WORLD OF GOOD

A host of energetic tech companies have begun to recalibrate the planet's throwaway culture with ocean-cleaning tools, plastic-eating enzymes, biofuels and clean energy. **Marisa Cannon** reports

Tucked away in a small lab in an office in Rotterdam's Old West neighbourhood, petri dishes brimming with grains of plastic sit on a display unit, alongside battered shards of broken jerrycans, blocks of crumbling polystyrene foam, decaying shoe soles, bottle caps and pieces of trawler nets.

This is just a snapshot of the 100,000 tonnes of trash that currently lie between Hawaii and California. Known as the Great Pacific Garbage Patch, it's the largest of five ocean rubbish dumps where waste has been driven by a vortex of ocean currents. "You can compare them to the drains in your bath tub," says Boyan Slat, CEO of The Ocean Cleanup, whose office this is. "It's a good thing that they exist – can you imagine having to skim the entire ocean surface? It's shocking but convenient."

In October 2012, the then 18-year-old Slat gave a TedX talk in his home town of Delft about his ideas for an ocean-going, plastic waste-collecting device. Nothing much happened until the following March, when a clip of his talk suddenly went viral after the story was covered by an American online magazine. That allowed him to crowdfund £70,000, which he used to recruit an initial team and organise a feasibility study with a voluntary team of 70 scientists and engineers. The Ocean Cleanup's 528-page feasibility study was presented in New York in June 2014, providing a stepping stone for a second crowdfunding campaign that within 100 days had raised £1.5m from donors across 160 countries – a sum that has grown to a whopping £30m today, with backing from the likes of Silicon Valley tycoons Peter Thiel and Marc Benioff.

Slat was just 16 years old and scuba diving in Greece when the germ of the idea took root. "I saw more plastic bags than fish, and thought, 'Why can't we clean this up?'" he says. After six months ruminating over potential solutions, he came up with the concept of a structure that could capture ocean waste using natural currents and, just before his second semester at Delft University of Technology, dropped out to work on the design full time.

Slat's project aims to clean up the patch (and the four others, eventually) with a fleet of 60 600-metre-long 'floaters' attached to three-metre-deep geotextile skirts that are designed to prevent waste plastic from escaping underneath, and buoyant enough to stop it flowing over. Both the plastic waste and the floater will be transported by ocean currents, with the idea being that wind and waves will propel the floater forward faster than the plastic, so it can concentrate and capture the debris.

"It takes the waste around seven years to get to the patch, where today there is an average 180 times more plastic than naturally occurring sea life," says Slat. "We've identified plastics there from the 1970s, so it's safe to say that it's not going away by itself."

"We've identified plastics in the Great Pacific Garbage Patch from the 1970s, so it's safe to say that it's not going away by itself"

Boyan Slat, CEO, The Ocean Cleanup

MAGIC TORCH

9 MINS

Today, the organisation is spread across three floors in an unassuming building, where a team of 80 data analysts and engineers are working towards getting Wilson, the beta floater, back up and running after its maiden voyage saw an 18-metre end-section detach from the structure. Extensive root cause analysis has found that the break was a result of material fatigue. Slat says another challenge they need to work on is speeding up the system so that it consistently moves faster than plastic. Upgrades are in the works at the project's base in California, and Slat estimates that Wilson should be back at sea by this summer.

Another Rotterdam-based initiative making waves in aquatic innovation is RanMarine Technology, which has developed a floating drone called the WasteShark, designed to trap and collect plastic found in urban waters before it even gets to the ocean. Stunned by the amount of waste he saw in Cape Town's V&A harbour, South African entrepreneur Richard Hardiman built the first WasteShark prototype in his swimming pool before being accepted into Rotterdam's PortXL accelerator, which is focused on port and maritime technology. He subsequently took on staff and the company quickly became a commercial proposition, based out of the city's waterfront RDM district, a hub of cavernous industrial warehouses now home to a buzzing community of entrepreneurs and creatives.

"We spent another year and a half developing the prototype and went commercial in August last year, so in that sense we're still very young," says RanMarine's chief commercial officer Oliver Cunningham. The company has attracted a host of high-profile customers ranging from Panama to Vietnam's Ha Long Bay, while the World Wide Fund for Nature recently deployed a WasteShark to clear trash in Devon's Ilfracombe Harbour.

"A swarm of drones can continuously operate 24/7 without ever having to leave the water," says Cunningham. "It acts as a responsive, self-organising membrane that sits between the human population and the sea." With a roaming distance of 5km, the drones are also equipped to remove oils and other pollutants from the water and, if used five days a week, could collect more than 15 tonnes of waste each year.

