israel succeeded in transferring 8.5 kW of energy with a 91%

efficiency recharging a Renault Zoë in transit. ElectReon has signed a collaboration agreement with Renault-Nissan-Mitsubishi alliance.

ElectReon will also supply their DWPT system for a 1 mi (1.6 km) electrified road as part of a 2.5 mile (4.1 km.) highway between their airport and Visby on the island of Gotland. In February 2020 ElectReon successfully wirelessly a fully electric 40-ton truck and trailer at a test facility in Sweden. The next step will be to the truck through dynamic wireless power on the public road in Gotland, Sweden. *(electreon.com)*

“ “Wattway” : quel bilan tirer de cette première année de test ? ” *Le de l’Energie*, January 12, 2018; Felix Todd “What is China’s solar highway? Profiling the 1km energy-producing road in Shandong,” *NS Energy*, February 26, 2019; “Electric truck ready for dynamic wireless charging on public roads in Sweden; Smartroad Gotland,” *Green Car Congress*, February 26, 2020.

:Roadside wind turbine

Problem:

2.5 billion cars, most of which while using motorways generate unharnessed wind turbulence.

Solution:

Roadside wind turbine

Pakistani engineer Sanwal Muneer was standing on the side of a Malaysian racetrack four years ago was inspired as to how the breeze from the racecars might generate energy.

The roadside wind turbine Muneer created stood 8ft (2m50) tall and was of recyclable carbon fibre. The turbine weighed just 20lb. (9 kg), which makes it easy to transport and install. The fully- battery can hold a kilowatt of electricity, which is enough power to run two lamps and a fan for around 40 hours. The idea is that this turbine could supply electricity for rural communities in developing countries, or could be used to power traffic lights or road signs in areas.

Winning *the UN Clean Energy Award in 2014, then* funding from the 2015 Shell LiveWIRE programme, Muneer teamed up with Asad Liaquat, a friend since university days in Islamabad, Pakistan, when they were both studying electrical engineering, to found Capture Mobility to trial and commercialise his solution. Dundee, on the east coast of Scotland was the first local authority to allow Muneer's company, to test the turbine beside its roads. Captive Mobility exhibited at at Ecoville during the 2018 Edinburgh International Science Festival.

Even innovative is the *Alpha 311* roadside wind turbine, developed by John Sanderson and Barry Thompson of Whitstable, Kent, England. Instead of its own pole, this can be retrofitted any lighting column or pole lining the central reservation of motorways.

While the first prototypes were from drinks bottles in a shed in Whitstable, *Tom* the 2m tall Alpha 311 Mk.X was by from carbon fibre and recycled PET Trials showed it to generate the amount of energy as 21m² of solar panels.

The business : The turbines are not sold, but leased – but pay their way from the electrical energy gained by the local council – the electrical energy used can light the motorways making financial savings. Alpha 311 has already received requests for projects in India and New York.

:Robo bees

Problem:

The honey bee (*Apis Mellifera*), which pollinates nearly one-third of the food we eat, has been dying at unprecedented because of a mysterious phenomenon known as colony collapse disorder (CCD). The crisis is generally attributed to a mixture of disease, parasites, and pesticides. If the bee disappeared off the of the Earth, man would four years left to live. No bees, no pollination, no plants, no animals, no man.

Solution:

In 2014, The White House a new task just 180 days to devise a coping strategy to protect bees and other pollinators.

Inspired by the biology of a bee, researchers, led by engineering Professor Robert Wood at the Microrobotics Lab of the Wyss Institute, Harvard University, began developing Autonomous Flying Microbots aka *RoboBees*, man- systems that could perform myriad roles in agriculture or disaster relief.

A *RoboBee* measures about half the size of a paper clip, weighs less one-tenth of a , and flies using "artificial muscles" compromised of materials that contract when a is applied. To construct *RoboBees*, researchers at the Wyss Institute developed innovative manufacturing methods, so-called Pop-Up micro-electromechanical (MEMs) technologies that already greatly expanded the boundaries of current design and engineering.

A *Robobee* can lift off the ground and hover midair when tethered to a power supply. After two years of R&D, in 2016 the Wyss team announced that their *Robobees* can now perch on objects from any , using an electrode patch and a foam mount that absorbs to perch on surfaces and conserve energy in flight, like bats, birds or butterflies.

The new perching components weigh 13.4 mg, bringing the total weight of the robot to about 100mg, similar to the weight of a real bee. The robot takes off and flies normally. When the electrode patch is supplied with a , it can to almost any

surface, from glass to wood to a leaf. To detach, the power supply is simply switched off.

But they need to be to fly on their own and communicate with each other to perform tasks such as a real honeybee hive is capable of . The researchers believe that as soon as 10 years from now these *RoboBees* could artificially pollinate a field of crops, a critical development if the commercial pollination industry cannot recover from severe yearly losses over the past decade.

RoboBees will work best when employed as swarms of thousands of individuals, coordinating their actions without relying on a single leader. The hive must be resilient enough so that the group can complete its objectives even if bees fail.

The new generation four- hybrid *RoboBee* X- can dive into water, swim, propel itself back out of water, and safely . Although one-quarter the weight of a paper clip, it needs the extra lift provided by its two extra wings to carry its on-board electronics and six tiny solar cells.

Since the robot is untethered unlike other similar insects, it gets its power from the sun -- or from powerful lamps, which the researchers used during their tests. The solar cells generate 5 volts of electricity, and a small onboard transformer turns it into the 200 volts of electricity the *RoboBee* needs to lift off. That causes the bee's piezoelectric actuators to bend and contract such as the real insect's muscles would, leading to the flapping motion of the robot's wings. *(wyss.harvard.edu)*

Even though the X- does not need a tether, it cannot be deployed in real missions. For one, it requires light three times the intensity of our sun to be to generate the power it needs. In addition, it does not work when it is not directly under the light and could fly for a second or two during testing until it veers out of view. The researchers need to equip it with a power solution so it can fly in the dark. But that would it heavier.

In 2017, Eijiro Miyako, a researcher at Japan's National Institute of Advanced Industrial Science and Technology, developed a to deliver pollen between flowers. The bottom is covered in horsehair and coated in a special gel. When the flies a flower, pollen lightly to the gel, and then rub off on the next flower visited. *(aist.go.jp)*

In March 2018, Walmart filed a patent for autonomous, pollination . In 2019, scientists at the Tomsk Polytechnic University (TPU) Russia launched a robo-bee prototype at least seven times bigger real bees, or the size of a human palm.

Another approach was taken by Anna Haldewang, a 24-year-old industrial design student at Savannah College of Art and Design (SCAD) in Georgia, USA. Haldewang created 50 designs of a bee before landing on the final model, *Bee*, which does not resemble a bee at all.

The consists of a foam , a plastic-shell body and two propellers. There are also six sections of the that meet at the bottom, all of which tiny holes that let the machine gather pollen while it hovers over plants. It can then release the pollen at a later time for cross-pollination.

Haldewang noted that *Bee* is in its early stages, but she has filed a patent for the technology and design. Its application in backyards as a teaching tool has potential, but the could conceivably be used in -scale farming, even in hydroponic farming.

Dina Spector, "Tiny Flying Robots Are Built To Pollinate Crops Instead Of Real Bees. *Business Insider*. July 8, 2014.

:Roof insulation

Problem:

Roof insulation by fibreglass and polystyrene is efficient in situ, but very slow to biodegrade removed.

Solution:

Cellulose insulation is considered one of the most environmentally friendly insulation materials because it is of 80 to 85 % recycled newsprint. The term "cellulose" refers to the fiber for all plant life. Wood, paper and other plant-based products all are cellulose materials. types of cellulosic materials been used, including newspaper, cardboard, cotton, straw, sawdust, hemp and corncob. Recycled waste paper goes into a primary mixer, then a shredder, then a fiberizer and acid mixer to it fire retardant.

Modern cellulose insulation began in the 1950s and into general use in the US during the 1970s While in 1976 there were roughly 100 cellulose insulation firms with 125 plants, by 1978 there were 350 firms with 500 plants. With the movement for the Passive House (see entry), cellulose insulation was validated.

In 2007, Eben Bayer and Gavin McIntyre of Green Island, New York developed and then patented a method of growing a mushroom-based insulation, initially called Greensulate before founding Ecovative Design in 2007. In 2014 their material was used in a form in 'Hy-Fi', a 40 feet (12 m) tower displayed in New York by the Museum of Modern Art and they started selling 'grow-it-yourself' kits. Cotton-denim and sheep's wool also provide bio-based insulation.

David Bozsaky, "The historical development of thermal insulation materials," *Periodica Polytechnica Architecture*, 41: 2, January 1, 2010; "Sealed Air and Ecovative Complete Agreement to Accelerate Commercialization of New Sustainable Packaging Material," *The New York Time*s, 20, 2012.

:Room-temperature superconductors

Problem:

Powerful superconducting electromagnets are already critical components of maglav trains, magnetic resonance imaging (MRI) and nuclear magnetic resonance (NMR) machines, particle accelerators and other advanced technologies, including early quantum supercomputers. But the superconducting materials used in the devices usually work at extremely low temperatures — lower any natural temperatures on Earth. This restriction makes them to maintain — and too to extend to other potential applications

Solution: In 2015, a team led by physicist Mikhail Eremets at the Max Planck Institute for Chemistry Tomorrow achieved superconductivity at -70 Celsius (-94 Fahrenheit) in the form of a high-temperature superconducting hydride, by placing a piece of lanthanum into an insulating , then placing it into a box full of pressurized hydrogen gas.

They clamped the gasket between a pair of diamonds, and continued squeezing the diamonds until they hit the desired pressures, 200 gigapascals, nearly 2 million times the pressure on the surface of Earth. Then, they hit the sample with a laser to form the lanthanum hydride.

Finally, they took measurements to confirm they really created the material and that it's really a superconductor. But if confirmed, the feat would be the first example of superconductivity above 0°C, and some physicists consider that the work could be a miletone in the study of superconductivity, which researchers hope will one day the generation, transmission and use of electricity vastly efficient.

Two condensed matter physicists, Ashkan Salamat, at the University of Nevada, Las Vegas, Dias at the University of Rochester in New York, and other collaborators created a 3-element compound of hydrogen, carbon and sulphur that seems to conduct electricity without any resistance at temperatures of up to about 15 °C or 58° Fahrenheit (room temperature).

To do this, they used the mixture to photochemically synthesize simple carbon-containing sulfur hydride from production in a diamond anvil cell, a research device used to study tiny amounts of material called picoliters – roughly the size of a single inkjet particle under extremely high pressure.

They then triggered chemical reactions in the sample with laser light, and watched as a crystal formed. As they lowered the experimental temperature, resistance to a current passed through the material dropped to zero, indicating that the sample had become superconductive. Then they increased the pressure, and found that this transition occurred at higher and higher temperatures. Their best result was a transition temperature of 287.7 Kelvin at 267 gigapascals — and a pressure of about 39 million pounds per square inch (psi).2.6 million times atmospheric pressure at sea level.

This is a new record for superconductivity, a phenomenon usually associated with very cold temperatures. The material itself is so far poorly understood, but it shows the potential of a class of superconductors discovered in 2015.

The superconductor has one serious limitation, however: it survives under extremely high pressures, approaching those at the centre of Earth, meaning that it will not any immediate practical applications. , physicists hope it could the way for the development of zero-resistance materials that can function at lower pressures:

Applications would include:

Power grids that transmit electricity without losing up to 200 million megawatt hours (MWh) of energy that is now created due to the resistance in the wires

A new way to power floating trains and other of transport

Medical imaging and scanning techniques such as MRI and magnetocardiography

Faster, efficient electronics for digital and device technology

The next challenge is to find ways to produce the superconducting materials at room temperature at lower pressures so that they can be economically produced in larger volumes. Compared to the millions of pounds of pressure created in diamond anvil cells, the earth’s atmospheric pressure at sea level is about 15 psi.

“We live in a semiconductor society, and with this type of technology you can turn society into a superconducting society where you never need things like batteries again,” said Ashkan Salamat of the University of Nevada in Las Vegas, co-author of the discovery.

Mikhail Eremets “Superconducting Hydrides under Pressure” *Annual Review of Condensed Matter Physics* September 2019; Elliot Snider, Nathan Dasenbrock-Gammon, Raymond McBride, Mathew Debessai, Hiranya Vindana, Kevin Vencatasamy, Keith V. Lawler, Ashkan Salamat and P. Dias “Room-temperature superconductivity in a carbonaceous sulfur hydride”, *Nature* 14 October 2020.

:Biodegradable nylon ropes

Problem:

Nylon ropes may be tough, but they are not biodegradable.

Solution :

In 2016 a research team from the CSIR–Central Salt and Chemicals Research Institute, Bhavnagar, Gujarat developed a biodegradable material of seaweed extracts to replace synthetic ropes that are used in seaweed farming and other applications.

Polysaccharides extracted from three seaweed species Gracilaria dura, Gelidiella acerosa and Kappaphyucus al varezi, were first heated and then treated with potassium persulphate, vinyl acetate and glycerol to them tolerant to saline water.

Intermas Nets SA of Llinars del Valles, Barcelona, Spain is one of the world leaders in the manufacture of extruded mesh. It works in particular in the field of aquaculture for oyster and / or screens. It has developed a compostable and biodegradable . The Biorope begins to decompose from 58 degrees in an on-composter and three months are enough to degrade it entirely.

On the other , Biorope retains its mechanical properties at sea. Tests on the catining nets show the durability of the material in the environment, submerged and emerged. A hemp end lasts 3 to 4 months when the catinage net will hold for a year and even for the Biorope end.

With negative buoyancy and high elasticity, the biorope tip could find applications in boating, especially as a hawser. The mooring of buoys or pontoons for port managers is also possible. Objective: replace 15 to 20% of plastic ropes.

In November 2019, BIOGEARS, an innovative project funded by the European Union under the European Maritime and Fisheries Fund, set out to develop biobased gear solutions for the creation of an eco-friendly offshore aquaculture sector using a multitrophic approach and new biobased value chains.

This will include biobased ropes that though durable and fit-for-purpose, biodegrade in a shorter time; With EU-funded running until 2022 partners in the consortium include Azti, Gaiker and Itsaskorda from Spain, Centexbel from Belgium and Intrigo from Ireland.

There are other manufactures of biodegradable : 366 has already featured hemp (Solution N° xx)

:Rotting Veg

Problem:

One of the shortcomings in solar energy production is poor environmental conditions while vegetable waste needs to be usefully recycled.

Solution:

AuREUS vegetable waste

Carvey Ehren Maigue, a 27-year-old engineer from Mapua University in Manila, the Philippines has developed AuREUS (=golden) a new fluorescent material out of waste fruit and vegetables such as carrots that that can be attached to the sides of buildings to harvest invisible ultraviolet (UV). While ‘resting’, the particles remove excess energy, which bleeds out of the material as visible light and can be transformed into electricity.

The engineer was inspired by the fact that UV light seeps through on dark gloomy days when there’s not much sunlight that could potentially be harvested AuREUS could the side of tower blocks to turn them into ‘vertical solar energy farms’ and power them for a fraction of the cost.

For his solution, in 2020, Maigue became the first-ever recipient of the £30,000 James Dyson Sustainability Award.

: Recycled asphalt (RA or RAP)

Problem:

Under normal circumstances, a road building or renovation project consisting of two or three asphalt layers which are installed successively, would require 25,000 truck journeys of 70km, to the material to the site.

Solution:

Recycled asphalt (RA or RAP)

Ammann Group Holding AG is a Swiss mechanical engineering company specialised on machines for the building industry and road construction.

In Ariolo, a municipality in the Swiss Alps, Ammann is on a €240 million project to completely renovate a 10km stretch of the N2 motorway. The work is due to be completed in 2022, but challenges include the fact that the current road consists of material created during the excavation of the nearby Gotthard tunnel – the aggregate has a - content of 8%, meaning it is not frost-resistant.

The project is proceeding under the auspices of the Federal Roads Office (Astra), which has stipulated that the materials that form the current road be processed on site and reused in the new asphalt mix.

In addition to this, however, the project planners calculated that transport of 55,000 tonnes of would be required, as well as almost 400,000 tonnes of asphalt, of which 140,000 tonnes would be reclaimed.

For this reason, an area beside the motorway was provided for asphalt preparation and production. On the site – a former military airfield – an asphalt crushing plant, an ABP 240 HRT asphalt mixing plant and a washing plant were all installed adjacent to the N2 motorway in the Swiss Alps

In the RAH100 system, the recycled asphalt is heated by a counter-current process. Rocks and bitumen are indirectly and evenly heated and protected from

overheating. The plant can produce between 240 and 310 tonnes per hour of asphalt depending on moisture levels.

Ammann's solution has crossed the Atlantic where Smith has set up RAP Management on a site near John Glenn Columbus International Airport Columbus, Ohio. From here a fleet of almost 200 trucks drop off loads of old road material, while others haul away new hot mix for parking lots and streets.

Martins Zaumanis et al. "100% Hot Mix Asphalt Recycling: Challenges and Benefits" *Transportation Research Procedia* December 2016.

:Saltwater lamp

Problem:

The Philippines third as the most disaster country in the whole world. And in disaster situations such as super typhoons, earthquakes, a steady supply of food, drinking water and a sustainable light source is very essential.

Solution:

After living with the natives of the Butbut tribe for days relying on dangerous kerosene lamps and moonlight to do evening chores, Aisa Mijeno, both a faculty member of Engineering at De La Salle University in Lipa and a member of Greenpeace Philippines, together with her brother Raphael, invented the Sustainable Alterative Lighting (SALt) lamp.

The SALt LED lamp which can be powered by saltwater through metal-air technology is an alternative environment-friendly light source suitable for off-grid in areas near the sea. It uses the science behind the galvanic cell, the for battery-making, changing the electrolytes to a non-, saline solution, making the entire process and harmless.

The consumables of this lamp need to be replaced every 6 months. The SALt lamp operates 8 hours a day every day, with proper maintenance, with an lifespan of 6 months. For emergencies, the user can their smartphone using this lamp, simply by plugging in the USB cable.

In 2017, the SALt lamp went into production It won the Good Design Award 2018 presented by the Japan Institute of Design Promotion, a Japanese comprehensive design evaluation and commendation system. The Mijenos found two partners; one of them is a semi-conductor company located at Laguna Technopark; the other one is San Miguel Yamamura Packaging Corporation.

They are the helping SALt with all of their packaging needs: the box it comes in, the plastic, and even the design of the package. Their short-term goal is deploying the first 45,000 units to and beyond the Philippines.

An alternatve, the Aria Natural Himalayan Crystal Salt Lamp from Levoite was displayed during the 2017 Consumer Electronic Show (CES) in Las Vegas, Nevada.

Kathlyn dela Cruz, "All about Aisa Mijeno and her SALt lamp," *ABS-CBNnews.com*, November 19, 2015.

: Sanctuary for former circus elephants (EHEES)

Problem:

20 European countries already limit or ban circus animals, as do about 400 towns and cities in . Of the 500 wild animals in circuses at present, 100 are elephants. Relocating them back to their country of and rewilding them is not always possible.

In 2012, Tony Verhulst and Sofie Goetghebeur, both of whom worked for years as animal keepers at the Antwerp Zoo (Tony took of elephants for 14 years) created a non-profit sanctuary for ex-Circus elephants.

This solution after their successful lobbying of the Danish Parliament, which recently announced its commitment to ban the use of wild animals in circuses. Over 50,000 animal lovers in Denmark called for the government to end the cruelty inflicted on circus elephants.

Elephant Haven is located in Bussière-Galant, a beautiful, 70- location in southern . It plans to its first barn in November 2020.

: Sanitary pads from banana trunk fibre

Problem:

According to the UNESCO report on puberty education and menstrual hygiene management, at least one in ten girls in Sub-Saharan Africa misses school during their menstrual cycle. They weren't going to work when they had their periods because maxi pads cost more than a day's wages.

Solution : Sanitary pads from banana trunk fibre

In 2018, Elizabeth Scharpf from Colts Neck, New Jersey started up Sustainable Health Enterprises (SHE) to make sanitary pads out of the highly absorbent trunk fibers from the forests of banana trees growing around Ngoma in the Eastern Province of Rwanda.

The process starts with 600 local farmers collecting banana trees and by using extractors developed from paper-making machines, they extract fibres, the latter have a high rate of absorption properties. They remove leaves and roots from the ripe banana to make it ready to extract the fibers, they obtain a fluff which proceeds to the green sachet packaging to avoid humidity and the pad cotton is generated! The process has been made so simple so that the pads are produced with very minimum processes.

With six cooperatives and a total workforce of 1,200 people of whom 80% are women, SHE has made and distributed almost 200,000 pads to 10,000 girls. throughout the country. SHE sells packs of pads for 70 cents, which is 35 percent less expensive than the next cheapest option.

Elizabeth Scharpf, Liying Huang, Hannah Brice, "Highly Absorband and Retentive Fiber Material" Patent N° 20120097351. Publication date: April 26, 2012.

School benches and desks from Tetra Pak cartons

Solution:

In 2009, led by Clean Air Systems engineer Monisha Narkethen, a group of mothers from a school in Mumbai, Maharashtra, India, formed a group RUR or ‘Are you Reducing, Reusing, Recycling?’ Collaborating with Tetra Pak India they launched the, ‘Go Green with Tetra Pak’. Under this flagship program, RUR set up collection centres with special bins made from recycled milk and juice cartons that were placed across 42 Reliance Fresh and Sahakari Bhandar major retail stores where people could drop off their used Tetra Pak cartons. Monisha also designed and filed patent for "GreenGold Aerobic Bio Composter" which ensure 100% aerobic, non electricity dependent, Hygienic and manual solution

Since its inception in 2010, the RUR Greenlife initiative has resulted in the collection of over 4,500,000 used Tetra Pak cartons which have been recycled into chipboard sheets and then transformed into more than 300 school desks for lesser-privileged schools, 170 community garden benches from the 'Bin Se Bench Tak' campaign , and many other useful items such as the base of rickshaw and car seats, dustbins, pen stands, coasters, trays among others. In December 2020, Go Green with Tetra Park organised Go Green its first “Tetra Pak Van Collection drive” to recuperate further cartons. RUR Greenlife has successfully diverted 650 tonnes of solid waste from landfills annually in the past decade.

:SCoPEx

Problem:

Emergency measures may need to be taken to counteract anthropogenic global warming.

Solution:

The idea is simple: spray a bunch of particles into the stratosphere, and they will cool the planet by reflecting some of the Sun’s back into space.

This high-risk geo-engineering is inspired by historical events. An intense volcanic eruption of Mount Tambora (Indonesia) in 1815 released an incredible amount of volcanic ash, droplets of sulfuric acid, and water into the atmosphere,

obscuring the Sun and creating a global cooling event. For exactly this reason, 1816 was known as the "year without summer".

Equally, when Mount Pinatubo erupted in the Philippines in 1991, it injected an estimated 22 million tons (20 million tonnes) of sulfur dioxide into the stratosphere — the atmospheric layer that stretches from about 6 mi to 31 mi (10 to 50 km). above Earth's surface. The eruption created a of sulfate particles that cooled the planet by around 0.5 °C. For about 18 months, Earth's average temperature returned to what it was before the arrival of the steam engine.

In 2009, while at the University of Calgary in Canada, experimental physicist David Keith founded the company Carbon Engineering, in Squamish, which is to commercialize technology to remove carbon dioxide from the atmosphere.

After joining Harvard University, Keith used research funding he had received from Microsoft co-founder Bill Gates, to begin planning the experiment. In 2011 he moved to Harvard Univesity where he teamed up with atmospheric chemist James Anderson, who had been investigating a variety of geo-engineering options off and on for 25 years.

They were joined by Keutsch to prepare the Stratospheric Controlled Perturbation Experiment (SCoPEx). The experiment is backed by Bill Gates, the Hewlett Foundation, the Alfred P. Sloan Foundation, as well as university and donations from other groups and individual contributors.

At the heart of SCoPEx is a scientific balloon, fitted with re-purposed off-the-shelf airboat propellers. The re-purposed propellers serve two functions. First, the propeller forms a well mixed volume (roughly half a mile and 330 ft in diameter (1 km and 100 m) that serves as an experimental 'beaker' to which are added particles of calcium carbonate powder which is expected to absorb less heat volcanic sulfates and to less impact on .

Second, the propellers allow repositioning the gondola to different locations within the volume to measure the properties of the perturbed air. The payload can achieve walking speed relative to the surrounding air, generally for about ten minutes at a time. The advantage of the SCoPEx-propelled balloon is that it allows the team to create a small controlled volume of stratospheric air and observe its evolution for over 24 hours. *(projects.iq.harvard.edu)*

In February 2019, Aerostar of South Dakota, specialized in stratospheric (high-altitude) balloons and airships was selected to the prototype flying machine. The first phase involves two flights 12 mi. (20 km.) above the southwest United States, when small plumes of calcium carbonate, each of around 3.53 oz. (100 g.) will be released. The balloon will then turn around to observe how the particles disperse.

The technical aspects of this experiment are far less important its political, social, and geopolitical implications. After all, the risks of geo-engineering could not be serious. If deployed at scale, SRM (Solar radiation management) could disrupt the monsoons in Asia and cause droughts in Africa, affecting the food and water supplies of two billion people.

David Keith et al,"Stratospheric controlled perturbation experiment: A small-scale experiment to improve understanding of the risks of solar," *Philosophical Transactions of The Royal Society A Mathematical Physical and Engineering Sciences* 372(2031) · December 2014; Renforth and Henderson (2017) Assessing alkalinity for carbon sequestration. *Rev. Geophysics, 55, 636 – 674*

:Seabin

Problem:

Garbage is always to be found floating near ports and harbours, private marinas and yacht clubs.

Solution: Seabin was invented and developed by two Australian lovers, Andrew Turton, skipper, boat builder and surfer and Pete Ceglinski, surfer and industrial designer in injection-moulded plastic products. Witnesses of the

damage caused by plastic pollution across the globe, they chose to devote their energy to find effective solutions and to carry out educational actions to behaviors.

They developed a “trash skimmer” whereby rubbish and debris are brought into a bin thanks to a submersible water pump capable of displacing 6,600 gallons per hour (25,000 LPH (liters per hour), plugged directly into a 110/22v outlet. They are then collected in a catch bag which is removed and replaced.

The product was tested for four years and never had fish caught up in the bin. Although Ceglinski has taken out a patent, he was not the first. In 1992 Louis W. Pasoz obtained a patent for Apparatus and method for removal of floating debris.

The design and development of the Seabin project is based in Palma, Mallorca, Spain at the design center “The Sea” a factory space set up for creatives. The Sea has office and meetings space, an events gallery and a workshop area ideal for the Seabin project. The Palma Mallorca location is important for the Seabin project, the central hub of Europe’s industry and also having international access.

Following trials in at La Motte, Seabins built of recycled materials by Poralu , were soon trialled at various European ports. In 2017, the major shipbuilder, Wärtsilä signed up, as the first big industrial company, to partner with the Seabin Project and donated 35 Seabins to various locations globally.

By 2019 there were over 60 Seabins in Europe from the UK to Liguria, including the canals of Paris and Swiss Lugano. Three Seabins in Toronto, Canada are the first to be installed in a North American harbour. By 2019, following a video campaign which went viral, SeaBins are in use in 52 countries around the world which collected half a million of litter.

Before , Seabins had arrived at Pete Ceglinski's native country with the installation of two Seabins in the Port Macquarie Marina, New South Wales, Australia. The purchase of the first Seabin was possible through a NSW EPA litter , the first one in Australia to be used for the purchase of Seabin clean technology.

Seabin is also supported with a seed investment by Australian technology development company Shark Mitigation Systems Pty. Ltd. (SMS). SMS has technology partnerships with Google and Australian telecommunications company Optus, and is on a pathway to IPO listing on the Australian Exchange. *(seabinproject.com)*

Leïla Marchand, "Beau départ pour « Seabin », la poubelle flottante qui nettoie les ports," *Les Echos*, May 28, 2018 ; "How Seabin is helping clean the of plastic waste," ITU News, March 21, 2019.

:Seashell absorption of CO^2

Problem:

It is estimated that 10-20 billion metric tons of carbon dioxide need to be extracted from the atmosphere every year, starting in 2050, to offset the effects of climate change.

Solution:

Seawater as a medium for carbon removal

Gaurav N. Sant, a professor of civil and environmental engineering at the UCLA Samueli School of Engineering. Together with UCLA Samueli assistant professor Dante Simonetti of chemical and biomolecular engineering, have bio-mimicked seashells, formed naturally over a long period due to the ocean's high concentrations of carbon dioxide. Their solution was to accelerate the conversion of carbon dioxide into seashells.? In a lab, the team built a prototype machine that collects carbon-saturated seawater in a chamber. Then, as the saltwater passes through a screen, the mesh charges the water, sparking a chemical reaction. Dissolved CO^2, combined with calcium and magnesium, forms limestone and magnesite — basically, bits of seashells. Then the machine

returns carbon-free seawater to the ocean, where it can then soak up more atmospheric carbon dioxide. For long-term carbon storage, the “shell” fragments can be tossed into the sea or buried on land. As a byproduct, the device creates hydrogen, which could help power the equipment or be sold as fuel.

Stripe, a tech company paying for carbon decided to purchase CO2 removal from the team, which has spun the technology into a new company called SeaChange so as to build a prototype on a demonstration site, working with other experts to ensure that the process doesn’t have any negative impact on the marine environment. In July 2021 SeaChange secured S$1 million (US$735,000) as the top prize in the 2021 Liveability Challenge backed by Singapore-based nonprofit Temasek Foundation and organized by media company Eco-Business, triumphing over 450 applicants from more than 60 countries. Once the technology begins to roll out, it will have to happen at a large scale: Capturing 10 billion metric tons of CO2 each year would take 1,800 of the SeaChange devices.

:Seagrass

Problem:

Mitigation and adaptation to extreme weather conditions is particularly applicable to small islands.

Solution:

Similar to several Indo-Pacific islands, the Maldives is committed to building a business to protect tropical coastal wetlands given their importance for fish production, coastal protection, water purification and carbon (i.e., Blue Carbon). One solution to this is the cultivation of sea *(angiosperms)*.

Seagrass produces , stabilises sediment, protects shorelines, and gives food and shelter to life. A sea meadow creates a home for up to 20 times fish. Up to 100,000 fish can live in just one hectare of sea . 2.5 ac (1 ha) of sea can be a home for up to 19 turtles.

In 2016 the Maldives Underwater Initiative (MUI) and Blue Foundation (BLUE), with luxury resort Six Senses Laamu joined together to demonstrate how sea and tourism can coexist and generate positive outcomes. As their work gained momentum, the collaboration launched the "ProtectMaldivesSeagrass" campaign, asking resorts, as well as the public, to pledge their support for the protection and preservation of sea beds in Maldives. *(maldivesunderwaterinitiative.com)* Seagrass bed restoration is also taking place elsewhere. As of 2019 the Coastal Ecosystems Research Centre of Central Queensland University has been growing seagrass for six years and has been producing seagrass seeds. They been running trials in germination and sowing techniques.

In a study of a species of seagrass called *Posidonia ,* Anna Sanchez-Vidal, a biologist Department of Stratigraphy, Paleontology and Geosciences at the University of Barcelona has discovered that plastic debris on the Mediterranean seafloor can be trapped in seagrass remains called "Neptune Balls", eventually leaving the environment through beaching.

With no help from humans, the swaying plants - anchored to shallow seabeds - may collect nearly 900 million microplastic items in the Mediterranean every year, nearly 1,500 pieces per kilo of Neptune Balls or up to 600 bits per kilo of leaves.

"Maldives Underwater Initiative – Uniting To The ," *ORP,* November 21, 2018; Jacquie Mackay and Stünzner, "Seagrass nursery in central Queensland could offset carbon emissions", *ABC News*, October 24, 2019.

Seaweed combined harvester/planter

Problem:

The process of seaweed farming can be fairly labour intensive. The traditional method for growing seaweed is to attach pieces of seaweed to rope lines or nets by hand, wait for it to grow, and then manually harvest and "re-seed" the lines.

Solution:

Since 2010, Sri Sailaja Nori and Sowmya Balendiran and a team at Sea6 Energy Ltd in Bangalore India have innovated Dweep, an artificial floating island system, designed to survive in the harshest of ocean conditions. Combining several Dweeps could create artificial land of several hectares in the ocean and they could be used for a wide range of applications like solar power generation, which can provide the needed power for sustainable offshore farming, deep-sea aquaculture, provide power and water by desalination for offshore processing stations. Such floating islands could also be used for developing offshore houses and hotels.

Sea6's other invention, currently being used in Bali, Indonesia, is the SeaCombine, a seaweed harvester catamaran that helps in the large scale offshore industrial farming of the sea plants to produce large amounts of the biomass needed for manufacture of various products. Its product range includes plant bio-stimulants and immunostimulants for use in agriculture, animal feed, organic food pigments, bioplastics and biofuels.

SeaCombine travels back and forth through the lines, harvesting and replanting the seaweed automatically in deep ocean waters.

With such solutions seaweed farming could scale up - a necessary precursor to the wide-scale use of seaweed as a biofuel. Seaweed farming also avoids many of the sustainability issues involved in land-based agriculture—there is no need for irrigation or fertiliser, and the seaweed grows incredibly rapidly – as much as two feet a day.

The harvested seaweed is carried to the coast and transported to a factory where it is processed to make products that increase the growth of agricultural plants on land. It also protects these plants from viruses and converts the seaweed into biofuel.

In 2015, Sea6 Energy received Series A funding of Rs 35 crore from Tata Capital Innovation Fund. In July 2021, the company received a further $9 million in a Series B round led by the Netherlands-based Aqua-Spark, a Dutch investment fund focused on sustainable aquaculture, and co-investor Singapore-based Silverstrand Capital.

:Seaweed biopackaging

Problem:

Plastic pollution is a big problem in Indonesia. Heavy in Jakarta often highlight the painful problem of plastic, with piles of waste swept away from municipal landfills and washed up on shorelines

Solution:

Seaweed biopackaging

In 2016, after six years' research Nory Mulyono, head of the Food Technology Department at the Atma Jaya Catholic University of Indonesia in Jakarta co-founded Evoware with David Christian to manufacture and sell seaweed-sourced edible cups called 'Ello Jello', as well as packaging including food films, burger wraps and coffee and noodle-flavouring sachets which can be dissolved in hot water and eaten. The products are odourless, tasteless and, importantly, meet stringent food safety standards.

its accolades, Evoware was Circular Design Challenge winner of The New Plastics Economy Innovation Prize, led by the Ellen MacArthur Foundation and launched in collaboration with HRH The Prince of Wales's International Sustainability Unit.

:Seconds-recycling Shopping Mall

Problem:

A proportion of goods sold in the thousands of shopping malls around the world eventually end up in landfills, particularly their packaging.

Solution:

Second- recycling shopping centre

Anna Bergstrom moved to Eskilstuna an hour's journey west of Stockholm in 2012, after becoming disillusioned with the waste she encountered during her career in commercial fashion;

Eskilstuna was already implementing a spate of green initiatives, vying to it the most environmentally friendly city in Sweden – and perhaps the world. Public buses and cars are run on biogas and electricity, and the town uses low-carbon combined heat and power plants, which use the thermal energy from electricity

production to heat water. Residents sort their waste into seven multicoloured categories at home – green for food, pink for textiles, grey for metal, yellow for paper, blue for newspaper, for plastic and for mixed.

Three years' later, Bergstrom added her solution, "ReTuna Återbruksgalleria" ("Tuna" because that's the nickname for the city where it is based - Eskilstuna, - and "Re" because the goods on been recycled or repurposed)

At ReTuna, run by the municipality- company Eskilstuna Energi och Miljö (EEM), it is easy for visitors to sort materials they are discarding into the containers and then drop off reusable toys, furniture, clothes, decorative items, and electronic devices in the mall's depot, called "Returen". In the depot, staff from AMA (Eskilstuna Municipality's resource unit for activity, motivation and work) perform an initial culling of what is usable and what is not.

The items are then distributed to the recycling shops in the mall. The shop staff then perform a second culling, where they choose what they to repair, fix up, convert, refine – and ultimately sell. In this way, the materials are given new life.

It's very important to Anna that this place is enticing, because Bergstrom feels it is making a statement. Everything for here, in 14 specialist shops covering everything from clothes to DIY tools, is recycled.and for the past four years people been to drop off their unwanted goods for recycling at Bergström's secondhand mall.

In a store that specialises in handmade household ornaments, Bergstrom is keen to show off a nice example of this, from one of her star tenants. Shopkeeper Maria Larsson has upcycled a container that resembles the body of a . Each segment of its skin has been cut from leather jackets.

In 2018, ReTuna Återbruksgalleria had SEK 11.7 million in sales for recycled products.

ReTuna also organizes events, workshops, lectures, theme days, and – all with a focus on sustainability. The folk high school Eskilstuna Folkhögskola conducts its one-year education program "Recycle Design – Återbruk" in the premises. There are also conference rooms, where guests can hold climate-smart meetings. lunch and baked treats are on offer at Returama.

:Seismic-resistant/earthquake-proof buildings

Problem:

According to The National Earthquake Information Center (NEIC) there are an average of 20,000 earthquakes every year, 1,500 of these in Japan. In an earthquake in Port-au-Prince, Haiti, in 2010, 316,000 people died as a result.

Solution: Flexible building systems and materials

Traditionally the shinbashira central pillar, of Japanese cypress (*hinoki*) has been thought to be the key to the Japanese 5-storey pagoda's exceptional earthquake resistance. two pagodas collapsed during the mast 1,400 years. Ordinary houses in Japan to do with a form of rubber absorber 12 to 20 in .

For skyscrapers, today's solutions include flexible pad foundations; tuned dampers attached to beams which use pistons and oil to convert the motion into heart and absorb ; pendulum power for skyscrapers suspending a ball with steel cables with a system of hydraulics at the top of the building; steel plate shear walls, cross braces and trusses which movement away to the foundation. Materials include reinforced concrete, structural steel, memory alloy, bamboo and spider silk

The 54-storey Mori Tower in Tokyo uses reinforced steel piping and semi-active oil dampers consisting of 192 absorbers which are filled with oil.

The levitating house by Air Danshin Systems, designed by inventor Shoichi Sakamoto, literally pushes a house into the air using a airbag which inflates activated by seismic-sensors.

Japanese architect Kuma's Fa-Bo solution employs thousands of thermoplastic carbon fibre rods externally hold the building from roof to ground.

For the 57 storey, "Torre Reforma" in Mexico City, , influenced by Aztec techniques, architect Benjamin Romano has flexible hinges on the glassfront which has "crumple zones" allowing it to shift in a quake. Irregular gaps punched in the concrete outer walls of the tower allow them to bend instead of crack while coupling beams help to dissipate energy.

The 163-storey “Burj Khalifa” in Dubai, the tallest building in the world, built to withstand an earthquake of up to magnitude 7, is composed of mechanical floors where outrigger walls connect the perimeter columns to interior walling

The 2000 ft spiral-shaped Shanghai Tower in China, the second tallest building on the Planet has been constructed using 980 piles, some nearly 300ft deep – secured with 2.15 million cubic feet of reinforced concrete. It uses an oscillating 1,000 stabilising pendulum suspended by steel cables with a system of hydraulics at the top of the building.

Researchers at Harvard University’s Wyss institute for Biologically Inspired Engineering and John A Paulson School of Engineering and Applied Sciences say a double lattice, by the flexible sea *Euplectella aspergillium* could lighter but skyscrapers and bridges.

:SEKEM

Problem:

Desertification on the south-eastern edge of the Nile Delta, just outside Cairo, was hostile and lead to poverty, overpopulation, environmental pollution and much ;

Solution

SEKEM integrates social, economic and environmental development in an farming community

In 1975, Dr Ibrahim Abouleish, pharmacologist based in Austria, returned to his native Egypt and was shocked by the surrounding conditions. He bought 70 hectares of desert northeast of Cairo and founded the SEKEM Initiative.

His vision: “Sustainable Development towards a future where every human can unfold his or her individual potential; where mankind is living together in social forms reflecting human dignity; and where all economic activity is conducted in accordance with ecological and ethical principles.”

The SEKEM according to an ancient Egyptian hieroglyph “vitality of the sun”. Dr. Abouleish and his helpers started against all odds to revitalize the desert soil

by using Biodynamic agricultural methods and by n 1983, had succeeded in harvesting herbs, fruits, vegetables, cotton and other crops.

SEKEM grew to several thousand hectares with two thousand workers championing sustainable agriculture while Dr. Abouleish incorporated other companies under the umbrella of SEKEM to continue processing the crops, like ATOS Pharma for pharmaceutical products in 1986, LIBRA for Biodynamic cultivation of crops in 1988, ISIS for production of processed foodstuff 1997 and ConyTex (now NatureTex) for manufacturing textiles in 1998. The companies been united under the umbrella of the SEKEM Holding since 2000.

In 1989, a School was created in SEKEM and a Medical Center takes of SEKEMs employees and the surrounding residents since 1996. One year later, the SEKEM Vocational Center and an Arts School were introduced. In 2000 Abouleish became Chairman of the Cooperative of SEKEM Employees.

SEKEM also demonstrated the possibility of successfully growing cotton by using biological pheromones to control cotton insects. By 2000, the use of pesticides on Egyptian cotton fields had fallen by over 90% and 80% of Egyptian cotton is now grown without synthetic insecticides.

By 2005, the organization had established a network of 2,000 farmers and numerous partner organizations in Egypt and began increasingly to seek to extend its "experience and acquired knowledge" to other countries, including India, Palestine, Senegal, Turkey, and - in partnership with the Fountain Foundation - South Africa.

In 2009, the Heliopolis University for Sustainable Development received its acknowledgment by the Presidential Decree No. 298 and opened its gates for Students in 2012

On 15, 2017, Ibrahim Abouleish passed away at age 80 on the SEKEM Farm where he was laid to rest in the presence of the whole SEKEM community.

In 2020, SEKEM was chosen as one of 16 ‘Sustainability Champions’ in the developing world which are tackling environmental and social problems

:Selective fishing net

Problem:

In 2008, the Norwegian coast guard filmed a Scottish fishing vessel riding swells, dumping 5 tonnes of dead fish back into the North Sea. Over the European Union catch quota and unable to keep all the fish they had caught, the fishermen had to ditch some. To the Norwegians, who part of the EU and hold a strict discards ban, the waste was shocking.

Solution:

In 2011, Dan Watson, a Royal College of Art student in Glasgow designed an trawling system that would allow certain fish to escape via lighted , offering catch selectivity.

For his SafetyNet, Watson received an MA in Innovation Design Engineering. The escape can be retrofitted into any net to keep the holes of the net stretched , permitting small fish to escape and ensuring that marketable are caught (ordinarily, the mesh becomes compressed as it is through the water by the boat). The are illuminated to the exits visible.

An internal separator running horizontally within the net delineates the border between a finer upper mesh and wider-spaced lower mesh, taking advantage of the fact that endangered cod tend to swim downwards when under stress but the desired haddock and whiting will tend to swim upward.

Two models of escape are both capable of snapping existing mesh nets; one is battery-powered, and the other is self-charging, capturing the energy from the flow of water over a small built-in turbine in to generate power to the LEDs. Using the ‘safetynet’ system, the fishing industry can become sustainable. In 2012 SafetyNet won the James Dyson Design Award.

To further commercialise, Watson founded SafetyNet Technologies, enlisting the help of Dasan and Steven Ogborne. This included integrating their PISCES light-emitting devices into fishing gear to lower non- by-catch in

fishing activities. PISCES was trialled by Carrefour's suppliers, FROM Nord, in the Eastern Channel fishery in to avoid the capture of juvenile whiting.

SafetyNet Technologies has great ambition to fishing sustainable, and part of that is to sustain the fishermen's livelihoods, by making devices that not work to fish selectively but are easy to use and maintain.*(sntech.co.uk)*

"Art student designs net to address bycatch, discards," *fis.com,* November 15, 2012.

:Sentinel-6 Michael Freilich

Problem:

Sea-level is one of the biggest threats we as a consequence of climate . Satellite data show that global sea level has risen, on average, by just over 3 mm (one-eighth of an inch) every year since 1993. Even worryingly, this of has increased in recent years.

Solution:

Satellites to monitor sea-surface height, significant height, and wind speed, so as to improve weather forecasts, climate models, and hurricane tracking

This solution was started in 1992 by the French–US Topex *Poseidon* and then the *Jason* series of satellite missions;

On November 21st 2020, the latest technology called *Copernicus Sentinel-6 Michael Freilich* was launched from Vandenberg Air in central California

The satellite will be followed in 2025 by its twin, Sentinel-6B

Accurately monitoring the changing height of the sea surface over decades is essential for climate science, for policy-making and, ultimately, for protecting the lives of those in vulnerable low-lying areas with solutions already published on this website such as flood barriers, amphibious housing and floating schools.

:SGMA

Problem:

California State's lack of management of the complex and aquifer groundwater system on which 85% of its population and much of its $50bn agriculture industry rely has led to a phenomenon called "overdraft" that can cause severe subsidence, making it even difficult for some aquifers to recharge with water.

Solution:

The Sustainable Groundwater Management Act (SGMA) is a three-bill package that passed the California state legislature and was signed into California state law by Governor Jerry Brown in September 2014. Its purpose is to ensure better local and regional management of groundwater use and it seeks to a sustainable groundwater management in California by 2042. It emphasizes local management and formed groundwater sustainability agencies (GSAs) from local and regional authorities.

By 2019, SGMA implementation haD included local agencies groundwater sustainability agencies (GSAs), two rounds of boundary modifications and prioritizations, and alternative webpage "Best Management Practices and Guidance Documents."

GSAs was work with stakeholders in the to define what sustainability is in their basins and where it will be tracked through time using a monitoring network. To fill in data gaps, the Department installed 22 new monitoring wells, groundwater monitoring training and 17 downhole video camera surveys of existing wells (over 35,000 in all) to them back online as a monitoring point, so increasing the monitoring across the State.

31st January 2020 was the first big deadline for SGMA as dozens of agencies completed initial plans to protect over-drafted water resources. This marks the start of the even harder work of actually implementing submitted GSPs to groundwater additions and withdrawals into balance during the next 20 years. That doesn't the sustainability process will begin right away. Instead of imposing immediate limits on new wells and water pumping, the plans will "glide" toward sustainability in 2040.

:Shaded farming aka Agrophotovoltaics

Problem:

The expansion of renewable energies aims at meeting the global energy demand while replacing fossil fuels. However, it requires areas of . At the time, food security is threatened by the impacts of climate and a growing world population. Some highly urbanised countries, such as Belgium and the Netherlands, lack the necessary space to install solar power plants.

Solution:

Agrophotovoltaics

In 1981 Adolf Goetzberger, head of the Fraunhofer Institute for Solar Energy Systems, proposed the idea of installing solar modules on agricultural or in the hot and dry regions of the world. He predicted that the consequent shading would the hard soil bloom.

In 2016 Fraunhofer built a test installation at in Heggelbach near Constance which during the next three years proved the concept: They founded that, given the impacts of climate and conditions in arid climates, potential benefits are likely for crop production through additional shading and observed improvements of water productivity. In addition, APV enhances the economic value of farming and can contribute to decentralized, off-grid electrification in developing and rural areas, thus further improving agricultural productivity.

ENGIE BENELUX has taken up the challenge and is implementing a -scale project of this type in the Netherlands that aims is to install a 45-megawatt solar farm combined with a crop-growing activity by 2021. It also envisages the development of an APV project in Chile’s Arica Province. Ombrea has installed an AI-based mobile shade system on a vineyard in , , and the first harvest was a conclusive success.

Endesa, Spain’s largest utility has added bee hives to two AGV sites in Carmona, south-west Spain. By establishing at the 50 Mw Las Corchas and Los Naranjos solar plants, the additional bee pollination will increase productivity

even further. The underground cable network spanning 4.5 km may also act as electroculture.

Axel Weselek et al. “Agrophotovoltaic systems: applications, challenges, and opportunities. A review”, *Agronomy for Sustainable Development,* volume 39, Article number: 35 (2019)

:Sharana Daycare Facility

Problem:

Towards the end of the 20th Century, energy-intensive heating and cooling systems allowed designers to ignore the climate. Building styles became similar without any regard for the climate or terrain.

Solution:

Low impact buildings

Anupama Kundoo started as an architect in 1990s in Auroville, a township in the southern Indian state of Tamil Nadu, where she built structures celebrating sustainable design. This included her residence, The Wall House, a porous structure with lacy concrete doors and intricate brickwork.

One project designed by Kundoo is Sharana Daycare Facility in Puducherry (earlier Pondicherry), Tamil Nadu, India. ‘Sharana’, which literally ‘shelter’, is a social and development organisation established to address the critical educational needs of socio-economically disadvantaged children and communities in Puducherry and its surrounding villages. The facility’s foundational belief is that all human beings are equal in rights and dignity, and everyone is entitled to food, clothing, and shelter.

Kundoo’s architecture revolves around a central strip of an inner garden court with the multipurpose activity spaces on the rear side of the site, while the reception and administration services are based toward the , the street. To achieve high standard of architecture and in affordable , the building has been

constructed using reinforced cement concrete slabs on columns, out of the material.

To enclose the various spaces economically, walls been built out of porous terracotta screen modules that are easy and to erect and eliminate the need for windows and frames. This allows ventilation throughout the wall surface while maintaining the climatic comfort in the tropical context with minimal . These screen wall elements allow transparency from floor upwards, allowing small children to remain in contact with the garden outdoors.

These porous elements practically require no additional finishes like plasters and paints as required in regular masonry, further minimising maintenance.

Kundoo her practice, Anupama Kundoo Architects, from India and Germany.

"Rethinking materiality. Buildings voids with less resources." Excerpts from a lecture by Anupama Kundoo. 2003

Energy-efficient shower head

Problem:

Spending too taking a shower in the bathroom is energy inefficient in both water and electricity. According to Ademe's estimates, the shower represents 40% of the water consumed by a household.

Solutions: Gabriel Della-Monica has invented *Hydrao,* a LED shower head which automatically colour depending on shower length to you of how you been showering.

This shower head also has an integrated flow restrictor disc to limit the water flow to 2.6 gallons per minute (10 litres/min). Della-Monica, a telecoms engineer, has 4 teenage daughters at home, and was also looking for ways to reduce his water bill and to some hot water left over in the .

During the first 3 minutes of showering, the LEDs glow green with approximately 8 gallons (30 litres) total water consumption, from 3 to 5 minutes: the LEDs glow ,5 to 6 minutes: the LEDs glow red (approx. 15.8 gallons/ 60 litres) total water consumption and from 6 minutes after, the LEDS red.

In 2015, Della-Monica founded the Hydrao startup in Grenoble as part of French Tech, the Minalogic technology cluster and the GreenTech Verte incubator overseen by the French Minister of the Environment.

Following the company's first ever award for Best-in-Innovation from ST Microelectronics, HYDRAO has since garnered numerous awards both in and abroad: amongst which are a 2016 CES Innovation Award and two 2017 CES Innovation Awards and two 2017 UK Water Efficiency Product Awards from the well-respected NGO Waterwise. *(hydrao.com)*

A mist shower atomizes water to very drops (less 10 microns), which greatly reduces the water flow. Buckminster Fuller invented the first one in 1936 as part of his Dymaxion bathroom (he called it a "fog gun"). The idea was taken up again in the 1970s, when several trials and experiments were conducted with both atomised washing and showering.