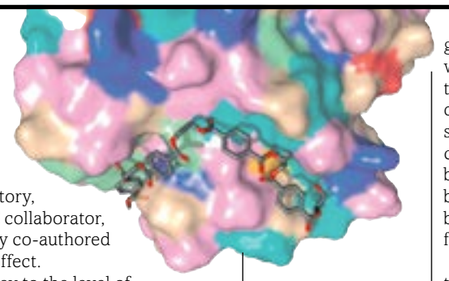
Making waves
The Ocean Clean Up and visionary CEO Boyan Slat. Below: John McGeehan is conducting research into a plastic-eating enzyme

EXTRAORDINARY ENZYMES

Once plastic is recovered from the ocean, it then needs to be properly recycled, and an exciting discovery in a Japanese dump may well revolutionise the way this is done. Currently, recycled plastic is transformed into pellets that can be used to make polyester clothing and carpets, but it almost always eventually ends up in landfill or is incinerated. Back in 2016, however, scientists discovered bacteria in a bottle recycling facility in Japan's port city of Sakai that produced an enzyme capable of 'eating' polyethylene terephthalate (PET) – the most common 'single-use' plastic.

> "The enzyme would let you break down the plastic into its building blocks and reuse it infinitely"

"We saw the story and decided to invest some researchers into the project, and they cloned the gene from the bacteria and started growing it in our lab," says John McGeehan, director at the Centre for Enzyme Innovation at Portsmouth University, which is leading research into the enzyme's capabilities. As soon as McGeehan's team was able to generate enough of the enzyme, they shared it with the National Renewable Energy Laboratory, the centre's US collaborator, with whom they co-authored a paper on its effect.



Timing was key to the level of interest that the research attracted, says McGeehan, with the paper arriving shortly after the recent airing of David Attenborough's *Blue Planet II* docuseries and around the same time as Earth Day in the US. News of the enzyme was picked up by the mainstream media, and investors have since come knocking, although research is still at an early stage.

"The PETase enzyme would allow you to break down the plastic into its building blocks, or monomers, and then reuse it infinitely," explains McGeehan. "That would remove the need for oil-based monomers and therefore the need to dig up more oil to make plastic. It would also remove the chance of it being incinerated and generating CO_2, giving us a sustainable way to recycle plastic. If we can make the process efficient enough, we're hoping that waste plastic will start to have a value and, when that happens, industry becomes much more interested."

While the enzyme will only be able to break down PET plastic, there are plans for a discovery programme to find other enzymes that can break down other plastic types, eliminating the need to sort them, as is currently necessary. The project has around 40 interested investors, including GlaxoSmithKline, whose own fermentation technology offers the potential to scale the enzyme for commercial use, though its processing speeds need to pick up first.

"We accidentally engineered a faster enzyme – about 20 per cent more so – but we need to make it much faster," says McGeehan. "Currently we're in the realm of days and weeks, but we need to get this down to hours or minutes to be commercially viable."

WASTE NOT WANT NOT

Part of the University of Edinburgh, the Edinburgh Centre for Carbon Innovation (ECCI) supports projects centred on low carbon initiatives. Making use of waste streams is one area that has seen huge pick-up from the centre's startups, such as Celtic Renewables, which has found a way to create biofuels from the by-products of Scotch whisky.

"Everyone likes drinking whisky," says Ed Craig, the ECCI's interim executive director. "But for every litre of whisky, you get eight litres of pot ale, a nitrogen-rich waste product that's typically dumped in the sea or spread on land. You also create draff [the residue of malted barley], which is spread on the land, too. Celtic Renewables created one of the world's first sustainable biofuel processes by combining these by-products and fermenting them to make biobutanol, which is the equivalent of four-star petrol."

The process uses a strain of bacteria to treat and ferment the draff and pot ale, turning them into a broth of butanol, acetone and ethanol. The components can then be separated into liquids and solids, with the solids dried to produce high-grade animal feed, and the liquid butanol used to sustainably fuel cars.

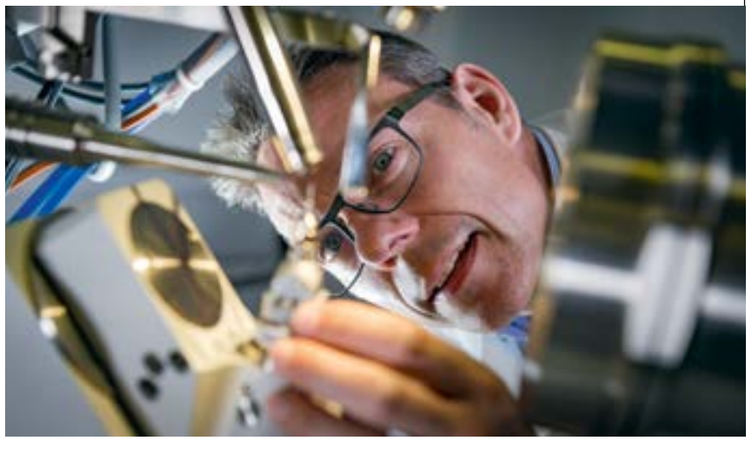
"It's such an obvious little idea, I do get asked, are you sure no one has done this before?" says the startup's founder, Professor Martin Tangney OBE. "Well, if someone had thought of it ten years ago, they would have been asked the same question. Somebody has got to be the first and on this occasion it was me."

Renewed energy
Celtic Renewables creates biofuels from the by-products of whisky. Top: a PETase enzyme tucks into some plastic

Spearheaded by Celtic Renewables, construction has begun on a biobutanol plant in Grangemouth, near Falkirk in Scotland, which will produce half a million litres of biofuel each year. "This is a very exciting time for biotechnology in Scotland," says Tangney. "Our plant, which will use entirely sustainable raw materials to make high-value, low-carbon products, will be the first of its kind in the world."

GLOBAL GRID

Renewable energy is one field still in need of concerted investment, with fossil fuels accounting for more than 80 per cent of our global energy consumption. One outfit



YURI VAN GEELEN, STEFAN VENTER, ASHLEY COOMBES

making efforts to redress this is the Beijing-based Global Energy Interconnection and Cooperation Organisation (GEIDCO), which aims to build a worldwide electricity system allowing users to access clean energy sourced from all corners of the globe.

"Global clean energy resources are currently unevenly distributed and some 85 per cent of them in Asia, Europe and Africa are concentrated on the energy belt [China's multi-billion-dollar Belt and Road initiative, which plans to connect Asia, Africa and Europe]," says the project's spokesperson Zhang Yibin. "GEI will allow UHV lines [ultra-high voltage lines that can transmit large amounts of power over long distances] to create large-scale, long-distance energy transmission as well as improving efficiency and supply."

The project is fronted by Liu Zhenya, former CEO and president of the State Grid Corporation of China, where he led tests into the world's first UHV transmission systems. "We have solved the problem of supplying electricity to 1.4 billion people," Liu announced at Harvard Law School last year, having used UHV lines to carry power from western China to the populous cities on the eastern coast. Today, China has 21 UHV projects that cover some 37,000km, and Liu plans to apply the tech across international borders with this new grid.

As it stands, distributed power is mostly consumed locally, but GEIDCO's 180,000km grid will span more than 100 countries and give 80 per cent of the world's population access to renewable energy. "It is a radical solution for overcoming the world's energy dilemmas," says Liu. "Just 7.7 per cent of the Sahara's solar energy would meet global electricity demand." Due for completion in 2050, the grid expects to amass around £29trn of investment, driving economic growth by 0.2 per cent and saving global electricity expenditure by £1.4trn.

In the US, New York-based startup LO3 is making use of blockchain technology to allow energy consumers and prosumers – those who generate energy through their own renewable resources – to trade within their communities.

FUTURE OF FUELS

British Airways has partnered with Cranfield University to challenge UK academics to develop a sustainable alternative fuel of the future. Called BA 2119: Future of Fuels Challenge, this is the first time the industry has tasked experts in the fields of aerospace and fuels to work together on an environmental issue. The winner is set to be announced this month, and will receive £25,000 to help fund further research, alongside support from the airline to help develop their idea. The winner will also be invited to present their project at the IATA Alternative Fuels Symposium in New Orleans and the Aviation Industry Annual Sustainability Summit in Montreal.

Power surge China's National Wind and Solar Energy Storage and Transmission Demonstration Project in Zhangbei. Above: LO3's Scott Kessler

"When our co-founders, who have backgrounds in the energy and carbon spaces, got to talking, they began thinking about how the future of electric might look and realised that as more distributed energy devices take part in the grid, the result would be a marketplace for these devices to buy and sell their value," says Scott Kessler, LO3's director of business development. "Whether that value is to produce, store or use the energy at different times, it would need to be tracked and find counter parties, which led to the idea for LO3 energy."

Kessler says that the company's focus today is on expanding the choice that customers have on the electric grid, which has led to an emphasis on local, clean energy. "As we mature and options for energy expand, we can imagine a future where, ten to 15 years down the road, every building has the ability to generate electricity through a source like solar, store it in a battery, and programme when the energy is consumed."

Blockchain will allow users to trade transparently and securely, using 'smart contracts' to automatically create buy and sell orders. "You then have a historical database that all the parties can return to as a shared public ledger," says Kessler.

The company now has nine projects globally, mostly with energy retailers or distribution utilities. The Brooklyn Microgrid was one of LO3's first schemes, launched in 2016, through which citizens can buy and sell energy in a simulated marketplace accessed by an app, with the choice of purchasing locally sourced solar, upstate renewable energy or grid energy. Projects in Texas, South Australia and Allgau in Germany have taken shape through partnerships with local service providers, while British provider Centrica plans to trial the technology in Cornwall across some 200 businesses and residences.

> "Just 7.7 per cent of the Sahara's solar energy would meet global electricity demand"

There's a future for developing economies that have yet to implement this sort of infrastructure, too. "If you have an area without electricity, then putting a marketplace on a blockchain has no impact," says Kessler. "But I think there's an opportunity to rethink the way these places go about developing their grids, where we adapt the historic generation and transmission models and leapfrog a lot of what has been done in the 20th century." ■