In San Francisco, USA, *Nebia Spa Shower* was developed in 2014 as a prototype designed to cut down on water in Mexico's largest athletic club chain, where one of the company's co-founders, Carlos Gomez Andonaegui, was CEO. By utilizing the technologies that engineers use for rocket engines and medical devices, the *Nebia* (= "mist" in Italian), developed by a team of world-class thermo and mechanical engineers, industrial designers, atomizes the water stream into tiny droplets, allowing 10 times the surface area to be covered with a fraction of the water volume; all while maintaining water pressure and decreasing water wastage.

Soon, *Nebia* made its way as a beta product the campuses of Google and Apple, with the fledgling startup eventually wooing prestigious Silicon Valley investors including Tim Cook and Eric Schmidt. Patent US20160059243A1 was 2018. In four years, *Nebia 1.0* claim to saved 100 million gallons (380 million litres) of water. In 2019 Nebia teamed up with Moen to develop the *Nebia* 2.0, designed to 65% of the water and 60% of the heating energy used by a standard shower. *(nebia.com)*

In the Netherlands, Jonas , a designer who graduated from the Design Academy Eindhoven in 2019, became fascinated by the history of the mist shower and decided to build one himself. Compared to earlier mist showers, has improved the concept in two important ways. First, he developed a kit that can turn almost any shower into a mist shower with very little effort. Second, in contrast to earlier experiments, his mist shower uses not one but three to six nozzles. It far less the *Nebia*.

Another alternative solution is *Ilya*, a cyclic shower, developed by Simon Buoro, Antoine Escande and Nathan Guiraud, three engineers graduated from INSA, the National Institute of Applied Sciences in Toulouse, . With each new shower taken, the system draws 10 to 20 pints (5 to 10 liters) of water from the water network, as would be the with a conventional shower.

These few litres of water correspond to the volume of water required to fill the system and guarantee closed circuit operation in the various subsystems (filter, heater, etc.) of the cyclic shower. This is possible because it turns out that the shower water is in fact very little polluted, especially if natural soap and shampoo are used. For a conventional shower the water is heated to 40 degrees at a cost. With this cyclic system, energy consumption is lower because the recovered water is hot.

Dami Lee, “The Tim Cook-backed ‘shower of the future’ is back with a Moen partnership,” *The Verge*, February 12, 2019; “Toulouse. Ils planchent sur la douche à recycler l'eau, ” *Le Depeche*, January 28, 2019.

Shrimps and sun power

PVF (Photovoltaic Fishery)

Problem:

With space at a premium, floating solar farms on their own and fish farms on their own, up hectares.

Solution:

Combine the two.

In 2015 a successful 120 MW prototype PVF (Photovoltaic Fishery) built above the fish pond in Yintu Township of Jinhu County, east China's Jiangsu Province. Tow years later a 220 GWh PVF was installed above a fish farm on the Zhouxiang and reservoirs in Cixi City in the Zhejiang Province in eastern China, 150 km south of Shanghai. The local division of the State Grid Corp of China (SGCC) power utility supported the project by building two new 110-kV booster stations.

It consists of 300 hectares of solar panels that can generate enough power for 100.000 households, negating the need to burn 7,4 tns of coal instead. By connecting the power station to the national grid, the fishery can expected an annual yield of 240 million RMB (US$34M) above the annual income already generated through the fish farm.

Acting as a “canopy system”, the solar panels intentionally been spaced far enough apart in to let sunlight penetrate the water so not to disturb the growth of the fish beneath the surface. In addition the PV panels installed above the pond will provide shade that will facilitate fish farming under the water.

In Taiwan, Google a subsidiary of Alphabet is with Taiyen Green Energy the Fisheries Research Institute (COA) unit of the Taiwan Council of Agriculture on the installation of a 10-megawatt canopy system PVF on a 60-hectare fish pond in southern Taiwan's Chiayi County. It should go into operation in 2022.

In Vietnam, funded by the German Government the Fraunhofer Institute for Solar Energy Systems is with Viet Uc Seafood to develop a 100 kWp pilot PVF in the Mekong Delta. Fraunhofer ISE reports that according to its initial analyses, a 1 MW project installed in Bac Lieu should see a CO_2 reduction of

around 15,000 metric tons per year and water consumption would fall by 75% per year compared to a conventional shrimp farm.It later hopes to expand the idea with smaller, affordable solar fish farms. This will enable everyday aquaculture farmers to benefit from "dual use.”

:SilverLining

Problem:

Global warming is accelerating towards the point of no return.

Solution: Injecting sunlight-reflecting aerosols, how to shoot the right size particles into clouds to them brighter, and the effect on the world’s food supply.

On Wednesday October 28th 2020, a nonprofit organization called SilverLining, founded by technologist and entrepreneur Kelly , announced $3 million in research to Cornell University, the University of Washington, Rutgers University, the National Center for Atmospheric Research and others.

Prior to founding SilverLining, Kelly co-founded—and currently serves as Senior Advisor to—the University of Washington Cloud Brightening Project, an effort to research and understand one possible form of climate intervention: the cooling effects of particles on clouds. One challenge is to build spray nozzles between 30 and 100 nanometers that consistently produce the right size particles, and finding ways to prevent them from sticking together. A research that may from 12 to 18 months.

previously served as a strategic advisor to national environmental and energy groups, assisting with policy for Conservancy and developing industry strategy for fusion energy for the Lawrence Livermore National Laboratory. She previously founded companies in the IT infrastructure, analytics, and security fields, and has authored 20 patents.

The from SilverLining will pay for the center to run and analyze hundreds of simulations of aerosol injection, testing the effects on weather extremes around the world. One goal of the research is to look for a sweet spot — the amount of artificial cooling that can reduce extreme weather events, without causing broader in regional precipitation patterns or similar impacts.

:Engineering simulation technology

Problem:

Before they are manufactured, solutions must be trialled and this time and money

Solution:

Digital twins, virtual replicas of physical devices

The ability of engineering simulation technology **t**o monitor structural health in real-time and fix things before they break will result in safer, resilient infrastructure and everything from aerospace (UAVs), mining, oil & gas, power systems such as wind farms to bridges protected by a real-time digital twin.

In 2011, RB-FEA technology developed over 15 years at theMassachusetts Institute of Technology (MIT) project "High resolution simulations for system analysis" was further developed by David Knezevic, Thomas Leurent and Phuong Huynh into a start-up called Akselos SA. The company is headquartered in Lausanne, Switzerland at the EPFL Innovation Park, and has research centres in the USA, Italy, the UK, the Netherlands and Vietnam.

Akselos' digital twin technology, is built on a reduced 3D modeling platform that enables a 1000x speedup compared to current generation FEA analysis tools, while preserving full accuracy and capturing complex physics.

As one example, Akselos SA (Akselos) structural Digital Twin was selected by Shell Nigeria Exploration and Production Company (SNEPCo), Shell's deepwater company in Nigeria and operator of the 225,000 oil barrel capacity FPSO, because of its unique ability to realise a number of operational objectives. These include the identification of critical areas for prioritised inspection, maintenance and repair; a reduction in personnel on board the asset; reduced necessity for physical inspections in hard-to-reach areas such as tanks; and to support scenario planning for extreme weather events and asset modification.

:Skateboards from recycled and since recycling

Problem:

The exact number of skateboards manufactured every year is unknown, but it is estimated to be in the millions. Most skateboard decks are from a high of maple (Acer spp.) veneer plywood and typically last a few months before they break or deteriorate beyond use. Millions of used skateboard decks are discarded annually, ending up in landfills

Solution:

Recycling them into rainbow-coloured bowls, swings, furniture tables and chairs, wall tiles toys and new skateboards etc.

In the USA, various start-ups are recycling boards from coast to coast. From Jason and Adam Podlaski of www.deckstool.com in Clifton Heights Pennsylvania to Rocha of Iris Skateboards in San Francisco California (rainbow in Portuguese =“arco iris”) www.irisskateboards.com. In Canada, Adrian Pool, Martinus Pool, and Tranholm of AdrianMartinus Custom Woodworking in Calgary, Alberta are crafting similar products. www.adrianmartus.com

In Guillaume Corcaud at Atelierplanchon in La Tremblade, Nouvelle Aquitaine sells his recycled skateboards onlinen 60 % are sold to the USA and across Europe www.etsy.com.

Skateboards can be from recycled materials such as bottle caps, purchased by Jonathan Morrisson Aernout Zappey and Rogier Heijning at WasteBoards of Diemen in the Netherlands from the Geleidehonden (Royal Dutch Guide dogs foundation). They collect the caps to money to their dogs.
www.wasteboards.com

Dylan T. Willard and Joseph R. Loferski, “Skateboards as a Sustainable Recyclable Material”, *Recycling* 2018, *3*(2).

:Skin-friendly nail polish and make-up

Problem:

Most nail polish is with the plastic softener dibutyl phthalate: a hormone disrupter that's been known to cause birth defects in animals. And like other skincare and cosmetic products such as lipstick, nail polish contains petroleum-derived products. Its smell comes from polluting VOCs like carcinogenic formaldehyde and neurotoxin toluene. Inhaling a lot of it can damage your kidneys, , and liver.

Solution:

Eco-friendly make-up and nail polish

Archaeological evidence of cosmetics certainly dates from ancient Egypt and Greece. According to one source, early major developments include the use of castor oil in ancient Egypt as a protective balm and skin creams of beeswax, olive oil and rosewater described by the . During the dynasty, nail polish was often from a mixture that included beeswax, egg whites, gelatin, vegetable dyes, and gum arabic.

today’s growing number of eco-friendly products, Estelle & Thild founded by Pernilla Rönnberg in Stockholm, Sweden in 2007. As a mother,

Rönnberg became of the on the body and the environment of synthetic and impure substances used in cosmetics, which led to the following reflection: "In what world will my daughters grow up?"

She created its and natural cosmetics in 2007, named Estelle & Thild, after her two daughters: Estelle & Mathilde. The certified draws from cutting edge scientific research using ingredients using nature's most exclusive oils and extracts, rich in antioxidants, vitamins and other phyto-nutrients that the skin needs. formulas are free from pesticides and residues and are certified by Ecocert.

Acquarella Polish (www.acquarellapolish.com) prides itself on avoiding toluene, formaldehyde, phthalates, alcohol, acetone, and acetate. Its water-based nail polish in a wide variety of shades is also vegan and -free!

As a fully equipped zero waste store, EcoRoots doesn’t actually create their own waste free beauty products, they sell a variety of options (mostly skin products, from facial oils and masks to toners and moisturizers) by other well known plastic free beauty brands, like Meow Meow Tweet, River and Bathing Culture. While each they sell differs slightly in terms of sustainability, they’re all cruelty-free, non-, SLS-free, palm oil free, largely , and of course, come in mostly zero waste packaging. There are a few products which are not vegan though, as they typically contain beeswax.

Naturismo, founded in 2008 in Slough, Berkshire England has been with some of the most pioneering brands in ethical beauty and lifestyle, Our delivery boxes are 100% recyclable and FSC (Forest Stewardship Council) approved (*naturalismo.com*)

:"Skolstrejk för klimatet" (School strike for climate)

Problem:

For decades, heated exchanges between scientist, politicians and industrialists over the threats to our Planet rumbled in slow gear. What was need was a catalyst, somebody who was of these.

Solution:

In August 2018, Greta Thunberg, 15 years' old and other activists sat in of the Swedish parliament every Friday for three weeks, to protest against the lack of action on the climate crisis.

She posted what she was on Instagram and Twitter and it soon went viral, starting a nationwide, then a worldwide movement, where schoolchildren out in their thousands to march through their local town or city. After Thunberg addressed the 2018 United Nations Climate Conference, student strikes took place every week somewhere in the world.

In 2019, there were multiple coordinated multi-city protests involving over a million students each (13 million including adults). To avoid flying, Thunberg sailed to North America where she attended the 2019 UN Climate Action Summit.

Her speech there, in which she exclaimed "For 30 years, the science has been crystal clear. How you continue to look away and come here saying that you're enough, when the politics and solutions needed are nowhere in sight!.... How you pretend that this can be solved with just "business as usual" and some technical solutions? With today's emissions levels, that remaining CO_2 budget will be entirely within less eight and a half years."

Despite some negative reactions to Thunberg as a person and activist, the protests she inspired are creating an environment that may governments to be accountable and sustainable. The nonagenarian naturalist and broadcaster Sir David Attenborough described the impact she has as "astonishing," adding: "She has achieved things that of us who been on it for 20-odd years failed to achieve."

(fridaysforfuture.org)

: CO2 repurposed

Solution:

Led by Ah-Hyung (Alissa) Park, researchers from the Lenfest Center for Sustainable Energy at the Univeristy of Columbia, New York are with Baotou Steel in Inner Mongolia to run a revolutionary new plant that will recycle amount of and waste CO2 into raw materials used in paper, plastic, paint, plastic, cement, and the oil and gas industries.

In December 2016, executives from China's Baotou and Steel (Group) Co. visited the Columbia Engineering lab of Ah-Hyung (Alissa) Park and Xiaozhou () Zhou to see the operation of a prototype processing unit designed by Park and Zhou to repurpose . The project was named "green."

By 2018, a pilot run had been completed enabling researchers to analyze the data, while the team is moving forward with a phase-2 demonstration, which is near commercial scale. (*energypolicy.columbia.edu*)

Ah-Hyung Alissa Park et al, "Accelerated Carbonation of Steel via Two- Carbon Mineral Capture Technology," *Conference Paper*, April 2009; Ah-Hyung Alissa PARK, Xiaozhou ZHOU, "Methods and Systrems for recovering products from and steel ." *US Patent N° 20180245182* August 30, 2018

:Smart hook for sharks

Problem:

It is estimated that tens of millions of sharks end up as accidental bycatch every year, especially with longline fishing. Longlines use thousands of baited hooks on a single to try and catch a particular species of fish such as tuna. However, sharks much on the bait just as often.

Solution:

In 2001, Eric and Stroud at Oak Shark Lab in northern New Jersey founded Shark Defense to develop a smart hook intended to repel sharks particularly for bycatch reduction.

Their early work sought to research the existence of chemical messengers in elasmobranchs, cartilaginous fish comprising sharks, , and skates, and to

develop a series of highly selective chemical shark repellents using state-of-the-art analytical and synthesis techniques.

Two types were available: an electropositive metal and magnetism, which the Strouds combined into the SMART (Selective Magnetic and Repellent-Treated) hook and tested on the spiny dogfish shark *S. acanthias* in the Gulf of . Results obtained after 26 days of longline gear deployment demonstrated that SMART hooks decreased *S. acanthias* capture by 28.2%; however, SMART hooks had no observed influence on thorny skate (*Amblyraja radiata*), barndoor skate (*Dipturus laevis*), and teleost capture.

SMART hooks also been tested with bonnethead sharks, *Sphyrna tiburo,* and the researchers saw success. Of 50 different tests with two groups of sharks, there was a 66% reduction of baits taken from small sized SMART hooks (which would be used for recreational fishing) and a 94% reduction of baits taken from sized hooks that would be used in commercial fishing.

P. O'Connell et al."Effects of the SMART™ (Selective Magnetic and Repellent-Treated) hook on spiny dogfish catch in a longline experiment in the Gulf of ," *& Coastal Management,* Volume 97, August 2014.

:Smart textile, Radiative heat

Problem:

textiles are for social etiquette and aesthetic purposes, but the pressing threat of global warming has created demand for innovative textiles that help to better cool the person who wears them.

Solution:

Stanford engineers developed a low-cost, plastic-based textile that, if woven into clothing, could cool the body far efficiently is possible with the natural or synthetic fabrics in clothes today – and without air conditioning. If you can cool the person rather the building where they work or live, that will energy.

Photon-to-cooling phenomenon relies on the atmospheric transparency window to dissipate heat from the earth into outer space, which is an energy-saving cooling technique.

The emissivity of aluminized Polymethylpentene (PMP) thin films as selected by the Stanford team matches well to the atmospheric transparency window so as to minimize parasitic heat losses.

This new material works by allowing the body to discharge heat in two ways that would the wearer feel nearly 4° F cooler if they cotton clothing.

The material cools by letting perspiration evaporate through the material, something ordinary fabrics already do. But the Stanford material provides a second, revolutionary cooling mechanism: allowing heat that the body emits as infrared radiation to pass through the plastic textile.

First, they found a variant of polyethylene commonly used in battery making that has a specific nanostructure that is opaque to visible light yet is transparent to infrared radiation, which could let body heat escape. This provided a material that was opaque to visible light for the of modesty but thermally transparent for purposes of energy efficiency.

They then modified the industrial polyethylene by treating it with benign chemicals to enable water vapor molecules to evaporate through nanopores in the plastic, said postdoctoral scholar and team member Po-Chun Hsu, allowing the plastic to breathe like a natural fibre.

To test the cooling potential of their three-ply construct versus a cotton fabric of comparable thickness, they placed a small swatch of each material on a surface that was as warm as skin and measured how much heat each material trapped.

The comparison showed that the cotton fabric the skin surface 3.6 F warmer their cooling textile. The researchers said this difference that a person dressed in their new material might feel less inclined to turn on a fan or air conditioner.

The researchers are continuing their work on several fronts, including adding colours, textures and cloth-like characteristics to their material. Adapting a material already mass produced for the battery industry could it easier to create products.

Po-Chun Hsu et al, “Photon engineered Radiative cooling textiles” *Science,* 13 November 2020.

Smart thermostat for small commercial buildings

Problem:

Imperfect room temperatures waste energy. Traditional building controls systems are overbuilt and require extensive resources to install, setup, custom program, and maintain which creates high of acquisition and ownership.

Solution: In 2012 after having designed some of the world's fastest networks for Tier 1 service providers such as AT&T, NTT and Verizon, Deepinder Singh of Burnsville, Greater Minneapolis St Paul, originally from New Delhi, up with the technology behind the 75F thermostat after he Tomorrow'sed temperature control problems at his home when his baby awoke cold and crying at night.

Physiologically office workers are geared to a temperature of 75F for relaxation of their dress code. Singh's 75° Fahrenheit thermostat offers an intelligent building solution that utilizes the Internet of Things and the latest in Cloud Computing to create systems that predict, monitor and manage the needs of small office buildings. It is ideal for 90% of the light commercial buildings in the USA under 25,000 ft.² (2,320 m²).

Literally easy enough for elementary students to install and configure, the 75F system reduces install time, makes occupants productive and comfortable, while cutting for facility managers.

In September 2019 75F Inc. raised a US$18 million Series A funding round, co-led by Breakthrough Energy Ventures, the venture arm of a coalition backed by Michael Bloomberg, Jeff Bezos and Bill Gates, and with participation from Building Ventures, Revolution's of the Rest Seed Fund, and Clean Energy Trust. This, the company claimed in a press release,was the largest investment till in the energy-efficiency technology category in the Asia-Pacific region. *(75f.io)*

Carrigan Miller, "After six startups, here's why Deepinder Singh is sticking with 75F," *Minneapolis / St. Paul Business Journal*, August 28, 2019.

:Smartseille eco-neighbourhood

Solution:

In 2007, Eiffage, a French multi-product builder and developer created the Phosphorus laboratory to anticipate and research and development towards a truly global approach to sustainable development, the progress of which would no be measured by its technological advances but would into account the city's adaptation to the consequences of climate and social .

An EcoCité Euroméditerranée demonstrator of innovations and know-how in favor of the inhabitants and users of a sustainable Mediterranean city they called their first location *Smartseille*, 2.7 hectares of to north of Marseille, on the site of a former gas plant

By 2019, Smartseille had provides 58,000 m^2 of homes, offices (including the City of Marseille, Eiffage, Ingerop in particular and amenities. It offered 385 positive-energy housing units, including 100 used for social housing, a 100-bed residence for seniors, 27,500 m^2 of office space, 300 m^2 of retail space, a 90-room hotel, an intergenerational residence and a 35-cot day nursery.

The principle of energy solidarity imagined by Eiffage and investigated by the Phosphore research programme makes use of the calories produced by office buildings to heat housing units—and vice versa. The seawater heat-exchange system, implemented by EDF, that living spaces can be heated and cooled down using thermal exchange with the sea, leading to energy savings of 30%.

Work is in progress.

: Smog-dissipating gun for Delhi pollution

Problem:

Home to 21 of the world's 30 most polluted cities, New Delhi was the world's most polluted capital city for the second straight year in 2019, according to IQ AirVisual, a Swiss-based group that gathers air-quality data globally. India was also said **in** the study which focused on the amount of PM2.

Solution:

-smog gun

Alongside the solutions of cleaning up the most polluting factories and transitioning to electric vehicles, the -smog gun was first tested in New Delhi in 2017. It was designed to create a ultra- fog consisting of very water droplets(10 Micron size) These tiny water droplets were spread in larger areas with the help of a high speed fan and absorb even the smallest dust particles in the air, yet fall to the ground without wetness.

The solution was first patented in 1971 by Jo F. Mercer of Gonzales, Texas USA as “a method and apparatus for removing smog and smoke” US3572264A

Connected to a water and mounted on a vehicle, the 360° Indian version can be taken across the city to spay water to settle dust and other suspended articles such as PM 2.5. Built by Cloud Tech in Haryana, India, a of 5 skid/tower/ trolley/trucks are available – whilethe 3kW model has a of 20 metres, the 50kW can project its spray to 100 metres. During the 2020 peak of pollution, smog-guns were installed at 14 project sites in Delhi

:Smog Free Tower

Problem:

Building industrial and vehicle-generated PM10 particulate matter contribute to life-shortening cardiovascular illnesses and respiratory diseases.

Solution:

In 2015, adapting ENS Clean Air’s patented positive ionization technology, Dutch designer Roosegaarde whose Studio Roosegaarde is located in a former

glass factory in the harbour of Rotterdam, also known as the Dream Factory, created a 23ft (7 m.) tall air purifier called the Smog-Free Tower.

Roosegaarde had been driven by nature's gifts such as light emitting fireflies and jellyfishes since an early age. His fascination for nature and technology was reflected in his iconic designs such as Smart Highway (roads which from sunlight and glow at night), Waterlicht (an installation which shows the and poetry of water) and Smog Free Tower.

The technology powering the Smog Free Tower is based on air-purification systems in hospitals often use to clean air, attracting particles of pollution through electricity, but on a larger scale. It sucks up smog from the top and then releases the filtered air through its six-sided vents. By charging the Smog Free Tower with a small positive current, an electrode will send positive ions into the air.

These ions will attach themselves to dust particles. A negatively surface—the counter electrode—will then the positive ions in, together with the dust particles. The dust that would normally harm us is collected together with the ions and stored inside of the tower. This technology manages to capture ultra-smog particles which regular filter systems fail to do.

A Smog Free Tower can clean 1 million ft^3 (30,000 m^3) of air per hour and uses no electricity a water boiler. In September 2016, the Smog Free Tower traveled to China for a tour several Chinese cities.

In both Beijing and Tianjin people were to experience what it is like to breathe clean air. In May 2017, Studio Roosegaarde shared new results about the cleaning effect of the tower.

The functioning of the Tower was examined by Eindhoven University of Technology, and they confirmed that the Tower eliminates up to 70% of the incoming PM10 and 50% of the incoming PM2.5. In 2018, a second Smog Free Tower was realized that, after traveling to Jordana Park, Kraków, Poland in, returned to Studio Roosegaarde in Rotterdam.

In 2019, a Smog Free Tower was installed at the center of Pyeongchon Central Park in Anyang, Gyeonggi Province, South Korea, while Delhi considered adopting them to reduce its lethal pollution.

After the Tower collects piles of powder, the designers will turn it into . Diamonds too much energy to produce so, instead, the designers will square with a cube of compressed pollution. Every holds as much smog as 35,000 ft ³ (1,000 m³) of city air.

Perhaps inspired, an experimental tower over 328 ft. (100 m.) high in in Shaanxi, northern China — dubbed the world's biggest air purifier by its operators – has brought a noticeable improvement in air quality. The tower has been built and is undergoing testing by researchers at the Institute of Earth Environment at the Chinese Academy of Sciences.

The head of the research, Cao Junji, said improvements in air quality had been observed over an area of 3.86 mi.² (10 km²) in the city over the past few months and the tower has managed to produce 353 million ft³. (10 million m³) of clean air a day since its launch. Cao added that on severely polluted days the tower was to reduce smog close to moderate levels. *(studioroosegaarde.net)*

Communication from Roosegaarde July 14, 2019; Stephen Chen, “China built a tower that acts like 'the world's biggest air purifier,' and it actually works,” *South China Post,* December 20, 2018.

:Smokestack scrubbers

Problem:

Coal-fired power plants are the largest human-caused source of sulfur dioxide, a pollutant gas that contributes to the production of acid and causes significant health problems. Although natural processes such as volcanic eruptions, biological decomposition, and forest fires also produce sulfur dioxide, emissions caused by human activity far exceed natural production in developed countries

Solution:

A scrubber is an apparatus that cleans the gases passing through the smokestack of a coal-burning power plant and lessens the formation of acid .

In this use, scrubbers are towers in which aqueous mixtures of lime or limestone absorbers are sprayed through the emissions, known as flue gases, exiting a coal boiler. The lime/limestone absorbs some of the sulfur from the flue gas.

As ago as 1930, Henry F. Johnstone of the University of Illinois was awarded a patent for the removal of SO^2 from flu gases, while some scrubbers had been built in Great Britain in the 1930s, although it was not until 1967 that the first full-scale scrubber at a coal-burning power plant began operating in the United States.

The Clean Air Act of 1970 imposed stringent pollution control requirements on coal-fired power plants, and companies attempted to comply by building taller smokestacks to disperse the flue gases over a wider area, or by burning lower sulfur coal (coal that developed primarily in fresh water, as opposed to high sulfur coal that formed primarily in salt water swamps).

However, the 1970 Act also accelerated research on a “flue gas desulfurization unit”, or “scrubber.” Rather trying to remove sulfur from coal before it was burned by washing it, which had little effect, scrubbers aimed at the “back end” of a power plant, trying to remove sulfur in the form of sulfur dioxide (or SO2) from the flue gas exiting a coal boiler.

In 1971 the EPA set a maximum limit on sulfur dioxide in air, then in 1977 a revised Clean Air Act required all new power plants to install scrubbers to remove sulfur dioxide. In 1990 further revisions to the Clean Air Act under the Acid Program allotted allowable amounts of sulfur dioxide emissions to electric utilities, which could allowances to meet their quotas. Sulfur dioxide emissions from power plants in 2001 were 33 % lower in 1990 and 5 % lower in 2000 according to the EPA.

In September 2009 Siemens, in Erlangen, Germany trialled a new smokestack scrubbing process at the Staudinger coal-fired plant, near Frankfurt. The plant was adapted so that part of its exhaust gases were fed into a chimney containing a 82 ft high (25 m) column that off a solvent mist that reacted with CO_2 under pressure. As the flue gases pass through the mist, the CO_2 is chemically absorbed, leaving residual gases to pass out of the chimney. The CO_2 can then be separated from the solvent, which can be reused.

Recently, researchers found that in 75 % of the countries analyzed, it is cheaper to use plants to mitigate air pollution it is to add technological interventions, such as smokestack scrubbers to the sources of pollution. A tree can absorb as much as 48 lb (21 kg) of carbon dioxide per year and can sequester 1 ton of carbon dioxide by the time it reaches 40 years old.

Varsha Gopalakrishnan, Guy Ziv, Satoshi Hirabayashi, Bhavik R. Bakshi. **“**Nature-Based Solutions Can Compete with Technology for Mitigating Air Emissions Across the United States**.”** *Environmental Science & Technology*, 2019; DOI.

: “dead”trees

Problem:

When trees die, one approach is to cut them down, them up and use them for firewood.

Solution:

Leaving dead trees as they are decomposed (by fungi, bacteria and other life forms) and promote new plant growth by returning important nutrients to the ecosystem.

In gardens, a “dead” or decaying tree with a bough or a small cavity might provide a nest site for a bird or bat. Dead also excellent and display perches for birds.

The recognition that species were threatened by low levels of this resource initiated a of research into the ecology of dead wood beginning in the 1970s to 1980s. It is now estimated that 20–45 % of organisms in forested ecosystems depend, during some part of their life cycle, on wounded or decaying woody material from living, weakened, or trees.

 trees are valuable habitats (providing food, shelter and breeding conditions, etc.) for a number of and threatened species: saproxylic insects, invertebrates, lichens, bryophytes, birds and mammals. Hollow trees, in particular, provide suitable microhabitats for mammals (e.g. rodent species, squirrels, martens, bat species and wild cats) and cavity-nesting birds (e.g. woodpecker, tit and owl species).

In natural forests in Romania, deadwood is associated with several relict, and protected animal species (e.g. Rhysodes sulcatus, R. americanus, Cerambyx cerdo, Lucanus cervus, Rosalia alpina, Camponotus herculeanus). lichens (Parmelia, Peltigera and Lobaria species) indicate the continuity of natural forests and the presence of 20 species of fungi contribute to the ever-present processes of decay.

quantities of deadwood (50–130 m3/ha) also play a significant in forest nutrient cycles, carbon budgets, soil morphology and natural regeneration. Natural forests in Romania provide exceptional conditions for research into the ecological of deadwood habitat.

In Yellowstone National Park in Wyoming, fallen logs provide a home for which in turn feed grizzly bears in summer, especially in years when berry crop fails.

In Scandinavia and Finland , invariably trees, known in Finnish as *kelo* and in Swedish as *torraka*, are collected for the production of different objects, from furniture to sauna cabins and even entire log houses. Commercial enterprises market them abroad as "dead wood" or in Finland as "kelo wood." *(huliswood.fi)*

Stelian Radu , “The Ecological of Deadwood in Natural Forests”, *Nature Conservation* pp 137-141.

:Sneakers

Problem:

Sneakers are manufactured with harmful chemicals that are released into the environment. They are also disposed of in harmful ways, such as incineration or dumping them in landfills, which exposes our environment to these chemicals.

Solutions:

In 2015, Cyrill Gutsch of New York, founder of Parley for the teamed up with Adidas, with its 9.7% athletic footwear global market , to produce sustainable running shoes called *UltraBoost X,* entirely of yarns and filaments reclaimed and recycled from plastic waste and illegal deep-sea gill-nets.

A chip in the heel of the shoe enables the runner to use their to their shoe and follow its story from plastic waste to stylish sneaker. As part of their

commitment to tackle plastic waste, Adidas's trainers use one material and no glue, making them easier to recycle.

In addition, in between 2017, Adidas and Parley for the organised "Run For The ", a global running movement that uses the power of sport to awareness for the threat of plastic pollution.

They hosted a series of physical in several key cities worldwide including LA, New York, Paris, Berlin, London, Barcelona, Milan and Shanghai, and mobilizied the global Adidas Runners network to weekly running initiatives in 50 Adidas Runners communities worldwide.

For the 2018 event Adidas matched every kilometre run with US$1 dollar, for the first one million kilometers – to support the Parley Plastic Program, focusing specifically on the Parley School initiative, which educates and empowers the next generation of Guardians through immersive experiences in the environment we are fighting to protect.

With in-school and water sports activities, the program introduces youth to the underwater world, teaching them about the impacts of plastic pollution and giving them the tools and inspiration to protect their future with Parley AIR.

In 2019, Adidas produced 11 million pairs of shoes with Plastic® by Parley by intercepting plastic waste on beaches, remote islands and in coastal communities. Adidas has launched a sneaker from virgin plastic that can be ground up and remade again, as part of the company's bid to mitigate the plastic crisis.

The *Futurecraft Loop* shoe was launched April 17 by Adidas as a first step for the to help "get off plastic waste". The aim was to create a product that could be recycled as part of a closed-loop system. To do this, Adidas developed a high-

performance running shoe completely from a single material, virgin thermoplastic polyurethane (TPU). This single material is the key to its recyclability.

One of the biggest challenges in recycling sneakers is that they are of different materials, which are difficult to separate, sort and re-purpose. To test the *Futurecraft Loop*, 200 users trialled the sneakers then sent them back to Adidias for washing and grinding up into pellets, which wefre then heated for future sneaker components. Thus, the plastic pellets can be re-used to a second edition, which will then be tested. *(adidas.com)*

Adidas is not . Reebok manufactures a sneaker from cotton upper and -based sole, which is then shipped with 100% recycled packaging.

For its 100% vegan sneakers, Veja uses cotton grown by farmer associations in Brazil and Peru that harvest it with respect for people and the environment and wild rubber that helps preserve 300,000 ac (120,000 ha.) of the Amazon rainforest. The fabric used for its Veja's *B-Mesh* sneaker is crafted from recycled plastic bottles and its *CWL* is out of waste from the food industry. *(veja-store.com)*

In 2019, West, the American rapper, , songwriter presented a new sneaker prototype called the *Yeezy Foam Runner*, in Atlanta from a combination of petroleum-based ethylene-vinyl acetate and foam produced from algae. West told the audience that his new Yeezy headquarters in Cody, Wyoming, would include a hydroponic farm where the company can grow its own algae.

By making foam from algae, the company can help clean waterways to protect wildlife and drinking water, and it can avoid using the fossil fuels typically used to foam. The prototype pair West showed off were a bland khaki color, Yeezy is looking into environmentally friendly dyes. Manufacture will begin in 2020.

Mark Wilson, “Adidas’s radical new shoe could how the world buys sneakers.” *Fast Company.* April 17, 2019.

:Snow skis and snowboards

Problem: In 2017, the number of skiers in the United States amounted to around 14.94 million and the number of snowboarders in that year was at about 7.56 million. Most modern skis and snowboards been of fiberglass, carbon fibers, or a type of epoxy. Polyethylene is the most popular material used in the bases of modern skis. Those skis which do not end up in the garage or the loft, end up in the landfill.

Solution:

From 2007 a team of skiers in a workshop in Munich began to assemble a ski using 100% industrial hemp fiber, volcanic basalt rock, Paulownia tree resin.

Calling themselves Grown Skis, 10% of subsequent sales of these biodegradable skis been donated to the WWF Arctic Program. Grown’s all-mountain free ski for Alpine or Telemark is built with a wood from balsa with flax fibre enforcements, a different basalt fibersandwich belt, and lighter wood for the veneer. The ski surface is coated with biological varnish based on resin.

Grown Skis are on in Verbier, Davos, Saas-Fee in Switzerland and various locations in Germany. *(grownsks.com)*

For their snowboards, Jones of Austria use bioplastic topsheets and bamboo veneers. Edges and sidewalls are from recycled steel and ABS respectively. All rubber components are recycled too, and the boards are brought up to their high aesthetic standards with linen fiber, water-based paint, solvent-free varnish and natural board wax.

Anticouf in Switzerland use bamboo and FSC certified wood, natural fibre and cork, as well as producing similarly sustainable wakeboards, longboards and inboards.

Luthe, T., , T. and J. Reger, "A Systems Approach to Sustainable Technical Product Design. Combining life cycle assessment and virtual development in the of skis," *Journal of Industrial Ecology*, 2013.

Soap

Problem:

Liquid soap in a one-use plastic bottle is usually a synthetic detergent, from chemical compounds rather fats and oils. This is especially with antibacterial liquid soap which may be contributing to antibiotic resistant bacteria.

Solution:

It is commonly believed that the Crusaders brought Aleppo soap back to Europe in the 11th century, based on the claim that the earliest soap in Europe was just after the Crusades, but in fact the Greeks knew about soap in the first century CE and Zosimos of Panopolis described soap and soapmaking in c. 300 CE. Following the Crusades, production of this soap extended to the whole Mediterranean area.

Marseille soap or Savon de Marseille is a traditional hard soap from vegetable oils that has been produced around Marseilles for about 600 years.

The first documented soapmaker was recorded there in about 1370 : Savon de Marseille is traditionally green or white. The white soap is with palm oil, the green with at least 50% olive oil. Both varieties are exquisite, ultra-moisturising skin . Marseille Soap is recommended by dermatologists throughout the world for dry skin and other ailments. Its incredible purity and moisturising properties it ideal for sensitive skins. In it has been trusted for generations to cleanse everything from linens to little faces.

Savon de Marseille is totally biodegradable, requires little packaging and its manufacture is environmentally friendly. Authentic Savon de Marseille is stamped with its weight in gm, a practice left over from years ago which allowed households to compare prices and their inventories.

The white powder on the surface of the soap is a bit of the sea salt, which will disappear the soap is wet. This beloved characteristic affirms the authenticity of genuine Savon de Marseille. Fresh Marseille Soap can be a bit moist. Allowing it to dry and harden will it last . *(savon-de-marseille.com)*

In Spain, the origins of Dr. Bronner's Castile soap, an olive-oil-based hard soap, go back to the Levant, where Aleppo soap-makers hard soaps based on olive and laurel oil for millennia.

Andreas Abildlund, “Study reveals: soap is not harmful to the environment,” *ScienceNordic*, September 19, 2014.

:Soapbottle

Problem:

On average, we use eleven bottles of shower gel and ten bottles of shampoo every year, resulting in about 75 kilotons of plastic waste — about a thousand full olympic swimming pools. but why is a product that is used for about a month of a material that takes an average of 500 years to disintegrate?

Solution:

A packaging from soap.

Developed by Berlin-based designer Jonna Breitenhuber, SOAPBOTTLE aims to solve this problem by creating a packaging for liquid washing substances from soap. As the content within is used, the soap packaging very gradually dissolves. As in the of the ice cream wafer for example, the „wrapper“ can even be used completely. When finished, remnants can be used again, as soap or processed into detergents. Soap is of natural ingredients and is biodegradable: waste can be completely avoided

Soapbottle is promoted and sold by Patrick Munsters and Carel Neuberg founders of -Stella-Maris, an Amsterdam-based lifestyle that is committed to increasing access to clean drinking water worldwide.

Soccket ...and MORE

Problem:

In Nigeria, regardless of whether you live in the village or the bustling city, it is common to lose power several times a day, sometimes every day. When the power went out during 17-year-old Jessica Osemudiamen Idoni Matthews aunt’s wedding, the acrid odour from the kerosene-fuelled generator that allowed the event to go on marked the beginning of a turning point for her.

Solution:

SOCCKET, an energy-generating soccer ball.

In 2008, as a final project for his course in Engineering Sciences, Harvard University Professor David A. Edwards challenged his undergraduate students with: How to Create Things & Have Them Matter." The device had to help address a key challenge in developing countries.

Jessica Matthews Jessica Lin, Julia Silverman, Hemali Thakkar, who were those undergraduates with Aviva Presser, who was a Harvard graduate student at the time, invented a ball which, when someone plays with it, spins a gyroscope and creates electricity which is stored in in a rechargeable lithium-ion battery, to light up a small LED lamp: just the job in third-world countries like Nigeria.

They called their patented invention a Soccket. Following the appearance of their patented *Soccket* in 2010, Matthews and Silverman started up Uncharted

Play Inc. as a power solutions company. Soccket was followed by *Pulse* skipping/jumping rope which also doubles as a light. In 2013, President Barack Obama played with the ball in Tanzania alongside Matthews and said, “You can imagine this in villages all across the continent.” Her success in entrepreneurship led to a White House invitation from President Obama to represent small companies for the signing of the America Invents Act in 2012

When Uncharted Play moved to New York, Jessica changed her company's focus to developing a broader range of kinetic-energy-storing products in partnership with experienced manufacturers. This included her trademarking M.O.R.E., an acronym for “Motion-based Off-Grid Renewable Energy”, a system which uses Soccket's energy-storing method in consumer products beyond toys. harnessing kinetic energy and turning it into a source of power. MORE technology is an energy harvesting and emanating building block that can be seamlessly integrated into various infrastructures, objects and products — everything from floor panels, streets, speedbumps and sidewalks, to subway turnstiles, strollers, shopping carts and beyond. To achieve this, Matthews has already raised $7 million, which she claimed in Business Insider in 2016 is “the most raised by a woman of colour, ever.”

:Solar-powered automobile, series production

Problem:

Electric vehicles must be recharged with electricity, sometimes supplied by the garages or airports where they park. This recharging is not a continuous process. Even for solar roads to supply energy, vehicles must move them.

Since 1955, when William G. Cobb demonstrated his tiny 15-in (38 cm) Sunmobile with its 12 selenium PV cells and a small electric motor and T. Freeman tested his solar-powered tricycle in 1977, solar-powered cars mostly been one-offs where square or oblong panels are mounted the chassis.

Solution:

A vehicle covered with solar panels integrated it its bodywork could supplement its battery state anywhere, whether it was parked or moving .

Several countries are on this. In 2015 **South Korea,** Hyundai Motor Group launched Sonata Hybrid, its first vehicle with a solar top, or roof, charging system. Hyundai states that the technology can capture enough solar energy to 30 to 60 % of the vehicle's battery. The company estimates that with six hours of daily charging, the system could increase a driver's yearly travel distance by 800 mi (1,300 km).

In **,** the CEA (Commission for Alternative Energies) has collaborated with INES (L'Institut national de l'énergie) to modify a C-Zen electric car whose glassless rigid curved solar panels perfectly match the body of the vehicles, whose PV energy extends its to an average 2.5 mi (4 km) per day by simulation, with a high variability between summer (> 2.5 mi/10 km per day) and winter (< 1.3 mi/ 2km in winter).

The 18.2 ft² (7m²) non-rectangle surface area is to accommodate 14 ft² (3 m²) of active cells for a total power of 206 Wc. The electrical system has been optimized to power both the 12 kWh Li-ion battery and the vehicle's 15 kW electric motor.

In **The Netherlands**, *Lightyear One* is a series-produced solar automobile developed by ex-members of Solar Team Eindhoven University, a team of engineering students who won the solar-powered World Solar Challenge in their Stella prototypes in 2013, 2015, and 2017.

With its 54 ft² (5 m²) of solar panels, which cover its roof and hood panels giving it 7mi. (12 km) per hour of extra , *Lightyear One* has an increased autonomy of 450 mi. (725 km). Lightyear claims these solar cells are 20 % efficient traditional models, and they're encased in safety glass to protect them from damage. In 2020 Lightyear began to taking preorders for the first 500 *Lightyear One* cars *(lightyear.one)*

In Munich, **Germany**, Sono Motors' *Sion* solar car is due to begin manufacturing in the second half of 2020. The 158 mi (254 km.) all-electric car can gather a further 21 mi (34 km) of energy from its solar panels, the energy in its 35 kilowatt-hour battery. *(sonomotors.com)*

In **Japan**, Toyota been trialling a solar-automobile on the streets of Toyota City, Aichi Prefecture, Tokyo, whose Sharp solar panels give a staggering efficiency of 34 %-plus, adding up to 28 mi. (45 km.) to the car's battery per day when parked, and an incredible 35 mi. (56km) to the car in a day when driven. It has a power generation output at around 860 watts, fueled by triple-junction compound solar cell modules. Each cell is around 0.3mm , meaning the developers could install it over curved parts of the car. Panels are located on the roof, hood, rear hatch door, and the rear hatch door garnish.

Jon Porter, "The Lightyear One is a prototype 'solar car' with 450 mi. of ." *The Verge,* 25, 2019.; "NEDO, Sharp, and Toyota to Begin Public Road Trials of Electrified Vehicles Equipped with High-efficiency Solar Batteries." *global.toyota,* July 4, 2019.

:Solar-powered trash compactor

Problem:

The increase in the quanity of trash makes ever-increasing demands on personnel to collect it and it to recycling plants.

Solution:

Ecube Labs in South Korea developed CleanCUBE, a solar-powered city trash compactor, which can hold up to 8 times waste compared to non-compacting bins, reducing collection frequency by up to 80%.

It is compatible with standard 120L and 240L wheelie bins for easy and trash removal, and it also communicates information about what it collects in real time through wireless transmission to CleanCityNetworks, a cloud-based monitoring and data analytics platform. This reduces the impact of overflowing bins.

CleanCUBE can be equipped with various optional features such as LED backlight, LCD , graphic wraps, and WiFi router. Ecube Labs has offices in North America and Asia. Their products and services can be seen throughout all major regions including North and South America, Europe, and the Middle East.

It has established some 2,500 smart waste networks at cities, campuses, amusement parks and restaurants worldwide, and expects to double the number. In 2015 Ecube Labs equipped two cities, Ibague and Santa Marta, with smart waste networks using 130 of its Clean Cubes.

Several Latin American cities such as Bogota, Buenos Aires, Mexico City and Santiago are already adopting digital tracking of waste collection trucks. In March 2019 an additional 100 CleanCUBEs were installed in Korea's Largest Theme Park. *(ecubelabs.com)*

A similar unit is Bigbelly solar for use in public spaces such as parks, beaches, amusement parks, universities, retail properties, grocery industry and food service operators. The bin was designed and originally developed by James Andrew Poss and Jeffrey T. Satwicz and manufactured in Needham, Massachusetts by Seahorse Power, a company set up in 2003 with the aim of reducing fossil fuel consumption. Bigbelly is recognized as a C40 Cities Climate Leadership Group best practice.

Kumar Jha, "Design and analysis of 200Wp solar trash compactor." November 2018.

:Solar-wind combo turbine

Problem:

Wind turbine blades a reasonable surface area and extra power from solar panels mounted on them could be transmitted to the grid via existing wind farm infrastructure. But even so, the idea is pretty impractical. For one thing, the blades are mounted vertically, so panels would harvest decent solar power with the Sun low in the sky at sunrise or sunset. And turbines facing the optimum wind direction are not necessarily ideally orientated to catch sunshine.

Solution:

In 2012, B.N. Prashanth at the Amrita School of Engineering, Bengaluru, India proposed a model combining both horizontal axis wind turbine and solar panels where the blades of the wind turbine are by PVC pipes and the solar tiles are fitted with the turbine blades.

The powers produced from both the sources was combined together using a controller and then connected to an inverter. Finally, this power was fed to the residential load. Moreover, wind turbine can be operated at lower wind speeds thus increasing the efficiency of the total system.

In England, a team of scientists led by Dr. Joe at the University of Liverpool developed a set of spinning solar blades. Early computer simulations found that the turbine mounted solar panels would cause blinding beams of light to shoot out across the surrounding area. There was a real concern that the turbines could potentially blind aircraft pilots as well as anyone living in the vicinity. Not just that, but on a particularly hot day the turbines would generate ‘lethal’ solar that could set buildings on fire if concentrated.

Another idea by Cleantec Wind based out of Colorado Springs, is to add lightweight narrow-profile Savonius wind generators to the top edge of solar panels. The blades on each turbine are twisted and are not perfectly straight as the images suggest. This twist allows for a corkscrew effect of catching the wind at just head on. This would put the wind generators a few ft. above the ground

and in the very turbulent air that will exist in a hot solar array with wind blowing across it.

However, solar farms are engineered for the weight of the panels, the shadows that the panels cast and the output of the solar farms, so the prospect of strapping on a wind generator poses some challenges. Cleantec's 10 ft (3 m.) The *Gust SI* turbine in peak wind produces twice the amount of power the solar panels produce.

Courtney Boyd Myers, "The world's first solar-powered wind turbine? *Shareables*, April 3, 2011.

:Solar cloth and film

Problem:

Since their commercialisation in the 1970s PV panels been sold in rigid, rectangular formats.

Solution:

Integrating them into cloth enables a much versatile application. In 1966, Charles A. Escoffery of the International Rectifier Corporation in El Segundo obtained patent US3255047A for a "Flexible fabric support structure for PV cells" Six years later, Escoffery had toured both the United States and Europe with a 1910 Baker Electric automobile which he had outfitted with a of solar cells as an advertisement for International Rectifier Corporation.

In 2014, Alain , a sailmaker of Mandelieu-la-Napoule in the Alpes-Maritimes department in southeastern , innovated SolarSailCloth, with the thickness of a banknote and flexible enough to be rolled in a tube.

He then developed a machine in a "clean room" enabling the integration of layers of very thin (25 to 65 microns) films within laminated or woven textiles.

Its applications are widespread: on the sea for zero emission and cruising ; on the for tents for refugees or agricultural projects; and in the air for stratospheric scientific balloons.

In 2018, SolarSailcloth teamed up with UK Sailmakers a 1kW Power Sail) as part of the 380Z production zero emission sailboat built by Arcona of Sweden, with its motor from Finnish electric engine manufacturer Oceanvolt, SuperB lithium batteries and Victron regulators from the Netherlands. (See Yacht – Zero Emissions)

In 2015, in partnership with the American leader MiaSolé, manufacturer of these multi-junction cells, Solar Cloth System has greatly improved the performance of its solar panels. The new cells, using 4 different sensor metals to harvest solar radiation from a wide of brightness, offer 17% efficiency, almost similar to rigid panels.

With the textile integration of SolarCloth System, the result is the best weight / load capacity on the market. With a peak power of 170W / m² and an average weight of 500 g / m², the energy density is 340 W / kg. The semi-flexible solar panels on the market are around 70 W / kg and the rigid 13W / kg. That year the French Government awarded SolarClothSail 1st Prize at the ADEME Innovation-Growth Competition. *(solarclothsystem.com)*

Also in , Hubert de Boisredon and a team at the ink and print cartridge manufacturer Armor, in Nantes, (Loire-Atlantique) , collaborating with the National Institute of Solar Energy (INES), developed an ultra-thin, durable and very light solar film (450 g / m²) called *Asca.*

Its flexibility allows it to marry rounded or complex shapes and to cover domes. Its translucence allows it to be placed on glass surfaces such as agricultural greenhouses such as conventional panels, Asca contains elements of and not metals making it perfectly recyclable.

A production tool has been designed, capable of producing 10.7 million ft² (1 million m²) of Asca film per year. In Togo, West Africa, Armor has partnered with UNESCO to provide 200 schoolchildren with solar kits. A pocket fitted

with Asca film allows children to a mobile lamp during the school day so that in the evening they the essential light to study, in a region where access to energy is sorely lacking. *(armor-group.com)*

"Première mondiale pour la fabrication d'une voile Power Sail® sur un bateau de série," *polemermediterranee.com*, January 11, 2015 ?; "Power Sails, Sails Built with Integral Solar Panels," *Sail*, March 9, 2015; "ARMOR up new perspectives for the production of ASCA® photovoltaic film*," armor-group.com*, November 12, 2018.

:Solar cooker

Problem:

In places such as Eastern Africa native women travel 20 to 30 mi. (32 to 50 km) to gather a two day supply of cooking fuel. In other parts of the world increasingly high of malnutrition are caused by a lack of fuel. foods cannot be cooked without cooking fuel, and water likely to contain disease-causing bacteria must be heated before drinking. Continued gathering of wood cooking fuel by chopping down trees has resulted in eroded hill sides with loss of precious topsoil thus reducing their ability to grow food.

Solution: An reflector type solar cooker is a device which uses the energy of direct sunlight to heat, cook or pasteurize drink and other food materials. Because they use no fuel and cost nothing to operate, non-profit organizations are promoting their use worldwide. Solar the sun's heat inside insulated boxes with transparent lids

Barbara Kerr was one of the primary founders of the current solar cooking movement. In 1973 she and her friend Sherry Cole designed a cardboard solar box cooker and an early solar wall . It was based on published descriptions, including Ghosh's box cooker in India.

In 1976, Kerr and Cole used invention to cook 2 meals per day for 40 people for two weeks for a women's conference. Kerr went on to develop a -type solar cooker known as the *CooKit*. She was a founding board member of Solar Cookers International. She co-founded the Kerr-Cole Sustainable Living Center in Taylor, Arizona (USA), where numerous solar applications and sustainable practices can be learned.

SCI developed the *CooKit* as an adaptation of a cooker designed by Dr. Bernard in . The cooker consists of a foil-lined cardboard reflector with a dark pot inside a plastic bag. This simple mechanism converts hundreds of watts of sunlight into heat and can cook one or two pots of food at a time. SCI has set up local production of this cooker in Nairobi, Kenya and in Sacramento, California.

The *CooKit i*s used in solar cooking projects around the world. Cardboard, aluminium foil, and plastic for well over 10,000 solar cookers been donated to the Iridimi Refugee Camp and Touloum Refugee Camps in Chad by the combined efforts of the Jewish World Watch, the Dutch foundation KoZon, and SCI. *(solarcooking.org)*

:Solar farms (800 MW+)

Problem:

Photovoltaic electricity is limited to the surface area of the solar panels used.

Solution:

There is no limited to the size of a solar farm. By 2017, Longyangxia Dam Solar Park, located in Qinghai province in north-western China, with its capacity of 850 MW, its 4 million solar panels covering 9.6 mi² (25 km²) it the largest solar farm in the world. Currently, this solar park produces around 220 GW hours of electricity annually, which is enough to power 200,000 homes. Phase I of the project was completed in 2013, followed by Phase II in 2015. By 2020, the Park had increased its capacity to 2.2 GW.

After completing the Kurnool Ultra Mega Solar Park in Andhra Pradesh, India claimed the title of the largest solar park in the world. The solar park's total capacity is 1000 MW. Kurnool solar park is spread over 9.6 mi² (24. km²), with 4 million solar panels installed, each with a capacity of 315W.

The Shakti Sthala, Pavagada, solar project located in Karnataka's Tumkur district, India is spread across 13,000 ac (5,260 ha) and five villages. This project is part of the "Karnataka Solar Policy 2014-2021." The massive 2,000 MW capacity solar park, when completed, will generate enough electricity to power almost 700, 000 households.

Dubai's Mohammed bin Rashid Al Maktoum Solar Park, the world's largest single-site solar farm is near completing the final phase of its expansion. work is completed by Nextracker and Shanghai Electric Power Generation Group, the solar park, spread over a total area of 77 km² in Seih Al-Dahal, about 31 miles (50 km) south of Dubai, has a planned production capacity of 1 gigawatt for phase five and 5 gigawatts in total.

It was commissioned in 2013 and is expected to be completed by 2021. The park's solar power tower is the tallest in the world standing 262.44m (861 ft) tall

Qatar is building a plant on a 10 km² plot at Al-Kharsaah, west of Doha, its 800 MW capacity equalling 1/10th Qatar's current peak electricity demand. Pre-selected bidders included big European players, such as Enel, Total and Engie, and big solar manufacturers including JinkoSolar, Hanwha Q Cells and GCL. Further bids from big Japanese conglomerates, and companies from Spain, Germany, South Korea and Turkey. Qatar's Siraj Energy will hold a 60% stake, while the other 40% will be by Marubeni of Japan and Total of .

Half of the plant is expected to be in operation by the first quarter of 2021 and will be running at full capacity by the first quarter of 2022. During the project's lifetime, the plant will contribute to reducing 26 million tonnes of CO_2 which aligns with the objectives of the national program for conservation and energy efficiency "Tarsheed" to reduce 1 million tonnes of carbon emissions annually until 2022. *(sirajpower.com* and *marubeni.com)*

Iberdrola Group, through its subsidiary in Spain, is building the biggest photovoltaic plant in Europe. Located in Badajoz province of Extremadura, in southern Spain, the Núñez de Balboa plant will cover an area of nearly 1,000 hectares (2,470 acres) and will produce around 832 GWh per year, thanks to its 1,430,000 photovoltaic panels, installed on 288,000 ground mounts and with a total weight of 13,300 tons (12,100 tonnes) and supply clean energy to 250,000 people.*(iberdrola.com)*

In Imperial Country, southern California, approximately 175km east of San Diego the Mount Signal Solar Farm cluster also has an 800 MW capacity, enough energy to power over 1 million people during the daytime. Its three farms been developed and built by 8minutenergy Renewables, LLC founded in 2009 by Martin Hermann and Tom Buttenbach on a very aggressive timeline. built, the Gemini Solar Plant, 30 miles northeast of Las Vegas and extendiin across 7,100 acres in the Mojave Desert, will produce 690 megawatts of electricity — enough to power 260,000 households in Nevada, Arizona and California — and annually offset greenhouse emissions of about 83,000 cars. *(areviapower.com)*

The Newcastle Waters cattle station in the Northern Territory roughly halfway between Darwin and Alice Springs in Australia is transformed by Singaporean company Sun Cable into potentially the world's largest solar farm. The $20 billion project has the backing of tech billionaire Mike Cannon-Brookes, as well as resources billionaire Andrew Forrest, and earlier in 2020 it received major project status from the Federal Government.

The 10-gigawatt farm will cover 12,000 hectares of and in operation will supply energy to Singapore via a (2,800 miles) 4,500-kilometre undersea cable the bed, first through Indonesian waters. Sun Cable is the heart of an ambitious electricity network called the Australia–ASEAN Power Link

The Adelaide to Darwin corridor will enable transport of all the equipment to Newcastle Waters where a crew of up to 1,000 jobs will construct it, following by 300 operational jobs in the term. Construction is set to begin in 2023 with operation by 2026

Sun Cable's solar farm will be built near Woods, which during times of flood can cover up to 1,000 square kilometres.

According to Sun Cable CEO David Griffin "If you the transmission of electricity over very distances between countries, then the flow of energy from liquid fuels – oil and LNG – to electrons. Ultimately, that's a vastly efficient way to transport energy. The incumbents just won't be to compete."

In December 2020, a combination of various solar & wind power park with 41.5 GW worth of wind and solar is approved for the Kutch district in the Indian state of Gujarat. For perspective, that is almost as much solar as is currently installed in the entire United States. According to saurenergy.com, firms getting allocation include SECI (Solar Energy Corporation of India), NTPC, GIPCL, GSEC, Adani Power and Suzlon, which are expected to get for their 23,000 MW, 5000 MW, 2,500 MW, 3,500 MW, 3,500 MW and 4,000 MW solar and wind power generation projects respectively.

Hernandez et al.,"Environmental impacts of utility-scale solar energy," *Renewable and Sustainable Energy Reviews* 29 · January 2014.

:Solar Inverter

Problem:

PV systems could not determine that a had been de-energized under all conditions and it could continue sending electricity through the . In for PV systems to be connected to the grid, they must meet specialized hardware requirements for different utility jurisdictions.

Solution: In 2000, scientists at the Department of Energy's Sandia National Laboratories in Albuquerque, New Mexico invented the "non-islanding inverter," which automatically diverts or turns off electricity flow from grid-connected PV systems when an electric distribution shuts down.

Since solar farm inverters are not in use during the night, they been an under-used resource. But in November 2019, Lightsource BP, the largest solar developer in Europe, and third largest in the world outside of China teamed up with the UK National Grid and fitted out its 4-MW St. Francis solar farm in the

East Sussex England with a solar inverter capable of providing overnight reactive power.

"New Sandia control method doors for photovoltaic systems safely linked to electric grid," *Sandia National Laboratories*, September 13, 2000.

:Solar kits for internet access (SDHS) OniriQ

Problem:

The Internet is not always available rural communities in Third World countries.

Solution:

In 2016 a team led by Rodolphe Rosier in Senegal developed an off-grid access system for 600 million Africans.

Called SOLARBOX50 it combines solar energy and digital home systems (SDHS) and is a crossover between traditional solar home systems (SHS) and set-top boxes. A typical SDHS device (solar box) comes with a 50W solar , 3 LED lamps, a 19-inch TV set and an embedded Internet connection for use and for IPTV; all for a monthly subscription fee.

Joined by Michael Hernandez, the renamed OniriQ was improved from a traditional design model to a design that resulted in savings and increased data redundancy. Like every startup, OniriQ experienced difficulties raising money, especially for hardware development.

But following the completion of the first set of prototypes and the warm reception from testing at , a rural community 370 mi. (600 km.) from Dakar, the team behind OniriQ got the needed motivation to keep on pushing. While it is seeking fund to enable it attain 5,000 units of production, ten were deployed in homes of influencers and local personalities in the community where testing was carried out, with financing from an NGO named Energy Foundation for the World. OniriQ's is to export its solar kits to seven African countries, available on the micro company's internet platform (oniriq.com)

Tom Jackson, "Senegal's OniriQ provides solar-powered digital services to off-grid populations," *Disrupt Africa*, December 17, 2018.

Solar Panels

Problem:

The requirement to reduce greenhouse gas emissions.

Solution:

While solar panels are considered a form of clean, renewable energy, the manufacturing process does produce GHG emissions. Additionally, to produce solar panels, manufacturers need to handle chemicals. However, solar panels are not emitting toxins into the atmosphere as they're generating electricity.

On April 25, 1954, Bell Labs announced the invention of the first practical silicon solar cell. Shortly afterwards, they were shown at the National Academy of Science Meeting. These cells had about 6% efficiency. The New York Times forecasted that solar cells would eventually lead to a source of "limitless energy of the sun."

During the past sixty years, the question for efficiency has continued. In 2016, University of New South Wales engineers established a new world record for unfocused sunlight conversion to electricity with an efficiency increase to 34.5% The record was set by UNSW's Australian Centre for Advanced PVs (ACAP) using a 4.3 in.² (28 cm²) four-junction mini-module – embedded in a prism – that extracts the maximum energy from sunlight.

During that year, India added 715 MWs of solar power to the system, up from just 2,227 the year before. Producing 1.3 gigawatts of solar energy, it was estimated to reach 9.5 GW by 2022. The amount of solar power capacity expected to be added in the coming years is equivalent to 70,000 new solar panels every hour – enough to cover 1,000 soccer pitches every day.

It is estimated that global solar power capacity will triple by 2022, driven by Chinese demand and the ever-falling cost of buying and installing solar panels. *SolarPowerEurope* predicted that in the post-COVID19 recovery global solar capacity may reach 1,448 GW by 2024.

Reference to solar-powered applications such as dye-sensitised solar cells, solar towers and floating solar farms can be found elsewhere in this book.

Kevin Desmond, *Innovators in Battery Technology: Profiles of 95 Influential Electrochemists.* Jefferson, NC: McFarland, 2016.

:Double-sided Solar panels

Problem:

Most solar panels installed around the world are fixed in one position, without the ability to adapt to where the sun is in the sky. Therefore, research has previously been focused on how to these systems efficient instead of looking at how the electricity produced could be increased in other ways.

Solution:

The USSR space program first developed this solution for use on satellites. In 2012, An Israeli company bSolar commercialised a bifacial cell concept, based on a boron BSF back surface field (BSF) replacing the traditional opaque aluminum BSF, providing an increased -side efficiency together with an backside.

The panels were produced in Heilbronn, Germany at a converted solar cell production plant, while with 15-20% energy per dollar production the best of breed counterparts, Shahar Energy in Israel dealt with sales and installation. In Japan the bSolar won a 730 kWp project from Tokyo Solar Building Materials Corp (TSBM).

Since then, a growing number of companies placed bifacial modules on the market, including LG, , Lumos Solar, Prism Solar, Silfab, Sunpreme, Solar and Yingli Solar.

The next step is with bifacial solar panels which move to follow the sun's position and so produce over a third energy standard systems. Scientists at the Solar Energy Research Institute of Singapore (SERIS) been looking at bifacial solar panels which uses global weather information from NASA to tilt the panels so they are in the best position to get the most sun throughout the day.

By combining data from bifacial panels and sun tracking technology, Carlos Rodríguez-Gallegos and his team at SERIS found that energy production could be increased by 35 %. In addition to gains in the power produced, it could also decrease the cost of electricity by an average of 16 %. SERIS processed the results of tests carried out by 25 global laboratories on eight reference bifacial products, in to assess the testing methods of the research centers and certification in question. Although the dual axis tracking panels capture the most energy, their added cost and complexity does not wash out enough to be worth it; instead of a simple back-and-forth tilt, they require something akin to a gyroscope.. *(seris.nus.edu.sg)*

Carlos D. Rodríguez-Gallegos et al."Global Techno-Economic Performance of Bifacial and Tracking Photovoltaic Systems," *Joule*, 3, 2020.

:Dust-protected solar panels

Problem:

Dust adhesion on multiple arrays of solar panels in desert regions is a major challenge to energy harvesting through PV cells and solar thermal collectors.

Solution:

Using bio-mimicry, researchers at Ben-Gurion University of the Negev, Israel developed a new method to remove dust from solar panels using nanowires. The team includes Tabea Heckenthaler, a Master's student from Düsseldorf Germany

at the BGU Zuckerberg Institute for Water Research, Jacob Blaustein Institutes for Desert Research.

They mimicked the self-cleaning properties of the lotus leaf (*Nelumbo*), the super-hydrophobic silicon substrate (Si)-based nanotextured surface removes 98 % of dust particles. This significantly increases the potential of solar energy harvesting applications in the desert. *(in.bgu.ac.il)*

Tabea Heckenthaler et al. “The Self-Cleaning Mechanism: Why Nanotexture and Hydrophobicity Matter” August 2019.

:Solar tower heliostatic array

Solution: The solar power tower, also known as 'central tower', power plants or 'heliostat' power plants or power towers, is a type of solar furnace using a tower to receive the focused sunlight. It uses an array of flat, movable mirrors (called heliostats) to focus the sun's upon a collector tower (the). Concentrated solar power (CSP) is seen as one viable solution for renewable, pollution-free energy.

The PS10 Solar Power Plant (Spanish: *Planta Solar 10*), is the world's first commercial concentrating solar power tower operating near Seville, in Andalusia, Spain. The 11 MW solar power tower produces electricity with 624 movable mirrors called heliostats. It took four years to build and so far cost €35 million (USUS$46 million).

PS10 produces about 23,400 MW-hours (MW·h) per year, for which it receives $360 per MW·h under its power purchase agreement, equating to a revenue of $6.8 million per year. The mirrors were delivered by Abengoa, the solar receiver was designed and built by Tecnical-Tecnicas Reunidas, a Spanish engineering company; and the Solar Tower was designed and built by ALTAC, another Spanish engineering and construction company. Construction began in 2004 and the plant was commissioned by 2007.

A second tower, the PS20 went into operation in 2009. In Chile, Abengoa has built the 210-MW Cerro Dominador Solar Power Plant, a combined CSP and PV

plant located in the commune of María Elena in the Antofagasta Region. Controlled by Washington-based private equity firm EIG Global Energy Partners, Cerro Dominador will prevent the emission of approximately 643,000 tons of CO_2.

From 2009 Abengoa had also been active in South Africa. In 2018, the firm constructed its third solar thermal plant XiNa Solar One near Pofadder, in the Northern Province, its parabolic trough collector system giving it a capacity of 100 MW and 2½ hours of thermal molten salt to provide clean, sustainable and dispatchable electrical energy to 95 000 sub-Saharan African households, especially in peak hours.

Since 2013, the Abengoa's Solucar technology is also in service with a solar power tower in Arizona, about 70 mi. (112 km.) southwest of Phoenix where it produces enough energy to power 70,000 homes. In 2017, the US National Renewable Energy Laboratory (NREL) estimated that by 2020 electricity could be produced from CSP for 5.47 cents per kWh. *(abengoa.com)*

At the 2019 SolarPACES Conference, Vast Solar of Sydney, Australia took the SolarPACES Technical Innovation Award for their use of high temperature sodium-based HTF in tower CSP. Their design appears such as a small modular tower system, but it also borrows attributes of CSP's earlier technology, the tried and tested and bankable trough CSP.

Vast Solar's key innovation is the use of high temperature sodium as a Heat Fluid (HTF) piped horizontally continuously around the solar field like in a trough plant. In this, it takes the best of trough plants, but makes it better. Trough plants been limited by thermal oil HTF to operating at around 400°C.

Tower CSP has promised greater efficiency because its molten salts HTF can operate at 565°C to stay within degradation limits at about 600°C. But a sodium HTF can reach even higher – 900°C. *(vastsolar.com)*

A European Horizon 2020 project known as Solpart, up of a total of 8 partners from 5 different European Union countries, plus 2 international partners respectively from Morocco and Switzerland, aims to create partially solar-powered cement plant in Spain by 2025. In 2018 its researchers used an experimental solar reactor in to replicate the step. *(ec.europa.eu)*

On September 19 2019 in China, Supcon connected its second Gonghe 50MW CSP to the national grid. The contract for its power was signed in mid 2018, the heliostat field was completed six months later, the receiver tower was completed by August, and just a month later the grid connection was . *(en.supcon.com)*

In the USA, Heliogen's technology uses an array of 400 AI computer-controlled octagonal silica-glass mirrors that collect and concentrate sunlight on a point, enabling that point to reach extremely high temperatures of 1,500°C. This is equivalent to one-third of the temperature on the solar surface and is enough to power the processes to cement, steel, mining glass and other industrial processes currently rely solely on fossil fuels. If applied to all these processes, Heliogen's technology could help reduce the world's GHG emissions by 20%.

The configuration where the heliostats are grouped in staggered linear rows and each of the rows is parallel to another row has been developed over seven years by a team of researchers from Caltech and M.I.T. A commercial prototype has been built and successfully tested in Lancaster on the outskirts of the Mojave desert, California.

-named as Heliogen Inc by Bill Gross engineer-entrepreneur, also the Founder and Chairman of leading technology incubator Idealab, it is financed by Microsoft billionaire Bill Gates and Los Angeles Times Patrick Soon-Shiong.

November 2019, Gates's announcement of his investment in this project catapulted its landmark achievement into media around the world. Gates's serious interest in solar is part of his overall belief, first published in 2016, that the world will a "clean energy breakthrough" by 2031.

Heliogen is also with Parsons Corporation, a global leader in the defense, intelligence, and critical infrastructure markets. Heliogen plants could also

produce HelioFuel, the company's for its fuel products, such as hydrogen, that its technology creates, to power both transport and heavy machinery. In April 2020, *Fast Company* awarded Heliogen a 2020 World Changing Ideas award. *(heliogen.com)*. As evidenced elsewhere in this book, Concentrated Solar Power (CSP) installations are also in use in Morocco.

James Baker "Heliostat array intensity and polarization tracking." Heliogen, Inc. Patent N° 10,359,215. Filed: August 6, 2015. of Patent: July 23, 2019.

:Solar Tree for Fossil-Free Farmers

Problem:

If rural Indian farmers are to the transition to electric agricultural machinery they will need a local supply of electricity.

Solution:

The Central Mechanical Engineering Research Institute (www.cmeri.in) led by Dr Harish Hirani, developed world's largest 'solar tree' (सौर वृक्ष = saur vrksh) which is installed at its Residential Colony, in Durgapur in West Bengal. With a total of 35 solar panels, it has an installed capacity above 11.5 kWp (kilowatts peak, with the potential of saving 10-12 tons of CO_2 emissions.

In Canada, in 2010, an Ontario Power Authority microFITcontract had funded the creation "the tallest solar tree in the world" at 23 feet (7 m). The Solar Tree, designed to mimic the of the City of London, Ontario's logo had 27 'leaves" each outfitted with a solar with an output of 8.6 kW of electricity, enough to provide for about half the electricity needs of the Tourism London offices on Wellington Rd.

India's solar tree solution can be aligned with the Pradhan Mantri Kisan Urja Suraksha evem Utthan Mahabhiyan (PM KUSUM) scheme for farmers, for developing a Renewable Energy based Energy Grid. This would enable it to power high capacity pumps, e-tractors, e-tillers and other electric agricultural machinery. The solar tree also has the capability to incorporate IoT based features, i.e. round-the-clock CCTV surveillance in agricultural fields, real-time humidity, wind speed, rainfall prediction and soil analytics sensors.

The Institute has also developed solar powered e-Suvidha Kiosks may also be connected to the Solar Trees for real-time access to the vast majority of agricultural database as well as to the eNAM i.e. National Agricultural Market Place for instant and real-time access to an unified online market. If “a forest” of these were built, it would be a quantum leap towards making an energy reliant and carbon negative India.

:Solar updraft tower

Solution: The solar updraft tower (SUT) is a design concept for a renewable-energy power plant for generating electricity from low temperature solar heat. A massively , transparent canopy, or collector, is suspended 6 to 65 ft. (2 to 20 m.) off the ground, and the air beneath it, warmed by the sun, becomes hotter the air outside.

In the middle of the collector is a tall, slender tower. As the buoyant, warm air is up through the tower, it passes through turbines attached to the tower's that feed off the rising air's kinetic energy, powering a generator to produce electricity.

So far, there has been one -term test of the technology. In 1982, with German government funding, SBP built and ran a small, experimental 50-kilowatt solar updraft plant in Manzanares, Ciudad Real, 150 km south of Madrid, Spain. It consisted of a 640 ft (195 m) tower, fashioned from corrugated steel, and a canopy 800 ft. (244 m.) in diameter. And it worked very well.

The pilot plant operated for approximately eight years but the tower's guy-wires were not protected against corrosion and failed due to rust and storm winds. The tower blew over and was decommissioned in 1989. SBP continued to do in-house research on solar updraft technology during the 1990s.

In 2000, it partnered with Australia's EnviroMission to build a solar updraft plant in Western Australia. But the project was predicated on expected government funding that never materialized, and the partnership ended in 2004.

As of mid 2019, although several prototype models been built, no full-scale practical units are in operation. Commercial investment may been discouraged by the high initial cost of building a very novel structure, the area required and by the risk of investment. However, there is renewed interest in solar updraft towers, especially in sunny remote areas. A few prototypes recently been built, and projects are proposed for parts of Africa, the US and Australia.

Xinping Zhou, "Solar updraft tower power generation." *Solar Energy,* April 2016.

:Space Debris Clean-up

Problem: Also known as space garbage, space litter, and space junk, abandoned satellites can pose a serious collision threat to others if they remain in orbit.

On February 10th 2009, a derelict Russian military Kosmos-2251 satellite crashed into an active Iridium-33 satellite at a speed of 11,700 m/s (26,000 mph; 42,000 km/h) and an altitude of 789 kilometres (490 mi) above the Taymyr Peninsula in Siberia, creating over a thousand pieces of space debris and showing the dead satellites present. NASA called this collision one of the "worst known debris generation events in Earth orbit."

Currently, the US Space Surveillance Network tracks 40,000 objects and estimates claim there are 7,600 tons (6890 tonnes) of debris in orbit. Some of the trash is orbiting at 32,000 mph (52,000 kph) and could pose a hazard to communications gear. The project is co-funded by the European Union.

Solution:

In the 1990s and early 2000s, the international community started to get serious about the problem. Guidelines were set encouraging operators to equip satellites with debris mitigation systems. While they're not compulsory, ESA research

shows between 60% and 90% of new satellites launched since 2000 into the so-called geostationary orbit are complying.

Since 2017, Virginia-based Iridium been de-orbiting their 65 legacy satellites while leaving the possibility of paying an active-debris-removal company to deorbit 30 that failed in the decades since the operator deployed its first-generation constellation

One solution is the D-Orbit Decommissioning Device D3, based on solid rocket propulsion which not removes a satellite quickly and safely from orbit but prolongs its useful life. It's capable of quickly and safely disposing of a satellite at its end-of-life in a controlled , freeing up the orbital slot for a replacement, even in the of satellite failure.

In another solution, a reserve of fuel allows satellites to just leave the geostationary orbit when they reach the end of their lives, joining orbits where no active satellites operate. The lower orbits, between zero and 2,000 kilometers from the Equator, are proving challenging

As satellite use becomes increasingly pervasive, low Earth orbit (LEO) is becoming crowded. With an increased need to track and identify satellites and space debris in densely populated LEO, a team led by astrophysicist David Palmer at the Los Alamos National Laboratory's Intelligence and Space Research Division built The Extremely Low Resource Optical Identifier or ELROI.

It will carry codes embedded in pulses of light to identify small-scale satellites. Small, light-weight, and powered by solar energy, these electronic "license plates" could be employed as a new standard in satellite technology or launch requirements and it easier to attribute ownership of defunct satellites. ELROI will be sent up to a satellite for the first time for testing and evaluation through a collaboration with the New Mexico Institute of Mining and Technology (NMTech).

In 2018, a European satellite called RemoveDEBRIS designed to test different methods of "active debris removal" was launched to the space station on a

SpaceX ship. The US$18.5 million satellite was funded half by the European Commission, and half by a consortium of 10 companies, including the spacecraft's builder, Surrey Satellite Technology in England, and Airbus, which contributed the net and harpoon mechanisms to be evaluated in the tests. In the first test, a CubeSat released from the main spacecraft manoeuvred to a distance of 20 ft. (6 m.), where it unfurled a balloon (to provide a bigger). On 16 September 2018, a net similar to the kind used in commercial fishing was deployed from the main spacecraft to capture the CubeSat. Atmospheric should cause the netted CubeSat to burn up in the atmosphere in a matter of weeks. For the second test, another CubeSat was released to fly at a distance from the main spacecraft, where a camera and LiDAR observed to assess how well future trash-collecting satellites could judge the position and speed of a piece of debris. In July 2019, the RemoveDEBRIS harpoon was fired at a speed of 45 mph (20 meters per second) successfully penetrating a simulated extended from the satellite on a 4.9-foot (1.5-m.) boom. Following further trials, the technologies tested on RemoveDEBRIS will be incorporated into planning for the e.deborbit mission planned for launch around 2024. That project, aims to capture and de-orbit the eight-ton Envisat spacecraft.

In November 2019, Surrey Satellite Technology Ltd. (SSTL) shipped a 16kg satellite for Astroscale's End-of-Life Services by Astroscale demonstration (ELSA-d) mission to Tokyo, where it will be bolted to the Chaser satellite for environmental testing ahead of launch in 2020. The ELSA-d mission is designed to simulate capture of orbital debris and validate key technologies for end-of-life spacecraft retrieval and disposal services. The and Chaser satellites will be attached for launch and de-orbit, but while on-orbit at 500-600km they will be deployed in a series of increasingly complex separation and capture maneuvers using search, identification, rendezvous, docking, and de-orbit technologies. *(sstl.co.uk)*

One solution is the *D-Orbit Decommissioning Device D3*, which not removes a satellite quickly and safely from orbit but prolongs its useful life. D-Orbit's Decommissioning Device D3 is an independent and autonomous system based on solid rocket propulsion. It's capable of quickly and safely disposing of a satellite at its end-of-life in a controlled , freeing up the orbital slot for a replacement, even in the of satellite failure.

According to Elon Musk, SpaceX could use its Starship vehicles to clear out space debris in Earth orbit, alongside the program's publicized purpose of ferrying people and to the moon and Mars

Dutch artist and designer Dan Roosegaarde calls his solution the Space Waste Lab, a multi-year living lab with the European Space Agency and Studio Roosegaarde to capture space waste and upcycle it into sustainable products. The project is accompanied by an education programme with 2,000 students participating. The current Space Waste Lab Performance is a unique -scale outdoor artwork of LEDs and real-time tracking information to visualise space waste above your head with beams of light at an altitude of 125 – 12,500 mi. (200 to 20.000 km.). The artwork works in compliance with strict safety and aviation regulations. The ambition is to create the first phase of Shooting Stars from captured space waste and present it at a World Expo or upcoming Floriade 2022. *(studioroosegaarde.com)*

Sumito Forestry and a team including former astronaut Takao Doi at the Unit of Synergetic Studies for Space (USSS) of Kyoto University joined forces to develop what they hope will be the world's first satellites out of wood by 2023: *LignoSat*

Sumitomo Forestry, part of the Sumitomo Group, which was founded 400 years ago, is developing wooden materials highly resistant to temperature and sunlight. Sumitomo Forestry is also an active player in the market for wooden house construction in Japan, the USA , China , the Republic of Korea and others

LignoSats would burn up without releasing harmful substances into the atmosphere or raining debris on the ground when they plunge back to Earth.

Jason L. Forshaw et al, "RemoveDEBRIS: An in-orbit active debris removal demonstration mission." *Acta Astronautica* 127, 2016; David Palmer and Rebecca Jones, "ELROI: A License Plate For Your Satellite" *ResearchGate*, February 2018.

chili pepper chemical boosts solar efficiency

Problem:

The transport layer, playing a critical in high-performance perovskite solar cells (PSCs), suffers from significant non-radiative recombination, limiting their power conversion efficiencies.

Solution:

Capsaicin ($C_{18}H_{27}NO_3$)

Qin-ye Bao, a professor in the School of Physics and Electronic Science at East China Normal University in Shanghai and his colleagues found a secret ingredient for making solar panels that absorb the sun's energy efficiently. Capsaicin, $C_{18}H_{27}NO_3$ is the chemical that gives chili peppers (from the genus *Capsicum)* their , also improves perovskite solar cell efficiency.

Bao and his team suspected that capsaicin might an energy- effect because it can free up electrons that can go on to carry . They tested the capsaicin-treated solar cells in the laboratory by exposing them to artificial light to simulate sunlight and measuring the electrical current running through them.

Capsaicin the solar cells efficient, yielding a power conversion of 21.88 per cent, versus 19.1 per cent without capsaicin. The team then analysed the solar cells with spectroscopy while conducting energy and found that the addition of capsaicin did indeed lead to a greater number of free electrons available to conduct current at the solar cells' surface. This reduced energy leakage via heat.

Conflicts between farmers and elephants been widespread in African and Asian countries, where elephants nightly destroy crops, houses, and sometimes kill people. Farmers found the use of chilies effective in crop defense against elephants. Elephants do not like *capsaicin,* the chemical in capsicum chilies that makes them hot. Because the elephants a and sensitive olfactory and nasal system, the smell of the chili causes them discomfort and deters them from feeding on the crops. By planting a few rows of the pungent fruit around valuable crops, farmers create a buffer through which the elephants are reluctant to pass.

:Spirajoule

Solution:

Spirajoule is a low heated worm screw conveyor for converting plastic waste into syngas. It was designed by ETIA of Compiègne, for advanced thermal treatment in high temperature pyrolysis conditions (up to 800°C).

The temperature of the screw is maintained due to the joule effect. Treated product temperature is precisely controlled by the regulation of screw temperature setting. The residence time of treated material is regulated by setting of screw rotation speed. One machine can process between 5 and 12 tonnes of plastic waste per day

Since 2017, ETIA's subsidiary Biogreen has been with for Water Foundation using the Spirajoule to convert 5-12 tonnes of plastic waste per day into an energy-rich syngas to produce 2.5MWh/ electricity & commercial gases while discharging waste at 10% of incoming volume.

Pilot projects been set up third world zones Peru, Dominican Republic, Malaysia previously dependant on fossil fuel to generate electricity.

ETIA, "A low heated worm screw conveyor for converting plastic waste into syngas" French Patent N° 98 02530, March. 3, 1998, published under No. FR 2 775 621 A1.

:Hydrogen-powered steel

Problem:

Worldwide steel production currently totals about 1.5 billion tons (1.36 billion tonnes) per year, and each ton produced generates almost two tons of carbon dioxide, This accounts for about 5 % of the world's GHG emissions.

Solution:

In 2016, Swedish-Finnish steelmaker SSAB, pellet supplier LKAB (Luossavaara-Kiirunavaara Aktiebolag), and electricity generator Vattenfall joined forces to create HYBRIT – an initiative to replace coking coal, traditionally needed for ore-based steel making, in the direct reduction of (DRI) ore, using hydrogen.

During 2018, work started on the construction of a pilot plant for fossil-free steel production in Luleå, Sweden. Trials are set to run from 2021–2024, then scaling up to a demonstration capacity of 500,000 t/y in 2025 with completion set for 2035. the goal to a solution for fossil-free steel by 2035.

Hybrit is a significant part of the road towards SSAB's goal of fossil-free by 2045 If successful, HYBRIT a reduction of Sweden's CO_2 emissions by 25%. and Finland's by 7%. *(hybritdevelopment.com)*

In 2019 steel and mining company ArcelorMittal with an annual production volume of 8 million tonnes crude steel, launched a project in Hamburg, Germany using hydrogen on an industrial scale to directly reduce ore for steel production.

The company aims to enable low-CO_2 steel production. In ArcelorMittal's process, 95% pure hydrogen will be separated from the top gas of an existing plant by pressure swing adsorption. To allow economical operation, the process will initially use grey hydrogen produced at gas separation. Grey hydrogen refers to hydrogen produced as a waste or industrial by-product. 'Green' hydrogen – produced using renewable energy – will be used in the future, when sufficient quantities are available. ArcelorMittal, with academia, will test the procedure in the coming years at a site in Hamburg. Reduction will initially be carried out at demonstration scale – 100,000 t/y. *(arcelormittal.com)*

In North -Westphalia, steelmaker Thyssenkrupp also plans to phase out CO_2-intensive coke-based steel production and replace it with a hydrogen-based

process by 2050. It has partnered with Air Liquide and the non-profit research institute BFI to convert a blast furnace to hydrogen operation.

On November 11, 2019, in an initial test phase, hydrogen was blown into one of the 28 Cu cooler tuyeres on Blast Furnace 9 in Duisburg. The NRW state government is funding this initial project phase under its IN4climate initiative. Following analysis of the test phase, hydrogen is then to be used at all 28 tuyeres of the blast furnace in 2023. *(thyssenkrupp.com)*.

On the day, what is currently the world's largest pilot plant for the CO_2-neutral production of hydrogen successfully commenced operation at voestalpine AG in Linz, Austria. As part of the EU-funded H2FUTURE project, partners voestalpine, VERBUND, Siemens, Austrian Power Grid, K1-MET and TNO are researching the industrial production of green hydrogen as a of replacing fossil fuels in steel production over the term. *(voestalpine.com)*

Since November 2020 a 1.2 Mt DRI production plant powered by hydrogen enriched gas is set up in China by the HBIS Group including a 600,000 ktpy Energiron DRI plant jointly developed by Tenova and Danieli in Italy. The HBIS DRI plant will use -up gas with approximately a 70% hydrogen concentration, with a final net emission of just about 125kg of CO2 per ton. This is a historic step forward for the decarbonisation of the Chinese steel industry, which represents half of global steel production and related carbon dioxide emissions. It is scheduled to begin production by the end of 2021.

Valentin Vogl, Max Åhman, Lars J. Nilsson (2018) "Assessment of hydrogen direct reduction for fossil-free steelmaking," *Journal of Cleaner Production*, Volume 203, 736-745 doi: Peter Hergersberg "Metal industry is about to undergo one of the greatest upheavals in history." *phys.org* November 12, 2019.

:Steel production using solar power

Problem:

Recent studies found that 14% of steel firms' market value is in jeopardy if they are unable to decrease their environmental impact. The and steel sector is the "world's largest industrial source of climate pollution," according to the Cold Steel Hot Climate report, which notes that steel represented approximately 5% of final energy use and 7% of emissions worldwide in 2013.

Solution: The first steel mill to be powered by sustainable energy is EVRAZ North America's 240-MW Bighorn Solar Project at its Rocky Mountain operation in Pueblo, Colorado. USA. Xcel Energy, as the power provider for the steel mill, will purchase the power generated by the solar farm under a -term contract with Lightsource bp. The solar facility will be located on on 1,600 acres of at the steel mill.

McCarthy Building Companies was selected by Lightsource bp as EPC — installing nearly 750,000 Canadian Solar bifacial solar panels, mounted on trackers from Nextracker. Commercial operation is expected by 2021

While the mill operates 24 hours a day, solar panels do not. Over the course of a year the solar farm is expected to produce electricity roughly equal to 95% of the mill's annual demand. On sunny days, excess power will be sold to the Colorado grid, but at night the mill will power from the grid, which includes a good bit of fossil energy.

Luckily, about the time solar panels are dark, winds whip up across the plains of eastern Colorado, where wind turbines will turn it into power. At certain hours during the night, wind farms can supply as much as 70% of the power on the state grid, and that is likely to be and often as the company signs contracts with new wind farms.

:Steel cutlery

Problem:

For 6,000 years, there was a quest for an affordable tasteless metal such as and silver to eating utensils.

Solution:

Stainless steel cutlery, often passed from generation to generation, does not need recycling. Following Harry Brearley of Sheffield's Tomorrow'sy in 1913 that adding chromium to molten produced a metal that did not rust, the following year, Robert F Mosley& Co Ltd, also of Sheffield, became the first factory to produce and market stainless steel commercially. Trademarked as "Rusnorstain", Mosley's original knives and cutlery, regularly reconditioned with a honing steel are in use a century later, despite their ivory or handles. Modern cutlery can be with wooden handles

Stepwells

Problem:

Summer in Rajasthan is sweltering with average temperatures as high as 45 degrees.

Solution:

At the height of summer, the campus of The Pearl Academy of Fashion, in the industrial suburbs of Jaipur, Rajasthan, remains 20° cooler. When Manit and Sonali Rastogi of Morphogenis Architects, NewDelhi, drew up the plans for this building in 2008, it needed to be a confluence of modern adaptations of traditional Indo-Islamic architectural elements and passive cooling strategies prevalent in the hot-dry desert climate of Rajasthan

At the base of the building is a vast pool of water called a Stepwell, a body of water encased by a descending set of steps, a passive cooling concept developed locally over 1,500 years ago to provide refuge from the desert heat. The stepwell may have originated to ensure water during periods of drought.

Together with this, the building is protected from the environment by a double skin which is derived from a traditional latticed screen element called the 'Jaali' which is prevalent in Rajasthani architecture. The double skin acts as a thermal buffer between the building and the surroundings. The density of the perforated outer skin has been derived using computational shadow analysis based on orientation of the façades. The outer skin sits 4 feet away from the building and reduces the direct heat gain through fenestrations. Drip channels running along the inner face of the Jaali allow for passive downdraft evaporative cooling, thus reducing the incident wind temperature. In this way the warmth is slowly released at night when the temperature drops. The whole building is raised above the ground on pillars, creating an airy and shaded pavilion that is used as

a recreation and exhibition space. Energy efficiency is a prime concern and the institute is 100% self sufficient in terms of captive power and water supply and promotes rain water harvesting and waste water re-cycling through the use of a sewage treatment plant.

:Stern Review on the Economics of Climate

Problem:

It is necessary to know the effect of global warming on the world economy.

Solution: On October 30th 2006, a 700- report released for the UK Government by economist Nicholas Stern, chair of the Grantham Research Institute on Climate and the Environment at the London School of Economics (LSE) and also chair of the Centre for Climate Economics and Policy (CCCEP) at Leeds University and LSE.

Prepared over a period of one year by a single team, although not the first economic report on climate , it became significant as the largest and most widely known and discussed report of its kind. It attempted to address climate and its impact on the global economy vs. what would happen if the world continued emitting carbon pollution unchecked.

Weighing all these and benefits in terms that governments can create policy solutions around and businesses can prepare for is no small task. Stern's Review provides prescriptions including environmental taxes to minimise the economic and social disruptions. The Stern Review's main conclusion is that the benefits of , early action on climate far outweigh the of not acting.

It found that cutting carbon emissions so that carbon dioxide peaked in the of 450-550 parts per million would cost 1 percent of the GDP annually, but ignoring climate could cause economic damage on the of up to 20 percent of the GDP. Translated into real world numbers, the Stern Review put a price of about $85 per ton of carbon pollution emitted today, well above the current used by the U.S. of $40 per ton.

In an interview at the 2013 World Economic Forum, Stern said "Looking back, I underestimated the risks. The planet and the atmosphere seem to be absorbing less carbon we expected, and emissions are rising pretty strongly."

The Economics of Climate : The Stern Review, Cambridge University Press, 2007.

:Stone Paper

Problem:

To produce one ton of paper, takes 20 trees, and a single sheet requires 30 pints (14 liters) of water. Each year 4 billion trees are cut for the production of paper. Chlorine, acid, solvents and chemicals are required for the whitening of paper from vegetable fibres. The recycling of cellulose based paper is also a filthy process.

Solution:

Stone paper, also known as limestone paper, rock paper, bio-plastic paper, mineral paper and rich mineral paper, is a type of and durable paper-like as material manufactured from calcium carbonate bonded with small amount of resin high-density polyethylene (HDPE).

Used paper is shredded in thin strips, warmed up until it has the texture of a dough, then it is pressed through a pasta making machines, dried and then broken down into pellets of polyethylene (20 %) and powder (80 %) without any need to use chemicals to remove ink. Those pellets are extruded for a new of paper, with no need for additional plastic in the mix. In other words, plastic is initially required, but it can be re-used endlessly to paper.

This is the first time that synthetics are used as they should be according to their functional capacity: forever. By contrast, paper from vegetable fibres can be recycled four to six times before the fibers become too short and weak to a quality product. Both the production-process as well as the end-product are cleaner and non-wasteful.

In addition, Paper paper is easily broken down by sunlight; 200 micron G-ECO paper will begin to break and crack like an egg shell in the outside air in a period of 9 to 12 months (if the material is left in the sun 10 hours a day). It can also be easily burned without the release of harmful gasses.

The process for creating Paper was first developed by Taiwan Tech Co. in Taiwan during the 1990s, and from 2010 a series of Chinese patents were obtained for Paper and some of the key players are Paper Company Ltd.of Auckland, New Zealand (product Rockstock), Karst of Sydney, Australia, Kapstone Paper of Northbrook, Illinois, Gaia-Concept BV, Taiwan Technology Co. Ltd, Sluz Paper S.A., Packaging Corporation and Parax Paper.

Valentina Palladino, "This Paper Is From minerals, But It Isn't Exactly Eco-Friendly", *wired.com*, 2013; Cancy Chu and Petronella Nel, “Characterisation and deterioration of papers,” *ResearchGate*, October 2019.

: Organic food stores

Problem:

Foods produced using pesticides and fertilizers, antibiotics, GMOs, and additives are detrimental to health both of humans and of farmland.

Solution:

Founded in 1936, Sawall Health Food Products, Inc. is the United States' oldest family- natural foods store in existence, now in is fifth generation. It sells powdered minerals and vitamins alongside natural and foods. *(sawallhf.com)*

In Germany, from 1974, Thomas Greim of Moosach, Munich began selling his Demeter dairy products including milk in glass bottles. Two years later, Greim added added biodynamically grown fruits and vegetables to the . By 2019, 600 products were available under the exclusive brands Dennree, Königshofer, Gustoni and Yalia.

For example, DennreeNaturkost in Austria distributes around 13,000 products to 1,400 independently-run and health food stores in Germany, Austria, Luxemburg and South Tyrol (the German-speaking part of Italy). In 2003, Dennree opened its first denn's Biomarkt in Bavaria. It now operates 215 denn's supermarkets in Germany and 27 denn's markets in Austria. *(dennree-biohandelshaus.de)*

In 1973 Michael Radau of Münster founded health food store Makrohaus and twenty years later Radau expanded the company into Super Bio Markt, the first full- supermarket in North -Westphalia and set up a chain selling 7,000 items. *(superbiomarkt.de)*

In 1984 Götz Rhen launched the Alnatura food , with 59 stores by 2010 and 107 supermarkets across Germany by 2019. *(alnatura.de)* According to data by EHI Retail Institute, the food market in Germany was worth US$ 10.27 billion (€9,48 billion) in 2016. Over half of this turnover - 5,45 billion Euro - was generated by sales of products in the conventional supermarket channel

In 1985 introduced The Agriculture label (or AB label) based on the ban on the use of products derived from synthetic chemistry. It it possible to identify products resulting from farming. From 1991 the European Union began to apply the regulations governing this label to other member States gradually replacing it with a star-shaped leaf logo.

In , in 1993, Claude Gruffat brought together cooperative and non-cooperative societies and opened an food shop he called Biocoop in Blois, a hillside city on the Loire River.

In 2005, Biocoop merged its logistics platforms and helped create Enercoop, a renewable electricity supplier. It also created its subsidiary Biocoop Restauration whose objective is the development of collective catering. In 2006,

Biocoop created its own transport company, Société de Transport Biocoop (STB).

By 2017, Biocoop had 431 points of ; 2019 600 stores throughout , developing farming. Currently, its network is composed of several hundred stores throughout . In England, Planet , founded in 1995 by Elliott was the UK's first supermarket. *(biocoop.fr)*

Bio went "giga" in March 2109 when Japanese-American 7-Eleven Inc. the world's largest grocery store chain with over 46,000 outlets in 16 countries, debuted its first "lab store, stocked with gluten-free, paleo, vegan, , and naturally sweetened options, at the Dallas outpost of Laredo Taco Company, in South Texas.

Hugues Toussaint, "Biocoop 1986/2006 la bio en mouvement"; Annemarie Kruse "A look at Germany's top retailers," *organicwellnessnews.com*, August, 30 2017.

:Storm Board

Problem

One of the side effects of the COVID-19 pandemic is the multiple pile-up of medical equipment: disposable facemasks, plastic gloves; visors and face screens; safety gear (helmets, bump caps), lateral flow tests etc. Approximately 129 billion disposable masks, mostly made from plastic microfibres, and 65 billion disposable gloves have been used every month during the pandemic, according to a study in the journal "Environmental Science and Technology". They often end up on beaches and in rural areas, destroying the landscape as well as hurting wildlife.

Solution:

Storm Boards

ReWorked, based in Hull, England have developed standard boards made from 100% mixed plastic waste. Materials can include COVID single use waste. Indeed in 2021, ReWorked provided the Brighton & Hove Council in Southern England with “Leave No Trace” PE recycling bins and hand sanitiser stations in busy areas of the city centre, including at the popular Sea Life Centre, Komedia. Again with ReWorked, the UK supermarket chain Morrisons (483 stores) have launched a Mask Force campaign to bring single-use face mask recycling to the masses, promoted by the top-selling national newspaper “The Sun”

:STRAP, or Solvent-Targeted Recovery and Precipitation processing

Problem:

While a bag of chips might not look very complex on the outside, it is in fact a multi-layered plastic bag. Polyethylene is up of several extremely thin films stacked on top of each other to provide strength, flexibility, and integrity. The layers are chemically incompatible when it comes to breaking them down. They simply cannot be recycled en masse like soda bottles can.

Solution:

STRAP, or Solvent-Targeted Recovery and Precipitation processing.

University of Madison-Wisconsin professors of chemical and biological engineering Huber and Reid Van Lehn and their students created a technique called that could be the solution.

The key to the new process is to selectively dissolve a single polymer layer in a solvent system in which the targeted polymer layer is soluble, but the other polymer layers are not. In other words, you need to break down each polymer layer individually, and use a solvent to dissolve them one at a time.

STRAP relies on a computational approach used by Van Lehn called the Conductor-like Screening Model for Realistic Solvents (COSMO-RS) to guide the process.

COSMO-RS is to calculate the solubility of polymers in solvent mixtures at varying temperatures, narrowing down the number of potential solvents that

could dissolve a polymer. The team can then experimentally explore the candidate solvents.

The researchers . In a study published November 20th 2020 in the journal *Science Advances*, the researchers lay out their for why the technique could start a recycling revolution.

The Madison-Wisconsin team tested their process using a real-world multilayer film built by Amcor Flexibles, which designs pouches and for food, drinks, healthcare, and other essentials. The process achieved separation of these three components with nearly 100 % material efficiency

The goal is to eventually develop a computational system that will allow researchers to find solvent combinations to recycle all sorts of multilayer plastics.

The team is continuing its research on STRAP processing through the newly established Multi-University Center on Chemical Upcycling of Waste Plastics, directed by Huber. Researchers in the $12.5 million U.S. Department of Energy-funded centre are investigating several chemical pathways for recovering and recycling polymers.

The STRAP process could eventually level up to on current levels of plastic waste.

W. Huber et al. “Recycling of multilayer plastic packaging materials by solvent-targeted recovery and precipitation”, *Science Advances* 20 Nov 2020, Vol. 6, no. 47

:Straw construction

Problem:

Timber buildings can be destroyed by fires and tornadoes/

Solution:

Sustainable straw insulation is a protective solution can stand up to fire twice as as those built with standard materials. Straw bales’ availability and low cost are definite draws. The material is dry straw left over from harvesting such as wheat, rye, and , which it is readily found and reasonably priced compared to other high-performance insulation materials.

Its nontoxic, biodegradable nature there's no off-gassing from it. If sourced locally, it has low embodied energy; the energy used to cut and straw is significantly less that used to manufacture and transport other insulation products, which are rarely locally sourced. It is also carbon sequestering.

When laid flat and stacked like in a 'running bond' pattern, a plastered straw- wall is ±27" . Stacked 'on edge', with straw parallel to the of the wall, an R-33 insulation level is achieved in 25% less width (±18"). This is several times the value of typical insulated wood wall.

People probably began to use straw in the Neolithic period when they first grew cereals. In most of England, thatch remained the roofing material available to the bulk of the population in the countryside, in towns and villages, until the 1800s. From the 1880s homesteaders in the Great Plains of Nebraska started building walls with straw produced by their reapers that used a knotter device to bundle and bind hay into bales. of these structures stand today.

Then in 1920, the "Nebraska system" was improved by Émile Feuillette to build his home in Montargis in the Loire region of . Feuillette's patented system has been further improved and today 5 000 buildings using straw bales are located throughout with 500 new units built every year.

The first thatched houses were built in Europe in Great Britain in 1994 and in Ireland in 1996, adapted to the different local climatic-environmental needs (England, Ireland, Wales, Scotland, etc.). In Italy, the Edipaglia Association is responsible for straw houses throughout the peninsula.

Nearly all of Berkley-based Arkin Tilt Architects' straw- projects located adjacent to or within wildfire zones in Northern California survived recent wildfires. In response to this summer's wildfires throughout California, ATA is offering the plans for these two homes, plus six others, to anyone who lost their home in the fires, for free on their website www.strawbaleplans.com.

:Straw drinking-straw

Problem:

Americans use 500 million disposable straws per day - or 1.6 straws per person. 500 million straws could fill over 127 school buses each day, or 46,400 school

buses every year! Some scientists estimate there are 7.5 million plastic straws polluting U.S. shorelines, and anywhere from 437 million to 8.3 billion plastic straws on shorelines around the world. consumes 9 million plastic straws per year. For a few seconds of pleasure, people been ready to use a plastic product which will hundreds of years to decompose.

From January 1, 2020, it became illegal to sell plastic drinking straws and drinks stirrers, in and the UK. But an alternative had to be found. In 2018, McDonald's fast food chain announced it would replace its plastic straws with paper , for CocaCola but inadequate for milk shakes. The month, Starbucks announced plans to ditch plastic straws in all its coffee shops around the world by 2020.

Solution:

Glass-making Schott AG developed high-quality glass drinking straws not optically enhance every favourite drink; they are also taste-less, reusable and recyclable. Tested at bars all over the world, they are non-porous, do not affect the taste of the drink, and are easy to clean and dishwasher . Consumers are to purchase Schott glass drinking straws in handy packs of 4 from one of their dealers.

Straws out of agricultural straw.

Jeff Lubrano, a 50-year-old designer at Studio Fertile in Paris, teamed up with 26-year-old Mike Sallard on his farm in Courgeoût, in region, where with his father they been cultivating cereals for twenty-five years. Having shared and been shocked by a video on the Internet of a tortoise suffering from a plastic straw in its nasal cavity, they decided something must be .

Having experiments to create straw drinking straws in the "Fab Lab" the Elabo de Bellême, Messsrs. Lubrano and Sallard launched the *La Perche*. The is to produce 3 million straw-straws in the first year, 15 million the second and 70 million the third. They are now planning to produce straw-based ear-buds and

another project: « La sucette normande »**.** ("The Normandy lollipop"): a candy apple, attached to the end of a rye . The packaging would be biodegradable of flower seeds.*(laperche.bio)*

Another alternative is bamboo. Green Enterprises of Boca , Florida was founded in 2007 by Terry Lehmann, determined to bio-degradable hot cups and straws. These are using sugar husks and bamboo, the two fastest-growing renewable sources of fiber for paper products in the world. It is better a normal paper straw because of the qualities of bamboo. Terry developed the Green2 for Retail and the TreeFree for Commercial . In 2018 Terry received the WBE Star Award for women's excellence in business leadership. *(green2tec.com)*

Another is the *Lolistraw*, of a seaweed-based material and designed by Chelsea F. Briganti of Loliware in New York. This straw can be consumed after you finish your drink (if you don't eat it, it can go in the compost or just dissolve in nature.) Briganti coined the term "Hyper-compostable" to convey that all of their products, including *Lolistraw*, will break down at the as food waste in compost or in the natural environment, such as a waterway.

The company is VC backed and has partnered with IDEO, The Ellen MacArthur Foundation, The Last Plastic Straw, Plastic Pollution Coalition & The Lonely Whale Foundation. The team recently announced their to replace one billion plastic disposables by 2020. *(loliware.com)*

laperche.bio; Fabrice Pouliquen, " le Perche, ils préparent l'après-plastique avec des pailles à … en paille," *20 minutes,* September 11, 2019.

:Submerged sculptures for protecting life

Problem:

Off the coast of Tuscany, Italy, the illegal act of industrially trawling the sea bottom with heavy nets, was devastating the benthic flora and fauna that exists

down below, especially the seagrass meadows which work at a natural barrier against erosion and are home to a unique ecosystem which teem with a myriad of fish.

Solution:

12-ton sculptures on seabed to the passage of the nets

Paolo Fanciulli has been fishing for 47 years with his small boat, *La Sirena,* off the Tuscan village of Talamone. From the 1980s, he began to that his catches were less and less abundant, in particular because of competition from industrial trawlers.

Initially, Fanciulli disguised himself as a police officer, blocked an industrial port, and he even tried to pierce nets with barbed wire. This not attracted media attention but also the local Mafia which sent him death threats and blacklisted him from fish markets.

In 2006, the Tuscan authorities began to install concrete blocks to obstruct the passage of these trawls. There are now nearly 800 in this area of the Mediterranean. But Fanciulli wanted to go further to attention to the problem of overfishing.

The solution was to solicit artists to sculpt the dissuasive blocks and create a real underwater museum. He launched a crowfunding campaign,“La Casa dei Pesci” (=The House of Fish in Italian), obtaining permission from ARPA, the regional environmental protection association, to install these sculptures 50 meters deep on the sea bottom.

His was realised when Barattini, President of the Michelangelo di Carrara quarries donated an army of marble blocks to the project, carved by artists such as an obelisk by Massimo Catalani and Giorgio Butini. Before artists from all over the world were participating: the acclaimed British artist Emily carved four 12-ton sculptures she calls “Weeping Guardians” while nearby lies a mermaid

by the artist Aurora Vantaggiato. Massimo Lippi has contributed 17 sculptures representing Siena's *contrade*, or medieval districts.

To-, thanks to the support of Greenpeace Italy and tourists, 39 sculptures been placed although the is 60. These attract diving enthusiasts, while pointing out the issue of overfishing. Algae covers the statues, and lobsters taken up residence nearby, while turtles and dolphins return to swim near the coast.

Paolo Fanciulli now offers eco-fishing tours on his boat Sirena in the Maremma Regional Park. This practice he calls **"***pescaturismo*" (fish tourism) which aims to combine profitability while also teaching eco-sustainability and a greater appreciation for the Italian coastline.

:SunBOTs

Problem:

Moveable PV panels require electricity to them.

Solution:

Biomimicry. The stem of the natural sunflower (*Helianthus annuus*) moves throughout the day so that its flowery head always squarely faces the sun, wherever it is in the sky. This is known as phototropism.

Ximin He and a team at the UCLA developed artificial flowers known as SunBots. Less one millimeter in diameter, the sunflowers use materials that expand and contract with heat to bend towards sunlight.

When part of a SunBOT's stem is exposed to light, it heats up and shrinks. This causes the stem to bend and point the artificial flower towards the light. The stem stops bending SunBOT is aligned with the light because the bending creates a shadow that allows the material to cool down and stop shrinking. A "field" of SunBots, constructed using almost any reversibly photo-responsive soft materials, could increase the efficiency of solar power. *(samueli.ucla.edu)*

Ximin He et al. "Artificial phototropism for omnidirectional tracking and harvesting of light." *Nature Nanotechnology* volume 14, pages1048–1055(2019).

:Supercomputer analysis of materials

Problem:

The to protect the Planet through searches for safer fuels, catalytic materials, and batteries involves hundreds of scientists across the globe. There are about 100 elements in nature. But they can form billions of different materials and chemicals. Which of these possible substances can create the chemical environment needed to form good catalysts for something such as making fertilizer or producing the myriads of other substances we need, such as fuels, and will cause less harm to our earth? And can theses catalysts be safely, reliably, and economically? Time is running out.

Solution:

To find new catalysts to produce hydrogen competitively is commercially today, a team of researchers at Danmarks Tekniske Universitet (Technical University of Denmark—DTU) in Kongens Lyngby are using the Niflheim Linux supercomputing cluster.

This is equipped with Huawei XH620 v3 servers with two 12- Intel Xeon processor E5-2650 v4 (24 cores in total) per node and from 256 GB to 512 GB of DDR4 memory per node connected by Intel -Path Architecture fabric. The team used the supercomputer to screen for thousands of different materials. By modeling the dynamics at these interfaces with time-steps in the simulation on

the of femtoseconds (10^{-15} or 1/1,000,000,000,000,000 of a second), they found a fairly short list of about 15 materials.

One of these, Lanthanum-Yttrium Sulfide (La-Y), was then by an experimental group at DTU and it turned out to some promising properties for water splitting. The Niflheim supercomputer cluster has also been used in conjunction with AI machine learning to search out the right couples, such as metal- and metal-sulfur cells, for the next-next generation of batteries with a a ten-year battery life. *(dtu.dk)*

A research team at the NanoScience Technology Center of University of Central Florida used AI to optimize the materials used to spray-on perovskite solar cells (PSC). The team reviewed 2,000 peer-reviewed publications about perovskites and collected 300 data points that were fed into the AI system the team created.

The system was to analyze the information and predict which perovskites recipe would work best. The perovskites thus isolated can be processed in solid or liquid state, and used to spray or paint bridges, houses and skyscrapers to capture light, turn it into energy and feed it into the electrical grid. Thze UCF team also predicted the best recipe to PSC with different bandgap perovskites. *(nanoscience.ucf.edu)*

Oxford PV™ – The Perovskite Company™, co-founded in 2010, by Kevin Arthur and Henry Snaith as a spin-out from the University of Oxford, England developed a technology whereby when perovskite crystal cells are built on top of conventional 156 mm x 156 mm silicon solar cells, in a tandem configuration, the resulting perovskite-silicon tandem solar cells can generate almost a third electricity.

Significantly improving the performance of silicon solar cells on the footprint, enables cost reductions that transform the economics of silicon solar energy generation. Oxford PV has a research and development site in Oxford, UK and an industrial pilot near Berlin, Germany enabling the accelerated of its

technology into industrial scale silicon solar cell production. In 2019, they announced plans to move into full commercial manufacturing.

Production of perovskite solar cells is "dirty" and positioned between other material layers they degrade over time, which they wind up in landfills at some point..

The new technique to build perovskite-based solar cells that allows for swapping out the perovskite it starts to degrade—without losing efficiency has been developed by a team at the Center for Nanoscience and Nanotechnology of Hebrew University in Jerusalem, Israel involves using screen-printed, three-layered all-nanoparticle networks as rigid frameworks for building cells bases on perovskites. Such frameworks allow the perovskites to percolate in a way that leads to photoactive networks. The final result is a substrate of porous conductive oxide layers which are separated by an insulator. The design results in a perovskite layer that is easy to remove and replace.

The team also tested their technique by allowing one of the cells to run enough to degrade and then recycled the perovskite material—after so, the cell was found to be just as efficient as new cells.

Jinxin Li et al, “Perovskite Solar Cells: Predictions and Strategies Learned from Machine Learning to Develop High−Performing Perovskite Solar Cells,” *Advanced Energy Materials,* 46/2019. Henry Snaith and Michael Lee, “Photovoltaic device comprising perovskites,” *Oxford University Innovation Ltd* European Patent N° 2850669B1 February 24, 2016. ; Extance, “The reality behind solar power’s next star material,” *Nature,* 25, 2019. Avi Schneider et al. “Green energy by recoverable triple-oxide mesostructured perovskite photovoltaics”, *Proceedings of the National Academy of Sciences* (2020).

:Supervolcano cooling system

Problem:

There are around 20 known supervolcanoes on Earth, with major eruptions occurring on average every 100,000 years. One of the greatest threats an eruption may pose is thought to be starvation, with a prolonged volcanic winter

potentially prohibiting civilisation from having enough food for the current population. In 2012, the United Nations estimated that food reserves worldwide would last 74 days.

Solution: A team of researchers led by Wilcox at NASA's Jet Propulsion Laboratory (JPL) at the California Institute of Technology, realising that the threat is substantially greater the asteroid or comet threat, found that the most logical solution could simply be to cool a supervolcano down.

A volcano the size of Yellowstone is essentially a gigantic heat generator, equivalent to six industrial power plants. Yellowstone currently leaks about 60-70% of the heat coming up from below into the atmosphere, via water which seeps into the magma chamber through cracks. The remainder builds up inside the magma, enabling it to dissolve and volatile gases and surrounding rocks.

this heat reaches a certain threshold, then an explosive eruption is inevitable. But if of the heat could be extracted, then the supervolcano would never erupt. NASA estimates that if a 35% increase in heat could be achieved from its magma chamber, Yellowstone would no pose a threat.

The strategy would be to drill a series of wells around the perimeter of the supervolcano. The wells would be some of the deepest in the world, reaching up to 6 mi (10 km) below the surface. Cold water would be pumped down into the wells, which over time, would cool a of rock around the magma chamber. The water would beheated to around 340° Celsius (662° F) as it moves through the chamber.

So the is to loop it back through the wells and use it to drive an electric generator, which could power the surrounding area for tens of thousands of years, essentially transforming Yellowstone into a geothermal power station. And ultimately, paying for itself in the end.

The is in extracting 20 gigawatts of energy to cool the volcano down to a temperature, which would an estimated 16,000 years from start to finish. Not to

mention, the would cost US$3.46 billion. This makes up about 20% of NASA's annual budget. Even , cooling the rock could create fractures near the magma chamber, which might trigger the supereruption you are intending to prevent. But to prevent a catastrophe, such -term thinking and planning may be the choice. Yellowstone explodes roughly every 600,000 years, and it is about 600,000 years since it last exploded, which should cause us to sit up and .

David Cox, “NASA’s ambitious to Earth from a super volcano,” *bbc.com*, August 17, 2017.

:SupraPulp

Problem:

The amount of plastic waste flowing into the could triple by 2040, choking our already strained ecosystem.

Solution:

Combining decades of experience in the packaging and hi-tech industries, Joseph Siani and Lior Itai at the Kibbutz Gan Shmuel in northern Israel created and patented a compostable, non-coated food packaging solution from a new material they called SupraPulp.

SupraPulp is compostable yet hardy enough to keep structural integrity when holding greasy, hot food. Targeted for frozen, ready- meals, It can be frozen to -40°C and heated in or microwave to 270°C. After use, it can be thrown out with waste. Plus, SupraPulp trays a luxury look and feel compared to plastic, aluminum, or bioplastic containers.

W-Cycle, their start-up is currently in advanced discussions with ready-meal manufacturers and a series of major airline catering companies from Europe and the Far East. Emirates, Ryanair and Portuguese charter airline Hi Fly all significant progress in reducing plastic dependency or pledged to become entirely plastic free in the coming years.

The company has also announced a partnership with Neto, a major Israeli food group.

:Plant-based polyurethane rigid foam surfboards and SUPs

Problem :

In 2015, Transworld Biz released a State Of Surf report, guesstimating that there were 2.7 million surfers in the world. Over 400,000 surfboards are sold worldwide per year. The Outdoor Foundation's Special Report into paddlesports found that 2.8 million Americans participated in standup paddleboarding *(*SUP). The majority of these are in fibreglass, polyurethane polyurethane foam, are non-recyclable and finish up in landfills.

Solutions:

In 2004 when a balsa tree toppled in the Humid Tropics Biome of the Eden Project in Cornwall, UK, leading team members to discuss what could be with the timber. Chris Hines and colleague Pat Hudson worked with local companies to a "blank" – a surfboard - from the timber and environmentally-friendly materials those used in conventional board production.

As the first balsa prototypes were too heavy, the team worked with three local companies Homeblown, Sustainable Composites and Hillzee Surfboards to produce an eco polyurethane foam blank, 15-20 % of which is from plant-derived material such as a bio-resin almost entirely from linseed oil.

The Ecoboard was launched at Fistral Beach in Newquay in March 2009 when leading British professional Mark "Egor" Harris and junior British surfing champion Tassy Swallow tested and approved it. Throughout the summer Ecoboards were available to try at a number of **surf** events organised by Surfers against Sewage. *(edenproject.com)*

The year, Edward "Ned" McMahon, a surfboard maker from San Diego formed Malama Composites Inc. to develop a foam material that comes from materials

such as bamboo, hemp, kelp and castor oil. Ned found the solution in a methylene-based compound which although is a petroleum-based product, is far less harmful toluene, a standard but ingredient used to rigid foams. It also has good insulating qualities and water resistance.

McMahon called his 2 lb (1 kg) density, closed cell, plant-based polyurethane rigid foam, Studio BioFoam. For its contribution to taking better of the , in 2015 Malama received an official “Certified Biobased Product Label” from the U.S. Department of Agriculture (USDA).

(malamacomposites.com)

Jeffrey Gotro, “How One Company Put Renewable Polymer Technology at the of Its Business Model,” *Polymer Innovation Blog,* February 11, 2011.

:Surgical Stapler plant-based and re-usable surgical textiles

Problem:

The U.S. healthcare sector is the second most intensive commercial user of energy. Hospitals are one of the largest energy users, contributing 8 % of the U.S. greenhouse gas emissions through the purchase of healthcare goods and services, and produce 4.67 million tons of waste each year.

Solution: Realizing the significance of these impacts, in 2012 Robert N. Chase of San Rafael, California created the start up NewGen Surgical with a vision to single-use medical devices sustainable through their redesign and material input.

Their first product, the NGS35W Skin Stapler is with 69 % plant-based material. It includes a handle assembly 80% of paper pulp products or other eco-friendly material. After use, skin staplers are disposed of in sharps bins and are either incinerated or sterilized and sent to landfill.

A healthcare system using 40,000 skin staplers per year could replace their existing plastic product and reduce their sharps weight by one ton and avoid 1.8 tons of plastic in the waste stream.

There are approximately 18 million single-use skin staplers disposed each year in the U.S.; that is potentially 630 tons of plastic that could be avoided in the landfill with the replacement of one sustainable product in one year.

Since then NewGen Surgical produced a needle counter, a , emesis ,.

Alongside, Austria is a worldwide pioneer and model country regarding reusable surgical textiles as by rental companies such as Salesianer Miettex of Vienna, compared to disposable products. Low energy and water consumption, their use of environmentally friendly chemicals, as well as low-emission vehicles and fuel-saving transports – these are the main criteria for the Austrian **eco**-label awarded to the chain of Salesianer Miettex laundries in 2015.

Using photovoltaics to generate electricity at these laundries has proved to be an ideal addition for Salesianer Miettex. As a partner of “klimaaktiv”, 1.2 kWp per year are harvested in the form of solar energy in total. This saves the environment some 330 tonnes of CO2 annually. Six projects involving photovoltaic plants are in the planning . Our medium-term planning goal is to gain a further MW of this clean energy.

Robert N Chase, Paul Kardel “Skin stapler with components optimized for construction with plant based materials”, NEWGEN SURGICAL, INC. Patent number: 9820739 **of Patent:** November 21, 2017

:Sustainable aviation fuel

Problem:

Prior to the COVID-19 pandemic, global fuel consumption by commercial airlines had increased each year since 2009 and is predicted to reach an all-time high of 97 billion gallons in 2019. During recent years, total fuel consumption of US airlines per year has been between 16 and 17 billion gallons (60 to 65 billion litres)). Airplanes could generate 43 gigatonnes of AGW pollution through 2050, consuming almost 5 % of the world's remaining carbon budget. While electric airplanes are developed, others been concentrating on Direct Air Capture, while some consider that the solution lies in less polluting fuel.

Solution:

In 2016, Oskar Meijerink, a sustainable energy scientist, and the Future Fuels team at SkyNRG in Amsterdam began to provide Sustainable Aviation Fuel (SAF) initially from residual lipids such as used cooking oil, thereafter progressing to sourcing either drought-resistant crops such as *Camelina,* grown on marginal in EU Mediterranean areas.

They now progressed to converting captured CO_2. For the latter, in a separate process, electrolysis splits water into hydrogen and . The hydrogen is mixed with the captured CO_2 to form syngas, which can be transformed into jet fuel called BIO4A. SkyNRG has supplied over 25 airlines on all continents worldwide, cutting CO_2 emissions by 63% to significantly reduce the aviation industry's carbon footprint.

In October 2019, SkyNRG launched its Board Now program with companies including PwC and Skyscanner signed up to the purchase of SAF for a period of five years, during which they will reduce their carbon emissions from business air travel and contribute to the development of a new fuel production facility.

The renewable fuel will be produced by Europe's first dedicated SAF production plant in Delfzijl, the Netherlands, which has an annual capacity of 100,000 tons of sustainable aviation fuel and gets its energy from solar panels. The partners in the project hope to produce the first fuel in 2021. *(skynrg.com)*

Oskar Meijerink, "Investments in Renewable Jet Fuels Barriers and opportunities for investors" *University of Utrecht, Imperial College London, Clmate-KIC*, 2015.

:Sustainable Cities: Masdar and Neom

Problem:

The oil-rich Middle East must focus on sustainable fuels.

Solution

Sustainable cities

Masdar (= city) 17 km east-south-east of Abu Dhabi in the United Republics was designed by Foster & Partners for the Mubadala Development Company to create a city whose recycling energy centre enabled a 40% reduction in energy consumption. Its chairman is Sultan Ahmed al Ramahi.

Covering some 6.35m², the first six buildings were completed and occupied by 2010.There are now some 860 companies with offices in Masdar including Siemens, Honeywell and Energy. Its estimated price now stands at US$ 22 billion. Automobiles are forbidden but personal rapid transport (PRT) pods are in regular operation.

KAUST, conceived by Abdullah bin Abdulaziz Al Saud, is a Science and Technology City located in Thuwal, Saudi Arabia. US$20 billion to create, it is home to 400 students from 60 nations and is a hub for innovative solution.

Neom *(= "new future")* a $9 billion smart city is part "Vision2030" , revealed in 2017, of Saudi Arabia's controversial Crown Prince, 32-year-old Mohamed bin Salman (MbS) to propel his nation into a carbon-free future.

Billed as "An Accelerator of Human Progress", the 26,500 square km (10,230 square miles) development has been laid out in Tabuk, in north-western Saudi Arabia on the corner of the Red Sea. This will allegedly enable "70 percent of the world's population to reach it in less eight hours." Much of this will come via an ambitious bridge project which is to connect NOEM with Egypt and the rest of Africa. It will be an "independent special ," governmentally, judicially, and culturally autonomous from Saudi Arabia.

In July 2020, Neom and ACWA Power signed a joint venture agreement with Air Products of the U.S. to build the largest green hydrogen and green ammonia plant in the world. The hydrogen will be produced by 4GW of wind and solar, managed by robots. By the end of the decade, NEOM aims to produce 15 gigawatts of renewable energy.

The NEOM will focus on nine sectors including food technology, energy, and water. As a tourist attraction, it will robot maids, robot MMA fighters, an island with robot dinosaurs, and an artificial moon with screens that will broadcast images of the cosmos, replacing the stars outshone by neon lights.

:Sustainable energy device

Problem:

There is a technical challenge in the surplus energy produced by wind turbines of solar panels.

Solution:

At the Institut Mines-Télécom Atlantique, a engineering school serving companies located in Nantes, teams from the research laboratory with others, in partnership with the family company Segula Technologies of Nanterre, Isle de found a non-polluting way of locking the energy produced to redistribute it on demand.

The principle is simple: the wind turbine, when there is wind, provides electricity. Part of this electricity is used to power a water pump which will push water into a piston and compress air. This compressed air will be stored. When there is less wind or no wind but there is a demand for electricity, the air will be decompressed. The water is then pushed back into a turbine that supplies electricity.

Following two years of R&D by a team lead by David Guyomarc’h, head of energy Segula Technologies, the process was patented in 2015 then developed through Remora offshore technology. *(segulatechnologies.com)*

The realisation is complicated. Pistons that will allow the compression of air must be installed on at sea, near offshore wind turbines. They will a height of 33 ft (10 m). The air will be compressed at sea and stored under water. The stored energy will be dependent on the number of wind turbines disposed.

The construction and commissioning of the first demonstrator, called the ODySEA with a power of 10kW in the laboratory, was scheduled for summer

2019. This three-year project, labeled by the S2E2 competitiveness cluster, is funded by Ademe. Cetim is taking of the test bench, from conception to operation at its Nantes site. In particular, it will study the hydraulic and pneumatic reversible operation of the system by making use of its expertise in dimensioning hydraulic networks with complex dynamics. Scaled up the system could provide electricity for an entire town.

Thibault Neu, " Etude expérimentale et modélisation de la compression quasi isotherme d'air pour le stockage d'énergie en mer," *Thesis* 2017 ; David Guyomarc'h et al., "Optimal energy management of an underwater compressed air energy station using pumping systems," 2018.

Synthesized dairy products

Problem:

Butter third, below beef and lamb, for carbon dioxide emissions per pound of food. Cheese comes fifth.

Solution:

Synthesized dairy products

From 2014, Pandya and Perumal Ghandi of Perfect Day Inc in Berkeley California produced synthesized milk by altering sections of the DNA sequence of food- yeast into *Trichoderma reesei* fungus such that the microorganisms, fed with certain nutrients, produce of the dairy proteins, casein and whey found in milk (casein, lactoglobulin, and lactalbumin);

Combine those with water, plant-based fats, vitamins, and minerals, and you get dairy products—without having a cow - like mozzarella cheese, baked goods that require milk, yogurt, and milk shakes.

Smitten Ice Cream and Robot turned the proteins into delicious vegan, dairy-based ice cream, but Perfect Day is hoping to expand into a whole of creamy products, for example nosh on a with real schmear that doesn't contribute to the climate crisis.

Perfect Day, the most well-funded protein fermentation company in the world, has over $360 million in total funding to-. The recent acceleration has been supported by continuing expansion of production capacity of its animal-free dairy protein, solidifying new and foodservice partners, and establishing commercialization plans in new product categories within the next year.

In Glil Yam, Tel Aviv, Israel, Ori Cohavi and Aviv Wolff also founded the start-up Remilk to commercialise their patents for microbial fermentation to create a that is identical to dairy milk but free from animal-derived ingredients.

The Israeli solution was to recreate the proteins by taking the genes that encode them and inserting them into a single-cell microbe, which they manipulated genetically to express the protein in an efficient and scalable way. Using a microbial fermentation process, they increased the number of proteins, which they then dried into a powder. When mixed with water, plant-based oils like coconut oil or sunflower oil, and plant-based sugar, the milk liquid and its derivatives can be produced with exactly the properties, taste and structure, he said

Remilk has raised $11.3 million in capital to move its goal of disrupting the global dairy industry into production.

Perfect Day’s and Remilk’s solution for food production will be up to 100 times efficient the existing dairy system, 25 times feedstock efficient, 20 times time-efficient, and 10 times water-efficient, he said.

:Swarm electrification

Problem:

In 2000, 68 % of the Bangladeshi population had no permanent access to electricity. As part of its response to the UN's Millennium Development Goals (MDGs), the Bangladeshi government set a of providing electricity to all its citizens by 2020.

Solution:

The Solar Home Systems (SHS) initiative began in January 2003 and was facilitated by the government- Infrastructure Development Company Limited

(IDCOL) in Bangladesh, which cooperated with international and local partners to install solar home systems in remote rural areas, which are not easily accessed by the national electricity grid.

Dr. Sebastian Groh of the Berlin Technical University, Germany, has questioned the traditional approach of a top-down, centralized and fossil-fuel based scheme, introducing a bottom-up concept based on decentralization and resource-efficiency, coined as swarm electrification. In 2013, Groh pointed out the millions of solar home systems already existing in Bangladesh and the extreme user behavior when people try to electricity and at what cost.

In 2015, Groh set up SOLshare in Dhaka to inaugurate the world's first P2P (peer to peer) cyber-physical energy platform that enables low-income rural households with and w/o solar home systems to their (excess) solar electricity via a mobile money platform. SOLshare's signature product, the SOLbox, developed by Neel Tamhane, is a machine-to-machine (M2M) enabled integrated direct-current bi-directional power meter that forms one node of a peer-to-peer (P2P) solar nanogrid.

SOLBox is an affordable pay-as-you-go device that has two options – buy or sell. It is the precursor of the 'swarm' approach for sustainable rural electrification. That people can sell excess power into the network, where neighboring homes and businesses can buy it in small increments with a mobile . If connected to the main grid, this so-called "swarm electrification" approach, which allows grids to grow dynamically, could lead the way for the future of utilities globally.

SOLshare was the winner of the Intersolar Award 2016 in the category of "Outstanding Solar Project" and was one of 13 winners of the United Nations climate awards. As of May 2017, over 4 million solar home systems had been installed, impacting 12 % of the entire Bangladeshi population. By 2019 this had grown to 5 million and is growing. *(me-solshare.com)*

SA Chowdhury, S Aziz, S Groh, H Kirchhoff, W Leal Filho, “Off-grid rural area electrification through solar-diesel hybrid minigrids in Bangladesh: resource-efficient design principles in practice,” *Journal of cleaner production* 2015 Vol. *95,* pp. 194-202.

SWIIM

Problem:

As populations in Colorado and the West continue to grow, water is moving from farms to cities. The current practice of “buy and dry” in Colorado – buying farmland for its water – is bad for farmers, bad for rural communities and bad for critical ecosystems across the state.

Solution:

SWIIM

In 2009, Regensis Management Group was searching for a solution on how to help growers throughout the west quantify, protect and monitor their crop-water in a precise, while cost-effective way. They wanted to limit what is referred in our parts as “buy and dry” – the buying up, and drying out of swaths of agricultural , for their most valuable asset: water.

Hydro geologist Bob Stollar and international water engineer and irrigation expert Stephen W. Smith spent five years of research and development on the technology through agreements with the U.S. Department of Agriculture–Agricultural Research Service (USDA-ARS) and Colorado State University (CSU). In 2013, the company added Utah State University to its partnerships.

It secured a research and development site in northern Colorado in 2009. In 2010, the company began receiving support from the State of Colorado's Water Conservation Board to help support the system's implementation and in 2012 received a from the USDA to continue development.

The solution, called Sustainable Water and Innovative Irrigation Management (SWIIM) comprises a toolkit for farm-optimization and water-conservation to help transform the way agricultural water is distributed, bought, and sold.

This includes monitoring crop-water on-and off-flows, consumptive use, subsurface deliveries, precipitation and weather data to produce a comprehensive, defendable water budget that can then be balanced like you would your financial account.

In 2020, SWIIM released their “SWIIM Software as a Service” model, for advanced water use analytics.

Stephen W. Smith et al. “System and method for conserving water and optimizing and water use”, *SWIIM System, Ltd., The United States of America as Represented by the Secretary of the Department of Agriculture* **Patent N°:** 9202252, December 1, 2015.

:Chemicals-free swimming Pool

Problem:

There are 10.4 million residential and 309,000 public swimming pools in the United States, according to the Association of Pool & Spa Professionals (APSP). has the highest number of private swimming pools in Europe: 1,860 000. of these are built in fibreglass. For swimming pool maintenance, chemical disinfectants, such as chlorine (usually as a hypochlorite salt, such as calcium hypochlorite) and bromine, are commonly used to kill pathogens. absorbed through the swimmer’s skin, extended contact can potentially cause health problems such as red eyes and dried-out skin and hair.

Solution:

Natural pools were developed in the early and mid-1980s by designers and landscape architects with environmental concerns. They recently been growing in popularity as an alternative to traditional swimming pools.

For example Toronto-based architects, gh3 unveiled a chemical-free natural pool in the city of Edmonton, Alberta. The Borden Park Natural Swimming Pool, which replaced an existing pool that dated back to the 1950s, was incorporated with several innovative natural filtration processes that use a combination of , , and filtering to keep the waters clean and pristine.

The project was a massive undertaking from the start. The old pool and infrastructure had to be completely gutted to room for the new, completely chemical-free swimming pool. The 64,465 ft² (6,000 m²) complex is up of a seasonal pavilion and landscaped pool area that accommodates up to 400 swimmers. In addition to the main swimming area, there is also a kids' pool. Next to the outdoor area, a contemporary building houses the universal changing rooms, with showers and bathrooms. There is also a sandy beach and picnic area, as well as a volleyball court and exhibition space. *(gh3.ca)*

Another example of a chemical-free swimming pool is King's Cross swimming pool, a man- freshwater pond filtered and kept clear through natural processes. Designed by Rotterdam Studio architects and artist Marjetica , the "Of Soil and Water: King's Cross Pond Club" project was commissioned as part of the public art program RELAY and the 66 ac (27 ha) King's Cross redevelopment. The 130 ft. (40m.) bathing pond can accommodate over 100 bathers and explores the relationship between nature and the environment. *(.eu.com)*

In *Mother Earth News* August/September 2002, Douglas Buege and Vicky Uhland explained how to build a natural swimming pool on a homestead, including information on pool zoning, natural filtration, sealing the pool and algae control. They recommended that rushes, sedges and water lilies not provide a beautiful border around a natural swimming pool, but they keep the water clear and clean.

Companies such as Clear Water Revival in Bristol (UK) and Mick Hilleary at Total Habitat in Kansas City (US) can retro-fit private pools with regeneration zones and even a whole array of plants that swimmers can even eat.

Douglas Buege and Vicky Uhland, "How to Build a Natural Swimming Pool," *Mother Earth News,* August/September 2002; Dan Howarth, "Freshwater bathing pond to in London's King's Cross," *Dezeen*, March 25, 2015; Cynthia Dovell, " Master Stroke: Borden Park Natural Swimming Pool, Edmonton, Alberta," *Canadian Architect*, December 4, 2018.

Switchgear, free of SF6 gas

Problem:

With the exponential increase in the use of electricity, using the array of devices described elsewhere in this book, the vast majority of electrical switches and circuit breakers that are needed to prevent serious accidents, collectively known as switchgear, use Sulphur hexafluoride (SF_6) gas to quench arcs and stop short circuits. However, SF_6 is 23,500 times warming CO_2.. It also persists in the atmosphere for a time, warming the Earth for 800–3,200 years.

Solution:

The Kyoto Treaty (1992) stipulates that emissions of SF_6 gas must be reduced. The United Nations institution that monitors this, the Intergovernmental on Climate (IPCC), has since then added SF_6 to the list of extremely harmful GHGes.

The first high- SF_6 circuit breaker built in 1956 by Westinghouse but it was not until the 1980s, that the Holec Machines in Hengelo, the Netherlands a fundamental choice not to use SF_6 as a switching and insulation medium for medium equipment, due to the complexity of the treatment required and the need for additional safety measures when used in public locations such as residential areas and shopping centres.

There was also the possibility that SF_6 could be labelled an environmental risk, as was the then with PCB's and asbestos.

At the time, Hitachi Ltd. in Japan. 72-kV developed an SF_6 –free dry-air insulated switchgear unit for railway use. The Eaton Power Group's Cutler-

Hammer , which was the market leader in the United States with NEMA/ medium equipment, was also developing SF6 free medium vacuum switchgear for the reasons.

Eaton's medium and low- SF_6-free switchgear offers a wide of innovative UL® 1558 and UL® 891 designs providing , intelligent and flexible solutions to optimize operational performance, enhance safety and space. In September 2018, Eaton Industries Netherlands BV announced production of the 100,000th Eaton Xiria , an important mi. for a leading SF6-free medium switching device which is used today by customers in 30 countries. *(eaton.com)*

Other major players are making the transition. Siemens Energy Management has received an from Bergenshalvøens Kommunale Kraftselskap (BKK Nett) in Norway to supply the world's first SF_6-free GIS (gas-insulated substation) with "clean air" and vacuum interruption systems for a level of up to 145 kilovolts (kV). *(Siemens.com)*

In 2019 at CIRED (the International Conference and Exhibition on Electricity Distribution) Schneider Electric also announced its digital SF6 free technology using pure air insulation and vacuum interruption. *(se.com)*

In the North Sea some 27 mi (43 km) from the Suffolk coast, Scottish Power Renewables has installed one of world's biggest wind farms where the turbines will be free of SF_6 gas. East Anglia One will see 102 towering generators erected, with the capacity to produce up to 714MW (MWs) of power by 2020, enough to supply half a million homes. The farm will use a combination of clean air and vacuum technology within the turbine. It allows us to a very efficient, reliable, high- network but to also be environmentally friendly. *(scottishpowerrenewables.com)*

The electrical industry overall is now rolling out green switching alternatives to SF_6 gas as the European Commission starts a wide- review that could result in a decision to ban SF_6 from MV switchgear by 2020.

, W. and Schoonenberg G.C. “Green Switching - Opportunity to avoid SF6 emission from electrical networks”, *Fifth International Symposium on Non-CO_2 GHGes (NCGG-5), Wageningen,* The Netherlands 2009 3.

Tamsui River solution

Problem:

the shore of the Tamsui River, there are a few items that don't belong: plastic water bottles, Styrofoam, fishermen nets, plastic crates, and . The trash strewn here varies, from the plastic and PET bottles to household waste.

Solution:

Plogging afloat - pladdling

In 2020, a retired Englishman named Peter Lowe visited his son in Taiwan. When his return flight was cancelled due to COVID, he got himself boat and decided to look at the wildlife on the Tamsui River

Horrified by the amount of garbage he discovered in the river. He began picking up the trash himself, bit by bit. His self-initiated environmental action caught the locals’ attention, a growing number of whom volunteered to join the mangrove cleanup.

Two to three days a week, a fleet of 20 and sampans head out the Tamsui to pick up rubbish the riverbank and mangrove. As the tide rises and falls at the estuary, trash gets between in the mangroves on both sides. The volunteers to work together to pull up garbage that's buried deep in the river.

Interviewed by the Media, Lowe suggested that people who are in the situations could do something positive and meaningful, especially something that would and protect the Earth.

:Tapioca – the Osaka Solution

Solution:

Japanese scientists developed a new biodegradable plastic. They claim it's twice as as conventional plastic from polyethylene. from cassava starch, a raw material for tapioca, and cellulose from wood pulp, the plastic can be broken down by microorganisms in water in 30 days. The team hopes the plastic could be used to reduce plastic waste in the .

The project was a joint effort from Osaka University and Nippon Shokuhin Kako Company, a Japanese agricultural that produces starch-based food products.The team extracted starch from cassava provided by Nippon Shokuhin Kako and combined it with cellulose taken from wood pulp. The mixture was dissolved in a water solution and spread into a transparent sheet that is 100 micrometers but it has twice the strength of widely used plastics of polyethylene. To test its biodegradability, they placed samples of the new plastic in several different containers filled with seawater, each of which had varying levels of microorganisms in them.

The team found that the plastic fully down within 30 days in the seawater sample with the highest concentration of microorganisms. Because these materials are cheap and the manufacturing process is simple, the Japanese researchers expect that the developed material will be put to practical use as food packaging materials, which are very familiar to people and are often contained in the waste in the sea.

:Tax on Plastic Packaging

Problem:

With two million tonnes of plastic used each year, manufacturers must be encouraged to replace single-use plastic with recycled plastic.

Solution:

Plastic Packaging tax

In March 2018, the UK Government announced it would be introducing a plastic packaging tax.

In October 2020, Her Majesty's Revenue & Customs (HMRC) published draft legislation and a policy paper on the 'Introduction of a new plastic packaging tax'

The policy paper states: "Recycled plastic has a carbon footprint that can be up to four times lower that of virgin plastic. The policy may also help to divert plastics from landfill or incineration, and drive recycling technologies within the UK."

Included in the tax would be a £200 per levy for packaging with less 30% recycled plastic as opposed to an exemption for businesses which manufacture and/or import less 10 tonnes of plastic packaging in a 12-month period

This Tax should come into force from April 2022.

Taxi fleet (x600) hydrogen-powered

Problem:

In cities around the world, fleets of taxis contribute to CO^2 emissions and pollution.

Solution:

A fleet of hydrogen taxis

At the end of 2015, French start-up STEP (Société du Taxi Electrique Parisien) in partnership with Air Liquide launched a hydrogen-powered taxi fleet called HYPE.

Four years after its creation, thanks to a new delivery of cars by Toyota, Hype counts 110 taxis operating in Paris, for a driving of around 500 kilometers. This makes it the largest fleet of FCEVs in the world and has announced it will grow its fleet to 600 hydrogen vehicles by 2020, thanks to a recent partnership with Toyota and Air Liquide.

Air Liquide continues to support the growth of the "Hype" fleet by building up the necessary network of hydrogen charging stations. These deliveries are part

of the ZEFER project, thanks to which Hype is accelerating its development in Paris and which has received funding from the Public Private Partnership on Fuel Cells and Hydrogen 2 Joint Undertaking (FCH JU).

Hydrogen offers a number of benefits for clean transportation. Used in a fuel cell, it combines with the in the air to produce electricity, with water as the byproduct. s. It takes less five minutes to recharge hydrogen-powered electric vehicles like ‘Hype taxis’

A *complete* 'zero-emission' *taxi* sector by 2024 with the Olympic Games is the ultimate dream. HysetCo will not manage a *fleet* of 600 *taxis*

At the time, in Paris, , the birthplace of the battery bus in 1881, bus operators Île de Mobilités and embarked on a bold new initiative to integrate total of 1,000 electric buses in their fleets by 2025.

:Polypropylene-free tea

Problem:

Canadian researchers published a study in the American Chemical Society’s *Journal of Environmental Science and Technology* which found that steeping a single plastic tea bag at brewing temperature releases about 11.6 billion minuscule particles known as “microplastics” and 3.1 billion “nanoplastics” into each cup. Teabags could be as big a cause of plastic pollution as microbeads or carrier .

Solution:

 tea are by a dozen manufacturers including Brew Tea Co., Teapigs. Aldi, Duchy , Hampstead Tea, Steenbergs We are Tea and Nemi.

Based in Keynsham, England, Pukka Herb teabags are of a special blend of natural abaca (a type of banana) and plant cellulose fibres. Their supply of tea bag paper is also unbleached. They are staple-free and 100% biodegradable and/or recyclable. The tea bag strings are from 100% , non-GMO, un-bleached

cotton use a simple of cotton and a unique folding process. This they do not need to use polypropylene or a metal staple to hold their teabags together.

The tea bag is a century old. Before that loose tea leaves would brew in a tea pot, while the tea infuser or strainer of stainless steel was for one or two people. These systems are eco friendly.

:Eco-friendly teddy bear

Problem:

The chemicals used in most teddy bears can cause and interfere with hormones, the reproductive system, nervous system, and overall development. By far, the most component of stuffed animals is the flame retardant, dangerous to health and environment any fire.

Solution:

In February 1996, Yvonne Wright & David Antony Sterricker in Catalunya, Spain, their first Ecobear, named “Harvest”. It was sewn on the finca, using photovoltaic solar energy to power the sewing machines in the workshop and used vintage English hemp/recycled cotton/recycled wool mix fabric.

Italian olive wood buttons are used for the limb joinings. glass & safety eyes are used accordingly. For other bear clothes & accessories Ecobears incorporate pieces of 100% hemp; hemp/ cotton; hemp-silk; raw silk; ecofelt from recycled soda pop bottles; and any other ecofabric Wright and Sterricker, relocated to Alicante, Valencia, like the look of.

Ecofriendly teddy bears are also by Elly Lu ; Under the Nile products are in Egypt with 100% Egyptian cotton that is Fair certified; Bears for Humanity; and Steiff.

:TEDx talks, ideas worth spreading.

Solution:

Information about solutions can often reach millions. TED was in 1984 out of Richard Saul Wurman's an American architect and graphic designer. observation of a powerful convergence three fields: **T**echnology, **E**ntertainment and **D**esign.

The first six TED Talk events, given to audiences, were posted online on 27, 2006. By September, they had reached one million views.

At a TEDx event, TEDTalks video and live speakers combine to spark deep discussion and connection in a small group. These local, self-organized events are TEDx, where x = independently organized.

Some of these talks dealt with solutions to clean up, to repair and to protect our Planet. For example, Lauren Singer's TEDxTeen talk "Why I live a zero waste life" has received over 3 million views, likewise Al Gore's "The for optimism on climate " (over 2,100,000 views) and Greta Thunberg (over 2,600,000 views)

Three-component photocatalytic reduction of CO^2

Problem:

Carbon dioxide (CO_2) emissions from human activities have risen drastically over the last century and a half and are seen as the primary cause of global warming and abnormal weather patterns. So, there has been considerable research focus, in a number of fields, on lowering our CO_2 emissions and its atmospheric levels.

Solution: One promising solution is to chemically break down, or 'reduce,' CO_2 using photocatalysts — compounds that absorb light energy and provide it to reactions, speeding them up. With this strategy, the solar powered reduction of CO_2, where no other artificial source of energy is used, becomes possible, opening doors to a sustainable path to a sustainable future.

A team of scientists led by Drs. Shinji Kawasaki and Yosuke Ishii from Nagoya Institute of Technology, Japan, has been at the forefront of efforts to achieve efficient solar-energy-assisted CO_2 reduction. Their recent breakthrough is published in “Nature’s Scientific Reports”

A photoexcited electron from silver iodide (AgI) travels along the carbon nanotube to silver iodate (AgIO3) where carbon dioxide (CO_2) is reduced to carbon monoxide

The dispersion of the novel three-component photocatalyst can easily be spray-coated onto polymer films to produce flexible electrodes that can be integrated into numerous settings.

Dr. Ishii is hopeful about their photocatalyst’s potential: “It can make the solar reduction of industrial CO_2 emissions and atmospheric CO_2 an easy-to-scale and sustainable renewable energy-based solution tackling global warming and climate change, making people’s lives safer and healthier.”

Sustainable tooth cleaners

Problem:

All-plastic polyethylene toothpaste tubes were introduced in the 1990s. One billion toothpaste tubes end up in landfills every year harsh chemical residues Every year, 50 Empire State Buildings worth of toothpaste tubes end up in landfills or .

Solution:

Tube-free toothpaste

Determined to replace toothpaste tubes with tablets, in 2016, Lindsay McCormick, a TV producer in Hollywood, California, bought a new TDP 0 tablet machine in Texas and having learned how to use it, began experimenting in her Los Angeles apartment with a of different ingredients.

She talked to every dentist and dental hygienist who would give her the time of day and even took source online chemistry classes to develop the right formula, free from harsh chemicals, dyes, artificial flavors, and unnecessary fillers. The result was a product she called Bite Toothpaste Bits, a mint or mint charcoal flavored pill which bitten becomes foamy like toothpaste, quantities of which can be contained in a refillable glass bottle. Before Lindsay started getting orders from people who shared her passion for sustainability.

Desmond 56 should go here

So she bought a TDP 5 machine from the company in Texas for US$2,599 that could five thousand pills in an hour. A "Women's Health*"* video that she had shot on her iPhone started viral. Soon after, Lindsay ended up having to quit her job and has been full time on Bite ever since.

After featured in media outlets such *Cosmopolitan* and *Business Insider*, Bite operates out of a fully FDA-approved manufacturing facility to keep up with demand. Since August 2018, Bite has sold 12 million tablets.

Early in 2020, kid-friendly flavored Bits became available with their 4-month subscription. At the time, in response to the sanitizer due to COVID-19, Bite found the World Health Organization's (WHO) formula and it, using their repurposed and sanitized glass Bite bottles, then donating the first to those most in need in the Los Angeles area. *(bitetoothepastebits.com)*

Toothpaste can be applied by fingers, but usually by a brush. John and Heather McDougall grew up in a small town in North Dakota. With a dad as a dentist, John's path to design school, and Heather's to law, were far from the family business. During school, however, they decided to use their talents to create products with environmental and social value, and as would it, they could not resist starting with a toothbrush.

The result was the *Bogobrush* from sculpted wild bamboo with bristles from 62% castor oil and 38% nylon, and packaged in a cardboard box. Another firm, Radius, makes funky-looking toothbrushes called *Source* from cellulose and removable heads with vegetable-based nylon bristles. *(bogobrush.com)*

Patrick Triato, founder of Goodwell Co, in Portland, Oregon has developed the "BE" brush, standing for Beyond Electric, a wind-up toothbrush. The heads of the brush are 100% biodegradable and recyclable. Charcoal-infused bristles offer up to 80,000 brushstrokes to clean the teeth surfaces and along the gumline. By twisting the base of the aluminium-handled brush a few times, a user can power it for two minutes. In addition, Goodwell's Pacific Mint toothpaste, made up of fresh mint and Jacobsen's hand-harvested sea salt, comes is in a recyclable tube made of a bio-resin derived from sugarcane. It can stand on its own, which eliminates the need for unnecessary additional packaging

:Tennis balls and basketballs

Problem:

While the 360,000,000 tennis balls produced per year always been based on rubber, the felt, and the glue that holds them together approximately 450 years to decompose naturally.

Solutions:

Thanks to programs such as Tennis Ball Recycling, Project Green Ball, or Recycle Balls, as as 22 million broken, busted, or filthy balls are be recycled annually into rubber composite products like tennis court mats, stucco-like product, and playgrounds.

In 2019 Wilson Sporting Goods introduced their *Triniti* tennis ball, **s**ustainable, **h**igh-performing, **d**urable. Their R&D lab used plastomer for the , its lighter weight enabling its designers to thicken the core's walls, whilst the STR stretch felt is 50% flexible standard tennis ball felt, giving the player feel at contact. Further, Triniti's packaging is fully recyclable and from recycled cardboard.

The 2019 WTA Future Stars *tournament*, which was played the week prior to the Shiseido WTA Finals Shenzhen from October 22-27, debuted *Triniti*.

Basketball

Problem:

With approximately 2-3 billion in the US, Canada, China, and the Philippines, Basketball is the 3rd most popular sport in the world. This requires millions of basketballs are every year involving wastes and emissions that can a negative impact on the environment. On average, rubber takes 50-80 years to decompose.

Solutions:

 a basketball wears out and no serves its purpose, the rubber can be recycled into new rubber products while the nylon fabric found in the bladder can be recycled to nylon string or yarn.

Wilson Sporting Goods Chicago, Illinois, United States has developed
The Rebound Recycled Basketball of 40% scrap rubber from old tyres and shoes while the packaging is of 80% recycled boardIt is ideal for training.

:Terra Carta

Problem :

Big business must invest in the health of the planet and people. What good is all the extra wealth in the world, gained from 'business as usual,' if you can do nothing with it except watch it burn in catastrophic conditions?

Solution:

Terra Carta, (= Earth Charter), a pledge to put planet first and $10bn (£7bn) to ‘ prosperity into harmony with nature.’

On Monday 11th January, 2020, at the One Planet summit in Paris, with the participation of around thirty personalities, most of them in videoconferencing, Charles the Prince of Wales, a lifelong environmentalist and heir to the British , launched *Terra Carta*, a document that asked signatories of several international institutions to agree to almost 100 actions to become sustainable by 2030.

In the Terra Carta’s statement of intent, the voluntary commitments include supporting international agreements on the climate, biodiversity and desertification, regenerative farming and biofuels, and similar efforts to protect half of the planet by 2050, and investment and financial flows consistent with a future of low greenhouse gas emissions.

While some signatories are big investors or financiers for the fossil fuel industry and sectors linked to biodiversity loss, a $10 billion investment in nature will be by 2022 through the newly created Natural Capital Investment Alliance. Companies supporting the launch of the Terra Carta included BlackRock, of America and HSBC, BP. AstraZeneca (AZN), EY, Unilever (UL), Heathrow Airport, and Fidelity International.

The Prince stated “If we consider the legacy of our generation, 800 years ago, Magna Carta inspired a belief in the fundamental rights and liberties of people. As we strive to imagine the next 800 years of human progress, the fundamental rights and value of nature must represent a step- in our ‘future of industry’ and ‘future of economy’ approach.”

Later on Monday, the French president, Emmanuel Macron, announced that an envelope of 14.3 billion dollars (11.8 billion euros) over five years (2021-2025) had been constituted for an 8,000 km "great green wall" intended to prevent the advance of desert in the Sudano-Sahelian , which crosses 11 countries in Africa from the Atlantic to the Red Sea. The countries concerned in the foreground by the project are: Burkina Faso, Djibouti, Eritrea, Ethiopia, Mali, Mauritania, Niger, Nigeria, Senegal, Sudan and Chad.

The first One Planet Summit was aimed at leading, at the end of the year, to the adoption of a new roadmap for the protection of ecosystems at the 15th Conference of the Parties (COP15) of the Convention on Biological Diversity (CBD) to be held in early October in Kunming, China.

:Terrapods

Problem:

World environmental experts agreed the construction industry has a big to play in protecting the planet. The construction industry is one of the biggest polluters of the earth, mostly due to the use of concrete, particularly for foundations

Solution:

In 2018, Ledwith of Ireland, created Terratonics to commercialise his solution of pedestal beam carriers as building foundations to reduce the need for concrete foundations for timber buildings, with reducing the embodied CO_2 emissions of concrete in buildings, so making timber buildings even ecologically sustainable.

Ledwith’s terrapods, coming in a of sizes, are from an engineering polymer called Nyrim produced by FF Polymer in Donegal who couplings for use in the North Sea oil industry. Nyrim is noted for its exceptionally high shape stability over a temperature from -40 to 140° C. Moreover, this material distinguishes itself by its excellent impact strength and very high abrasion resistance

:Tetra Pak Daily Hub initiative

Problem:

Food security and nutrition are key challenges in Kenya, with levels of malnutrition remaining high. The country's well-established dairy industry produces 5.2 billion litres of milk per annum, most of which is generated by Kenya's 1.8 million smallholder dairy farmers. However, productivity per cow is low, with an average of just 4-5 litres per day. This is attributed to poor farm management, inadequate animal husbandry practices and lack of support services for cow nutrition, breeding and health.

Solution:

In 1944, Dr. Ruben Rausing initiated the development of the Tetra Pak (or Tetra Brik), a tetrahedron shaped package with the fundamental idea to form a tube from a roll of plastic-coated paper, fill it with the beverage and seal it below the level of the liquid. The aseptic technology allows the product inside to stay fresh, without the need of any preservatives.

Until recently Paks ended up in landfills. In 2015 Finnish dairy firm Valio rolled out Tetra Pak's innovative biomass-based carton packaging, Tetra Rex,which can be used for beverages such as milk and juices. of FSC certified paperboard cartons, bioplastic laminate films and necks and caps derived from sugarcane.

From November 2009 Tetra Pak and Tetra Laval Food for Development introduced a solution called the Dairy Hub a community dairy development program (CDDP) in which villages within 15-20 km radius are considered as one community. A team of Extension Service Officers (ESOs) is by Tetra’s Dairy Specialist, using reference dairy farms to showcase best practice for milk hygiene and quality, and animal nutrition, health and reproduction.

Following the first Dairy Hub with Engro Foods Ltd. in Pakistan, others followed in Honduras, Nicaragua, Kuala Lumpur and Kenya (Uplands Premium Dairies & Food, Ltd. in Kiambu County). In each thousands of smallholder farmers saw their cows' milk yield increase over 100%, while overall, milk collection has grown and cost has decreased by 5%. Bringing them out of poverty.

Textiles, 3D-printed

Problem:

Sometimes 3D printers mess up. They extrude too much material, or too little, or deposit material in the spot.

Solution:

DefeXtiles

Jack , who works in the Tangible Media research group with Professor Hiroshi Ishii at the Massachusetts Institute of Technology has developed DefeXtiles, a tulle-like textile developed by controlling that common 3D printing defect — the under-extrusion of polymer filament. His experiments were inspired by the work of a friend from his undergraduate days at Carnegie Mellon University, who had used under-extruded filament to produce vases.

used a standard, inexpensive 3D printer to produce sheets and complex 3D geometries with a woven-like structure based on the “glob-stretch” pattern produced by under-extrusion.

had been experimenting with 3D printing during the media arts and sciences class MAS (How to (Almost) Anything), led by Professor Neil Gershenfeld, director of the MIT Center for Bits and Atoms.. With his first attempts at under-extruding, "I was annoyed because the defects produced were perfect and periodic,” he says, “but then when I started playing with it, bending it and even stretching it, I was like, ‘whoa, wait, this is a textile. It looks like it, feels likes it, bends like it, and it prints really quickly.”

When MIT closed down at the start of the Covid-19 pandemic, was in the midst of preparing for an ACM symposium submission. He relocated his full lab set up to the basement of his parents’ cabin near Placid, New York.

has printed DefeXtiles into an interactive lampshade, full-sized skirts, a roll of fabric enough to stretch across a baseball diamond, intricately patterned , while future applications also could include 3D-printed surgical mesh with tunable mechanical properties.

:Azobenzine-based solar thermal energy

Problem:

The most efficient way to convert solar energy into electricity is to heat water into steam to turn a turbine. So instead of installing a steam boiler on your roof, solar panels are easier.

Solution:

Azobenzene-based solar thermal energy enhanced by gold nanoparticles for rapid, optically-triggered heat release at room temperature

A team led by Wei at the School of Materials Science and Engineering of Tianjin University in northeastern China developed a solution for using azobenzene (Azo) compounds for the capture, conversion, and transportation of solar energy.

The idea behind the system is that a parent molecule is isomerized by solar irradiation. The resulting photoisomer is stable for a period. Adding a catalyst will cause the photoisomer to revert back to the parent molecule, releasing energy in the process. The catalyst is a polyvinyl alcohol (PVA) polymer-templated, gold nanoparticle (AuNP)

:Thermal hydrolysis for sewage sludge

Problem:

Companies generating methane from waste are held back because of the massive quantities involved and also their limited acreage denying them the space to build a conventional digester which requires waste to cure for 20 days before methane can be extracted.

Solution:

Thermal hydrolysis process for sewage sludge

In the 1980s Odd Egil Solheim developed a steam explosion of thermal hydrolysis process for Norway’s paper and pulp industry called Cambi, named

after the Latin word ‘cambium’ which is the part of the tree where growth takes place. By the 1990s following promising results in laboratory tests, Solheim had modified his system for advanced treatment of sewage sludge and bio-degradable waste, whether planning new or upgrading existing wastewater treatment, food waste or co-digestion projects the wastewater treatment sector.

The Cambi THP utilizes high pressures and temperatures to convert materials to biogas quickly and efficiently traditional methods. When fully operational, a Cambi plant can generate 13 megawatts of energy and halve the amount of biosolids trucked off site.

Through Cambi’s well tested processes, material and energy recovery is lifted to a whole new level, while minimizing the amount of end-product & maximizing its quality. The results are reduced operational and problems turned into products.

The Cambi THP system that is now installed at over 40 wastewater treatment plants (WWTPs) in prominent cities like Washington DC, London, Santiago, Seoul and Singapore

In 2014, Cambi signed contracts for 14 new plants. The breakthrough deal was reached in China with the Beijing Group, to deliver five very CambiTHP® plants serving Beijing's population of 20 million. The largest, Gaoantun, holds the world THP plant design capacity record.

smaller projects were awarded to Cambi in 2014: in South Korea (Anyang, an underground facility), Spain (Ourense), the Netherlands (Hengelo), and the UK (Leigh in Burnley and Davyhulme in Manchester.)

: Mercury-free thermometers

Problem:

The traditional mercury-in-glass thermometer can be dangerous if the glass breaks and the silvery mercury is not cleaned up properly. The mercury will evaporate and can contaminate the surrounding air and become to humans

causing neurological problems and other ailments in people exposed to them and harm wildlife.

Solution:

Mercury-free thermometers

Federal and state authorities lobbied since 2002 for on medical mercury thermometers. Mercury can be recycled safely. NIST (National Institute of Standards and Technology, USA) recently sent the mercury from 8,000 industrial thermometers to facilities that use it to produce compact fluorescent lights. The one-sixtieth of an of mercury in a typical thermometer is enough to 125 light bulbs.

The alcohol thermometer or spirit thermometer is an alternative to the mercury-in-glass thermometer and has similar functions. Unlike the mercury-in-glass thermometer, the contents of an alcohol thermometer are less and will evaporate quickly.

For over 85 years, Amarell of Kreuzwertheim, Bavaria has been manufacturing precision thermometers. Recently their products use a mercury-free biodegradable non green fluid with the option of either a solid stem to reduce risk of accidental breakage or enclosed scale with milk glass for additional accuracy. Geratherm basal, has been developed by Geratherm Medical AG at Geschwenda and contains a patented liquid alloy consisting of gallium, indium and tin –called Galinstan. Galinstan is completely non- and environment-friendly.

Developed by NASA, non-contact ear and forehead infrared thermometers are not just as accurate as or rectal thermometers, but they are eco friendly with low power consumption if its two AAA batteries. Since 2020 when COVID-19 pandemic hit the world, infrared thermometers been used to provide and accurate testing.

:Biodegradable thermostat resin

Problem:

Conventional polyurethane and phenol formaldehyde thermostat resins are , flammable, and fossil based. They are not biodegradable and can be burned under strict precautions due to the release of substances.

Solutions:

In terms of biodegradability, in 2019, a strain of soil bacterium capable of breaking down the chemical bonds found in polyurethane was developed by researchers from the Helmholtz Centre for Environmental Research-UFZ in Leipzig, Germany, while visiting a garbage dump littered with brittle plastics. They called it *Pseudomonas sp.* TDA1. Research is underway to enable this bacterium to degrade quantities of discarded polyurethane en masse.

To replace traditional polyurethane, in 2011, Professor Gadi Rothenberg and Dr. Albert Henderikus Alberts at the Heterogeneous Catalysis and Sustainable Chemistry group of the University of Amsterdam developed a of new thermoset resins from renewable raw materials which are fully biodegradable, non- and non-hazardous.

By selecting the right raw materials and process conditions for the cross-linking reaction the scientists were to a of bio-plastics from hard foam material to flexible thin sheet materials. The process requires no ingredients and no harmful substances are released from combustion. Moreover, the raw materials are readily available at competitive prices on the world market.

Rothenberg and Alberts prepared over 800 different formulations of this new material, which is now produced on the ton scale by Plantics BV in The Netherlands under the names Glycix and Plantics-GX. When immersed in water

or humid soil, Plantics-GX foam swells up and hydrolyses back to glycerol and citric acid, a process that can days or years depending on the degree of polymerisation. Plantics-GX has not yet been commercialised. *(plantics.nl)*

"Chemists develop fully biodegradable and recyclable synthetic resin." *ScienceDaily,* 13 January 2011; Gadi Rothenberg and Albert H. Alberts, “Plantics-GX: A biodegradable and cost-effective thermoset plastic that is 100% plant-based,” *Faraday Discussions* 202 · August 2017; María José Cárdenas Espinosa et al., “Toward Biorecycling: Isolation of a Soil Bacterium That Grows on a Polyurethane Oligomer and Monomer,” *Frontiers in Microbiology*, March 27, 2020.

:Thermosyphoning

Problem:

Is it possible to heat without using electricity from the grid?

Solution:

Thermosyphoning is a high efficiency/low maintenance method of passive heat exchange, based on natural convection, which circulates a fluid without the necessity of a mechanical pump.

It is used for circulation of liquids and volatile gases in heating and cooling applications such as heat pumps, water heaters, boilers and furnaces. Thermosyphoning also occurs across air temperature gradients such as those utilized in a wood fire chimney or solar chimney.

In thermoelectric refrigerators, the cooling systems that work on the Peltier effect, creating heat flux between the junctions of two types of materials, a much smaller coefficient of performance as compared to the conventional compressor-style refrigerators, especially when the cooling capacity is . Nevertheless, to the small size of cooling units, their silent nature, the absence of any moving parts in them or any gases or liquids, and their life, thermoelectric refrigerators are used in a vast set of applications.

In 1983 Robert Draper of the Westinghouse Electric Corporation obtained a patent for “Thermosyphon coil arrangement for heat pump outdoor unit”. In 2012, Richard Boyle and a team at Naked Energy Ltd. in Guildford, England used thermosyphoning to develop a hybrid solar they called *Virtu*, capable of generating both electricity and hot water simultaneously.

Reviewing *Virtu*, the Imperial College London found that the panels they tested can produce up to 46 % energy the typical PV when the cells are heated to 65ºC. In 2015, Naked Energy teamed up with Jabil in the US to scale up production of Virtu. *(nakedenergy.co.uk)*

Thermosyphon installation accounted for over 55% of global solar water heater market in 2018. The product finds wide application in residential and small commercial buildings on account of ease of installation, simple design and cost effectiveness features.

Nancy , “Naked Energy touts hybrid solar in tube design,” *On Green Solution*, April 12, 2012.

Thermosiphoned geothermal energy

:Thermo-syphoned geothermal energy

Problem:

Traditional geothermal solutions been limited to cost for exploration and to their reliance on volcanic-like temperatures in combination with highly permeable aquifers.

Solution:

A thermosiphon which produces heat and electricity by capturing geothermal energy without any emissions. It circulates a benign fluid in a closed loop, collecting heat from the natural geothermal gradient of the Earth. The fact that the system works at drilling depths it can be implemented almost anywhere around the globe.

A team led by experienced gas and oil drilling engineer Matthew Toews near Rocky Mountain House, Alberta, Canada has developed a wellbore design which harnesses the unlimited geothermal energy emanating from Earth's 6000°C molten , a resource should last 17 billion years.

On August 2nd 2019, their start-up Eavor Technologies Inc began two months' of drilling for a trial plant called Eavor-Lite. The closed-loop system consists of a U-tube shaped well at 2.4 kilometres depth, with several kilometres of multilateral horizontal wellbores, and a pipeline connecting the sites on surface. Two drilling are operated simultaneously from both sites and used to intersect the multilateral wellbores at depth.

Water is circulated in the inlet well, through the parallel wellbores to extract heat by conductive heat with the rock, and rises up the outlet wellbore at a higher temperature. The density difference between the inlet well and outlet well creates a thermosiphon which completely drives the flow, without any pumping power.

As a completely closed-loop system, there is no fracking, no GHG emissions (unlike some geothermal projects), no earthquake risk, no water use, no produced or solids, and no aquifer contamination. Eavor's system circulates a benign fluid which is isolated from the environment in a closed circuit, much like a massive subsurface version of a traditional radiator. It simply collects heat from the natural geothermal gradient of the Earth, at common rock temperatures.

The thermosiphon was completed by February 2020 and validated by the Netherlands-based organisation for applied scientific research, TNO.

Eavor is backed by The Government of Canada, via Natural Resources Canada's Clean Growth Program and Sustainable Development Technology Canada and also by the New Energies Research & Technology program (www.shell.com) of Shell International Exploration and Production, itself a subsidiary of Royal Dutch Shell Plc (AMS:RDSA). Precision Drilling www.precisiondrilling.com is its key vendor partner and financial partner Vickers Venture Partners. Eavor is now to launch the first commercial projects implementing its technology as part of a "multi-year, multi-billion-dollar prospect pipeline."

:"30 x 30"

Problem:

The natural world produces everything we need, and it does so for free. But when it breaks down, our health, economies and national security are at risk. With one million species at risk of extinction, bold action is needed urgently.

Solution:

In 2010, inspired by conservation biologist E.O. Wilson's book "Half Earth: Our Planet's Fight for Life", the Convention on Biological Diversity (CBD), a multilateral treaty created by the United Nations CBD called for 17% of the terrestrial planet to be protected in some form and 10% of the by 2020. That goal was not reached – currently about 16% of the terrestrial planet has been protected, and less 8% of ecosystems. In 2019, The Wyss Campaign for Nature teamed up with The National Geographic Society to support the goals what they termed the "30x30" movement, a highly ambitious initiative that aims to protect 30% of the planet, on and at sea, by 2030. In January 2020, led by former US Secretary of State Madeline Albright, twenty-three former Ministers from six continents released a statement calling for conservation protections of 30% and for the of the planet, as well as national security. One month later, in , negotiators from 190 countries negotiated the details of the 30x30 program. Meanwhile, another organisation called "Nature Needs Half" has in scientists and conservation groups – including the Sierra Club and the International Union for Conservation of Nature, to press for the protection of 50% of the planet by 2030.

E.O. Wilson, *Half Earth: Our Planet's Fight for Life* New York: Liveright Publishing Corporation, a division of W.W. Norton & Company, 2016; Holly Jonas,"Exploring Territories of Life with the World's Most Iconic Nature Communications Organisation," *Icca Consortium*, July 30, 2019.

: 3D printing of body parts

Problem:

Titanium is 100% recyclable biocompatible eco metal due to its resistance to corrosion from bodily fluids. This ability to withstand the harsh bodily environment is a result of the protective oxide film that forms naturally in the

presence of . Titanium is used from head to toe in biomedical implants. But it other metals.

Solution:

In 2008, Mark Reiley, a surgeon in Washington, DC founded SI- to commercialise the patented triangular design iFuse hip-replacement titanium implant. This was designed to help patients who suffer from SI joint dysfunction. The porous structure of the 3D printed implant improved growth, regrowth and through growth. It has since used in over 26,000 procedures and supported by 50 peer-reviewed publications.

Reiley's next economising step was to 3D print the trabecular surface and unique patented fenestrated design of the iFuse implant, its surface mimicking native cancellous and using self-harvesting technology. In 2017, SI- was given FDA clearance and full U.S commercial launch of its 3D printed titanium implant, the iFuse-3D Implant.

one further, a team lead by Atieh Moridi, assistant professor in the Sibley School of Mechanical and Aerospace Engineering, Cornell University has developed a 3D printing technique that, using a nozzle of compressed gas to fire titanium alloy particles at a substrate, creates cellular metallic materials by smashing together powder particles at supersonic speed.

Rather carving a geometric shape out of a big of material and holding it together with glue, screws, heat or other traditional bonding methods, The Cornell team's"Cold Spray" Technology results in mechanically robust, porous structures that are 40% similar materials with conventional manufacturing processes. The structures' small size and porosity them particularly well-suited for building biomedical components, like replacement joints.

Similarly 320,000 unique Invisalign clear orthodontic teeth aligners for people been 3D-printed by Align Technology in Juarez, Mexico. Equally a patient's natural tooth has to be extracted, a dentist can its shape and size and 3D-print an exact copy from materials like titanium and zirconia.

Despite this, experts around the world agree that bio-based products are essential for a sustainable society.

The Norwegian scientists at the Swedish research institute PFI are on the verge of discovering technology that will allow them to human “body parts” out of nanocellulose, less expensive titanium.

Nanocellulose used to form tiny scaffolds would be placed inside a human body with nutrients and stem cells from the patient allowing body tissue to regenerate. The idea behind this is to help the body sustainably and effectively regenerate itself. Since this the method relies entirely on natural resources it would also a major to green-friendly industries and might give hope to implementing other green technologies.

 alongside the world’s largest organisation for rehabilitating disabled people in India, Dr Karthikeyan Kandan, a senior lecturer in Mechanical Engineering at the Montfort University in Leicester, England makes cheap and durable prosthetic limbs from ground-up plastic water bottles. These are heated and moulded to create a “solid yet lightweight” prosthetic limb that just £10 to produce.

Dr Kandan also worked with prosthetic experts at academic institutes in Jaipur, Salford, Southampton and Strathclyde.

The socket was trialled with two patients in India — one who had the leg amputated above the knee, and one below the knee. Both said the design was “easy to walk with” and allowed air to flow to the rest of the leg, which was key for India’s hot climate.

Atieh Moridi, “Solid-State Additive Manufacturing of Porous Ti-6Al-4V by Supersonic Impact,” in *Applied Materials Today*, November 9, 2020

3D house printer

Problem:

According to the United Nations, some 1.6 billion people lack adequate shelter, and a third of the world’s population lives in informal settlements or slums. Traditional building methods lead to wasted materials such as cement and excess labour , driving up housing prices beyond the reach of poor families.

Solution:

3D printed houses

At the Aeditive GmbH startup located in Norderstedt, next to Hamburg, Germany, a team led by architect and 3D software engineer Hendrik Lindemann is digitalising the construction industry.Their , “Aeditive”, is a -up word and based on “additive manufacturing” and “aedificium”, Latin for building.

Their 3D shotcrete printer known as the Concrete Aeditor can create elements up to 11x4x4 meters, including reinforcement and built-in parts.

A steel pallet is positioned in the Concrete Aeditor. One of the Kuka robots creates the element on the pallet based on RSP. The second Kuka robot supports this process by placing built-in elements such as reinforcements. The element’s surfaces are robotically post-processed. The pallet including the finished element is removed from the manufacturing space.

The Concrete Aeditor integrated system consists of six container modules and can be deployed flexibly and autonomously, both, offsite and onsite. After setting up the containers, it requires connections for freshwater, wastewater and electricity.

Aeditive is not . Based on the experience of Alex le Roux, previously co-founder of Vesta Printers, ICON of Austin, Texas has been using its Vulcan 3D tablet-operated printer, integrated material delivery system with a printing capability to approximately 2,000 square feet. It has an adjustable width (to accommodate different slab sizes) and is transported in a custom trailer with no assembly required. It uses a cement-based material called “Lavacrete”.

In 2018, ICON was the first company in America to secure a building permit for and in 24 hours build a 3D printed home in Austin. During 2019, it had built 16 houses in Austin and in Salvador, Mexico, where it is constructing the world’s first 3D-printed community of 400-500 square foot Tiny Houses designed to accommodate 50 low-income families.

Alongside this ICON has been with the US Defence Innovation Unit (DIU) at Camp Pendleton to demonstrate the use of commercial scale additive manufacturing for military use.

In October 2020, ICON was awarded a government Small Business Innovation Research (SBIR) contract including funding from NASA to begin research and development of a space-based construction system that could support future exploration of the Moon.

Aeditive and Icon's ultimate goal is to reduce the cost of homebuilding by 50%.

Henrik Liindemann et al "Adaptive Modular Spatial Structures for Shotcrete 3D Printing", *Conference paper*, April 2019.

:Tidal stream power generator

Problem:

How to harness the prodigioius electrical energy from outgoing and incoming tides?

Solution:

Immense supplies of electric energy are harvest from tidal streams. Electricité de (EDF) was a precursor with this technology when, in 1966, it built the tidal power plant on the mouth of the La River in Brittany, . It is one of just two such plants in the world with Sihwa in South Korea. The La plant has an installed capacity of 240 MW distributed between 24 bulb-type turbine generators, each with a capacity of 10 MW. For almost 50 years, it has been producing around 500 GWh/year, equivalent to the consumption of a city the size of Rennes, .

In 2007, Drew Blaxland, Director of Turbines and Engineering Services, having graduated from the University of Technology, Sydney, joined Atlantis to work with the Lockheed Martin Corporation, one of the world's largest and most sophisticated global systems integrators in the development of a central axis underwater power generator.

In October 2008, Atlantis chose a site near the Castle of Mey for a computer data centre that would be powered by a tidal scheme in The Pentland Firth, off the north coast of Scotland is well known for the strength of its tides, which are the fastest in the world, a speed of 19 mph (30 kph) reported close west of Pentland Skerries.

Two years later, MeyGen, a consortium of ARC, Stanley and International Power, received operational lease from the Crown Estate to a 400 MW project for 25 years. By September 2013 they had been consent to install four turbines to generate 9 MW, three from Andritz Hydro Hammerfest (AHH) and one from Atlantis developed by Blaxland's team.

Each turbine was installed on the seabed with a gravity- turbine support structure and a 4.4kV turbine subsea cable. The onshore construction works of the project began in January 2015 and the first turbine was officially unveiled in September 2016.

In 2017, two turbines set a world record for monthly production from a tidal stream power station when, connected to a 15MW local distribution grid network managed by Scottish Hydro Electric Power Distribution (SHEPD), they generated 700 MWh of electricity, enough power for 2,200 homes. In April 2018, MeyGen Phase 1A formally entered its 25-year operations phase.

By 2019, 17GWh had been exported to grid, a new record for the amount of electricity exported by a tidal stream project. Three months later, exported 21-gigawatt hours (GWh) of electricity to the national grid and the array had operated at above 90% availability during 2019. That year performance represented the longest period of uninterrupted generation from a multi-MW tidal turbine array ever achieved. Full-scale production from 400 turbines is expected to start by 2020. *(simecatlantis.com)*

In , the Paimpol–Bréhat project is an 8 MW tidal turbine demonstration farm off Île-de-Bréhat near Paimpol, . The project was initiated by Électricité de (EdF) in 2004 and work began in 2008. By 2017, a hydrokinetic demonstrator designed and built by Thomas Jaquier at Hydroquest with a power output of 1 MW was installed on the EDF test site In 2019 it generated its first MWs. The tidal farm will consist of seven turbines, 2 MW each. *(hydroquest.net)*

In 2018 Normandy Region, SIMAC Atlantis Energy formed Normandie Hydrolienne to build a tidal stream plant in Raz Blanchard that could eventually deliver around 2 GW of capacity to the Normandy region. The first phase will be completed in 2021 following by an expansion of the project to 200 MW by 2023, enough to power 250,000 homes. Some of these are on the isle of Alderney. The total theoretical tidal energy capacity in the English Channel region is nearly 4 GW, enough to power up to 3 million homes. *(energiesdelamer.eu)*

In the Netherlands Tocardo installed its first tidal turbine in 2005. Three years later Tocardo began to install tidal turbines into a primary sea defense, the Eastern Scheldt storm barrier. The Eastern Scheldt storm barrier is the largest of the famous Delta Works, a series of dams and barriers, designed to protect the Netherlands from flooding.

In September 2012, the complete 164 ft (50 m.) support structure, including turbines, was transported over water by famous heavy lift specialist Mammoet. Using a special and Mammoet's Self-Propelled Modular Transporter, the structure was put into place between two of the barriers' pillars. *(tocardo.com)*

The Afluitdijk, constructed between 1927 and 1932, is a major dam and causeway in the Netherlands. It from Den Oever in North Holland province to the village of Zurich in Friesland province, over a length of 20 mi. (32 km.) and a width of 300 ft. (90 m.) at an initial height of 23.8 ft. (7.25 m.) above sea level.

The Afsluitdijk is a fundamental part of the larger Zuiderzee Works, damming off the Zuiderzee, a salt water inlet of the North Sea, and turning it into the fresh water of the IJsselmeer.

In 2015 Tocardo installed three T1 turbines in the Afsluitdijk tidal barrage. The turbine array is an extension of the Tidal Testing Centre test facility and the tidal turbine that has already been producing electricity for seven years. The array has a capacity of 300 kW, producing electricity for about 100 local households. After -tuning and evaluation of the array, the project partners to deploy additional tidal installations in the Afsluitdijk with the capacity of up to 2 MW.

Tocardo has also installed its tidal technology at the Bay of Fundy Research Centre for Energy () in Nova Scotia, Canada. with Minas Tidal, four of its 250kW- T2 bi-directional turbines, which are attached to the company's semi-submersible Universal Floating Platform Structure to form a 1MW system held in place by catenary mooring systems.

In September 2019, Minas Tidal announced a partnership with Sustainable Energy-Schottel Hydro to develop a 1.26 MW array in Canada that would ultimately sell energy to Nova Scotia Power. The first phase of the project is financed by Reconcept Group of Hamburg, Germany.

Other firms such as Magallanes Renovables in Galicia, Spain launched a148 ft (45,m) artefact (a steel-built trimaran), which incorporates a submerged part where the hydrogenerators are fitted, facilitating access for servicing and repairs. In March 2019 Magallanes Renovables ATIR tidal energy converter (TEC) was installed at EMEC's Fall of Warness tidal energy test site in , Scotland, by -based Leask , as part of the _2G project. It was successfully connected to the grid via EMEC's sub-sea cables and onshore substation and generated its first power a short time after. *(magellaneserenovables.com)*

Lonneke Goddijn-Murphy et al., “Current Patterns in the Inner Sound (Pentland Firth) from Underway ADCP Data,” *Journal of Atmospheric and Technology* 30(1):96-111, · January 2013; "Pentland Firth tidal turbine project given consent," *BBC News,* September 16, 2013.

:Timbercrete

Problem:

The construction industry is one of the biggest contributors to landfills due to construction waste – as well as one of the biggest emitters of CO^2. 1000 kg concrete puts out 1000kg of carbon dioxide out to the atmosphere. And, according to concretehelper.com, 10 billion tons of concrete are produced every year.

Solution:

In 1994, Peter Collier, an Australian ceramic potter, began to experiment with various raw materials to find a cost effective material to build his house. Eventually he up with a lightweight solution of sawmill waste, cement, , binders and a non- deflocculating additive sawdust and concrete.

He found that “Timbercrete” as he named it, could be used to , pavers and cladding panels. When independent laboratories tested Timbercrete’s characteristics in accordance with the Australian Building Standards, they were surprised at its performance compared with traditional building materials, and suggested that Peter Collier and his wife Judi apply for a patent to protect the unique nature of the invention.

Patent applications were subsequently lodged in 28 countries, some of which since been approved, with the balance pending. Timbercrete's building blocks are aligned with the sustainability goal by providing environmentally-sensitive building masonry to build environmentally- homes. Timbercrete blocks actually store carbon gas and contribute to the reduction of CO_2 emission.

The Colliers also provided Timbercrete for building homes for underprivileged families via Habitat for Humanity (Australia); training indigenous Australians and Canadians to manufacture blocks for their own
housing needs (Perth, Dubbo, Canada); training people from Third World or developing countries to use Timbercrete in micro-enterprises (including India, Africa, South Africa and Fiji) and providing training for Nationals to build low cost orphanages and schools (Sri Lanka, Argentina, Romania, Pakistan).

Thousands of houses been built from Timbercrete's unique formula and after pleasantly surprised by the Tomorrow'sy of other positive qualities and attributes of the product the Colliers reached a point where they desire to on sell the unique Intellectual Property and licences to larger corporations throughout the world. This will increase product availability and awareness and also help the Colliers to achieve their ongoing goals and values.

Peter Collier, "Composite building having moisture barrier and insulation element," US Patent 8424261B2

:Tiny House

Problem:

In the USA, the average conventional single family home of 2,662 ft² (247.3 m²) consumes considerable energy.

Solution:

Small homes consume far fewer resources – they less to construct, less to heat and cool, and they occupy less space. 2018 International Residential Code, Appendix Q Tiny Houses defines a tiny house as a residential structure under 400 ft.² (37 m²)

In 1987 Lester R. Walker published "Tiny Houses : or How to Get Away From It All." In 1997 Jay Shafer of Sonoma, California, designed and lived in a 96 ft² (8m9²) house on wheels. Two years later he introduced the Tumbleweed Tiny House Company which provides building plans and detailed information all aspects of tiny houses. There are four models: Elm, Cypress, Farallon and .

In 2002, Shafer co-founded, with Johnson, Shay Salomon and Nigel Valdez the Small House Society. In 2012 Shafer left the Tumbleweed Tiny House Company to found Four Lights Houses. Instead of focusing solely on mobile tiny homes, the new company promoted hands-on workshops, books, and the development of tiny house communities.

The following year at the Tiny House Fair at Yestermorrow in Vermont, Shafer suggested promoting ethical business practices and offering guidelines for construction of tiny houses on wheels.

In 2015, while Lester Walker set up the non-profit organization, American Tiny House Association, John Kernohan founded the United Tiny House Association, based near Eatonton, Georgia which currently boasts 34,000 international members affiliated with the tiny house movement.

In 2014, the first "tiny house friendly town" was declared in Spur, Texas; however, it was later clarified that a tiny house may not be on wheels but must be secured to a foundation. In Ontario, a Tiny House is known as a Bunkie. In 2017, the University of Lund, Sweden built twenty-two 215 ft² (10m²) Tiny Houses in wood, designed by Tengbom.

Desmond 55 or 55B should go here

According to a survey by the National Association of Home Builders, half of Americans would consider living in a home that's less 600 ft² (56 m²).

Netflix has published a new show on its streaming service on the subject of tiny houses. “Tiny House Nation” follows renovation experts John Weisbarth and Zack Giffin across America, as they help design and construct tiny homes in spaces under 500 ft.² (46 m²).

In 2020, GoSun of Cincinnati, Ohio, manufacturers of solar , solar coolers, solar chargers, and solar lighting for any adventure, presented their solar water purification system and our solar tiny house on wheels.

There are roughly 10,000 tiny houses in existence in the US. 700 new houses are built every year from certified builders and just as are built privately. from concrete, it can also be demolished, pulverized, and reconstructed with the composite material, a mixture of cementitious powders, binders, and aggregates, which itself can come from local soil.

A Tiny House is nearly always a Passive House

"Living in Small Spaces – The Tiny Homes of Sonoma County," *The Press Democrat*, February 2, 2016; Maria Fredgaard, "Tiny House Statistics: 8 Really Encouraging Numbers & Facts." *Go Downsize*, May 3, 2019.

Traction motor, axial flux

Problem:

With the UK Government announcing a ban on the of petrol and diesel cars in 2030, a search is on for the most efficient engineering configurations. For example, the coil in a traditional ***radial*** flux motor is not beneficial for its functioning.

Solution:

Axial Flux Traction (AFT) electric motor

Since 1979, British self-taught engineer Cedric Lynch has been known for his innovative electric motors. His home-built axial flux motor, coupled to lithium-ion batteries helped to kick-start the revival of the electric vehicle in , aeroplanes, motorcycles, cars and trucks during the 1980s

Unlike radial flux motors with a cylindrical rotor turning within a cylindrical stator, axial flux motors use a disc-like rotor sandwiched between two (or facing one) disc-like stator(s). Advantages to this type of motor design include higher torque density; better cooling due to higher contact area; high efficiency due to lower cooling losses; and better overload capacity.

for Saietta in Oxford, England, Lynch continued to improve his design with the AFT140 providing class-leading performance with high-torque density at low . It is particularly efficient for “L-Category”: two- and three-wheelers (motorcycles, scooters and trikes), quadricycles, micro cars and duty cycles

In November 2020 Saietta won a major research contract through the Advanced Propulsion Centre (APC), which will enable it to fast-track the production process Saietta will work closely with UK-based specialists Brandauer of Birmingham and AEV on refining the process for motor component manufacturing and motor assembly, thereby delivering a cost effective, highly automated production process.

This will include a new, solar-powered factory for recruiting 150-250 new workers, with the potential to generate up to £1 million of new sales in the first 12 months following project completion and revenues to follow as manufacturing volumes increase. The Oxfordshire company also plans to sell its technology under license in Asia and the rest of the world.

Other companies taken up this technology. While Lynch has left Saietta to work for his friends Arvind and Hasmuk Rabadia’s Agni Motors in Gandhidham, India, another start-up Magnax in Kortrijk Belgium has also designed and built a powerful twin rotor, synchronous brushless DC (BLDC) motor that it hopes will find traction in the EV market.

:Transboundary transport of waste

Problem:

The ubiquitous transboundary movement of millions of tons of plastic wastes and microplastics is becoming a major concern as their property of durability makes their particles remain for period of time.

Solution:

The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal.

This convention was adopted on 22 March 1989 by the Conference of Plenipotentiaries in Basel, Switzerland, in response to a public outcry following the discovery, in the 1980s, in Africa and other parts of the developing world of deposits of wastes imported from abroad.

The Convention entered into in 1992, and has 188 Parties. The US is not yet a Party.

In January 2018, China decided to ban imports of plastic waste. As the biggest importer of plastic waste in the world, this decision had tremendous consequences. Countries began exporting plastic to other destinations, particularly Southeast Asian countries that don't the capacity to safely manage the massive amounts of plastic waste now entering their borders.

Swiftly reacting to this, during the Basel Conference of the Parties from 29 April to 10 May 2019, Governments amended the Basel Convention to include plastic waste in a legally-binding framework which will global in plastic waste transparent and better regulated, whilst also ensuring that its management is safer for human health and the environment. This empowers countries, particularly in Southeast Asia, to stop a flood of plastic waste from reaching their shores.

The procedure requires the exporter to submit documentation to its national authorities proving the existence of a contract with a recipient in the importing country, ensuring that the waste will be subject to environmentally sound management at its destination.

The corresponding authorities in the importing country may approve of the transport, deny import or set specific conditions. The exporting country shall not allow the transport to proceed before the importing country has given its

consent. This ensures that the waste is not sent to an unknown destiny. If anything goes , the exporter has a duty to re-import.

Tri-Haut

Problem:

Due to the waste thrown away annually by almost 3,500 high-altitude trekkers, scientists have even found trace amounts of plastic at an elevation of 27,690 feet, just 1,345 feet shy of the peak of Mount Everest, the world's highest mountain. Some materials are well valued, such as metals or some gas cartridges, but too much plastic ends up in open dumps or, worse, in rivers. The plastic then follows its path, polluting the Nepalese valleys and other adjoining countries, before ending up in the ocean.

Solution:

Through **t**he Sagarmatha Pollution Control Committee (SPCC), they tirelessly manage waste in the Khumbu region surrounding Mount Everest—making sure people have legal permission to climb and educating climbers and other visitors on how to take care of the area. But this is not enough.

Olivier Robelin, Robin Jager and Valentin Girard, three engineering students at the INP ENSE3, National School of Energy, Water and Environment in Grenoble, France have decided to make their contribution with their Tri-Haut association for Everest. Their solution: to take a plastic recycling pyroliser to the village of Pangboche at 4,000 metres altitude and carry out a clean up.

Their expedition was due to set out in October 2021.

:Tyre-recycling systems

Problem:

Tires are designed to last in some of the harshest conditions possible so their low biodegradability presents a greater challenge to recycling. The polymeric materials that tires are of do not decompose easily. In 1990, it was estimated that over 1 billion scrap tires were in stockpiles in the United States

Solution:

Recycling tyres

//

From 1994 to 2010, the European Union increased the amount of tires recycled from 25% of annual discards to nearly 95%, with roughly half of the end-of-life tires used for energy, mostly in cement manufacturing. The United States disposes of 279 million waste tires each year, representing over 4 million tons of scrap waste. Different agencies in the world are now recycling waste tires and other rubber goods into useful products instead of polluting the environment. Synthetic turf for example is up of crumb rubber which is recycled rubber from automotive or truck scrap tires.

There are several recycling systems. The pyrolysis method heats whole or shredded tires in a reactor vessel containing an -free atmosphere. In the reactor the rubber is softened, after which the rubber polymers break down into smaller molecules. These smaller molecules eventually vaporize and exit from the reactor. These vapors can be burned directly to produce power or condensed into an oily type liquid, generally used as a fuel.

Badly maintained, some pyrolosis plants in India are a hideous mix of heavy metals, benzene, dioxins, furans and other persistent chemicals, some of which are highly carcinogenic.

To avoid this, the Used Tire Recycling Company UTRC, in Victoria, British Columbia worked with the “Green Centre” in Canada which is a Government organisation focused on delivering environmental benefits to produce a eco-friendly chain. Tires are shredded into 4 cm strips then further reduced using a very high-temperature, natural/bio gas, zero-emission used-tire pyrolysis plant.

The pyrolysis process returns used tires to their original components, including heavy oil, carbon , steel wire, and fabric. A state-of-the-art, zero-emission carbon milling plant refines the carbon into 400 mesh size for use with pollution reduction and waste water treatment. UTRC holds numerous Patents

for the treatment of Carbon , having worked closely with the “Green Centre” in Canada which is a Government organisation focused on delivering environment benefits.

Designed by Ted Bushman Rogers, Michael Bradley Swenson and built in North Salt , Utah, the ECO Green two-shaft shredder, powered by two 75 kW electric motors engaging a rotor filled with ECO Green’s exclusive cutting blades and knives, can process up to 30 tons per hour of whole car/truck tires with an output of 2 in - 6 in (6 – 15 cm.) shreds wire-free chips, rubber mulch, crumb rubber, and rubber powder. In 2008 ECO Green entered the Latin American Market and by 2011 had become the largest supplier of tire recycling equipment in Colombia. *(ecogreenequipment.com)*

Another system involves is water jetting. In 1990 D & R Recyclers obtained a patent to recycle rubber tires using high pressure water jets (UHP). In Gent, Belgium, BTRC (Big Tire Recycling Corporation) has invested heavily in this system.*(btrc.be)*

From 2015, tire-recycling firm Genan of Viborg, Denmark started a cradle-to-cradle cryogenic milling system to produce ultra- rubber powder of uniformly high quality that can be used in the manufacture of new tires. *(genan.eu)*

“New ECO Green Tire Shredder System installed in Saudi Arabia,” *Recycling Product News*, February 16, 2017.

:Turbostratic graphene from plastic waste

Problem:

Currently most of the world’s plastic recycling technologies are ineffective, and that about 9% of produced plastic is recycled.

Solution:

A team of scientists the lab of chemist James Tour of University , Houston, Texas developed *ACDC*, a formula which creates flash graphene from plastic waste.

Simply, instead of raising the temperature of a carbon source with direct current, as in the original process, the lab first exposes plastic waste to around eight seconds of high-intensity alternating current, followed by the DC jolt.

The products are high-quality turbostratic graphene, a valuable and soluble substance that can be used to enhance electronics, composites, concrete and other materials, and carbon oligomers, molecules that can be vented away from the graphene for use in other applications. During the flashing process, a considerable amount of clean hydrogen is produced

Tour estimated that at industrial scale, the ACDC process could produce graphene for about $125 in electricity per ton of plastic waste.

Wala A. Algozeeb et al. “Flash Graphene from Plastic Waste” *ACS* ,October 29, 2020.

:Twin thin-film solar cell with 34% efficiency

Problem:

Solar cells come a way, but inexpensive, thin film solar cells are far behind expensive, crystalline solar cells in efficiency. Theoretically, two layers would be better one for solar-cell efficiency.

Solution:

A team led by Akhlesh Lakhtakia, Pugh University Professor and Charles Godfrey Binder Professor of engineering science and mechanics at the Pennsylvania State University, has suggested that using two thin films of different materials may be the way to go to create affordable, thin film cells with about 34% efficiency.

To do that the Penn State team had to the absorbent layer nonhomogeneous in a special way. That special way was to use two different absorbent materials in two different thin films. They chose commercially available CIGS — copper indium gallium diselenide — and CZTSSe — copper zinc tin sulfur selenide—

for the layers. By itself, CIGS's efficiency is about 20% and CZTSSe's is about 11%.

These two materials work in a solar cell because the structure of both materials is the . They roughly the lattice structure, so they can be grown one on top of the other, and they absorb different frequencies of the spectrum so they should increase efficiency

“It was amazing," said Lakhtakia. "Together they produced a solar cell with 34% efficiency. This creates a new solar cell architecture — layer upon layer. Others who can actually solar cells can find other formulations of layers and perhaps do better."

According to the researchers, the next step is to create these experimentally and see what the options are to get the final, best answers.The National Science Foundation supported this research

Akhlesh Lakhtakia et al. “Double-absorber thin-film solar cell with 34% efficiency” *Appl. Phys. Lett.* 2020

Tyre Microplastics Collector

Problem:

Every time a vehicle brakes, accelerates or turns a corner, tiny microplastic particles of tyre dust are worn away and released into the air or washed down drains into waterways. Tyre particles are the second most prevalent microplastic pollutant in the ocean. The amount of rubber expelled into the environment by one London bus in a single day is equivalent to the size of a grapefruit.

Solution:

Siobhan Anderson, Hugo Richardson, Hanson Cheng and Deepak Mallya, masters students from Imperial College London and the Royal College of Art have developed a clever solution. A device that can be fixed to a vehicle and uses an electrostatic charge to suck up tyre dust as it is produced, before it enters the environment. The prototype can be suspended from each wheel's steering knuckle, just above where the tyre meets the road, to capture the microplastic fragments released through friction every time the car brakes, accelerates or turns a corner.

Consulting with the Imperial Department of Aeronautics they identified this position to take advantage of airflow around a spinning wheel. They device

currently captures 60% of all airborne particles on our test rig. Their long-term goal is to increase this capture efficiency, integrate it into electric vehicles and reuse particles under 50 microns to make new tyres or other products.

In September 2020, their start-up, the Tyre Collective, registered in West London, won a James Dyson Award for innovation

:Tyres from natural components

Problem:

One of the key factors electric vehicle efficiency are the tires, whether for automobiles, motorcycles trucks or buses. The tires are the medium between the machine and the road it travels, and they play an integral in the battles for efficiency and against noise.

Solution:

Tyres from fruit and vegetables

Tesla and Chevrolet spent countless hours at Michelin's test track in South Carolina -tuning tire compounds and tread patterns. Goodyear has introduced a concept tire that uses tread design to combat the faster wear that electric vehicle tires experience due to higher torque and the heft of their batteries, which can an electric vehicle 10 to 20 % heavier a similarly sized conventional car.

In 2008, Tire manufacturer Yokohama produced a unit with 80 % non-petroleum material, substituting oil as the primary ingredient to vulcanized rubber. Oil is considered sustainable because it is produced from a renewable resource. The tire is called the Super E-spec and used by the Toyota Prius other electric automobiles where fuel efficiency is improved via a 20-% reduction in rolling resistance. oil from peel is considered sustainable because it is produced from a renewable resource. The philosophy of reducing petroleum use is utilized in producing plastics from starch or vegetable oil. Yokohama has not specified whether the oil will biodegrade over time.*(yokohamatire.com)*

In 2017 Hankook Tire & Technology Co., Ltd., based in Teheran-Gangnam-gu Seoul in South Korea, developed an EV-specific tire, the Kinergy AS EV. With a planet-protecting mission, Hankook's new donut relies on vegetable oil resin. Extracted from conifers, the substance Hankook calls "Aqua " improves wet road performance as well as general handling and due to its high tolerance for vehicle loading.

This creates a harder tire compound, improving traction and better managing the kind of high-torque acceleration familiar to EV owners. Jackrabbit starts are great fun, but a pain in the tread for the rubber connecting you to the road. The Kinergy AS EV also incorporates high strength steel belt wirewhich absorb external forces, increasing tire longevity and comfort. *(hankooktire.com)*

Hankook is not . At the Movin'On 2018 mobility summit, French tire manufacturer Michelin announced its ambition that by 2048, all of its tires will be manufactured using 80% sustainable materials (recycled and renewable materials) and that 100% of all tires will be recycled.

At the time of writing, the world-wide recovery for tires is 70%; of that 70%, some 50% are recycled for various applications. Michelin tires are currently using 28% sustainable materials (26% bio-sourced materials such as natural rubber, sunflower oil, limonene etc., and 2% recycled materials such as steel or recycled powdered tires).

For a sustainable future, Michelin is investing in high technology recycling technologies to be able to increase this content to 80 % sustainable materials. The to this ambitious sustainable material will be achieved by research . into bio-sourced materials such as "Biobutterfly" and with Michelin's high-level partners, and the advanced technologies and materials that are developed in these partnerships.

Michelin launched the Biobutterfly program in 2012 with Axens and IFP Energies Nouvelles to create synthetic elastomers from biomass such as wood, straw or beet. Butterfly covers all research and development phases in the process, from scientific concepts, to the pilot phase and validation on an industrial demonstrator. BioButterfly was backed by a US$ 56-million budget extending over eight years. The project was selected by Agency for the Environment and Energy Management (ADEME) to receive US$ 16 million in financing as part of the Investing in the Future program. *(michelin.fr)*

GRI, a leading producer of specialty tires, headquartered in Sri Lanka, in collaboration with a team of scientists from the Department of Chemistry at the University of Colombo, has developed the ULTIMATE XT eco-friendly version by replacing petroleum-based oil with natural oil, which is carbon neutral and renewable. The ULTIMATE XT has the capability to run on all surface conditions including, indoor, outdoor, low temperature, and high temperature, wet and dry conditions. *(gritires.com)*

"Michelin Launches 'Bio Butterfly' Program to Develop Greener Tires," *inhabitat.com*, April 12, 2013; "Hankook reveals Kinergy electric vehicle tyre," *just-auto.com,* August 28, 2018.

:Tissues

Problem:

Per year, Americans use upwards of 255,360,000,000 disposable facial tissues, by companies such as Kimberly-Clark with its Kleenex ,. The global demand for tissue paper (facial tissues, toilet paper, paper towels, and napkins) is expected to grow 4% every year through 2021 with China accounting for just over 40% of the growth, followed by Latin America (15%), Western Europe (11–12%), and the rest of the world. This consumes forests of timber

Solution:

Three brands of facial tissues from virgin paper pulp (Up & Up, Softly, and Kleenex) carry the FSC Mixed label.*(kimberley-clark.com)*

Gary and Jody Cohen of Natural Value in Sacramento 100% recycled compostable facial tissues without chlorine bleaching. Green² facial tissues are

from bagasse, a by-product of sugar production, and bamboo , both of which are rapidly renewable. They are with hydrogen peroxide – an alternative to bleach and are hypo-allergenic with no dyes, lotions, fragrances, , wheat or glue added.*(.com)*

The Cheeky Panda Bamboo toilet tissue is from 100% bamboo that grows without fertilisers or pesticide.*(thecheekypanda.co.uk)*

:Waterless toilet

Problem:

A traditional flush toilet wastefully consumes up to 8,000 gallons (30,000 liters) a year and requires plumbing, , or sewer connections. Given that drought-caused freshwater shortages are on the , water conservation is becoming a serious all the time.

Solution:

A composting toilet is a type of dry toilet that treats human excreta by a biological process called composting.

This process leads to the decomposition of matter and turns human excreta into compost-like material but does not destroy all pathogens. Composting is carried out by micro-organisms (mainly bacteria and fungi) under controlled aerobic conditions. In composting toilet designs, carbon additives such as sawdust or coconut coir is added after each use. This practice creates air pockets in the human excreta to promote aerobic decomposition. Most composting toilets use no water for flushing and are therefore called "dry toilets".

As with things, the of the earliest waterless toilets – composting toilets were first used in China.

In 1939, to prevent pollution from Stockholm into the Sea, a Swedish art teacher Rikard Lindström developed a composting toilet at his seaside home in Tyresö. It comprised a single chamber concrete , with sloped bottom and chimney, for disposal of kitchen and toilet waste. Lindström called it Clivus Multrum. "Clivus" is Latin for incline or slope; "multrum" is a Swedish composite word meaning "compost room," thus a "Clivus Multrum" is an inclining compost room. It functioned for several decades.

Then Kurt Atterberg, a patent engineer and also one of Sweden's most famous composers, persuaded Lindström to apply for a patent which was awarded in 1962. Lindström then founded Clivus Multrum AB in 1962, and the company soon spread across the Atlantic. In 1964, the first commercial model was constructed out of fiberglass. In 1973, wealthy American ecologist Abigail Rockerfeller founded Clivus Multrum Inc. in Massachusetts under license from Lindström to market its composting toilet worldwide.*(clivusmultrum.com)*

Since 1973, sixty thousand units of the Carousel composting system, by Ecotech in Norway into use. Carousel features four composting chambers used alternately via a convenient rotating carousel . *(ecotech.com).* Other dry toilets are by Nature's Head and Sun-Mar. In the USA, five States approved composting toilets Arkansas, Pennsylvania, Illinois, and Florida, where they are even encouraged in flood- areas.

-in- with the dry composting toilet is forest friendly toilet paper out of 100% bamboo. the manufacturers are "Who Gives A " of Melbourne, Victoria, who by selling toilet paper, paper towels and tissues to 36 countries, having been donating 50% of their profits to help build toilets for the 2.3 billion people across the world don't access to a toilet. *(whogivesacrap.org)*

Fabio Kaczala, "The 'Carousel' composting toilet from Norway," *ResearchGate*, January 2006; "Clivus Multrum the Company History," Wayback Machine, May 4, 2007.

:Biodegradable toy

Problem:

In 1919, the rubber shoe heel manufacturer Premo in Petersfield, England produced Minibrix, of hard rubber which had the ability to deform under pressure to allow firm interlocking of studs and holes. Then in 1949 Ole Kirk Christiansen of the LEGO factory in Billund, Denmark began producing plastic toys which included interlocking of different colors. Available in 53 different colours, 400 billion LEGO been produced in seventy years, with 19 billion LEGO elements produced every year. 2.16 million LEGO elements molded every hour, or 36,000 per minute. This makes LEGO the world's biggest toymaker. Since 1963, LEGO been with a , oil-based plastic known as acrylonitrile butadiene styrene. While boxes of LEGO are usually handed down in families are passed on, a proportion end up in landfills.

Solution:

Biodegradable toys

For centuries, off cuts left on the woodworker's bench had been used by their children to balance on top of each other. In 1837, Friedrich Fröbel built specific wooden building blocks to teach the alphabet and numbers for use in his preschool kindergartens.

In 2012 LEGO pledged to find and start using sustainable alternatives to its raw materials by 2030. Realizing the scale of the challenge, it later invested US$150 million to hire almost one hundred scientists and fund research and development.

During seven years, LEGO kept hitting walls. They tried making pieces from , but they were too soft. Its wheat-based did not absorb color evenly or the requisite shine. from other materials proved too hard to pull apart, or had what executives call "creep," when lose their grip and collapse. Over 200 combinations were tested.

In August 2018, LEGO launched 25 various shapes, derived from sugar grown in Brazil, colored green and shaped such as leaves, bushes and trees. Confident, LEGO next launched a 200-piece tree house kit again in ethanol-based bioplastic. The search goes on for an improved version to replace their traditional acrylonitrile butadiene styrene polymer.

In 2019 Lego launched a 12- build-on mug, of BPA-free plastic, coming in eight colors. *(lego.com)*

Ali Morris,"Lego to launch sustainable from sugar ," *Dezeen*, March 2, 2018; Axel Barrett, "Lego Goes For Bio-Based Plastics Instead of Biodegradable and Recycling," *BioplasticsNews,* December 9, 2018.

:Toy-sharing platforms

Problem:

Each year 40 million toys representing 82,700 tons (775,000 tonnes) of waste often end up in the storeroom or in the trash when a child outgrows or loses interest in them.

Solution:

Toy sharing

Since the 1940s, charity shop chains such as The Red Cross and Oxfam received donations of toys and sold them on.

Adrien Valentin and Baptiste Hasbrouck of Begles, near Bordeaux, created *La Petite Marelle* (= the Little Hopscotch), a toy rental platform enabling the rental of boxes of eco-responsible toys (plastic and battery-free) adapted to the parents' taste and the child's development. Boxes of toys can be renewed every 3 or 6 months. Initially planned for individual, *La Petite Marelle* is now aimed at nursery directors and nursery assistants.

In Italy, two mothers and entrepreneurs, Milvia Bonvicino and Alessandra Garini launched their toy rental platform, *il Club dei Giocattoli* in Milan, Monza and Brianza with plans to promote it throughout the Peninsula.

A similar platform *timefortoys* is running in Spain, as is Pickatoy in Argentina.

In , USA, since 2015, Shiva Kashalkar of *Green Piñata*, an online toy rental subscription service has been offering a selection of 250 toxin-free educational and fun toys. In Israel in the Kibbutzim kindergartens, parents often reward their children for sharing their toys.

In Beijing, China, Xu Shu the *ToySuperman* rental website with over 5 million registered users who placed their orders its mobile app or WeChat account. There are currently about 100,000 toys available for on the *ToySuperman* platform, with their models updated monthly. In Singapore, Marus Loy has started up *Toy Tomorrow'sy @ Kidisquare* an online platform which has a collection of 50 toys that parents can for nine days.

Sherlyn Sheah, "New toy-sharing platform lets parents toys, reduce wastage and clutter," *Today*, April 7, 2019.

Hydrogen-powered trains

Problem:

At present, Indian railways has a fleet of 19,000 passenger and goods trains. Of these, about 5,000 trains run on diesel. While diesel trains are energy efficient automobiles, they do their own effects on the environment, including producing nitrogen dioxide, carbon dioxide, and particulate matter that can contribute to air pollution and negative health effects. Diesel engines can emit a fair amount of nitrogen compounds and particulate matter as they burn diesel fuel.

Solution:

Sustainable electric trains

Indian Railways is currently on electrifying all of its lines apart from a few narrow-gauge lines. It has a of completing this by December 2023. The electricity will all be wind and solar generated. India Railways is also on development of a hydrogen-powered suburban and has floated an Expression of Interest for industry participation,

In 2018, two years after Alstom had presented its Coradia iLint hydrogen-powered at Innotrans in Berlin, iLint entered passenger service in Lower Saxony. It had had been designed by Alstom teams in Salzgitter, Germany and in Tarbes, , funded by the German Ministry of Economy and Mobility as part of the National Innovation Program for Hydrogen and Fuel Cell Technology (NIP).

Following the trials Alstom stated that it would build 14 Coradia iLint emissions-free trains, that can travel 621 mi. (1,000 km.) on one full hydrogen , and can reach a maximum speed of up to 87 mph (140 kph) with regular services beginning in 2021.

In May 2019, German public transport network Rhein-Main-Verkehrsverbund (RMV) subsidiary fahma placed a US$ 500m for 27 Coradia iLint trains. Alstom would supply the hydrogen fuel in partnership with Infraserv GmbH & Co Höchst KG. A refuelling station will be located at the Höchst industrial park.

During the first quarter of 2020, the testing of the Coradia iLint was carried out the track between Groningen and Leeuwarden at up to 87 mph (140kph). Dutch railway operators and regional authorities are looking to replace diesel fleets for operation on non-electrified lines find it a clean alternative. *(alstom.com)*

Also in Germany, Siemens and Canadian fuel cell manufacturer Ballard Power Systems with their FCveloCity® fuel cell modules announced plans to jointly develop a fuel cell drive for the Siemens Mireo aluminum railcar.

The collaboration will also include input from RWTH Aachen University and aims to develop a new generation of fuel cells featuring lifecycles, higher efficiency and greater power density. The project has received around $13 million in funding from the German Federal Ministry for Transportation and Digital Infrastructure (BMVI) as part of the Ministry's 'National Hydrogen and Fuel Cell Technology Innovation Program'. The fuel cell technology is currently

slated to be ready for service and integration on-board the platform by 2021. *(ballard.com* and *siemens.com))*

In England Porterbrook is in close partnership again with Ballard and the University of Birmingham's Centre for Railway Research and Education (BCRRE) to develop the HydroFLEX, the UK's first hydrogen powered . HydroFLEX, was developed using an existing Class 319 set.*(porterbrook.co.uk)*

Linda , "Hydrogen-powered gets on track in Germany," *Autonomous Vehicle Technology*, September 20, 2018; "Additional trains to provide higher capacity for the Mittelrheinbahn," *Railway Review*, May 22, 2019; "Mainline testing of UK's first hydrogen HydroFLEX gets green light," *Green Car Congress,* 2, 2019.

:Railway, solar-assisted

Solution: As linked to yesterday's solution, solar-assisted railways

India:

In May 2016, the Indian Railways began to conduct trials of its first solar - powered six-coach in Rajasthan's Jodhpur city. Though the would be pulled by conventional diesel-run engines, 16 solar panels on the rooftop of each coach were used for internal electricity gadgets such as lights and . In 2017 the India city of Guwahati became host to the first station in the country to be 100% solar-powered. The local government is further to adopt solar PV at 8,500 stations in the coming years.

Australia

In December 2017 the Byron Bay Railroad Company in New South Wales e-retrofitted a vintage diesel 100- passenger with a 77kWh battery as well as solar panels on its roof and at pit stops provide all of the power needed for its 3 kilometre (1.9 miles) .

England

In August 2019, a solar-powered railway went into operation in Hampshire thanks to collaboration between Riding Sunbeams Ltd. Community Energy

South and Network alongside a wider consortium of specialist engineering and renewable energy consultants and academics

 up of around 100 solar panels, the 30kWp solar test unit is connected to an ancillary transformer on the Wessex Route's traction system, with energy from the array set to power signalling and lights. The team are also gathering electricity demand data from six potential community solar sites in the south of England. Putting all this real-world data together, they will work out how to plug in much larger solar arrays to power trains. By the end of 2021, Riding Sunbeams hoped to build and connect the world's first ever full-scale community- and commuter- solar farm to UK railways.

There are also plans were under consideration to build a fleet of solar and onshore wind farms spanning the equivalent of 19,000 football fields alongside the of the controversial High Speed 2 is a planned high speed railway in the United Kingdom, in a bid to supply it with renewable power.

Italy

Giovanni De Lisi, founder of Greenrail of Milan, Italy is building solar-powered railway sleepers from an inner in prestressed concrete and an outer shell obtained from a mix of recycled plastics and end-of-life tires, also incorporating a piezo-electric solar panels to supply substantial amounts of electricity to stations and local grids.

:Translucent Barrier Paper

Problem:

Single-use plastic brands are coming under increasing consumer pressure to reduce, remove or replace plastic due to environmental concerns, and while some progress has been , until now there been no credible alternatives available

Solution:

Sylvicta translucent paper.

Paper manufacturer Arjowiggins of Chartham, Kent which has been making paper since the 17th Century, has developed a translucent paper, *Sylvicta* to provide a effective barrier to plastic, as well as a barrier to mineral oils and fatty foodstuffs. (*sylvicta.arjowiggins.com*)

The Sylvicta – a blend of the Latin word for forest (sylva) and the historic emblem of the county of Kent where the paper is manufactured (Invicta) – translates as the "forest that conquers", a perfect illustration of the that paper can play in creating green solutions.

Sylvicta is entirely recyclable, compostable and biodegradable, thanks to manufactured from renewable raw materials supplied from protected forests under the FSC and PEFC schemes. Unlike other such products on the market, the manufacturing process does not use harmful chemicals to achieve its translucency and functionality. Sylvicta is to the highest standards: it is food-contact approved according to the definitions of the European Food Safety Authority and the Food and Administration (USA).

Arjowiggins R&D team worked with board converter of Telford, UK, to develop ultra-high barrier packaging options by adding high-moisture protection and heat-sealability properties. They also worked with other specialised converters to add metallisation to achieve even higher barrier properties

Tredges

Problem:

Recent research suggests that tiny hairs on plant leaves in particular may play a big in trapping the solid and liquid particles that up PM particles in diesel exhaust. But which species are the most efficient?

Solution:

The silver birch tree (*Betula pendula*)

In May 2019, Barbara Maher and colleagues at the University of Lancaster, England tested the ability of nine tree species to capture PM particles in diesel exhaust in wind-tunnel experiments. Silver birch, yew and elder trees were the most effective at capturing particles, and it was the hairs of their leaves that contributed to reduction of 79%, 71% and 70% respectively. In contrast, nettles emerged as the least useful of the species studied, though they captured a respectable 32%.

Based on this, the Lancaster University team designed a programme to examine which plant species can best be used as a natural shield to reduce the health impacts of traffic-derived particulate pollution on primary school-age pupils.

'Tredges' (trees managed as hedges) were planted in four Manchester schools as part of an initial trial. The schools only railings or mesh fencing between their playgrounds and busy main roads in some of the most polluted parts of Lancaster city. Thirteen days later, they entered eight of the houses and, using dust monitoring devices and by swiping surfaces they were to analyze what was collected with magnetic remanence, a technique that provides information on concentrations of -bearing particles.

These wipes showed that the houses with the tree screens had 52 to 65% lower concentrations of metallic particles.

By examining the silver birch leaves with a scanning electron microscope, the researchers confirmed that the hairy surfaces of the leaves trapped metallic particles. Like the particles measured inside the houses, these metallic particles are most likely the product of combustion and wear from vehicles passing by.

A similar study at the University of Surrey also found tredges help to cut down the spread of air pollution from roads, including carbon, harmful heavy metals and microscopic particles. The hedges acted as barriers at breathing height, usually between 1.5 and 1.7 metres.

From this, Lancaster University has created a tree nursery: 'Forest of the Future' in a bid to restore natural and native ecosystems to the campus landscape. The 7,500 tree and saplings donated include a mixture of native deciduous species such as Oak, Hawthorn, and Elder - and Birch.

: a Trillion Trees

Solution:

During the 1930s, when 32nd US President Franklyn D. Roosevelt enacted his New Deals, the most popular of all, and much loved by the President, was The Civilian Conservation Corps which enrolled 3.4 million men who built 13,000 mi (21,000 km) of trails, planted two billion trees.

On January 21, 2020, The World Economic Forum in Davos, Switzerland launched a global initiative to grow, restore and conserve 1 trillion trees around the world over the next decade - in a bid to restore biodiversity and help fight climate .

The *1t.org* project aims to unite governments, non-governmental organisations, businesses and individuals in a "mass-scale nature restoration". A day ahead of its official launch, the initiative even received the support of US President Donald Trump. The Forum acknowledged the work of existing reforestation schemes such as the Bonn Challenge, the Global Partnership for Forest Landscape Restoration, and the work of environmental NGOs like American Forests, or the Trillion Trees Initiative (led by Birdlife International, WCS and WWF UK). 1t.org is an opportunity to help join-up these initiatives in a unifying platform.

1t.org is financed by Marc and Lynne Benioff, CEOs of cloud-based software company Salesforce which is contributing in the form of WEF's *UpLink*, a new digital platform built to 300 stakeholders of all sizes, to solve the United Nations' Sustainable Development Goals, which include taking on climate .

Second, in support of the *1t.org* mission, Salesforce has set a goal to support and mobilize the conservation and restoration of 100 million trees over the next decade. *1t.org* will encourage and enable millions grassroots reforestation

champions by providing a digital platform (UpLink) to connect them with the opportunities, tools and resources they need to thrive.

In its report “Our Future in the ”, The Food, Farming and Countryside Commission, set up by the RSA (Royal Society for the encouragement of Arts, Manufactures and Commerce) has proposed a voluntary scheme that would involve people 18 to 25 taking up agricultural work in rural communities,including the planting of trees.

This National Nature Service could be targeted at people from disadvantaged communities, as well as retirees who “time and resources to do the work”. In 2020, Wildlife and Countryside Link - a coalition of UK-wide organisations a coalition of e-NGOs petitioned the UK Government to invest in a NNS.

In the original study to 1 trillion trees, Thomas Crowther and a team at ETH Zürich found that before the Agricultural Revolution, there were almost 6 trillion trees on the planet. Today, the Crowther Lab estimates there are about 3 trillion covering about 2.7 billion ha (around 10.4 million mi²)] of . They a map that essentially evaluates where trees would naturally exist and with that, it can be observed that there is room for vastly trees there currently are.

While it is impossible to plant in agricultural or areas, those are eliminated, about 0.9 billion ha (about 3.5 million mi²) remain, or about a third of the area those 3 trillion trees currently occupy. Such an initiative should also accompany the protection of existing sequestration areas such as the Amazon Forest.

Rachel Cernansky, “How to plant a trillion trees,” *Nature* 560(7720):542-544 · August 2018.

:Tree-planting

Problem:

Every year, 15 billion trees are destroyed from natural and anthropogenic causes. Despite US$ 50 billion a year spent on replanting, there remains an annual net loss of 6 billion trees. Governments commitments to restore 860 million ac (350 million ha) of degraded , equivalent to an area the size of India, which could accommodate around 300 billion trees, by 2030.

Solution:

Tree-planting

Startups created -planting systems that achieve an uptake of 75 % and decrease planting by 85 %. These systems shoot pods with seeds and plant nutrients into the soil, providing the plant all the nutrients necessary to sustain life. Two companies are using to step up the of tree-planting: BioCarbon Engineering founded by Lauren Fletcher and DroneSeed, founded by Canary.

During the 1990s, Lauren E. Fletcher, with a Master's Degree in Civil and Environmental Engineering was a space systems engineer at NASA Ames Research Center, specialising in bio engineering. In 2007, he was at the International Space University, then from 2008 to 2010 at Stanford University. From 2010 to 2019 Fletcher was a Doctoral student at Oxford University's department of Physics on "Project Mars on Earth."

In 2009 by while Fletcher was at COP15 in Copenhagen, he became concerned about the state of our world: degrading climate, loss of natural environments, significant biodiversity losses, and a potential for global scale human suffering. After years of studying climate and the environment, Fletcher asked himself how the damage of a century of anthropogenic development could be reversed.

The answer, in part, is restoring the planet's decimated forests, to counter industrial scale deforestation using industrial scale reforestation.

In 2013, Fletcher linked up with businessperson Susan Graham with a PhD in healthcare innovation to found the company called BioCarbon Engineering (BCE), based in Eynsham, Oxfordshire, UK, to plant at least 1 billion trees a year with swarms. To do this needed a technician.

Enter French engineer, Jeremie Leonard. From 2005 to 2007 Leonard studied at the Lycée Marcelin Berthelot, Saint Maur des Fossés, , then at the Ecole Supérieure d'Electricité, at Gif Sur Yvette, Isle de . He then crossed the English Channel to study for his PhD at Cranfield University, between 2011 and 2014, where the aim of his thesis, named "Project Athena", was to develop a fully autonomous swarm of medium-altitude, -endurance Unmanned Aerial Vehicles (UAV) with integrated health management.

Leonard's work encompassed research on mission planning, multi-agent control and swarm energy management. In 2014 Leonard was recruited by Fletcher to BioCarbon Engineering. The "seed-dropping" system developed by BCE uses satellite and -collected data to determine the best location to plant each tree.

The planting fire a biodegradable seedpod into the ground with pressurized air at each predetermined position at 120 seedpods per minute. They fly at an altitude of 3 to 7 ft. (1 to 2 m.) above the ground. A small pressurized canister provides the necessary propulsive for the seedpods to easily penetrate the soil's surface.

The seedpods are filled with a germinated seed, nutritious hydrogel, and other vital components. The pods break upon impact allowing the germinated seeds to grow. These penetrate the earth, and, activated by moisture, grow into healthy trees.

Two operators equipped with 10 can plant 400,000 trees per day. Just 400 teams could plant 10 billion trees each year, with the capability to scale to tens of billions of trees annually. The fully automated and highly scalable BCE solution plants 150 times faster and 4-10 times cheaper current methods. This technology provides a new tool enabling global enterprises and governments to meet their restoration commitments.

With initial funding in 2016, a patent “for automated planting” was applied for by Fletcher and his team. BCE began its full commercial operations with the first paid project in May 2017 at abandoned sites in Dungog in the Hunter Valey, New South Wales Australia that were in need of reforestation. They executed nine projects in the UK, Australia, Myanmar, New Zealand, South Africa, and Morocco.

Environmentalists in Myanmar used to plant mangroves by . Myanmar has lost at least 2.5 million ac (1 million ha) of mangrove forest over the past several decades, making it vulnerable to cyclones and climate . Since 2012, Worldview has been to plant over six million trees, which is a achievement already. However, with the help of the BCE , they could plant another four million by the end of 2019. Since the began their work in September, the saplings grown to be 20 in (50 cm) tall.

In April 2018, BCE received a funding of US$2.5 million. The seed investment comes from SYSTEMIQ, a purpose-driven investment and advisory firm that aims to tackle economic system failures, and Parrot, the leading European group. Work in 2018 will expand to projects in the UAE, Canada, USA, Brazil, Peru, and Spain. Customers include private landholders, companies, non-governmental organisations, and governments.

In May 2018, Jeremie Leonard travelled to Canada to work with the Canadian Forest Service for the first-ever Canadian trial of using to plant tree seeds in northern Alberta. That year BCE its to (Dendra Dendra is Greek for tree).

Dendra employs a combination of Wingtra and DJI M600 for pre-planting surveys as well as a custom Vulcan UAV for the seed spreading however much of the equipment they're laden with has yet to be available commercially. Dendra's largest mapping can carry up to 22 kilograms of equipment and its sensors can resolve images at 2-3cm per pixel. This enabled Dendra to plant an additional 4 million mangrove seedlings in 2019 .

In September 2020, backing by At One Ventures, Airbus Ventures, Future Positive Capital, and Chris Sacca's LowerCarbon, Dendra raised $10 million to continue its program whereby just 400 teams of two operators, with 10 per team, could plant 10 billion trees each year, and at a much lower cost the traditional method of planting by . The is to plant 500 billion trees by 2060, in often hard-to-reach places. *(dendra.io)*

Dendra are not . DroneSeed based in Seattle, Washington also committed to reforestation efforts, has developed a for each planting area that maximises successful planting and tree growth. Understanding the environmental conditions of the site is paramount to successfully replanting the area. Using Lidar, topographical 3D maps are , photographs are taken with a multispectral camera to collect visual data, much of it outside of the realm of human detection, which can then be used for an analysis of the plants and soil before any planting can place.

Using this data, actual planting locations are determined so that each seed package has a much greater chance of survival. With the resulting map, the fly autonomously, as as five at a time, and are supported by a team that is ready to load up the and there in of any setbacks. The use machine learning models, setting out to find various 'microsites' where the seeds will better chances of survival. The seeds are pre-packaged into small bundles, filled with nutrients, and covered in the chemical capsaicin to keep hungry creatures at bay. It is this extra attention to detail which improves the odds of each tree's future success.

After planting, the location is monitored and growth is optimized with fertilizer, herbicide and water, all of which are also applied by the . In addition to

gathering data needed for planting, are also collecting data on growth, canopy cover and other factors which allow the creation of 3D models of the actual reforested area.

DroneSeed founder, Canary M.A. of Seattle, Washington is an environmentalist with a love of outdoor sports. He has spent his entire carrier within for-profit companies to benefit the environment including Vestas Wind Energy and the US Green Building Council. He raised US$10 million and built a 60,000 ft² factory to pioneer the commercialization of soldier flies (*Hermetia illucens*) to treat food waste and produce a sustainable supply of nutrients for sustainable salmon feed and agricultural uses. He also founded BioSystems LLC, a wholly subsidiary of Enterra, based in Portland, . At a loss for what to do next in his career and was told by a friend that perhaps he should just go and plant trees.

Realising that tree reforestation needed intensifying, Canary founded DroneSeed. He recruited Matthew M. Aghai as his Director of Biological Research; John Thomson, a systems engineer, responsible for specifying, designing, and manufacturing heavy-lift flight systems and supporting hardware to enable company operations; and Robert A Krob, a software engineer. They were soon joined by Matt Kunimoto, a systems technician who had built a hexacopter that uses recognition to guide its flight autonomously in to follow a custom pattern.

In 2015, DroneSeed first won the Beaverton, US$ 100,000 Challenge sponsored by the City of Beaverton and Technology and Business Center. Shortly after, they were one of the nine startups selected for Techstars Seattle 2016 out of over 1,000 applicants to the program. With funding from Techstars, Social Capital, and Spero Ventures, to the of US$4.8 million, DroneSeed received the FAA's first approval for up to five aircraft to be flown by a single pilot each carrying a 57 lb. (27 kg.) payload. The FAA classifies this exception as "precedent setting", referring to the exceptional lengths DroneSeed has to out its ability to scale operations to larger payloads for multiple concurrent flights. At the time, no other operator in the USA could legally operate with such heavy lift aircraft.

The firm works for 3 of the 5 largest timber companies and recently signed a contract with The Nature Conservancy to restore post wildfire burn sites to combat the spread of wildfires and keep affected areas healthy. Their first planting project was in October 2018, replanting after the Creek Fire which burned 2,800 ac (7,000 ha) near Medford, in 2018.

In 2018, the DroneSeed team was Patent N° 10,212,876 for "Aerial deployment planting methods and systems for making good use of recently obtained biometric data and for configuring propagule capsules for deployment via an unmanned vehicle so that each has an improved chance of survival."

In 2019, following a massive wildfire in southwest DroneSeed were contracted by Northwest. Hancock Forest Management, a international forest landowner and the Nature Conservancy to protect the ecosystem across the Pacific Northwest from invasive species. swarms of up to five aircraft will be deployed to restore rangelands by re-seeding threatened areas, especially in sagebrush steppe habitats. Invasive weed species harm the sagebrush steppe, resulting in a swathe of plant loss. In fact, 50 % of such plants exist, with the remaining 50 % at risk of lost in just the next 50 years. *(droneseed.com)*

NOW, founded by Jessica Jones, enables people to subscribe to support reforestation. with a nonprofit called Eden Reforestation Projects, the NOW will begin by supporting restoration projects in mangrove forests in Mozambique and Madagascar. But the company also began by planting trees itself using , beginning on tribal near San Diego.

In 2020, Rashid Al Ghurair, founder of the Cafu fuel delivery app launched a mission to plant a million drought-tolerant Ghaf evergreen trees (*Prosopis cineraria*), across the UAE by within the next two years. On January 8th 2020, Al Ghurair dropped 4,000 seeds over 10,000 m² in pilot project in Sharjah Dubai If successful the project could be outsourced to wildfire affected regions like Australia and the Amazon. Each Ghaf tree can absorb 34.6 kg of CO^2 emissions per year.

Ultimately, -in- with humans, could help support much massive tree planting, which would a significant impact on climate : researchers recently calculated that there is enough room to plant another 1.2 trillion trees, which could suck up carbon each year humans emit.

References: Lauren E. Fletcher et al, "Techniques for automated planting", *US Patent 201462054280P* (2014); *biocarbonengineering.com*; Jeremie Leonard et al,"Energy Management in Swarm of Unmanned Aerial Vehicles" *Journal of Intelligent and Systems* 74(1-2) · April 2014; , " Spray Tree Seeds From the Sky to Fight Deforestation," *The National Geographic*, November 29, 2017; Tony Kryzannowki, "CWFC evaluates seeding potential as Canadian industry introduced to cutting edge technology," *Logging and Sawmilling Journal*, May/ 2018.

:Fuel cell electric truck

Problem:

Diesel moves approximately 70 % of the USA's freight , and nearly all highway freight trucks are powered by diesel engines. Today, there are 711,000 trucking companies that rely on 3.5 million drivers to deliver for the U.S. economy. Diesel-powered vehicles and equipment account for nearly half of all nitrogen oxides (NOx) and two-thirds of all particulate matter (PM) emissions from US transportation sources. Particulate matter or soot is created during the incomplete combustion of diesel fuel.

Solution:

Fuel cell electric truck

Nikola Motors, based in Salt City, Utah, founded by Trevor Milton. In 2016 the prototype model, the *Nikola Zero*, a Utility Task Vehicle, with 72 or 107 kWh battery. It has 555 hp combined from a motor at each wheel. For the *Nikola One*, a 320 kWh EV battery supplies 6 traction electric motors with a combined software-limited 1,000 hp (750 kW) and 2,000 lb·ft (2,700 N·m) of torque

(nearly 86,000 lb·ft (117,000 N·m) after gear reduction), inspired by electric locomotives.

This is sufficient for keeping a speed of 65 mph (105 km/h) with a full load of 80,000 pounds (36 tonnes) on a 6% . The energy source is 300 kW hydrogen fuel cells consuming 10 lb (4.6 kg) H2 per 62 mi. (100 km.) from tanks with 220 lb. (100 kg.) of hydrogen, giving a of 1,200 mi (1,900 km). Consumption is equivalent to 15.4 mpg (6.5 kpl) of diesel. The truck has regenerative brakes to supplement the traditional disc brakes, decreasing stopping distance and fuel .

The hydrogen version was unveiled in December 2016 and is expected to be available by 2019. In some markets, compressed natural gas to power an on-board gas turbine generator may be used instead. The first 5,000 trucks are to be built by Fitzgerald in Byrdstown, Tennessee; the company is known for its "glider" trucks, which are built without engines. The company has announced plans to build a hydrogen powered day cab called the *Nikola Two*, with power and estimates similar to those of the *Nikola One*. Anheuser- ordered up to 800 hydrogen-fuelled semi trucks from the Nikola Motor company, which planned to build 700 hydrogen stations across the USA and Canada.

In September 2018, announced a partnership with Nikola to develop to develop fuel-cell powertrains for -haul trucks. In April 2019 Nikola showcased its pre-production *Nikola Two* hydrogen electric semi-truck and its 2.3-MW Phoenix hydrogen station hydrogen filling station. The production-ready, zero-emission *Two* will 1,000 mi (1,600 km) , 20% less operating per mile, horsepower, torque and safety features any other diesel ever built. By 2028, Nikola is planning on having 700 hydrogen stations across the USA and Canada.

In November 2018, Nikola announced R&D on a third version of its 120 kW FCT, the 1,000 hp *Nikola Tre* (Norwegian for three) with torque vectoring and a of between 310 to 750 mi. (500 to 1,200 km.) on a single with a refuel from empty in about 20 minutes. The *Tre* was conceived as a fully autonomous, level 5 platform with automated steering and . The *Tre* is aimed at the European and

Asia Pacific truck markets. Because of the restrictive length regulations in export markets such as Europe and Asia-Pacific, the Tre will less maximum because there is less room to accommodate the hydrogen pressure tanks.

Nikola worked with NEL Hydrogen of Oslo, Norway, to a fuelling infrastructure to supply the hydrogen fuel for the extension electrical generator subsystem by the time the trucks rolled out to the different market places. The *Tre* would start trialling from 2020 with production slated for 2023.

By 2028, Nikola planned to 700 hydrogen stations across the USA and Canada. Each station is capable of 2,000 to 8,000 kg of daily hydrogen production. Nikola's European stations are planned to come online around 2022 and are projected to cover most of the European market by 2030. By the end of 2019, private fleet Anheuser- Cos. and truckload carrier U.S. Xpress Enterprises had begun fleet tests of Nikola trucks.

Nikola may not be . In October 2019, Hyundai presented their HDC-6, a fuel-cell-powered tractor with nitrogen-cooled trailer, while the battery-powered Tesla Semi may go into production in 2021. *(nikolamotor.com)*

Kevin Desmond, "Electric Trucks, a History" (Jefferson, NC: McFarland, 2019).

:Tsunami warning system DART

Problem:

On December 26, 2004, 230,000 people lost their lives in the deadliest tsunami in history. The lack of any warning system or proper education was evident as people were caught by surprise when tsunami waves flooded coastlines around the Indian .

Solution:

Deep- Assessment and Reporting of Tsunamis (DART) is a component of an enhanced tsunami warning system.

A 2-way communication system allows the ground station to switch DART into Event Mode whenever detailed reports are needed. Each DART station consists of a surface buoy and a seafloor bottom pressure recording (BPR) package that detects pressure caused by tsunamis.

The surface buoy receives transmitted information from the BPR via an acoustic link and then transmits data to a satellite, which retransmits the data to ground stations for immediate dissemination to NOAA's Tsunami Warning Centers, NOAA's National Data Buoy Center, and NOAA's Pacific Environmental Laboratory (PMEL). When on-board software identifies a possible tsunami, the station leaves standard mode and begins transmitting in event mode.

In Standard Mode, the station reports water temperature and pressure (which are converted to sea-surface height) every 15 minutes. At the start of Event Mode, the buoy reports measurements every 15 seconds for several minutes, followed by 1-minute averages for 4 hours.

Following the 1993 Sea of Japan tsunami, the DART buoy technology was developed by a team led by Eddie Bernard at PMEL, the Pacific Environmental Laboratory (PMEL) at the National and Atmospheric Administration (NOAA) Office of and Atmospheric Research (OAR). The first prototype deployed off the coast of in 1995.

In the of the 2004 Indian earthquake and its subsequent tsunamis, plans were announced to deploy an additional 32 DART II buoys around the world. These would include stations in the Caribbean and Atlantic for the first time. For this, PMEL and NDBC received the Department of Commerce Gold Medal "for the creation and use of a new moored buoy system to provide accurate and timely warning information on tsunamis".

Furthermore, due to work by Christian Meinig, Scott Stalin, Dirk Tagawa, Nicholas Delich, in 2007 PMEL received its first patent for the DART buoy technology and also transferred the technology to SAIC that now builds and sells DART 4G buoys.

During the past sixteen years, DART® data been used 15 times in producing tsunami forecasts. The United States' array was completed in 2008 totalling 39 stations in the Pacific , Atlantic , and Caribbean Sea. The international community has also taken an interest in DART buoys and as of 2009 Australia, Chile, Indonesia and Thailand deployed 8 DART buoys which relay data to 26 national information centers (as of 2015), as well as the U.S. warning center in Hawaii and the Japan Meteorological Agency.to use as part of each country's tsunami warning system. *(ndbc.noaa.gov)*

Acharya, “Evolution of DART technology and development of fourth generation bouy system for deep assessment and reporting of tsunami-(DART 4G)”, *Indian Journal of GeoMarine Sciences* 47 (03), 519-521.

:Twistocaloric cooling

Problem:

According to the International Institute of Refrigeration, refrigeration and air conditioning consume about 20% of global electrical energy. Conventional refrigerators also release gases that significantly contribute to AGW.

Solution:

A team led by Dr. Ray Baughman, director of the G. MacDiarmid NanoTech Institute at the University of Texas at Dallas with Dr. Zunfeng Liu, a professor in the State Key Laboratory of Medicinal Chemical Biology in the College of Pharmacy at Nankai University in Tianjin, China has Tomorrow’sed a new technology for refrigeration that is based on twisting and untwisting fibers.

In research published in the October 11 2019 issue of the journal *Science*, they demonstrated twist-based refrigeration using materials as diverse as natural rubber, ordinary fishing and nickel titanium wire. It could cool flowing water by up to 7.7°C. They stretched rubber fibers, then twisted them until they not coiled, but also supercoiled. Fast release of the twist resulted in surface temperature cooling of 15.5 °C. Releasing both the twist and the stretch from the rubber produced even higher cooling of 16.4°C.

The international team are now seeking methods to this initial Tomorrow'sy to commercialization for twist fridges for diverse - and small-scale applications, but the twistocaloric cooling' technology certainly the meaning of refrigerator coils. (*centers.utdallas.edu* and *nankai.en.school.cucas.cn*)

Run et al., "Torsional refrigeration by twisted, coiled, and supercoiled fibers," *Science*, 2019.

:Typhoon-harnessing wind turbines

Problem:

Substantial winds are good for electricity production, but the very high wind speeds in storms can overwhelm traditional turbines. When the anemometer registers wind speeds higher 55 mph (cut-out speed varies by turbine), it triggers the wind turbine to automatically shut off.

Solution:

Atsushi Shimizu, founder and chief executive of Challenergy in Tokyo has developed a vertical axis wind turbine (VAWT), with cylinders in place of blades, and which use of a physics phenomenon known as the Magnus effect

While the motors require an energy input to spin, this is up to approximately 10% of the power generated by the turbine. The advantages of this turbine, in its vertical axis and Magnus-effect-exploiting design, is that it can adjust to any

wind direction, and power generation can be controlled in accordance with the wind speed. The latter is via flaps or “cylinder wings” incorporated alongside the spinning cylinders, which can be adjusted to control the magnitude of the Magnus effect.

Shimizu’s calculations show that a sufficiently array of his turbines positioned in typhoon ally could capture enough energy from a single typhoon to power Japan for 50 years

Because the Magnus effect acts as the main driver, the rotation of the turbine is almost 10 times slower conventional blade turbines. This they are less noisy, and Shimizu is also studying whether the lower rotational speed has a less detrimental effect on passing birds.

The 10KW version, installed in Ishigaki, Okinawa, has already recorded its first electricity generation during Typhoon Hagibis in October 2019 and the power and communication lines were maintained by continuously supplying the satellite antenna with power**.** Challenergy claim that their design can survive winds of up to 70m/s (156mph) but has an upper operating limit of 40m/s (89mph). (www.challenergy.com)

: Ultra Fast Carbon Electrode (batteries)

Problem:

Existing battery electrodes low electrical, thermal and ionic conductivity, with poor mechanical behaviour when discharged and recharged, and can also suffer from early delamination and degradation leading to safety and lifecycle issues.

Solution:

The Ultra Fast Carbon Electrode

A team at the CEA (Atomic and Renewable Energy Commissariat) led by French mathematician Pascal Boulanger has developed and patented an electrode using vertically-aligned carbon nanotubes (VACNT) a derivative of graphene, making it possible to manufacture super capacitors 1,000 times faster a lithium-ion battery. The electrode combines the highest ionic conductivity - thanks to a 3D fully accessible nanostructure - with the highest electrical and thermal conductivity, provided by its arrangement of 100 billion nanotubes per sq cm, all vertically aligned.

Put simply, a battery using this VACNT technology can give an electric car 800 to 1,000 km of with 5 minutes of recharging.

In 2014, Boulanger collaborated with Ludovic Eveillard to create a start-up called NaWaTechnologies based in Rousset, near Aix-en-Provence and the first carbon nanotube mats were two years later.(nawa in Japanese = short string, but na(no) + wa()

NaWaCap Power super capacitors offer power densities between 10 and 100 times higher existing super capacitors. Their Equivalent Series Resistance = ESR is 10 times lower.

The temperature (low and high) and frequency behavior is also greatly improved and NaWaCap Power super capacitors thus it possible to preserve 5 times energy at high or low temperature or at high frequency compared to current products.

NaWa set up a subsidiary NaWa America in Dayton, Ohio, created by the acquisition of the assets of the US leader in VACNT for composite applications, N12 Technologies. with Dr. Paul Kladitis' Multifunctional Structures and Materials at the University of Dayton Research Institute (UDRI), with Laboratory, NaWa America has developed NaWaStitch, a thin film of hundreds of billions of carbon nanotubes all aligned vertically which serves as an interface between the folds of composite materials and like a "-velcro" mechanically reinforces this interface.

NaWa America has also signed an exclusive license agreement with the Massachusetts Institute of Technology (MIT), and the work of the research laboratory of Professor Wardle (NECSTLAB), well known in the fields of composites and nanotubes.

In February 2020 NaWaTechnologies in raised €13 million to build next-generation production equipment at Rousset by 2021, allowing NaWa to steadily build up to over 100,000 ultracapacitor cells per month when at full capacity. The integration of this technology for future mobility, including electric buses, trams or autonomous vehicles is estimated at around 2024/2025.

At the 2020 Consumer Electronics Show (CES) in Las Vegas, as proof of concept, NaWaTechnologies revealed its 150 kg NAWA Racer concept e-bike which debuted their NaWaCap innovation. The bike's 9kWh lithium-ion battery can capture 80% energy by regenerative . The smaller battery is mounted low in the chassis and will weigh around 10kg, much less current electric sportbike batteries. This gives the NAWA Racer a 300km (186 miles) for inner-city riding, while recharging in just 2 minutes or an 80% entire battery in one hour.

NaWa Technologies is also developing a concept called NaWaShell, an integrated structural hybrid battery that incorporates VACNT to give two complimentary characteristics: enhanced mechanical strength and electrical energy within the of the composite structure.

NaWa's dry electrode technology also brings significant environmental advantages, easily recyclable and eco-disposable at the end of its lifecycle. As a result, NAWA estimates that by using an Ultra Fast Carbon Electrode in lithium battery cell, the CO_2 footprint could be reduced by as much as 60%, simply because less active material is required.

Pascal Boulanger et al, "Method for continuous production of aligned nanostructures on a running substrate and related device", *Commissariat à l'Energie Atomique et aux Energies Alternatives* Patent N°: 20160289826 November 2016.

Vaccine (messenger RNA)

Problem:

With the speed and frequency of global transport by sea and air involving the mass movement of millions of passengers, on the outbreak of a life-threatening virus there is always the problem of the speed at which a vaccine can be trialled, manufactured and avail

Solution:

First pioneered in the 1990s, (Messenger Ribonucleic acid) vaccines represent a promising alternative to conventional vaccine approaches because of their high

potency, capacity for rapid development and potential for low-cost manufacture and administration.

in 2019, Coronavirus (COVID-19) was first identified in Wuhan, China. As of 2 March 2020, 89,000 people across 58 countries had now been diagnosed with the infection, while the death toll globally had exceeded 3,000. The was on to find a vaccine and the challenge taken up by six companies across the world.

As one example, 42 days after receiving the genetic sequence of the COVID_19 virus, called SARS-CoV-2, from Chinese researchers, Moderna Therapeutics, a company based in Norwood, Massachusetts shipped the first batches of its -*1273* vaccine.

Hundreds of vials were sent to the National Institute of Allergy and Infectious Diseases (NIAID), part of the National Institutes of Health (NIH) in Bethesda, Maryland. A team led by Dr Stephen at Moderna had loaded its vaccine with that coded for the right coronavirus proteins which could then be injected into the body.

Immune cells in the lymph nodes could process that and start making the protein in just the right way for other immune cells to recognize and mark them for destruction. Like a software molecule in biology, this vaccine method can be scaled up quickly, saving critical time.

By mid March, human trials had already begun with a group of 45 healthy volunteers getting three doses of the vaccination 28 days apart. They were administered the 25-microgram dose level or the 100-microgram dose level, the low and the middle levels, In May 18 Moderna announced that all 45 participants had developed some antibodies in their blood that bound the virus.

The company began its second phase with The U.S. Food and Administration granting the Moderna Fast Track Designation to begin the mid- study soon with 600 patients.. In July 2020, Moderna announced that its -*1273* candidate in Phase 1 clinical testing had led to production of neutralizing antibodies in healthy adults.

Phase 3 could begin. The trial conducted at U.S. clinical research sites, would enroll approximately 30,000 adult volunteers who did not COVID-19. The trial is designed to evaluate the safety of -1273 and to determine if the vaccine can prevent symptomatic COVID-19 after two doses.

Under a deal with the US Government, worth up to $1.525 billion, Moderna agreed to deliver 100 million doses of its vaccine candidate if it succeeds in - testing. The deal does not stipulate a timeline for vaccine shipments, at least publicly, but does include "incentive payments for timely delivery," Moderna says. The pact also includes an option for another 400 million doses. *(modernatx.com)*

Moderna has not been alone in this research. On November 9th a team led by Mikael Dolsetn at Pfizer Inc of New York and SE of Mainz, Germany publically announced their -based vaccine candidate, BNT162b2, based on the first interim efficacy analysis conducted on November 8, 2020 by an external, independent Data Monitoring Committee (DMC) from the Phase 3 clinical study.

Following safety tests on 43,500 people in six countries, a preliminary analysis has shown that BNT162b2 can prevent 90% of people from getting Covid-19. The two companies say they will be to supply 50 million doses by the end of 2020 and around 1.3 billion by the end of 2021. Each person needs two doses

Pfizer/ started the phase 3 clinical trial around the time as Moderna. But while the former give the booster shot for their vaccine 21 days after the initial dose, the latter's protocol calls for doctors to wait 28 days before giving the second dose.

This vaccine needs to be stored at minus 80c. This could create major logistical challenges for mass treatment outside major areas and in low or middle income countries.

On November 16th Tal Zaks, the chief medical officer at Moderna announced that its -1273 vaccine, remaining stable at minus 20c is to protect 94.5% of people tested and hopes to 20 million doses available in the USA, with one billion doses worldwide.

It has since been authorized in Europe (EMA), the USA, Canada. Hundreds of millions of doses will soon be administered.

There are of course several other serious contenders in the to obtain efficient and reliable COVID-19 vaccines.

Norbert Pardi et al., “ vaccines — a new era in vaccinology,”*Nat Rev Discov*, April, 2018 17(4): 261–279; *Alexis.Hubaud, "RNA vaccines: a novel technology to prevent and treat disease," sitn.hms.harvard.edu. Harvard University,.* 17 February 17, 2020. *MessengerRNA*

:Vaccine vials recycling

Problem:

No matter which vaccine is used to counter the COVID19 pandemic, all the doses been delivered in glass vials – billions of vials – which must be dealt with afterwards.

Solution:

Recycable borosilicate glass

Schott AG headquartered in Minz, Germany, is the biggest supplier of *Fiolax* borosilicate glass for medical vials and . This firm operates a global validated production network with 20 plants and 600 production lines.

Borosilicate glass is using , chemicals, including sodium oxide and oxide, and crushed, recycled borosilicate glass, which is usually a leftover from the glass-making process. The mixture is then put in a furnace, which burns at around

1,550° C. Inside the furnace, known as a tubing , there are three chambers and several burners, which melt the mixture. All impurities are removed using chlorine gas before the liquid glass is into tubes by robots.

Since 1990, Schott has reduced its nitrogen oxide emissions by 75%, and in 2009, the firm became the first manufacturer of glass-ceramics to replace the use of the heavy metals arsenic and antimony from manufacturing with environmentally friendly refining agents.

BOROFLOAT and 33/SUPREMAX glass are produced using the finest natural raw materials and are therefore harmless to human beings and the environment in accordance with the requirements of the European guideline ROHS/2002/95. The glass can be recycled several times and disposed of without difficulties. One American firm this is Vitro Minerals, headquartered in Conyers, Georgia whose unique processing system provides consistent product quality and uniform particle size distribution for four , covering a of potential user requirements.

Vanadium Redox Flow Battery

Problem:

Leaving a battery completely discharged for periods can produce ill effects.

Solution: In the quest for new e-friendly batteries, the Vanadium Redox Flow Battery (VRFB) is a contender. The main advantages of the VRFB are that it can offer almost unlimited energy capacity simply by using larger electrolyte tanks; it can be left completely discharged for periods with no ill effects.

Because vanadium sulfate is non-, the batteries can be stored for periods of time without concern for environmental contamination. Because both the and cathode are of the material, cross-contamination within the battery is also prevented. The electrolyte never catches fire, such as the temperamental li-ion batteries in smartphones. The VRFB system is environmentally friendly because no waste products are produced. It can be thousands of times without degrading, making them ideal for projects that require immense cycling.

The first successful demonstration of the all-vanadium redox flow battery which employed vanadium in a solution of sulphuric acid in each half was by Maria Skyllas-Kazacos a Professor of Chemical Engineering at the University of New South Wales in the 1980s. Her design used sulfuric acid electrolytes, and was patented by the University of New South Wales in Australia in 1986.

A VRFB is undergoing trials in the picturesque German village of Pfinztal, about 30 mi (50 km) south of Heidelberg. Built by engineers at the Fraunhofer Institute for Chemical Technology, it can store and discharge 20 MWh of energy. Connected to a 330ft (100 m) tall wind turbine capable of generating 2 MW, it is used to test battery materials, design and performance, and simulating VRFB operations as part of a national grid. *(ict.fraunhofer.de)*.

Elsewhere, subsidiary of Bushveld Minerals called Bushveld Energy commissioned its first VRFB system in South Africa. The energy and delivery project was a joint effort by Bushveld Energy and national power supplier Eskom. The Bushveld Complex is home to the second-largest vanadium reserve in the world. *(bushveldenergy.com)*

In Canada, VanadiumCorp Resource Inc. is actively toward the development of its Lac VRFB project outside Chibougamau, Quebec. Canadian company CellCube Energy Systems and Pangea Energy revealed plans to install a 50 MW/200 MWh VRFB system in South Australia. The Pangea Project is in the latter stages of pre-development at a 195 ac (79 ha) Port Augusta site. Pending due diligence and review the constructions are set to place in 2019.

But these are but minnows compared to what China's Power, which was established in 2008 to commercialise the technology, is building on the Dalian peninsula, 340 mi. (550 km.) east of Beijing. A battery complex 40 times bigger and to store 800 MWh is due to come fully online in 2020. The battery stacks are manufactured at Rongke's new gigafactory, which opened in 2016 and will eventually a production capacity of 3 GWh a year.

The Dalian complex is just one of almost 30 battery installations built across China by , a spin-off from the Dalian Institute of Chemical Physics, a research division of the Chinese Academy of Sciences. It will be the largest battery installation in the world, and the Dalian site is just one of several big VRFB installations built in China. *(rongkepower.com)*

Lockheed Martin of Bethesday, Maryland and a Mitsubishi Hitachi Power Systems venture teamed up to develop the former's GridStar Flow 6-12 hour - capacity redox flow battery system, based on the principles of coordination chemistry, offering a new electrochemistry consisting of engineered electrolytes from earth-abundant materials.

There are another 30 VRB projects in 11 countries either deployed or under construction. are not in the VRFB market: there are also Sumitomo Electric, Gildemeister, UniEnergy Technologies, Primus Power, redTENERGY , and EnSync.

Kevin Desmond, *Innovators in Battery Technology: Profiles of 95 Influential Electrochemists.* Jefferson, NC: McFarland, 2016.

:Vanadium Redox Battery polymer electrolyte

Problem:

Until now, however, Vanadium Redox Flow batteries suffered from two weaknesses that prevented their widespread use. The first was the frequent of environmentally hazardous and heavy metal salts, such as vanadium dissolved in sulfuric acid, as electrolytes. The other problem was the restriction of the batteries to a maximum temperature of 40°C, which necessitated the of an elaborate cooling system.

Solution:

Ulrich S. Schubertand and a team at the Centre for Energy and Environmental Chemistry Jena (CEEC Jena) at the Friedrich Schiller University Jena

developed a new polymer electrolyte for redox flow batteries that is soluble in water.

This makes it suitable for use in an aqueous electrolyte, and that contains , which provides the ability to store electricity. At the time, the polymer can cope with a significantly higher temperature of up to 60 °C, so that the additional expense for a sensitive temperature management is eliminated.

Ulrich S. Schubert et al. “Aqueous Redox Flow Battery Suitable for High Temperature Applications Based on a Tailor- Ferrocene Copolymer”, *Advanced Energy Materials* (2020).

:Vanillin battery

Solution:

Researchers led by Stefan from the Institute of Bioproducts and Paper Technology at University of Technology succeeded in making redox-flow batteries environmentally friendly by replacing their element, the liquid electrolyte, which are mostly up of ecologically harmful heavy metals or earths – with vanillin.

 and his team refined lignin into vanillin into a redox-active material using mild and green chemistry without the use of and expensive metal catalysts, so that it can be used in flow batteries. The process works at room temperature and can be implemented with common household chemicals.

Vanillin is also present in quantities. Although it is native to Mexico, *V. planifolia* is now widely grown throughout the tropics. Vanilla is grown within 10-20° of the Equator. Most vanilla available today are from Madagascar, Mexico and Tahiti. Vanilla flavoring in food may be achieved by adding vanilla extract or by cooking vanilla pods in the liquid preparation.

Vanillin can be bought quite conventionally, even in the supermarket, but on the other we can also use a simple reaction to separate it from lignin, which in turn is produced in quantities as waste product in paper production.

 and colleagues are in concrete talks with Mondi AG, a leading global manufacturer of paper-based products, which is showing great interest in the technology.

Stefan et al. “2−Methoxyhydroquinone from Vanillin for Aqueous Redox−Flow Batteries” *Angewandte Chimie*, 20 August 2020.

:Vending kiosk for refillable biodegradable products

Problem:

In the United States , 9.5 billion lb (4.3 billion kg) of plastic bottles were discarded in 2017, and 30% of those bottles were recycled, according to The Association of Plastic Recyclers and the American Chemistry Council. While the vast majority are beverage bottles, there was 1.8 billion lb (0.8 billion kg) of plastic containers for products such as detergent, cleaning products and shampoos

Solution:

Henry Pino of Miami, Florida has invented the Ecopod, a vending machine which dispenses biodegradable cleaning products — laundry detergent, fabric softener, all-purpose cleaner, dishwashing gel and dish soap — into refillable containers.

The refills cost about 50% less what consumers pay for a new bottle of cleaner or detergent. In 1993, Pino another detergent company called Environmental Control Group producing commercial strength detergent and supplying it to hotels, hospitals, dormitories, restaurants and area jails. Trucks, similar to a fuel truck would pump and refill the detergent into clients' laundry machines.

With 1,000 clients, in 2001, Pino decided to sell the company for about US$800,000 and go into real estate instead.

Then in 2010, Pino challenged by his environmentalist daughter Gabriela, launched Environmental Solutions Group to create the Ecopod, the development of which Henry backed with US$ 1.2 million of his own money, hiring engineers to design a scaled down detergent production system similar to the one he used at his old business. He filed for a patent in 2015 and was one a year later.

Production began in September 2017. So far, Ecopods are available in five Miami apartment buildings that Pino has had a in developing, and at the Dadeland North Shopping Center. Tenants in apartment buildings where the Ecopod is installed, get a free starter kit that includes a one-gallon container of laundry detergent and three 32 oz (907 gm) containers of dishwashing liquid, degreaser and all-purpose cleaner. *(ecopod.com)*

At the World Economic Forum in January 2019, Procter & Gamble, Unilever, Nestlé, PepsiCo and other big global brands announced that they were teaming with TerraCycle's Loop, which will offer about 300 common household items, from Tide detergent to -Dazs ice cream, in reusable packaging, with refills delivered direct to consumers' doorsteps. After using the products, customers put the empty containers in a Loop tote on their doorstep. The containers are then picked up by a delivery service, cleaned and refilled, and shipped out to consumers again

In May, Loop launched a Beta test, connecting with several thousand consumers in New York and Paris with plans to expand to London later in 2019 and Toronto, Tokyo and San Francisco in 2020.

In October 2019, Sky Ventures broadcasting invested US$2m into the Loop initiative. In the UK Waitrose launched refillable options for items such as alcohol, and cleaning materials. *(terracycle.com)*

"Wiping Away Plastic One Wash at a Time," *AIM2Flourish*; Joel Makower, "Loop's launch brings reusable packaging to the world's biggest brands," *GreenBiz*, January 24, 2019.

:Vertical farms

Problem: For thousands of years the way to farm was horizontally or on terraced slopes.

Solution:

In 1999, the concept of the modern vertical farm was developed in a class led by Columbia University environmental health sciences professor Dr. Dickson Despommier.

In an effort to figure out an effective way to feed the population of New York using rooftop agriculture, Despommier and his students developed the idea of a a 30-story farm with a greenhouse on every floor: in other words, a contemporary vertical farming tower. (Despommier has since on to become the world's foremost expert on and proponent of vertical farms.).

The next key element was the employment of LED to balance light emissions in to increase the return of vegetables. This system was tuned to service two types of chlorophyll, one preferring red light and the other blue.

In 2006, Shinji Inada, a former vegetable trader, founded SPREAD, and opened his first indoor vertical farm facility the following year in Kameoka, Japan. The company spent years refining systems for lighting, water supply, nutrients and other . By 2013, producing 21,000 heads of lettuce per day, which at the time was the world's largest vertical farm in terms of production, Spread finally turned its first profits. Their , "Vegetus" was soon available in supermarkets nationwide.

In 2014, a partnership system and global expansion strategy for Spread's vertical farming business was established. In 2015, they announced the concept for the leading vegetable production system. This new low cost and environmentally friendly system would first be constructed in a new facility called Techno Farm Keihanna in the Kansai Science City, designed as the world's largest automated leaf-vegetable factory with an output of 30,000 heads of lettuce a day.

This system can produce or 648 heads of lettuce per m^2 annually, on racks under custom-designed lights using light-emitting diode. A sealed room protects the

vegetables from pests, diseases and dirt. Temperature and humidity are optimized to suitable growth of the greens, which are harvested by robots.

The Techno Farm will use 110 milliliters of water per lettuce, 1 % of the volume needed outdoors, as moisture emitted by the vegetable is condensed and reused. Electrical power consumption per head will also decrease, with the new factory using custom-designed LEDs that require about 30 % less energy. A collaboration with telecoms company NTT West on an artificial intelligence program to analyze production data could yields even . Spread won the Edison Award in 2016 for its vertical-farming system. *(spread.co.jp*)

Spread is not . As of 2014, Vertical Fresh Farms was operating in Buffalo, New York, specializing in salad greens, herbs and sprouts. In March the world's then largest vertical farm opened in Scranton, Pennsylvania, built by Green Spirit Farms (GSF). The firm is housed in a single story building covering 8 ac (3.25 ha), with racks stacked six high to house 17 million plants. The farm grows 14 lettuce crops per year, as well as spinach, , tomatoes, peppers, and strawberries. Water is scavenged from the farm's atmosphere with a dehumidifier.

AeroFarms in Newark, New Jersey heavily on intelligent machines, a sustainable 70,000 ft.² (6,500 m²) vertical farm located in a former steel factory in the Ironbound section. There, 2 million lb (907,000 kg) of greens and herbs are produced each year, using an aeroponic growing method. Aeroponic growing towers are a closed-loop system, recycling the water and nutrients with virtually zero waste.

AeroFarms patented growing system mists the roots of their plants with targeted nutrients, water, and . This system uses up to 95% less water field farming to grow high-quality produce faster and efficiently, with zero pesticides. After testing hundreds of growth media for their plants, they developed a patented, reusable cloth medium out of 100% recycled materials for seeding, germinating, growing, and harvesting.

With projects in development in China, the United Emirates, and Europe, AeroFarms has its sights on the world, but is very focused on Newark. Where they four farming operations and employ over 120 people -- 40 % of whom live in Newark, with 80 % within a 15 mi (24 km) radius.

AeroFarms produce is sold through their retail , Dream Greens. Meanwhile, Bowery, which is growing crops inside two warehouses in New Jersey, can promise people in New York that their “bok choy” did not travel far at all. *(aerofarms.com)*

Some commercial ventures targeted wealthy nations in the Middle East as prime candidates for vertical farms because of the high cost of importing fresh produce. In 2019, Dubai’s Emirates Flight Catering began construction of a 130,000 ft.² (12,000 m²) vertical farm, located near Al Maktoum International Airport at Dubai World Central to supply airlines in a joint venture with California-based Crop One Holdings. The US$40 million facility was planning to deliver its first vegetables to airlines and airport in December 2019.

Due to the COVID19 pandemic, the program to produce 6,000 lb (2,700 kg) of herbicide-free and pesticide-free leafy greens every day was postponed. In April 2020, the Abu Dhabi Investment Office (ADIO) invested US$100 million to four agri-tech companies to set up high-tech agricultural facilities including an 88,000 ft² (8200 m²) plant by AeroFarms.

In Canada, Elevate Farms is with North Star Agriculture to vertical farming and production of leafy green vegetables to northern Canada including Yukon and other isolated northern territories. the installation completed and begins to operate, it is expected to produce an estimated 9,100 kg of leafy green vegetables per week and reaching over 473,200 kg crops per year. *(elevate.farm)*

Other high- farms appeared in office towers or condos as part of the design. In Tokyo’s Ginza shopping area, stationery retailer Itoya tends a vertical farm on the 11th floor of its 12-story building to supply lettuces exclusively to its , at a cost that would be uncompetitive with vegetables grown in outdoor farms.

Javier F. and a team at Smart Floating Farms (SFF) in Barcelona, Spain hav designed a sustainable, solar-powered vertical farm that floats on pontoons, making it possible to grow food off a coast, in the sea or just about any body of water.

The designers estimate that SFF can produce an estimated 8,152 tonnes of vegetables and 1,703 tonnes of fish annually. The farm is comprised of three levels and features innovative agricultural technologies that are already in use around the globe. It can be modified or stacked in different ways to suit the needs of respective locations.

The top level incorporates rainwater collectors for irrigation needs, photovoltaic panels for electricity and skylight openings to provide natural light for plants. It's also possible to integrate other renewable power technologies such as micro wind turbines or energy converter systems.

The second level features a greenhouse and hydroponic systems (which allows crops to grow year round in any weather and without soil).

Lastly, the ground level is designated for offshore aquaculture. According to the designers, this fishing method takes place in the sea and eliminates the exposure to wind and waves. This level also includes a hatchery where fish eggs are incubated and hatched, a nursery for growing fish, a slaughterhouse and a room to hold the fish before they are ready for the market.

The designers said the farm is ideal for cities or densely populated areas with access to water,

Kevin Desmond, *Electric Machines in Agriculture* (New Delhi, India, NIPA, 2019 (pp 137-141).

:Vertical Forests

Problem:

The parks and gardens of traditional cities spreading out horizontally or on slopes up valuable building space, while potted plants and on balconies can capture miniscule amounts of CO_2.

Solution:

Perhaps the earliest example of a “vertical farm” is the legendary Hanging Gardens of Babylon, built by Nebuchadnezzar II 2,500 years ago. According to some scholars, the gardens consisted of a series of vaulted terraces, stacked one on top of the other, and planted with different types of trees and flowers. Reaching a height of 65 ft. (20 m.), the gardens were irrigated by an early engineering innovation known as a chain pump, which would used a system of buckets and pulleys to water from the Euphrates River at the foot of the gardens to a pool at the top.

In the 1970s, Ken , a Malaysian architect, began to propose that instead of hermetically sealed mass-produced agriculture, plant life should be cultivated within air, mixed-use skyscrapers or “Farmscrapers” for climate control and consumption.

In 2006, Stefano , Gianandrea Barreca and Giovanni La Varra, a team of architects in Milan, Italy, with horticulturalists and botanists, designed two residential towers near the Porta Nuova Garibaldi railway station of that city, What them different was that these towers, 364 ft (111 m.) and 249 ft (76 m.) in

height, would contain 900 trees (approximately 550 and 350 in the first and second towers, respectively) on 96,000 ft.² (8,900 m²) of terraces.

In short, they were a Vertical Forest (= Verticale), incorporating 900 trees, 20,000 shrubs and plants, which help mitigate smog by converting approximately 44,000 lb (20,000 kg) of carbon each year. Construction of the towers began in 2009 and early 2010, involving 6,000 onsite construction workers. Between mid-2010 and early 2011 construction progressed very slowly and the towers and by the beginning of 2012 the structures were completed, and construction of the facades and installation of the plants began on 13, 2012. The building was inaugurated in October 2014.

Before , residents found that their Vertical Forest was attracting new bird and insect species to the city such as bumblebees, hermit wild bees, *syrphidae* (hoverflies) and . It was also moderating temperatures in the building in the winter and summer, by shading the interiors from the sun and blocking harsh winds. The vegetation also protects the interior spaces from noise pollution and dust from street-level traffic.

The building itself is self-sufficient by using renewable energy from solar panels and filtered waste water to sustain the buildings' plant life. These green technology systems reduce the overall waste and carbon footprint of the towers. After five years, these residential high-rises seem to be almost disappearing under all that green, and continue to be a testament to sustainable living.

The Milano model is developed across the world. In Paris, Stefano Architetti are designing a 177 ft (54 m.) tower, Forêt Blanche, which will incorporate 2.5 ac (1 ha) of woodland. Another one is planned for Tirana in Albania.

The Vertical Forest concept is under development in future cities in China, including Shijiazhuang, Liuzhou, Guizhou, Shanghai and Chongqing The Nanjing Forest City project, scheduled to be finished in 2020, comprises a 340

ac(138 ha.) city featuring 40,000 trees and a million plants, a total of 1100 trees from 23 local species, as well as 2500 cascading plans and shrubs that will cover a 6,000 m² area.

As with the Verticale, the Chinese towers will help to regenerate local biodiversity and will provide 28 tons (25 tonnes) of CO_2 absorption each year. B+H Architects in collaboration with ECAD developed an " living room" and rooftop gardens to animate the Shenzhen Children's Hospital and Science and Education Building at the edge of Lianhuashan Park .Composed of gardens and play areas, this is to help children with nature and establish a playful, unintimidating medical environment.

In his book “A Forest City” has unveiled designs for three buildings covered with pollution-absorbing trees and plants in Egypt's new administrative capital, which is under construction in the desert east of Cairo. The Egyptian project will be the first of its kind for Africa.

In October 2019, Stefano , commissioned by developer and textile Grupo Karim, presented plans for a new “smart forest city” proposed across 1376 ac (557 ha) near Cancun, Mexico which would be home to 130,000 people.

Touted as “the first forest city of the new millennium”, the new plans for Mexico include 988 ac (400 ha) of green spaces with 7.5 million plants, and 400 different species, 260,000 of which will be trees equating to 2.3 trees per inhabitant, The smart forest city will absorb 116.000 tons (105,000 tonnes) of CO_2 with 5.800 tons 5260 tonnes) of CO_2 stocked per year. Water is a key element in the project: surrounded by a of solar panels and agricultural fields irrigated by a water channel which is connected with an underwater maritime pipe. Climate-responsive engineering firm Transsolar's involvement in the city plans for it to be completely food and energy self-sufficient.
(stefanoboeriarchitteti.net)

Other architects developing plantscrapers, include Vincent Callebaut of Belgium, Rogers Harbour & Partners of London (Skyfarm), Plantagon of Sweden (World Food Building) etc.

In, India, taking a modest approach, an Internal Revenues Services officer, Rohit Mehra with his wife Geetanjali and friends been creating "green walls" in Ludhiana, a industrial city in the north Indian state of Punjab, to minimise the effect of environmental pollution.

Very simply they empty 3 and 6 pint (1.5 and 2-liter) used plastic bottles then fix rows of them vertically as flower pots, using drip feed irrigation. Having decorated the 2,500 ft² provided by the walls of their home, Rohit then applied it to the walls of his own office at Rishi Nagar, where over 18,000 bottles were used.

The next location, unveiled on Income Tax Day 2017 was Ludhiana's railway station with a vertical garden displaying some 37,000 plants. Thanks to Rohit's initiative, involving building one vertical garden in three or four days on an average, there are now 75 vertical gardens in Punjab, include premium hotels, district courts, schools and colleges like Punjab Agricultural University and even religious institutions like Gurdwara Dukh Niwaran Sahib in Ludhiana. While this totals 1.85 lakh (185,000) saplings, Team Green's is 1,000 vertical gardens across India to help curb pollution.

Stefano , *A vertical forest. Un vertical.Instructions booklet for the prototype of a forest city,* (Mantova, Corraini Edizioni, 2015); Yudhvir , "Vertical garden changing cityscape," *The Times of India*, May 13, 2018.

:Video games

Problem:

Gaming is the world's favorite form of entertainment. The industry generates revenue Hollywood, Bollywood and worldwide sales combined. Some 2.4

billion people play video games on computers, consoles and phones. hours spent gaming risk losing time which might otherwise be spent in dealing with the realtime deterioration of the Planet.

Solution:

In March 2019, "Playing for the Planet: How Video Games Can Deliver for People and the Environment," a report published by UN Environment and GRID-Arendal, found that 87 per cent of the 50 leading gaming companies demonstrate a deep commitment to making a and are willing to support further action on this issue.

In 1997, players discovered *Final Fantasy VII*, the operatic, labyrinthine and often wonderfully weird of ecologically minded heroes out to their "living" planet from corporate energy raiders. It sold over 10 million copies worldwide.

In 2014, Professor Josh Lawler and Dargan Frierson and students at the University of Washington developed *EarthGames*, including *the Pikas*, a available in a beta version that with one of the whiskery, mountain-dwelling creatures, a tear trickling down its cheek. The pika players to purchase energy- and fuel-saving technologies to keep the planet cool, thereby protecting the heat-sensitive little mammals.

Some of the biggest names in the video industry, Microsoft, Sony Interactive Entertainment and others pledged to 'green gaming' during the October 2019 UN Climate Summit by founding the 'Playing for the Planet Alliance.'

Their mission was to harness the increasing popularity of video games on mobile phones to encourage people to lead environmentally-conscious lifestyles. Apart from setting a new to reduce its supply chain emissions by 30% by 2030, Microsoft, maker of the best-selling Xbox gaming consoles will try to gamers in real-life sustainability efforts through its Minecraft Build a Better World initiative.

Developed by of Sweden in collaboration with Minecraft YouTubers Rabahrex, Logdotzip and Stacyplays is a sandbox video that allows players to build things in a 3D world, has 100 million users worldwide. In 2018, around World Day, *Minecraft* had released a new pack *Update Aquatic*—that allowed players to build reefs in the virtual world. Some of these in- designs were then recreated into real-life underwater sculptures from BioRock, a method that enables steel structures running low- direct current to interact with seawater minerals, allowing solid limestone to grow on it. a revolutionary technology that promotes the growth of natural reefs.

The winning sculpture Axolotl – which is the of a Mexican salamander species was installed on the seabed off the coast of Cozumel, Mexico, as part of a partnership between the game's developers and a non-governmental organization, The Nature Conservancy. The initiative, called Crafters, gives players a chance to build virtual underwater worlds with the aim of promoting the rebuilding of real-life corals.

Microsoft is not . In India, Reliance Games, the developer of *Little Singham*, has pledged to generate awareness youngsters by making them ambassadors of climate with the help of in- events and initiatives. China's biggest independent gaming platform, *iDreamSky*, will also include "green nudges" in its games.

In Africa Internet of Elephants, a Kenya-based software company developed an augmented reality video *Wildeverse* that aims to promote conservation of endangered species. It features four animals from the jungles of Asia and Africa, including "Chilli", a gibbon native to Borneo jumping from tree to tree in parks from New York to Nairobi. French video- company Ubisoft, publisher of hit titles *Ghost Recon*, *Assassin's Creed* and *Far Cry*, are developing in- green themes and source materials from eco-friendly factories.

Hereward Holland, "Play the , the planet: Conservationists video gamers," *Reuters*, 5, 2019.

:Volcanic ash for carbon capture

Problem:

Most volcanoes lie close to the , and every year millions of tonnes of volcanic ash falls into them and settles to the seafloor. there, it increases carbon in sediments and reduces atmospheric CO2 levels. But it remains in near the volcano

Solution:

A team from the University' of Southampton's School of and Earth Science has modelled the impact of spreading volcanic ash from a ship to an area of floor to help amplify natural processes which lock away CO_2 in the seabed.

They found the technique has the potential to be cheaper, technologically simpler and less invasive other techniques to remove harmful gases.

The scientists modelled the effect of distributing volcanic ash from a ship to an area of . The results suggest that this method could sequester as much as 2300 tonnes of CO_2 per 50,000 tonnes of ash delivered for a cost of $50 per of CO2 sequestered – much cheaper most other GGR methods.

In addition, the approach is simply an augmentation of a naturally occurring process, it does not involve expensive technology and it does not require repurposing valuable agricultural .

JackLongman, Martin R.Palmer,Thomas M.Gernon "Viability of greenhouse gas removal via the artificial addition of volcanic ash to the ", *Anthropocene* 12 September 2020.

:Wall Plaster

Problem:

An estimated 52% of CO_2 emissions are from buildings and homes — from energy use, water use, and the actual building of the home and the materials in it. Drywall, Sheetrock, gypsum board, or plasterboard which makes up 15% of

demolition and construction waste, leaches toxins and releases hydrogen sulfide gas in landfill. The Chinese Dryall has linked been with indoor air quality problems and nausea for builders.

Solutions:

Wattle and daub

For at least 6000 years, wattle and daub has served as a composite building method used for making walls and buildings, in which a woven lattice of wooden strips called *wattle* is *daubed* with a material usually of some combination of wet soil, clay, , animal and straw.

From 1933, the Swedish Tomorrow'sed a way to compress agricultural fiber into what they called Stramit Boards, (stramit a derivative of the Swedish word for straw). From 1933 to 1945 Stramit boards were mainly used for thermal insulation. recently Ortech Industries been manufacturing their *Durra* Panels, created from agricultural waste by-products such as wheat and straw.

These resources are usually disposed of after a harvest through a burning process that causes the release of additional carbon emissions. *Durra* is out of paddy straw fibers compressing under extreme heat by extruding the straw fiber residual from the straw to dry extrusion process to form a solid . During this process a natural polymer is induced, to the heated and compressed straw fiber residual. a very solid , thereafter a water-based PVA glue is used to encapsulate the finished with a high strength recycled craft paper liner.

This process does not require any gas or water and is completely free of chemical additives and binding agents. This manufacturing process produces zero waste. *Durra* Panels can be recycled, turned into fertilizer mulch, or safely discarded in landfills. *(ortech.com.au)*

Another innovative but short-lived alternative to traditional gypsum drywall was EcoRock of 80% recycled content from cement and steel manufacturing plants. The overall manufacturing procedure is less energy intensive since it's naturally cured and dried without the use of heat or other harsh chemicals.

The venture was led by Kevin Surace and a team at Serious Materials in Sunnyvale, California. To arrive at the right material, they examined 5,000 different mixes finally arriving at an effective drywall that is mold-resistant and will not produce airborne mercury. Users are to install drywall with 60% less

dust. Like as gypsum, this sheet rock can be disposed in landfills without wrecking havoc on the environment. With a plant set up China, in 2011 EcoRock won the Green Product of the Year from *Popular Science.*

"Acoustic, thermal insulating and fire resistant from Ortech Industries," *Architecture&Design*, May 4, 2008; "Serious Materials' Kevin Surace Named Entrepreneur of the Year," *businesswire,* December 9, 2009.

:Biological washing powder

Problem:

Machine washes are often required to reach high energy-consuming temperatures to deal with stains and .

Solution:

Biological washing power

The use of protein and genetically engineered lipase and protease enzymes that are active at low-ish temperatures enable energy-saving low temperature washing applications. These enzymes are supplied by companies such as Novozymes of Denmark to Germany's Henkel AG., the maker of Persil Bio Washing Power, sold throughout Europe.

Biological detergents are effective at much lower temperatures, helping families all across the UK to money on their household bills, and become environmentally friendly. Whilst the enzymes contained in a biological detergent may to disperse within the environment, the temperatures for washing can be lower for a non-biological powder.(*henkel.com*)

: waste sorter

Problem:

The major challenge to recycle the wide diversity of waste requires just human power.

Solution:

recycling machine

In 2017, Bulk Handling Systems (BHS) of Eugene, , USA presented their Max-AI recycling machine with AQC 5 Autonomous Quality Control), linked to a camera-based VIS (Visual Identification System).

Each sorter can sort up to 40 picks per minute and up to three different material types. One Max-AI AQC unit is in a PET quality control (QC) to remove contamination and capture non-CRV PET. The other three monitor the plant's container to recovery, capturing any remaining PET, HDPE and mixed plastics.

VIS monitors the outbound residue, providing MRF operators with real-time and trending material composition of outbound material, allowing them to gauge performance and adjust the system to optimize recovery.

With this system facilities use the latest technology to recycle materials while producing high-quality bales of sorted recyclables. The machines are used to perform some of the dirtier jobs, and employee-owners will be assigned technical positions, developing new skills needed to manage and maintain high-tech equipment,

BHS subsidiaries include Nihot (Amsterdam), NRT (Nashville, Tennesee) and Zero Waste Energy (Lafayette, California). "Recycle Central", one facility using four BHS Max-AI units and one VIS is the 200,000 ft² (18,000 m²) materials recovery facility (MRF), designed and constructed by Recology in partnership with the City of San Francisco, serves as key infrastructure in San Francisco's recycling program, widely recognized as a top program in North America.

Recycle Central sorts approximately 750 tons (680 tonnes) of material every day over two shifts. It is the largest shipper of recycled paper on the West Coast and sends 30 shipping containers of recycled commodities six days a week to paper mills, glass plants and other manufacturers that purchase recycled materials to create new products.

Max-AI units been exported, for example to the Veolia center based in Amiens (Somme), which receives 22,000 tons of waste per year (all household waste streams combined, with the exception of glass). Since its launch in 2018, the robot's mission has consisted of the store, a stream of small paper and small boxes, and eliminating , bottles, plastics, and even shoes that might escaped the previous sorts, using a trommel and an overband. In 2020, a new unit, built for the metropolis of Nantes (Loire-Atlantique), will host two robots for over- of clear PET (bottles) and a flow mainly composed of polyethylene. Other robots, without artificial intelligence, are already deployed in the group. *(bulkhandlingsystems.com)*

Cook, Aakash Pathak and a team in Pittsburg, Pennsylvania, set up CleanRobotics to develop and commercialise TrashBot, an AI/Cloud-connected system to sort waste.

A piece of garbage is thrown into the TrashBot, then a small door slides closed over the opening. Under that door is a camera that analyzes the type of waste. The item is also weighed on a Teflon-coated plastic shelf that drains off liquid if there is any. CleanRobotics software determines whether the item is destined for the landfill or recycling facility and directs it into the appropriate bin below.

Other advanced features of the TrashBot help to reduce custodial and provide instant waste data via an online dashboard, thus allowing facilities to data-driven waste management decisions.

Unlike landfills, TrashBots can be deployed anywhere: stadiums, airports and malls where a robot is efficient. TrashBot likewise stops the contamination issued resulting from mixing different trash materials.

With an undisclosed amount of funding from AlphaLab and investors, CleanRobotics is prototyping TrashBot and selling the system to early customers, including Pittsburgh International Airport, San Francisco and Seattle.

TrashBot was a finalist in the US$5 million IBM Watson AI XPRIZE, an international competition for AI innovations tackling some of the world's greatest challenges. CleanRobotics is also planning to develop a personal garbage device for homes. *(cleanrobotics.com)*

"BHS Launches the Max-AI® AQC-**C,"** Eugene, , May 1, 2019**;** Monica Nickelsburg, "Meet the TrashBot: CleanRobotics is using machine learning to keep recycling from to waste," *GeekWire*, February 5, 2018.

:Water battery

Problem:

With global warming, the search is on to developed natural air conditioning systems.

Solution:

Air-conditioning "water battery"

During 2019, a team lead by Dennis Frost, of Energy and Infrastructure at the University of the Sunshine Coast (USC), Queensland, Australia in collaboration with energy and utility services company Veolia, began to trial a three-storey air-conditioning "water battery".

The thermal energy system will use a of water that is cooled using a "complex thermal process" by the output of 6,000 solar PV panels spread across campus rooftops and car park structures on USC's Sippy Downs Campus. The cooling and system is paired with 2.1 MW of on-site solar PV, which the University said is enough to cool 4.5 megaliters of water.

The water battery will help "slash 40% of grid energy use" at Sippy Downs. The cooled water will be stored and then used for air conditioning, currently the single biggest use of energy at the site is the start of an ambitious rollout of clean-energy developments that is planned to include renewably produced hydrogen and USC carbon-neutral by 2025. *(usc.edu.au)*

"Looking beyond lithium batteries: innovation in energy ," *energymagazine,* May 21, 2019; Tony Moore " water battery helps university cut energy by 40 per cent,"*Brisbane Times*, November 3, 2019.

:The Water Footprint

Problem:

Everything we use, wear, buy, sell and eat takes water to so we must seriously manage our consumption

Solution:

The Water Footprint

In 2002, Arjen Y. Hoekstra of the University of Twente, Enschede, the Netherlands introduced the water footprint, building on the concept of virtual water used by Tony Allan to discuss the of in alleviating water scarcity in the Middle East.

Hoekstra thereby opened a new dimension in the debate around fair and sustainable allocation of fresh water resources. He laid the foundations to show the of indirect water (that is, water used elsewhere to produce goods we consume) in our daily life beyond our direct use for drinking, cooking or washing. The water footprint is an indicator of direct and indirect water use by a producer or consumer, showing how water flows through our economies by it through supply chains and .

A water footprint can be calculated for any well-defined group of consumers (e.g., an individual, family, village, city, province, state or nation) or producers (e.g., a public organization, private enterprise or economic sector), for a single process (such as growing) or for any product or service.

In 2008, Hoekstra co-founded the Water Footprint Network, a vibrant global community of over 200 partners including public, private, academic and non-governmental organizations. The network organized e-learning courses, followed by some 1,000 students, and partnered with companies such as Tata Steel, Ikea, Coca-Cola and Heineken to their supply chains water-sustainable.

In February 2011, the Water Footprint Network and the UN, launched the “Global Water Footprint Standard”. In July 2014, the International Organization for Standardization issued ISO 14046:2014, Environmental management—

Water footprint—Principles, requirements and guidelines, to provide practical guidance to practitioners from various backgrounds, such as companies, public authorities, non-governmental organizations, academic and research groups as well as small and medium enterprises, for carrying out a water footprint assessment. The ISO standard is based on life-cycle assessment (LCA) principles and can be applied for different sorts of assessment of products and companies

For example the Global average water footprint table in litres per shows that while lettuce requires 238 l/kg, chocolate and leather (bovine) require 17,000 l.kg and vanilla consume an awesome 126, 000 l/kg.

Such statistics convinced Hoekstra to his own consumption behaviour, including becoming vegetarian.

In 2019, Arjen Y. Hoekstra was rewarded with a European Research Council (ERC) Advanced . He died soon after, 52.

his books, which been translated into several languages, can be mentioned “The Water Footprint of Modern Consumer Society”, “The Water Footprint Assessment Manual” and “Globalization of Water”.

:“Water is Life”

Problems:

Around the world, nearly 800 million people do not access to clean drinking water. Every year, 2 million people, mostly children, die from preventable diarrhoea contracted from drinking unsafe water. Every day, people suffer and die because they cannot access clean, water.

Solution:

The Blue Planet Project

Maude Victoria Barlow is a Canadian author and activist. She is a founding member of the Council of Canadians, a citizens' advocacy organization with members and chapters across Canada.

Having authored and co-authored nineteen books, including " Boiling Point: Government Neglect, Corporate Abuse, and Canada's Water Crisis" and "Whose Water is it Anyway? Taking water protection into public hands", Barlow co-founded the Blue Planet Project, part of a global movement, with partners around the world including Friends of the Earth International, Red Vida (the Americas Network on the Right to Water) and the People's Health Movement.

Their goal is to promote the fundamental truth that "Water is life" and to strive for water justice based on the principles that water is a human right, a public trust, and part of the global commons.

In July 2010, the Blue Planet Project joined with people around the world to celebrate the United Nations General Assembly adoption of Resolution 64/292, Recognizing Access to Clean Water, Sanitation as Human Right" During the session 122 nations voted in favour, against, 41 Abstentions

But all concerned knew this UN vote was one major step to ensure water justice for all. In to ensure that the newly recognized right served as a tool for social movements and frontline communities, Maude Barlow the report, 'Our Right to Water: A People's Guide to Implementing the United Nations' Recognition of Water and Sanitation as a Human Right'.

In 2020 a team from Esri software, the United Nations Environment Programme, and GEO Blue Planet partnered to develop a tool using satellite data and geospatial technology in support of the United Nations Sustainable Development Goal (SDG) to prevent and significantly reduce pollution of all kinds by 2025. The team received the 2020 GEO (Group on Earth Observations) SDG Award for the Special Category, Collaboration in recognition of the new tool they built.

:Water risk Management tools: Aqueduct

Problem:

The there is an urgent need for tools to identify and evaluate water risks around the world.

Solution:

World Resource Institutes (WRI) Aqueduct Water Risk Atlas tool

The World Resources Institute (WRI) is a global research non-profit organization established in 1982 with funding from the MacArthur Foundation under the leadership of James Gustave Speth. WRI's activities are focused on seven areas: food, forests, water, energy, cities, climate and .

Since 2013, WRI initiatives include AQUEDUCT, a global water risk mapping toolkit helping companies, investors, governments, and other users understand where and how water risks and opportunities are emerging worldwide

Aqueduct's tools map water risks such as floods, droughts, and stress, using -source, peer reviewed data. Beyond the tools, the Aqueduct team works one-on-one with companies, governments, and research partners to help advance best practices in water resources management and enable sustainable growth in a water-constrained world.

The Aqueduct tools and data were developed in collaboration with research partners at Delft University of Technology, Deltares, Utrecht University, Institute for Environmental Studies (IVM), International Food Policy Research Institute (IFPRI), PBL Netherlands Environmental Agency, and RepRisk. The Aqueduct platform was designed and built in collaboration with Vizzuality.

For example, Ecolab leverages WRI's Aqueduct Water Risk Atlas data for two key publicly available tools: The Water Risk Monetizer and the Ecolab Smart Water Navigator. The Water Risk Monetizer (WRM) is a global water risk assessment tool that monetizes the full value of water and risks to businesses. By placing a value on the full value of water, businesses are better positioned to support water-related investments for . The quantity-related data within the WRM is the Baseline Water Stress metric from WRI's Aqueduct Tool and helps businesses informed decisions to protect against water quantity and quality constraints to growth.

The Smart Water Navigator (SWN) bridges the gap between corporate goals and local action, offering comprehensive roadmaps to build circular water management at the site level. Water stress data from WRI gives users insights on the current state of water on a local level.

Other users include Abbott Pharmaceuticals, Tyson Foods, The Yamaha Motor Company, Pacific Institute, Coca-Cola, Nissan, Nestlé, Kimberly-Clark,

:Water-monitoring satellites

Problem:

Studies found that a third of Earth's largest groundwater basins are rapidly depleted by human consumption, despite not having accurate data about how much water remains in them. That significant segments of Earth's population are consuming groundwater without knowing when it might run out. In parts of the world, little or no information is publicly available on how much water a given aquifer contains. It's to know how much water people are withdrawing or how this relates to replenishment .

Solution

Satellites to reveal path to better water management

Gravity Recovery and Climate Experiment (), twin satellites launched in March 2002, circling the Planet, always between 106 and 193 miles apart, been providing invaluable assistance in managing natural resources on the ground. The two satellites (nicknamed "Tom" and "Jerry") constantly maintain a two-way, K- microwave- link between them.

has been generating weekly drought indicators at the National Drought Mitigation Center. This information already is helping water users and policymakers manage scarce groundwater resources in California, the Tigris-Euphrates and several other locations around the world. It is also providing an example of how satellites and remote sensing are reshaping the water world.

Agricultural yields in Syria and plummeted after 2007. Turkey -- the upstream user -- refused to release additional flows to the neighbouring countries, and water stress became so severe that some farmers abandoned their lands and migrated to Baghdad. As of this year, the region had the second-fastest of groundwater depletion on Earth, after India.

Researchers in Turkey at times refused to release their water-related data, citing security concerns. But the remote-sensing technology has created a bypass around the reluctance of countries to release their data.

In 2018, the Gravity Recovery and Climate Experiment Follow On (-FO) satellites—a joint mission launched in 2018 by NASA and the German Research Center for Geosciences (GFZ) joined “Tom and Jerry” in the mission of detecting subtle shifts in Earth’s gravity field, caused by in groundwater or by the decay of ice sheets and glaciers.

Recent data shows that the planet’s surface mass in August 2020 deviated from the average for all months between 2004 and 2009. with some of the most dramatic focused in the ice-rich areas of West Antarctica, Greenland, and southeast Alaska. Scientists analyzing data found that mountain glaciers had lost about 200 gigatons of ice per year between 2002 and 2016, contributing 8 millimeters to global sea level.

:Flexible and wind and water turbine

Problem:

Machines for harnessing energy from flowing rivers are mostly built on the riverbank.

Solution:

Mobile wind- and water-powered electronics chargers

In 2007, Robert Boyd, Geoff Holden, Adam Press and Andrew Cook of the Memorial University of Newfoundland, Canada co-founded SEAformatics to commercialise mobile wind- and water-powered electronics chargers they called *SeaLily* and *Waterlily.*

With a flexible support shaft that permits the water current to the turbine with the flow of water to optimize flow across the turbine blades, the units weigh 1.8 lb. (800g.) and measure 7 in. (180 mm.) across and 3 in. (75 mm.) . They can be placed into a river or a windy place to spin up some power for any device that via USB.

WaterLily is designed for hikers, paddlers, campers, and anyone who spends time off the grid. It phones, speakers, cameras, battery banks, and even 12V devices, by generating power from rivers and streams. SEAformatics *SeaLily* enables reduced cost for the collection of environmental data.

In 2018, the Memorial University of Newfoundland obtained U.S. Patent No. 9,784,236 for their "Flexible Water Turbine." *(seaformatics.ca)*

Desmond 65 should go here

Jeff Green, " by nature: Alumni turn heads with wind- and water-powered electronics charger," *Memorial University Gazette*, December 4, 2017.

:Waste Electrical and Electronic Equipment (WEEE) recycling machine

Problem:

Current Waste Electrical and Electronic Equipment (WEEE), consisting of computers, televisions, monitors, laptops, cell phones, DVD players, etc. is one of the fastest growing segments in a nation's waste, already consisting of 5% of the total waste volume. According to the Environmental Protection Agency (EPA), an estimated 30 to 40 million PCs will be ready for "end-of-life management" in each of the next few years

Most WEEE is sent to landfills or incinerated, which releases materials such as lead, mercury, or cadmium into the soil, groundwater, and atmosphere, thus having a negative impact on the environment. However, WEEE has a variety of valuable metals and minerals to be recovered by recycling for use in future production.

Solution:

(WEEE) recycling machine

MSS in Nashville, Tennessee began in 1974 to develop separation processes for ferrous and non-ferrous metals. The initial development began in 1969 at Vanderbilt University. The Sorter Project combined the efforts of over 50 scientists and engineers from the University together with recycling experts from industry.

Within two years MSS placed the first commercial eddy-current separator, (PULSORT™) for recovery of aluminum containers from municipal waste. By 2006 MSS had introduced the e-Sort™, an optical sorter specifically designed to sort WEEE into the different categories (printed circuit boards, copper, non-ferrous metals, ABS, HIPS, PC, PC-ABS, etc.).

In 2011 MSS introduced the CIRRUS® optical separator, the successor model of the e-Sort™ and, in the near future, other of the existing MSS optical sorters. MSS engineers Garry R. Kenny and Arthur G. Doak patented systems using lasers or narrow- electromagnetic radiation.*(mssoptical.com)*

The first publication to report the recycling of WEEE was published on the of *The New York Times* on April 14, 1993 in which Steve Lohr detailed the work of Advanced Recovery Inc of Belleville, New Jersey, a small recycler, in trying to safely dismantle computers.

In Switzerland, national telecom-companies had started to from electromechanical switchboards to computerized switchboards. As the old switches were very big and contained a lot of metals such as steel, copper, aluminium, brass and precious metals Cablofer Recycling SA of Bex in the canton of Vaud, realized that this was to turn into a gigantic pile of scrap with high value.

They got into contact with Eldan Recycling in Faaborg, Denmark to produce an efficient WEEE crushing and separating machine. Several other companies emerged since, where national ' back' laws such as the WEEE Directive of the European Union and the United States National Computer Recycling Act of 2005, compelled retailers to use them.

The European Union’s Waste Electrical and Electronic Equipment (WEEE) Directive focuses on maximizing the recycling and re-use of e-waste and

minimizes the amount of it disposed in landfills. According to this legislation, every year a minimum of 9 lb (4 kg) of e-waste per capita of the national population should be collected and recycled. *(thommen.ch)*

CP Manufacturing, Inc. of San Diego, California own their own operating electronic recycling site, where they get an operators perspective and are to field-test all of their electronics recycling equipment before selling to customers, giving them a advantage over the competition and better enabling them to gain hands-on experience with e-waste recycling. The materials recovered are largely ferrous metals, aluminum, copper, circuit boards as well as the plastics ABS, HIPS, PC and ABS-PC. *(cpmfg.com)*.

A similar service is carried out using the Redwave, manufactured by BT-Wolfgang Binder GmbH in Eggersdorf bei , Austria.

In China, Suny Group E Zengzhou, Henan, China offers similar machines. Through shredding, grinding, vibration screening, (the incompletely separated metal and nonmetal will re-entry into the grinding machine to be ground again) gravity separating, electrostatic separating and pulse dust collecting, the metal and non-metal will reach about 99% of separation so that the valuable components can also be recycled refined.

With four : Zhengzhou Zhengyang Machinery Equipment Co., Ltd., Zhengzhou Asia-Pacific Energy & Enviro-Tech Co., Ltd.,Henan Honest Heavy Machinery Co., Ltd. Suny their own comprehensive laboratory and 20 sets of internationally-advanced experimental facilities. They joined multiple industry organizations such as China Renewable Energy Industry Association (CREIA) and Manufacturing Institute. *(sunygroup.cn)*

Maria Holuszko, a mining engineering professor with PhD student Amit Kumar at the University of British Columbia (UBC) Canada, innovated a system that can cleanly separate the materials due to their different densities.

While precious metals such as gold, silver and palladium are often recovered from smartphones, the underlying printed circuit boards from fibreglass and resin are usually sent to landfill or incinerators. The research team is currently with recycling company, Ronin8, located in Vancouver BC to work out the any existing knots within their system, as well as to create a commercially viable model to fuel an industry fighting for reuse of materials.*(ronin8.com)*

In 2009, 38% of computers and a quarter of total electronic waste was recycled in the United States, 5% and 3% up from 3 years prior respectively According to a report issued by Wolf in August 2019, the WEEE market is expected to reach US$ 34.32 billion by 2022 globally.

Lohr, Steve, «Recycling Answer Sought for Computer Junk", *The New York Times,.*April 14, 1993; Christina Meskers, “Closed loop WEEE recycling? Challenges and opportunities for a global recycling society,” *Conference Paper TMS annual meeting at San* Francisco, USA, February 2009; Yifan Gu et al, “Waste electrical and electronic equipment (WEEE) recycling for a sustainable resource supply in the electronics industry in China,” *Journal of Cleaner Production* 127 · April 2016; Maria Holuszko and Amit Kumar “Characterization of the non-metal fraction of the processed waste printed circuit boards,” *Waste Management* 75 · February 2018.

:Waste not, want not!

Solution:

In 1576 Richard Edwards, a distinguished lyricist and playwright who compiled a bunch of poems together in one book he called “The Paradise of Dainty Devices”. On 88 was this proverb:

“For is nexte to waste, and shame doeth synne ensue,”

It is a useful advice because two centuries later, in 1772 it has transformed into the popular proverb;

"Waste not, want not. The less we waste, the less we lack in the future.”

“Almost last but not least” in our encouraging list of solutions,” “waste not, not” certainly deserves publication on this website.

:WasteShark

Solution:

A robot or aquadrone to eat waste and collect data.

Oliver Cunningham and Richard Hardiman co-founded RanMarine Technology in Rotterdam, the Netherlands to launch the The WasteShark, the world's first robot designed specifically to capture plastics, microplastics, oils and other pollutants and collect data. Hardiman, from Town, South Africa wanted to create a device that could help clean trash out of a harbour before it reached the .

WasteShark floats through the sea just like the former with its mouth , collecting garbage instead of fish As it navigates the water the electrically-propelled WasteShark emits no carbon, produces no noise or light pollution, and poses no threat to wildlife. It can travel up to 5 km and collect up to 350kg of waste at a time. WasteShark is also supported by a docking- and recharging station. One WasteShark can collect in excess of 15 tonnes of waste a year, with the plastic recycled to products.

With 10 WasteSharks tested around the world in India, the Netherlands, the U.S., and Town, from December 2020, WWF and Sky Rescue launched a WasteShark in north Devon, England to clean up Ilfracombe harbour

:Water degradable bag

Problem:

Plastic carrier which end up on the bottom of lakes, rivers and , do not totally biodegrade, leaving millions of micro-particles to pollute and poison flora and fauna

Solution:

Water degradable bag

In 2016, Robert Astete Boettcher of Santiago de Chile developed Solubag, a water degradable nonwoven fabric of polyvinyl alcohol resin and common minerals for the creation of a of non-polluting and surgical sheeting.

Solubag can be extruded in any plastic extrusion machine, which allows it to be scaled up very fast

The company is recognized by Singularity University and Silicon Valley, where Solubag was awarded a prize for the best Innovation in Latin America at the Summit Conference held in March 2018 in Chile. They are also making alliances with bag plastics producers to be their partners.

: Wave Killer

Problem:

Hurricanes are on the – not in the amount of storms but often in their severity too. and lives, coastal infrastructures and billions of dollars get washed away by massive waves with the coming of each storm.

Solution:

Wave killer

Destino Miguel Rivera of Glen Cove, NY, a master diver with 30 years of underwater construction experience, has patented a geo-engineering solution, called Wave Killer(as opposed to Killer), where an underwater air curtain turns the above it into a gas.

The system would be anchored on the floor, so the curtain's bubbles 10, 20, even 50 feet wide can for miles on end, go from the floor to the surface. In the shallows, of 30 ft. or less, this that waves are deleted, oil is repelled, animals a barrier that they cannot enter when the system is activated.

Used at deeper depths, the system has the ability to lower temperatures, by using bubbles to cold water from the floor to the surface thus protecting . The system also works as a sound barrier, because the is no solid above it.

Construction sounds and detonations are deleted as the system can be 10, 20 or feet , protecting whole coastlines.

Rivera also believes with the right satellite buoy alert systems in place, that Killer can potentially stop tsunami waves from reaching shore with very little advanced and that it's also possible to elevate cool water from the bottom to the warm surface, thus decreasing the surface temperature in hurricane 'hot spots' to slow climate and decrease the strength of massive storms globally.

If Wave Killer could a Category 5 and reduce it to a Category 1 storm just by making the surface temperature cooler in geographic storm tracks, lives, coastlines and billions of dollars' worth of damage could be saved in the process

Wave Killer comes in modular 20-foot sections with air pumped into a system of environmentally tubes, which then gets delivered to strategically positioned air dispersal heads with tiny holes releasing intermingling bubbles. The air gets supplied by centrifuge , compressors, or even the bypass of jet engines which can run on natural gas – depending on how miles of coastline are protected. It is also a sealed air system, so it always has air in it even when it is turned off..

Rivera has spoken with over 30 senatorial and congressional offices to alert them this technology now exists, as well as the Department of the Interior, the US Navy, NOAA and other agencies who can use this system to help the environment from storms, oil spills and other disasters. He is now looking for funding for a prototype.

Destino Miguel Rivera “Sealed underwater air curtain system”, **Patent** N° 10287738, Patented May 14, 2019.

:Wet wipes

Problem:

Regular wet wipes are not biodegradable. Flushing wet wipes causes “fatbergs” up of wet wipes, fat, and of sizes up to 250m which ultimately clog sewage systems so that the over-spill leads to contamination contributing to the global epidemic that is sea pollution. fatbergs were found clogging sewage pipes that took 8-9 weeks each to remove,

Solution:

Compostable wet wipes

Instead of flushing any wet wipes or cleansing wipes, dispose of them properly by using bins and composting where possible, whether it be regular wet wipes or plant-based biodegradable . parents prefer to buy natural baby wipes, as they tend to be gentler and less likely to cause irritation.

One , “Earth Friendly Baby Gentle Vera Wipes” are 100% biodegradable as they do not contain alcohol, parabens, phenoxyethanol artificial colours, synthetic fragrances or harsh chemicals. Their vera, chamomile and calendula extracts help to keep skin healthy and comfortable.

“Simply Gentle Baby Wipes” are approved by the Soil Association because they are from cotton and contain skin-nourishing ingredients such as and camellia sinensis leaf extract. Another Natural personal wipes from 100% cotton, the wipes are biodegradable, compostable and fragranced with essential oils and extracts such as , chamomile and calendula.

:Whales

Problem: Carbon capture should not need to be confined to land-based solutions such as reforestation, boreal, temperate and tropical.

Solution:

Whales

From an wide population of hundreds of thousands of whales, intense commercial hunting, collisions with vessels and entanglement in fishing gear has reduced Atlantic right and other whale populations to mere hundreds. This despite the International Whaling Commission (IWC) placing a moratorium in 1982 which set a catch limit for each country

In a trophic cascade, an ecological process in which predators in a food web suppress the abundance or alter behaviour of their prey, thereby releasing the next lower trophic level from predation or herbivory), whales help to sustain the entire system. While they eat tons of fish and krill every year, whales actually help to keep them alive.

Whales feed at depth in waters that are often pitch-. When they return to the surface, they release fecal plumes (aka poop) rich in and nitrogen—nutrients often scarce in surface waters. In this “ ” at the surface, there is enough light for photosynthesis to happen, and the and nitrogen provided by the whales fertilize the plant plankton living in that sector.

That’s not the thing whales do to keep plant plankton alive: their plunging up and down kicks sinking plankton back up into the , giving it time to reproduce before it drops into the abyss forever. plant plankton feeds animal plankton, on which larger creatures then feed. So, it could be argued, whales fish and krill.

The plant plankton, which proliferates with help from the whales, not feeds the animals of the sea, it also absorbs CO2 from the atmosphere. When the plankton eventually does sink to the floor, it takes this carbon dioxide down with it, where it will remain for thousands of years. The whales there are, the plankton there is. The plankton there is, the CO2 is out of the air. Phytoplankton contributes at least 50% of all to the Earth’s atmosphere and captures as much CO_2 as 1.7 trillion trees, or four Amazon forests.

Great whales are the carbon-capture titans of the animal world, absorbing an average of 33 tons of CO_2 each throughout their lives before their carcasses sink to the bottom of the and remain there for centuries. A tree, by contrast, absorbs no 48 pounds of the gas a year.

Researchers that if whale hunting were completely banned and by increasing Protected Areas, the whale population were allowed to gradually grow to back to hundreds and thousands, approaching the total before the era of whaling, they could capture billions of tons of CO_2 annually.

:WholeGarment

Problem:

The manufacture of garments has been wasteful in material known as scraps of tissue or chutes.

Solution:

WholeGarment

In 1962 Masahire Seima built the prototype of a fully automatic seamless glove knitting machine but it was considered to be difficult to put into practical use and incurred debt.

Thirty years later, in 1995, his company Shima Seiki presented the commercial version of a textile machine that could produce an entire garment without seams, using the amount of yarn required to knit that item, thus reducing labor and material loss associated with cutting and sewing processes, saving substantially on waste.

They called it WholeGarment.

It was unveiled at the unveiled at the International Textile Machinery (ITMA) exhibition, the machine was described by *SWG* (*Sächsische Walzengravur*) as “The Magic of the ”, to knit a single sweater from yarn in 30 minutes.

During the next twenty years, at the Innovation Factory, which was set up in 2016 as a of establishing a new production system for the Japan-based fashion retailer to utilize Shima's latest knit production technologies, the machine was improved to give greater productivity and efficiency, flexibility, reliability, and expanded patterning capability as well as product .

One innovation was the Slide Needle, (whereby a slider mechanism replaces the conventional latch, expanding possibilities in knit and , with increased number of knitting techniques.

In 2002, a no-plate ink jet printing machine "SIP-100F" was developed, and a "Total Fashion System" based on "SDS-ONE" strengthened the cooperation between "SIP" and "P-CAM," contributing to a revitalization of the industry, helping to optimise inventory levels and reduce consumption. In 2017 Uniqlo teamed up with WholeGarment to launch a collection which featured items to redefine quality knitwear at affordable prices.

As part of factory greening, Shima Seiki has a -scale solar power generation system at each factory and are promoting the reduction of energy consumption. They also planted approximately 12,000 trees, outside their factories making approximately 30% of the site "green space," and contributing to CO_2 reduction.

Some major customers are Max Mara (a fashion designer) and Paola Martignoni (an Italian knitwear manufacturer).

In the financial year to March 31 2019, Shima Seiki Ltd sold 1,521 machines worldwide. Liu Jingyuan, an analyst at Goldman Sachs who follows sales of WholeGarment in Asia, forecasts that annual sales will be roughly double that in the financial year ending March 2021. The main bottleneck, argues Mr Liu, will be parts shortages rather final demand.

In September 2019, Shima Seiki was selected by the Cabinet Office public relations office of the government of Japan as one of several innovative companies effectively undertaking Sustainable Development Goals (SDGs) outlined by the United Nations as a global agenda.*(shimaseiki.com)*

I. Voinea, “Shima-Seiki's technologies for whole garment.” January 2001; Nakashima, “Introduction to New Industries by WHOLEGARMENT” *Japanese Journal of Complementary and Alternative Medicine,* September 2017.

:Wild Law

Problem:

As slaves were formerly not considered legal subjects, nature too has been deprived of legal protection and rights; the legal system needs to evolve to be inclusive of the considerations of nature.

Solution:

To give Nature legal rights.

The world's first known conviction for animal cruelty was given in 1822 when Bill Burns was prosecuted by Irish- parliamentarian Richard Martin and found guilty of beating his donkey. Following this in 1824 a Society for the Prevention of Cruelty to Animals was founded.

Today, as the RSPCA, it is the oldest and largest animal welfare organisation in the world. In 2017, the RSPCA investigated 141,760 cruelty complaints and secured 1,492 convictions.

In 1972 American USC law scholar Christopher penned a visionary essay, "Should Trees Standing? – Towards Legal Rights for Natural Objects." argued that trees and other natural resources should rights (e.g. to exist) and that environmental groups should be entitled to speak for them and to present their claims in court. The idea failed to root in the 1970s, but it seeded a worldwide movement.

In 2002, Cormac Cullinan, a practising environmental attorney based in Town, South Africa, published a book, "Wild Law" that proposes recognizing natural communities and ecosystems as legal persons with legal rights. The book explains the concept of wild law, that is, human laws that are consistent with earth jurisprudence.

Four years later, the first law recognising the legal rights of nature was enacted in the borough of Tamaqua, Pennsylvania, in the United States. The community sought to prevent dredging sludge laden with PCBs (polychlorinated biphenyl)

dumped in an abandoned coal . The Community Environmental Legal Defense Fund, helped the council draft the law, transforming nature from rightless to possessing rights to exist and flourish. It was the first such law in the world.

Communities across 10 US States now followed suit, including New Hampshire, Colorado and Pittsburgh. In India, in 2017, the state high court in Uttarakhand ruled that in to protect the and Yamuna rivers, they should be considered legal persons with "all corresponding rights, duties and liabilities of a living person".

In 2015, an 33-year-old orangutan called Sandra was non-human personhood rights and moved from the Buenos Aires Zoo to a home in Florida.

On April 5, 2019, the association A.R.B.R.E.S (Arbres Remarquables: Bilan, Recherche, Études et Sauvegarde) presented, during a symposium organized in the French National Assembly in Paris, its declaration of the rights of the tree. The text has no legal significance but is symbolic.

There were 300 participants, but no deputies. The Universal Declaration of the Rights of the Tree stipulates that a tree is "sensitive to in its environment, must be respected as such and cannot be reduced to a simple object" (Article 2). Article 3 explains lays down that "the tree must be regarded as a legal subject, protected by rules govern the human ." Over 35,000 people signed an on-petition.

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Christopher , "Should Trees Standing? – Towards Legal Rights for Natural Objects." *Southern California Law Review* 45 (1972): 450-501; Cormac Cullinan *Wild Law: A Manifesto for Earth Justice* (Siber Ink, Town, South Africa, August 2002 (A revised edition published in 2010 includes the Universal Declaration of the Rights of Mother Earth).

: Ecocidal laws and offences

Problem:

Industries must no be allowed to pollute the , the sea and the air about them

Solution:

To ecocide a punishable crime or offense

The term ‘Ecocide’ was coined by US biologist Arthur Galston. In the 1950s, Galston was part of a team of scientists who helped prepare a chemical component for the defoliant Agent . When he was confronted with its use in the Vietnam War – poisoning human health and destroying vegetation on an enormous scale – Galston turned into a fervent -war activist. At the 1970 Conference on War and National Responsibility, he called the massive damage and destruction of the Vietnamese jungle an ‘Ecocide’.

12 nations including Vietnam and Ecuador passed ecocide laws, although ecocide has not yet been accepted as an internationally punishable crime by the United Nations. In November 2019 Pope Francis, addressing the International Association of Penal Law (AIDP), called on the international community to recognize ecocide as a “fifth category of crime against peace.”

In answer to the report submitted to the government in 2020, where the Citizen's Climate Convention proposed the creation of the crime of ecocide, the French the Minister of Ecological Transition Barbara Pompili and the Minister of Justice Eric Dupond-Moretti announced that ecocide will be an offense and not a crime

The penalties incurred from three to ten years imprisonment depending on whether there is an offense of recklessness, a manifestly deliberate breach of an obligation and the heaviest, an intentional infringement. The fines from 375,000 euros to 4.5 million euros. The second "seeks to penalize the deliberate endangerment of the environment by deliberate breaches of an obligation for which the penalty is one year in prison and a of 100,000 euros.

:WildEast Pledge

Problem:

Despite the successes of wildlife and conservation-minded farmers, “complicated but well-intended” environmental funding policies failed to reverse the “precipitous decline” in a region’s wildlife.

Solution:

Rewilding estate farms

Hugh Francis Savile Crossley, 4th Baron Somerleyton, British restaurateur and of a 5,000 estate near Lowestoft on the Suffolk/Norfolk border of East Anglia has converted give a fifth of his estate back to nature, restoring the natural ecosystems on around Fritton near Oulton Broad so it can of itself.

In this he has been joined by neighbouring farmers Argus Hardy and Olly Birkbeck so that in total around 250,000 hectares of East Anglia, Britain’s most intensely farmed region, will be converted to wildlife over the next five decades. Former arable is now left to gradually revert to its natural state.

Down at nearby Herringfleet, an area of river valley by the Waveney has been allowed to flood, bringing overwintering birds back to the location; tonnes of trees been removed from the woodland to encourage light in; while fencing has been erected to allow the arrival of sheep, ponies, pigs and even bison.

This also includes the Chet Valley B-, a 10-mile (17km) corridor of pollinator-friendly habitat, and the Suffolk pig farmers Dingley Dell, who sow wildflower strips alongside their outdoor pig pens, creating a habitat for a million bees

with Rewilding Britain, an organisation set up to restore wild nature and build a rewilding movement across Britain, they called their solution the “WildEast Pledge”, challenging everybody to devote “20pc of whatever we ” to nature projects, whether they are farmers, industrial estates, supermarkets, housing estates, churchyards, allotments, schools or individuals in their own back gardens.

The is for a million people to joined the movement and a pledge by 2025, while big businesses and government agencies will be asked to pledge to create ecological infrastructure such as “green bridges” for wildlife to cross major roads. On Sunday, August 23rd 2020, the WildEast movement featured on BBC TV One's flagship rural affairs show “Countryfile” with an average audience of 6 million viewers**.**

(wildeast.co.uk)

:Wildfire monitors

Problem:

During 2021, wildfires spread to many parts of the world, according to the Fire Information for Resource Management System of US space agency NASA. Most of North and South America, the African plateau, the northern Arabian Peninsula, and the Mediterranean coast of Europe as well as Northern and Eastern Europe were affected by fires. In Asia, fires were detected on the coasts of India and in Russia's Siberia region (more than 3.5 million hectares) as well as in China, Malaysia and Indonesia. European countries with Mediterranean coasts such as Italy, Spain, Greece (100,000 hectares) and France also struggled with forest fires.

Solution:

A BurnMonitor “cloud”

A system that allows close monitoring of highly sensitive areas, like a school located in a forested area for example, and get a warning as soon as a fire starts, as well as the necessary information for the fire department to best approach the fire and coordinate action.

One BurnMonitor project has brought together Inria, UC Berkeley, Analog Devices, Planet and Zonehaven to answer Moraga-Orinda Fire District (MOFD)'s needs. Thanks to its partners, BurnMonitor became wildfire early detection IoT (Internet of Things) solution which combines sensors on the ground, data analysis tools and satellite imagery.

The Fire District fuels the consortium with requirements and coordinates the testing. Inria & especially the EVA project-team architects the solution and

manages the BurnMonitor Cloud. The University of California, Berkeley tests the equipment and the system and coordinates with the MOFD during live fires. Analog Devices provides components of the sensors and builds them. Planet makes their satellite constellation available to the consortium. The servers of the BurnMonitor cloud are located at Inria de Paris. On them, monitors can to see the data in real-time, and run the algorithms which translate raw sensor measurements into fire detection events. Zonehaven builds the fire propagation model, turning the sensor data into recommendations to evacuate.

As the front of the fire progresses, it crosses the virtual fence of sensors, which, one after another, detect the presence of the fire. When a sensor detects a fire, it sends that information towards the gateway. Because the gateway can be out of wireless communication range of that sensor, that data may be relayed by other sensors. This causes the data "hop" from the sensor detecting the fire to the gateway. The gateway itself forwards the data to the BurnMonitor cloud using its 3G modem.

Solution 2: In the Marseilles region of south-east France, since July 2021 City Fire Brigade have been using a 13m helium balloon to monitor outbreaks of wildfire in Les Calanques national park.. Built by La Ciotat, the tethered balloon is able to detect an incipient fire 10 m away thanks to on-board infrared sensors and a geolocation system. All while flying at an altitude of 500 metres. The images thus filmed are transmitted live to the operational centre firefighters installed on the Luminy area. A forest fire operation behaves a bit like an airborne military operation," explains a captain of the battalion. "Trucks are like tanks, helicopters and aircraft are water bombers, and behind are the ground assets."

Wildflower meadows, the poppy and the pussy willow

Problem:

Over 97% of wildflower meadows been lost since the 1930s, a startling 7.5 million ac (3 million ha). Partly due to this, on average over the 13 years, about 29 % of colonies of honeybees died each winter. The 2018–2019 numbers from nearly 4,700 beekeepers, representing about 12 percent of the estimated 2.69

million U.S. hives. One third of our global food supply is pollinated by bees. Simply put, bees keep plants and crops alive. Without bees, humans wouldn't very much to eat. ... If bees do not enough to eat, we won't enough to eat..

Solution:

The opium poppy (*Papaver somniferum*) as a quintessential plant for pollen production; in studies it shows significantly higher response of honeybees.

Equally the goat willow (*salix caprea*), the earliest flowering tree in most of North America, provides abundant pollen and nectar for bees that leave the hive in search of food early in the year. Beekeepers often plant them close to the apiary to help the bees through the pollen-scarce months of March and April when little else is in flower. Their glands secrete sweetly scented nectar and are very attractive to bees, as very important source of food.

Beginning with wildflower prairie restoration efforts at the University of Wisconsin-Madison Arboretum in the 1930s and the re-establishment of native pastures following the Dust Bowl, the restoration movement has spread to commercial, government and private properties throughout North America's prairie biome.

In 1992, Philippe Lecompte, an beekeeper in Ville en Tardenois, near the Montagne de Reims, , set aside "une jachère apicole" or fallow meadow for wildflowers to nourish his swarms. the flowers was "le pavot somnifère." The idea caught on and by 2005 "le Reseau Biodiversité pour les Abeilles" (The Biodiversity Network for Bees) was founded by farmers and beekeepers, growing to some 300 members by 2008/ *(reseau-biodiversite-abeilles.fr)*

"Jachère" was an incentive scheme introduced by the European Economic Community (EEC) in 1988 to deliver some environmental benefits following considerable damage to agricultural ecosystems and wildlife as a result of the intensification of agriculture. It sought to achieve this by requiring that farmers leave a proportion of their out of intensive production.

In the UK, “ Our Magnificent Meadows” was partnered by the charity Plantlife to promote and protect the vanishing meadows. A “National Meadows Day” was first held in July 2015 and three years later, NMD saw almost 125 events place across England, Scotland, Wales and Northern Ireland to Tomorrow’s and plant wildflowers including the humble poppy. Individuals creating a wildflower bee-friendly garden and hives on their private property should a point of including the poppy. *(plantlife.org.uk)*

In Marseilles, , Hugo Rivier and Thomas Balana founded Grainettes to and distribute called Seed Bombs. These cork-sized capsules contain a cocktail of wild and endemic plant waste and seeds such as poppy, clover, sainfoin, and others with a melliferous power that exist in nature but which largely disappeared with intensive agriculture, or urbanization.

Used on flowered balconies, the sides of the roads, but also in gardens, Seed bombs are destined to feed as pollinating insects (bees, bumblebees, butterflies, etc.)as possible. Since 2019, 940,895 seed bombs been planted which represents a magnificent bouquet of 10 million flowers to collect. Hundreds of customers include tourism, construction, banks and insurance, higher education, communities, etc. For packaging, the recyclable aluminium boxes been replaced by cotton bundles.

Inspired by a technique from ancient Egypt, its composition protects the seeds it contains from predators (birds, rodents, and insects) and optimizes their chance of growth.

Grainette envisions a -term service, with the creation of a "Beebox" permanently installed at the reception of a company, so that its employees and customers can collect seeds daily. www.grainette.com

Researchers reporting in the journal *Current Biology* on 19th November 2020 created a map of bee diversity by combining the most complete global checklist of known bee species with the almost 6 million additional public records of where individual species appeared around the world. While there remains a lot to learn about what drives bee diversity, the research team hopes their work will help in the conservation of bees as global pollinators.

J. A. C. Miller et al., “Pollination biology of oilseed poppy, Papaver somniferum,” *Australian Journal of Agricultural Research* 56(5), January 2005; H.K. Srivastava and Singh Dwijendra, “Honeybees response in genetically diversified opium poppy,” *Bioresource Technology* 97(13):1578-81, October,

2006; Rachel Nichols et al., “The best wildflowers for wild bees,” *Journal of Insect Conservation,* September, 2019.

:Wildlife Conservation corridors

Problem:

Animals roamed the whole world, as a unique, limitless reserve ruled by nature. Yet, these wide areas been interrupted by urbanisation or intensive agriculture and fatal human-animal conflict in the form of vehicle-animal collisions

Solution:

Wildlife corridors

In to fix human-related damages, wildlife corridors been created all over the world, i.e. the restoration of interconnected habitats which allow fauna relocation and vegetable species to find resources, such as food and water and genetic exchange. There are two types of corridor: natural and man-

The Mesoamerican Biological Corridor (MBC) is a region that consists of Belize, Guatemala, El Salvador, Honduras, Nicaragua, Rica, Panama, and some southern states of Mexico. The area acts as a natural bridge from South America to North America, which is important for species who use the bridge in migration.

Due to the extensive unique habitat types, Mesoamerica contains somewhere between 7 and 10% of the world’s known species. The corridor was originally proposed in the 1990s to facilitate animal movements the Americas without interfering with human development and use, while promoting ecological sustainability. The Mesoamerican Biological Corridor is of four parts: Zones, Buffer Zones, Corridor Zones, and Multiple-Use Zones, each with varying availability for human use.

The man-assisted solution, known as écoducs or écoponts was first developed in in the 1950s. It took off in the Netherlands, where 600 crossings been constructed to protect badgers, elk and other mammals.

the man-assisted wildlife passages and corridors to be found today is a network in Banff National Park, Canada. Starting with the first two wildlife overpasses, there is not a total of 44 wildlife crossing structures — six overpasses and 38 underpasses — the -Canada Highway in Banff National Park and another 10 wildlife underpasses highways in Yoho and Kootenay national parks.

They are used by deer, moose, and bears. To , conservationists documented 152,000 animals crossing the highway using either the bridges or the underpasses. They also reduced the number of wildlife vehicle collisions by about 80 per cent.

The biggest wildlife corridor in the world is currently designed, and it will stretch over US Highway 101 to northwest Los Angeles and connect parts of the Santa Monica Mountain chain.

The corridor will it easier for mountain lions and other animals to roam freely through different parts of the mountains without the of human interference. Designers of the corridor chose to create a bridge surrounded by brush and trees, which extends 165 feet over a 10- freeway.

It is supposed to blend seamlessly with the mountains, so the animals don't realize they're on a bridge at all. The project, which is in its final phase of design, $87 million and was slated to in 2023.

:Wind Power Hub

Problem:

-based wind turbine farms up space which could be better used for housing and agriculture.

Solution:

A very big floating offshore wind farm

Equinor ASA, a Norwegian multinational energy company headquartered in Stavanger, Norway, builds energy captors offshore. They built the 88MW Hywind floating offshore wind farm to provide electrical power to the Snorre and Gullfaks oil and gas platforms in the Tampen area on the Norwegian continental shelf.

This farm is reducing CO_2 emissions by 220,500 tons (200,000 tonnes) per year, equivalent to the emissions from 100,000 cars. After this, Equinor teamed up with Korea National Oil Corporation (KNOC) and Korea East-West Power (EWP) to carry out a feasibility study for the world's largest floating offshore wind farm, the 200 MW Donghae 1 project to be located close to the KNOC-operated Donghae natural gas field off the coast of Ulsan. They aim to start building the farm in 2022, with possible electricity production from 2024.

Equinor is also linking up with SSE to build an offshore wind farm in the North Sea. It will use the largest, most powerful offshore wind turbine in the world: GE Renewable Energy, already with 50,000 turbines in the field, is preparing the *Haliade-X*. While each blade is 107m , the size of a soccer field, its 260m mast is five times the size of the iconic Arc de Triomphe in Paris, . Designed by LM Wind Power of Kolding, Denmark and built at their factory in Tianjin, China, one *Haliade-X* is capable of generating between 12 and 14 MW - up to 67 GWh annually, enough clean power for up to 16,000 households per turbine, and up to 1 million European households in a 750 MW windfarm configuration. GE Renewable Energy aims to supply its first nacelle for demonstration in 2021

Each of the new 720 ft. (220 m.) diameter rotor mega-turbines planned for the world's biggest offshore wind farm at Dogger in the North Sea will generate enough electricity for 16,000 homes. Together, the new generation turbines, built by GE Renewable Energy, will up a windfarm capable of generating enough renewable electricity to power 4.5m homes from 80 mi (130 km.) off the Yorkshire coast, or 5% of the UK's total power supply. In November 2020 Equinor and SSE completed a deal worth £8 billion to finance the first phases of the farm *(equinor.com)*

In 2016, nine countries – the Netherlands, Germany, Belgium, Luxemburg, , Denmark, Ireland, Norway, and Sweden – signed an agreement to cooperate in planning and building offshore wind parks. The goal is to reduce as quickly as possible and thus the wind parks economically viable.

A study commissioned by Dutch electrical grid operator TenneT reported in February 2017 that as much as 110 gigawatts of wind energy generating capacity could ultimately be developed at the Dogger location. TenneT (Netherlands and Germany) teamed up with the Centre for Electric Power and Energy at the Technical University of Denmark (Energinet) and signed a tri-lateral agreement for the creation of a connection point for thousands of future offshore wind turbines in the North Sea.

The 'North Sea Wind Power Hub' would the potential to supply 70 to 100 million Europeans with renewable energy by 2050. closely with Energinet, Vestas, MHI Vestas, Siemens Gamesa, ABB, NKT, Siemens and Ørsted, The North Sea Wind Power Hub is a proposed energy island complex to be built in the middle of the North Sea as part of a European system for sustainable electricity.

One or "Power Link" artificial islands or modules will be created at the northeast end of the Dogger , a relatively shallow area in the North Sea, just outside the continental shelf of the United Kingdom and near the point where the borders between the territorial waters of Netherlands, Germany, and Denmark come together. Dutch, German, and Danish electrical grid operators

are cooperating in this project to help develop a cluster of offshore wind parks with a capacity of several gigawatts, with interconnections to the North Sea countries. Undersea cables will international in electricity possible.

According to this , the first artificial island will an area of 2.3 mi² (6 km²). Thousands of wind turbines will be placed around the island, with short alternating-current links to the island. On the island itself, power converters will the alternating current to direct current that will be carried to the mainland via undersea cables. The Hub – one island at first, and later one or two – is intended to a substantial contribution to the energy transition and to achieving the goals of the Paris Climate Agreement of 2015.

The idea is that the structure would be built in modules, so that, over time, it would be possible to expand the Hub with islands or it so that up to 180GW of offshore wind capacity could ultimately be handled. To get to that point, a lot of new technology would be required, both to transmit energy and to store it, hence the project.*(tenet.eu)*

In October 2020 the Hub obtained a €4 million EU .

Meanwhile in March 2020, Shell, Gasunie, a Dutch gas grid operator, and the port of Groningen began to the *NortH2* Project to provide 3-4GW of offshore wind capacity established in the North Sea by 2030 that would be used for the manufacture of green hydrogen.

Electrolyzers would be installed the northern coast of the Netherlands, in Eemshaven, and by 2040 the project may expand with added offshore electrolyzers that are set to produce 10GW of power. Shell currently has a 20% stake in a consortium that is building around 730MW of offshore wind off the coast of the Netherlands. *(gasunie.nl)*

"Is this the future? Dutch vast windfarm island in North Sea", *The Guardian,* 29 December 2017; Nadja Skopljak, "North Sea Wind Power Hub Proves Feasible," *offshoreWIND.biz*, July 9, 2019 Wesley Doyle, "Shell starts exploring idea of world's largest green hydrogen project," *electric & hybrid technology international*, March 31, 2020

:Wind-powered ships

Problem:

The global shipping sector emitted just over a billion tonnes of greenhouse gases in 2018, equivalent to around 3% of global emissions – a level that exceeds the climate impact of Germany's entire economy. Fossil fuel engines replaced traditional and sustainable energy sources such as the wind

Solution:

Wind-powered ships

Sweden

Shipping company Wallenius is developing a ship called *Oceanbird*, which could transport 7,000 cars and trucks across the Atlantic propelled by the wind.

The concept called **wPCC** (wind Powered Car Carrier),which is essentially an outsized sailboat, would be twice as high as the largest comparable vessel due to the five 80-metre-tall sails that protrude from its hull. 5 with 80 metres tall sails for forward propulsion. These purportedly would it the world's largest wind-powered vessel, capable of travelling across the to the US at a speed of 10 knots and with a total journey time of 12 days.

According to Wallenius , this is four days a carrier powered by fossil fuel while emitting 90 per cent less CO_2 in the process.

The main partners in the project are Wallenius , Sweden's KTH Royal Institute of Technology and SSPA. It is supported by the Swedish Transport Administration, which has allocated SEK 27 million for the three-year development project during 2019-2022. Launch is scheduled for 2024.

Costa Rica

Ceiba is the first vessel conceived by Danielle Doggett of SailCargo, a company trying to that zero-carbon shipping is possible, and commercially viable. Built largely of timber at the AstilleroVerde shipyard, *Ceiba* (= kapok tree) combines both very old and very new technology: sailing masts stand alongside solar panels, two high-efficiency 120 horsepower electric motors and batteries. The variable-pitch propellers will re-generate solar power when the ship is under sail by as underwater turbines to batteries and meet onboard electrical needs

Ceiba, the first in the SailCargo fleet, should be navigating by 2021 and operating by 2022, when she will begin transporting up to 250 tonnes of between Costa Rica and Canada.

VPLP design's 121m RORO vessel *Canopée* which transports components of the Ariane 6 rocket from Europe to its launch pad in French Guiana, is fitted with four 30 m high Oceanwings providing a total surface area of 1,452 m². These automated and reefable soft wingsails assist the ship's main propulsion system, dual fuel engines (LNG and MDO), to reduce fuel consumption and carbon dioxide emissions by an average of 30% to 35%.

A new company, Ayro, has been set up for the specific purpose of applying Oceanwings to hydrofoil ferry .

Spain

Led by aeronautical engineer Cristina Aleixendri, a team at bound4blue, based in Rubi in Catalunya has developed and patented fully foldable concertina wingsails that ensure safety in weather, and at port or in daily operation; manoeuvrability thanks to the rotation capability which makes the system efficient and autonomous operation. They are currently integrating an 8x20m unit into the 37m *Balueiro Segundo* fishing vessel located at WCCA - Panama Canal. Bound4blue is also on an alternative application of the wingsail technology to design in the future a boat propelled by these wingsails, capable of producing hydrogen and by of the electrolysis of seawater in a clean and cost-efficient way.

Black-bladed wind turbine

Problem:

Collision of birds, especially raptors, is one of the main environmental concerns related to wind energy development. In Norway, 6-9 white-tailed eagles are killed annually within the Smøla wind-power plant located on the west coast of Norway, consisting of 68 turbines over 18 square kilometres, making it one of the largest onshore wind farms in Norway. This has caused opposition and conflict.

Solution:

Black-bladed wind turbine

Keen to test whether mitigation measures could reduce the of bird strikes, Roel May and Ketil Skogen, senior researchers from the Norwegian Institute for Nature Research, Department of Terrestrial Ecology in Trondheim (www.nina.no) up with the solution of painting one blade on each turbine so as to reduce "motion smear", allowing birds to see the rotating blades.

The results, published in the *Ecology and Evolution* journal, report how in 2013, each of the four turbines in the test group had a single blade painted . In the three years that followed, six birds were found dead due to striking their turbine blades. By comparison, 18 bird deaths were recorded by the four control wind turbines—a 71.9-percent reduction in the annual fatality . The researcher suggest that thousands of birds could be saved from killed by the blade solution although its efficacy may well be site- and species-specific.

:Recyclable wind turbine blades

Problem:

End of life wind turbine blades must be pulverised in to become recyclable and not end up in landfills.

Solution:

Recyclable wind turbine blades

In February 2020, the Institut de Recherche Technologique (IRT) Jules Verne based at Bouguenais near Nantes, formed a consortium of businesses to develop recyclable wind turbine blades using Elium, a thermoplastic resin developed by Arkema, a liquid monomer that polymerizes at room temperature.

For the project known as ZEBRA (for Zero wastE Blade ReseArch) the first objective, by 2022, is to manufacture two prototype blades using this resin. One will be 62 meters and the other 75 meters with integration of stiffeners

For recycling, two avenues will be explored: the mechanical process of compounding (process allowing the mixing by fusion of plastics and additives) with reintegration of the elements in a new matrix. The other, thermal, is that of depolymerization where the heated resin becomes a liquid monomer that can therefore be separated from the fiberglass.

The consortium is also mobilizing Engie, as a wind farm operator, the blade manufacturer LM Wind Power, a subsidiary of GE, , one of the world leaders in fiberglass, Suez, on the issue of recycling, and the Aquitaine technical center, specializing in composites. No has yet been communicated on the marketing of this new generation of blades.

:Frictionless magnetic wind turbine

Problem:

Renewable energy produced from the wind has garnered much attention and support in recent years but is often criticized for its low output.

Solution:

MagLev wind turbine generator

In 2007 based on a patent was to Guokun Li, Xiaopeng Li, Xiaobo Li of Energy the MagLev wind turbine generator was jointly developed by Guangzhou Energy Research Institute under China's Academy of Sciences and by Guangzhou Hengyuan Energy Science & Technology Co., Ltd.

The on the Maglev VAWT were designed Chinese aero-dynamicist Weiming. It was first unveiled at the Wind Power Asia Exhibition at the China World Centre in Beijing in 2006, was expected wind power technology to the next level with magnetic levitation.

The Maglev uses a magnetically levitated low-RPM high-torque power output turbine. The spinning turbine “floats” on a magnetic cushion, just as the high-speed “floats” above the railroad tracks. Configured to capture winds from any direction, the Maglev generator was expected to wind energy generating capacity by as much as 20 % over traditional wind turbines.

One Maglev wind turbine could generate one gigawatt of clean power, enough to supply energy to 750,000 homes This would effectively cut the operational expenses of wind farms by up to half, keeping the overall cost of wind power under 0.4 (US$US 5 cents). Further, the Maglev is to utilize winds with starting speeds as low as 5 ft per second (1.5 m/s), and cut-in speeds of 10 ft/s (3 m/s).

In November 2007, began construction of a plant to produce maglev wind turbines with capacities from 400 to 5,000 Watts.

In a report issued by *Materials Post* in October 2019 entitled “Economic Impact On Maglev Wind Power Generator, the key players in the Maglev market are Typmar, Lonja, Bluelight, OLBO, Green Elec, Saipwell, Greefenergy, Beijio and Zonhan. *(energas-group.cn)*

Rahul Jangam et al."Frictionless Wind Turbine Using Magnetic Levitation” *International Journal of Emerging Technologies and Innovative Research* Vol.5, Issue 5, no.253-258, May, 2018.

:Variable speed rotor wind turbine

Problem:

One weak link with wind turbines is the risk of blackouts and other disruptions. For example in August 2019, offshore turbine controllers at the One offshore wind farm in Essex, panicked after a lightning strike elsewhere on the grid. They inadvertently pulled the entire wind farm offline, resulting in widespread blackouts in England and Wales.

Solution:

Variable speed rotor wind turbine

A research team lead by Xiao- , Director of Smart Grid in the Birmingham Energy Institute at the University of Birmingham set out to tackle the issue of such frequency dips (or nadirs), such as when a generator gets damaged or some other systems failure occurs.

Their solution is to deploy the rotating kinetic energy of the turbine by using the variable speed of the rotors in wind turbine systems to closely regulate the supply of power to the grid. This that when electricity demand is high, stored kinetic energy in the turbines can be used intelligently to keep the grid stable.

To avoid a second dip, the Birmingham team proposes a sequence that starts with partial rotor speed recovery, then automatically moves on to a second phase for full recovery. With wind power projected to supply a of the UK’s power by 2030, it is important to equip wind farms with safety mechanisms against

frequency nadirs. University of Birmingham Enterprise has applied for a patent to protect the system.

Xiao- et al. “Fast Frequency Support from Wind Turbine Systems by Arresting Frequency Nadir Close to Settling Frequency.” *IEEE Xplore,* May 25, 2020.

Globally-transmitted wireless power

Problem:

The world is becoming exponentially hungry for electrical energy and every possible solution should be examined.

Solution:

Globally-transmitted wireless power

In 1901, Croatian electric engineer, Nikola Tesla persuaded a millionaire J.P. to finance $150,000 (today’s $4.2 million) for the building of a 187 ft (57m) tall wood and copper structure called “Wardenclyffe Tower” in Shoreham on Island, about 65 mi (100 km) from New York City. Power for the entire system was to be provided by a coal fired 200 kilowatt Westinghouse alternating current industrial generator.

Tesla’s tower was intended to excite the planet Earth’s natural electrical resonances, where high-power waves of electrical energy flow repeatedly around the entire planet times before eventually dying away. Tesla claimed it could transmit free electricity across the Atlantic and beyond, with no wires.

A number of experiments were to perform -Atlantic wireless power transmission, as well as commercial broadcasting and wireless telephony and

even facsimile images, based on his theories of using the Earth to conduct the signals. Experiments were discontinued through lack of finance and the tower was eventually disassembled in 1917.

Tesla's invention was considered crackpot until recent discoveries about electro-magnetic waves, in particular with a high Q-factor, all the way around the Earth times, over and over before eventually dying away, suggested that it could work.

In 2014, Leonid and Sergey Plekhanov, graduates of the Moscow Institute of Physics and Technology, claimed they had spent years scrutinizing the Nikola Tesla's patents and diaries and that Tesla very close to wireless power transmission. The enthusiasts say they need about $800,000 to reconstruct the famous.

According to the authors of the project, as of today all human civilization's electric energy needs could be covered with a single installation of solar measured approximately 316 x 316 km (100,000 km²) positioned in a desert somewhere near the Equator. They believed the stumbling to such a project is the delivery of electric energy to final consumers, as the loss of energy directly depends on the distance of transmission.

Unable to find the necessary finance, the Tesla/Plekhanov solution has not yet been built. On a smaller scale, their Global Energy Transmission (GET) enables battery-powered to fly forever by safely and quickly recharging while in flight.

In to , just need to hover over one GET's hotspots for a few minutes. This creates the opportunity to build Wireless Power Networks to enable to do things that were previously unavailable due to low battery limitations.

Tesla: Inventor of the Electrical Age W. Bernard Carlson, 2014; "Tesla's solution to world energy ," *The World Weekly*, July 5 2014; Sergey Plekhanov, Leonid Plekhanov "Wireless power assembly," *Global Energy Transmission, Co.* Patent N°: 10097046. October 9, 2018.

:Woad blue

Solution :

Founded in 1994 in the town of Lectoure in the Midi-Pyrénées, Bleus de Pastel de Lectoure been promoting the pastel blue (Isatis Tinctoria) through the cultivation, extraction and production of pigment for the use of arts, decoration and textiles/ Isatis Tinctoria", is a cruciferous plant whose flowers are yellow but whose leaves produce an exceptional blue.

Rightly regarded as the best in Europe during the Renaissance, pastel the legend of the " of " before challenged by Indigo and falling out of use. For Bleus de Lectoure, their woad plants are grown locally without the use pesticides or synthetic fertilizers. It takes 1 ton of Isatis Tinctoria leaves to get 2 kg of Lectoure blue powder.

Over in England, ‘Coventry Blue’ was a dye used in the city’s medieval weaving . This shade of blue was unique to Coventry, then the centre of the weaving , and from a secret recipe for the dye including water from the local River Sherbourne and the quality and type of woad plant used. Although their recipe and the precise colour hue been lost, but the colour of their football team and their buses is blue all the .

:Wooden furniture, antique

Problem:

Most new furniture contains particle board. The powerful synthetic glues that bind the sawdust into man- “wood” release formaldehyde and other chemical vapors into the air we breathe in our homes and offices for years.

Solution:

Antique wooden furniture

A 200 year-old has had probably 8 previous owners, passed down for 8 generations. What a history it has had and now you become part of its ongoing history and provenance. By definition, antique furniture is at least 100 years old. For a piece to last that and retain its integrity is a sure sign it has been with and skill, using quality materials and an array of complex, time-consuming techniques.

By restoring antique furniture, an decreases demand for virgin lumber, helping to forests; breathes new life into beautiful old wood; reduces by one chair or table the volume of a landfill, and often the carbon emissions from its to a landfill far away; improves indoor air quality and the local environment through the use of eco-friendly paints, primers and polishes

The lumber that is used in some reclaimed wood furniture is sourced from existing products, such as sheds, barns, fishing and other structures. Repurposing this wood for future uses reduces the amount of lumber that is discarded.

Often, the wood that comes from sheds, barns, and is very durable and has yet to reach the end of its useful lifespan, making it ideal for reclaimed wood furniture. Because this wood has already been harvested and treated, using it for furniture reduces need for refining chemicals that are often used in the lumber production process. This the lumber industry uses fewer harmful chemicals that can leach into the soil or water and pollute the watershed.

Maintenance of such furniture is all-important as it can be subject to woodworms, dry rot or cracking.

At their factory in Münster, Germany, Osmo wood finishing products based on natural oils including sunflower, soya, linseed and thistle oils and uses natural hard waxes like carnauba and candelilla in its finishes. These solutions are renowned for their deep penetration and ability to keep wood healthy and flexible, preventing it from becoming dry and brittle. And they're all for humans, animals and plants

The natural colour pigments Osmo uses are all food- too, and if they need to use solvents they use the smallest possible amounts of clean, odour-free petroleum spirit, directly in with EU recommendations. 3,000 specialist dealers who distribute Osmo products internationally

Eco Wood Treatment produced by Bruce Mac Nutt at Metchosin, Nova Scotia, Canada is a non-, mineral-based powder that, when mixed with water, permanently protects wood with one application. It has been tested by Independent Laboratory Testing to determine there are no harmful substances to the environment, including air, water, soil, and plants/trees. It contains no solvents and no chemicals. The natural weathering process results in high UV protection.

Alongside these, oil is by cold pressing the seeds of the tree (Vernicia fordii) which grows primarily in the mountainous regions of China. It has been used to protect and seal wood for centuries. Marco Polo in the 13th century "The Chinese some lime and chopped hemp, and these they knead together with a certain wood oil; and when the three are thoroughly amalgamated they hold like any glue, and with this mixture they paint their ships".

Wozniak's Efforce

Problem:

Currently, financing energy efficiency measures can be a complex mix of financial and regulatory challenges that limit the speed of growth. Due to the COVID19 pandemic, small companies cannot afford to switch to LED lighting, streamline production processes, or even insulate to conserve heat, all of which could them money in the term.

Solution:

Efforce cryptocurrency

In 2019, Apple computer company co-founder Steve Wozniak, a Silicon Valley icon and philanthropist for the past three decades teamed up with Jacopo Visetti previous founder of AitherCO2 and Jacopo Vanetti Airobot both of Milan, Italy to launch Efforce, a solution to democratise and finance energy efficiency investments worldwide.

Based in Valletta, Malta, Efforce uses an innovative web-based platform to leverage the blockchain, and cryptocurrency tokens called WOZX, as the mechanisms to create a seamless platform to spur global energy efficiency.

At no cost, business owners can safely register their energy upgrade project on the web and secure funding from all types of investors around the world. The companies will then available cash to use for other critical projects such as infrastructure or hiring and help the Planet.

Listed on 10th December 10 the price of Efforce (WOZX) jumped from $0.10 to highs of $2.88 in a week, an upside of over 2,800%

:X- NASA's 'moonshot' for aviation.

Solution:

NASA is pursuing its own solution, named the *X57 Maxwell* , an all-electric aircraft powered by batteries, with a to build even ambitious X-planes over the next decade.

Compared with conventional aircraft, the X-57 team, up of engineers from three NASA centers – Ames Research Center in California's Silicon Valley, Research Center in Hampton, Virginia, and Armstrong Flight Research Center in Edwards, California, has set a goal of using five times less energy and – if powered by electricity generated from renewable sources – producing zero inflight carbon emissions.

Their solution is called a "Distributed Electric Propulsion" system. to the fact that the electric motors are less powerful the original combustion engines they are replacing, it will fourteen of them to propel the X-57 during takeoff and landing. But the is in the air and at cruising altitude, the twelve motors in the centre will shut down to energy. The center motors will use folding centrifugal propellers, so that they are no rotating, they will lay flat against their nacelles to reduce . When additional power is needed, they will extend as the motors are spun back up.

The X-57 Maxwell program began in 2017. Modification I, using an 18-engine truck-mounted , took place at NASA's Armstrong Flight Research Center in Edwards, California, using a truck bed, acronym HeIST (Hybrid electric Integrated Systems Testbed), capable of accommodating systems that use up to 100 kilowatts of power.

By September 2018, the first Joby Aviation JM-X57 electric cruise motor were mounted with controllers, batteries and new cockpit displays at Scaled Composites in Mojave, Construction of the ESAero high aspect , low composite was then almost finished, to fly the Mod III by mid-2020.

Built by Xperimental, the cruise-optimized load testing was completed by September 2019, to ±120% of design load limit, verifying free movement of control surfaces and vibration testing for flutter predictions. After motor ground , ESAero delivered the Mod 2 X- with electric motors replacing the original piston engines to NASA on the first week of October 2019. flight tests were originally planned to begin in the third quarter of 2020. While the agency's response to COVID-19 has slowed or halted several major projects, NASA says work on the *X-57 Maxwell* is continuing in California, and that flight tests with the in its final configuration are expected before the end of 2021.

:Yeri districts

Problem:

In 2019, the major reservoirs supplying water to the 11 million inhabitants of city of Chennai, on India's south-eastern coast, ran dry. Chennai is dependent on the north-east monsoons and four reservoirs for its water. Its remaining wetlands of Chennai been historically encroached upon and polluted with waste dumping

Solution:

Wetlands restoration

Before British colonisation, Chennai and its neighbouring areas were known as "yeri () districts". A network of connected ponds, lakes, marshes and wetlands, reservoirs and small of water at temples known as "temple tanks" collected quantities of rainwater for use in the city, and kept the region's water table topped up through the year.

Pallikaranai wetland is a yeri in the city of Chennai, India. It is situated adjacent to the Bay of Bengal, about 20 kilometres (12 mi) south of the city centre. Due to the lack of understanding by the British Raj engineers, Pallikaranai had ended up a polluted landfill.

Jayshree Vencatesan of Chengalpattu, Tamil Nadu, India, who had been studying the Pallikaranai Marsh since 2001, founded a biodiversity research organisation Earth Trust,

Having found that the marsh had shrunk from around 6,000 hectares (23 square miles) in the 1960s to less 600 hectares (2.3 sq miles) in the early 2000s, due to unplanned development and rubbish dumping, the courageous determined to find a solution.

Initially she convinced the Ministry of Environment and Forests, Government of India to prioritise Pallikaranai marsh as one of the most significant wetlands of the country. Then the High Court of Madras decided to prohinit further encroachment on wetlands and to implement a to restore some of these ecosystems

In 2007, part of the marshland was declared a nature reserve. In 2018, 1.65bn rupees (£16.7m/$22.7m) were allocated to further restore the marsh. Since then, the Tamil Nadu Forest Department has worked to remove invasive species, and reduce untreated sewage disposal, waste dumping and illegal encroachment.

After restoration, species counts risen. Saplings from 173 species of native plants, including mangroves and mangrove associated plants like Rhizophora, Avicennia, and Bruguiera been planted over 350 acres (140 hectares) – and it seems to work. The number of species in the restored area over the course of the project from 141 in 2007 to 368 in 2019, and is now a thriving home to creatures from mudskippers and crabs, to monitor lizards.

As well as providing a haven for wildlife, the preservation of the marsh and the restoration of pockets of vegetation throughout the city again is offering a

chance for Chennai to absorb its ample rainfall, and replenish healthy groundwater.

In 2009, Jayshree Vencatesan and her team at Earth Trust were awarded India's highest award, the Indira Gandhi Paryavaran Puraskar by the Indian Ministry of Environment, Forests and Climate .

:Ecofriendly Yoga mat

Problem:

48% of yoga mats purchased every year are from polyvinyl chloride (PVC) Most PVC products that reach the end of their lifespan will end up burned or in landfill sites, where they can upwards of 1,000 years to biodegrade whilst releasing highly- Dioxin chemicals and Chlorine into the ground.

Solution: Not merely slowing down but , like fauna and flora can reduce the wear and tear on our Planet. Meditation goes back a way, particularly yoga. Yoga mats can be from lamb's wool or sustainable harvested tree rubber. Lottus Life of Bali's Jute Yoga Mat is from SGS-certified natural jute fibres, and is easy to keep clean with its -microbial and -fungal properties. Lottus also gives back 1 percent of profits to the Karma Project to promote clean water. *(lottuslife.com)*

ZAD = Zone to Defend

Problem:

Sometimes speeches, petitions and protest marches are not enough.

Solution:

A ZAD or Zone to Defend is a militant occupation that is intended to physically blockade a development project. By occupying the , activists aim to prevent the project from ahead.

Julia L "Butterfly" Hill, 23, lived in a 180-foot (55 m)-tall, roughly 1500-year-old California redwood tree for 738 days between December 10, 1997 and

December 18, 1999 to prevent Pacific Lumber Company loggers from cutting it down. A resolution was reached in 1999 when the Pacific Lumber Company agreed to preserve Luna and all trees within a 200-foot (61 m) buffer . In exchange, Hill agreed to vacate the tree.

Ende Gelände (German saying for "here and no further") is a civil disobedience movement occupying coal mines in Germany to awareness for climate justice. Every year since 2015, organises their ‘climate camp’.

In 2017, as the largest civil disobedience movement for climate justice in Europe Ende Gelände has grown to reach almost 6000 militants. From the 24th to the 29th of August, the group hosted an international meet-up, with the main objective of putting an end to the coal mining activity of the Cologne-based company RWE. The programme included talks, protests, and most importantly, peaceful ZADs of coal-fired power plants.

The most example is the ZAD which helped a broader campaign to defeat the Aéroport du Ouest, a proposed airport in Notre--des-Landes, a commune in the Loire-Atlantique department in western , around 20 km north-west of Nantes.. The €580 million project had been approved in February 2008, with construction then expected to start in 2012 and an opening in 2015. The ZAD was set up in 2012 and continued for the next six years. In an ongoing week-incident in

April 2018 2,500 riot police were deployed to remove the occupants of the fields in Notre--des-Landes. As in previous days, officers clashed with activists trying to maintain a ZAD Riot police officers used grenades which hurt both inhabitants and journalists. Riot police officers under a hail of stones and other projectiles and one was taken to hospital with wounds after hit by a homemade explosive device.

Journalists were prevented from filming the incidents by riot police. The airport project was abandoned by the government of Emmanuel Macron on 17 January 2018 in the of strenuous local opposition

Near Houston, B.C., Canada, in 2020 “ defenders” of the Gidimt'en clan built several ZADs to support Wet'suwet'en hereditary chiefs who were trying to stop the multi-billion-dollar Coastal GasLink pipeline crossing their traditional territories. Their camp grew into a whole community in resistance.

Volunteers helped build a permaculture garden, a solar powered mini-grid, and a healing /cultural centre, under the guidance of hereditary indigenous leadership to help create a vision for future generations. Although in January 2020, RCMP went into discussion with Wet'suwet'en heredity chiefs, by February the talks had broken down.

In Victoria, Australia, protesters camped at a site to defend culturally significant trees, including some where local Djab Wurrung women traditionally to give birth. They failed when a sacred yellow box tree, estimated at 350 years' old was bulldozed to clear for a highway. Footage posted by activists on social media showed Victoria police officers forcibly dragging people away, and some protesters who had climbed into the trees, refusing to leave the site as clearing work continued.

:Zeolitic membranes for carbon capture

Problem:

Zeolites used in gas separation are usually produced as membranes. The state-of-the-art zeolitic membranes are manufactured by a lengthy and complex crystallization process. It lacks in producing efficient gas-separation membranes, especially when it comes to the separation of hydrogen and carbon dioxide, which is necessary for pre-combustion carbon capture from power plants.

Solution: A team of chemical engineers led by Kumar Agrawal at EPFL Valais Wallis successfully simplified the chemistry behind zeolite membrane synthesis, making it simple, reproducible, and scalable.

The scientists developed a new material chemistry that eliminates the lengthy crystallization process altogether. To achieve this, they built Lego-like crystals – nanosheets – and bonded them on top of each other using silanol condensation chemistry.

The resulting membrane shows ideal hydrogen-carbon dioxide separation performance, with selectivity up to 100 at 250-300°C.

Mostapha Dakhchoune et al, “Gas sieving zeolitic membranes by the condensation of precursor nanosheets”, *Nature Materials* 5th October 2020.

:Generation Z

Solution:

In Hunter S. Thompson’s book Better Sex: Confessions of a Political Junkie, published in 1994, he comments “"Generation X got off easy compared to the hideous of the poor bastards in Generation Z. They will be like steerage passengers on the *Titanic*, trapped in the watery bowels of a sinking 'unsinkable ship.'"

Generation Z defines those people between 1995 and 2012. Gen Zs are indeed observing the onslaught of devastation left by man- disasters as well as natural disasters brought on by climate , which is raising awareness them. Some even go far as to refer to them as “The Post-Apocalyptic Generation.”

But they are practising an eco-conscious lifestyle such as using public transport such as trains, and early interest in environmental issues. After all, they will the full impact of radical to our environment much the generations before them. And they over 500 solutions to help them clean, repair and protect our Planet.

Reinforcements are already on their way from *Generation Alpha* between 2013 and 2025

:“Family zéro déchet, Ze guide”

Problem:

 serious academic books been published which report on Climate , AGW and on those visionaries who tried to warn the educated and academically minded about the coming , but do not offer any practical day-to-day solutions.

Solutions:

In 2007 Joanna Yarrow published “1001 Ways You Can the Planet: Practical Ideas to Heal and the World” (Duncan Baird Publishers); while Elizabeth

Rogers and Thomas M. published “The Green Book: The Everyday Guide to Saving the Planet One Simple Step at a Time”; in 2008 Ton Juniper, director of Friends of the Earth for England and Wales published “How Lightbulbs Does It To A Planet?” (Quercus); and in 2010, Kent Anderson published “Saving Planet Earth - A Practical Hands On Approach” (lulu.com).

This is just a selection.

Over in , “Famille zéro déchet, Ze guide”, was first published in 2016 by Thierry Souccar Editions written by Jérémie Pichon and his cartoonist companion Bénédicte Moret, settled in Seignosse, in the Landes, on the southwest coast of . Two years before, they had decided to involve their family into the Zero Waste challenge.

In three years, from 860 lb (390 kg) trash, they passed to 2.2 lb (1 kg), ie one jar per year, but above all Tomorrow’sed a new way of life. With humor and self-deprecation, the authors offer a detailed action and 10 Zero Waste challenges to get you started. Based on their knowledge of the ecology, they deliver hundreds of practical tips and simple alternatives for everyday life: shopping, cooking, cleaning, furniture, hygiene, -up, clothes, garden, DIY, festivities ... rubbish is everywhere!

The book, printed on 100% recycled paper, has sold 150,000 copies. In addition while running a daily blog, “famillezerodechet.com” with over 3 million visitors, Pichon and Moret published two other books: "Les Zenfants presque Zéro déchets", and “Family in Ecological Transition”, the latter an illustrated roadmap and practical guide to attempt to reduce as much as possible the carhon footpriont of a French family.

In 2018 Superprod began the production of animated series “Zenfants Zéro Déchet” adapted from the book. On March 5 2018, Jérémie a 16-minute

YouTube talk "Zero Waste a Way of life in Transition" at TEDxUNamur in Belgium. *(thierrysouccar.com)*

Sophie Loir-Galland,"Famille zéro déchet, Ze guide," *ma consience écolo*, July 29, 2016.

:Zero emission vehicles

Problem:

Globally, about 15 % of man- CO^2 comes from cars, trucks, airplanes, ships and other vehicles. The US publisher Wards estimates that as of 2010, there were 1.015 billion motor vehicles in use in the world. The total number of registered vehicles in India was 173 million as of March 2013. CO_2, NOX, PM10 and GHG emissions are lethal for both the Planet and for its inhabitants.

Solution: The Zero Emission Vehicle (ZEV) , adopted by the California Air Resources Board (CARB or ARB) in 1990, is arguably one of the most and controversial air quality policies ever adopted. Subsequently known as the ZEV mandate, it required major auto companies to " available for " vehicles with zero criteria-pollutant tailpipe emissions.

Vehicles and other mobile machinery used for transport (over , sea, air,) and for other uses (agricultural, mobile power generation, etc.) contribute heavily to climate and pollution, so zero emission engines are an area of hyperactive research. These technologies almost in all cases include an electric motor powered by an energy source compact enough to be installed in the vehicle.

These sources include hydrogen fuel cells, batteries, supercapacitors, and flywheel energy devices. The global between BEVs and PHEVs went from 56:44 in 2012, to 60:40 in 2015, and to 69:31 in 2018. Over 100 manufacturers are currently involved, including 42 bus and truck firms, not to mention the hundreds of manufacturers of pedelecs or electrically-assisted bicycles.

1 billion pedal bicycles been manufactured worldwide as of the early 21st century.

The IPCC demonstrates in its most recent report of 2018 that net emissions must be reduced to zero in to stabilize global temperatures. The report also states that any scenario that does not involve a reduction to zero will not stop climate . This objective has been ratified by Switzerland, the EU and other countries, under the Paris Agreement. However, it should be noted: The later this goal is reached, the higher the negative emissions need to be.

"Bicycles produced in the world". *Worldometers,* January 2 2012; IPCC 2018 Special Report 15; "Zero-Emission Vehicle Program" *California Air Resources Board.*

:Zig-Zag kiln

Problem:

Dating back thousands of years, traditional kilns, such as Fixed Chimney Bull's Trench Kiln (FCBTN) type pollute. Over 300,000 such inefficient kilns are in operation worldwide.

Solution: Natural draft Zig-Zag Kiln

The Natural Draught Zigzag firing kiln is a moving fire kiln in which the fire moves in a closed rectangular circuit through the stacked in the annular space between the outer and the inner wall of the kiln. This reduced energy consumption, reduced pollutant emissions and improved product quality

The dried are stacked in the kiln in chamber in such a way that it creates 3 parallel zigzag paths of air flow. Zigzag flow increases the air flow path length and turbulence in the air, thereby resulting in improved combustion & heat and uniform temperature across the kiln cross section. Also the firing and fuel feeding practice improves the combustion efficiency of the kiln. Traditionally zigzag firing was with the assistance of fan draught, in this kiln the zigzag operation is achieved through the chimney draught.

The tortuous, zig-zag kiln was invented in 1927 by Alois Habla of Munich Germany whose family had a 200 year history as industry proprietors. Prior to 1940 Alois oversaw the construction and operation of over 150 Habla Zig-Zag Kilns throughout UK, Europe, USA, even Australia. It was first introduced in India in the year 1970

In July 2020, Pakistan's Punjab Board of Investment and decided to provide in shape of matching for transferring kilns to zigzag technology to overcome problem of environmental pollution and enhancing production capacity of kilns.

700 kilns which earlier been transferred to zigzag technology will be given preference to facility. President Kilns Association Muhammad Shoaib Niazi remarked that with due cooperation of the government, all kilns can be transferred to zigzag technology within a of one year.

:Zinc Battery

Problem:

Rechargeable batteries been used to power various electric devices and store energy from renewables, but their components (namely, electrode materials, electrolyte, and separator) generally cause serious environment issues when disused. Such toxicity characteristic makes them difficult to power future wearable electronic devices.

Solution: Zinc battery.

Zinc-chloride cells (usually marketed as "heavy duty" batteries) use a paste primarily composed of zinc chloride, which gives a life and steadier output compared with ammonium chloride electrolyte

An environmentally friendly and highly rechargeable battery, based on a pyrene−4,5,9,10−tetraone (PTO) cathode and zinc in mild aqueous electrolyte has been developed by a team of researchers at Fudan University, Shanghai, China.

Their PTO//Zn full cell exhibits a high energy density (186.7 Wh kg^{-1}), supercapacitor−like power behaviour and −term lifespan (over 1000 cycles). Moreover, a belt−shaped PTO//Zn battery with robust mechanical durability and

remarkable flexibility is first fabricated to clarify its potential application in wearable electronic devices.

In a collaboration between Pacific Northwest National Laboratory in Richland, Washington, USA and the MEET Battery Research Center of University of Münster and Helmholtz Institute Münster, Germany, 12 scientists developed a new type of dual-ion battery.

The cell chemistry graphite zinc metal with an aqueous electrolyte is safer, cheaper and sustainable proven energy systems and showed a promising electrochemical performance. The cathode of the energy device can consist of graphitic carbons, which can be produced from renewable raw materials. In addition, water and biological binders, such as those found in yoghurt, can be used in electrode production. Further, the zinc metal-based offers a better material availability

For the charging and discharging mechanism: instead of one type of ion - lithium ions - the electrolyte anions are also involved in energy in the dual-ion battery. The electrolyte thus functions as an active material, which offers researchers further optimisation approaches. It also comes with an inherently lower risk of fire.

Zhaowei Guo et al "An Environmentally Friendly and Flexible Aqueous Zinc Battery Using an Cathode, *Journal of Materials Chemistry*, 18 July 2018; Ismael A. Rodríguez−Pérez et al., "Enabling Natural Graphite in High− Aqueous Graphite || Zn Metal Dual−Ion Batteries" *Advanced Energy Materials*, 28 September 2020.