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1.IPCC issues 'bleakest warning yet' on impacts of climate breakdown

From an article by Fiona Harvey Environment correspondent, Guardian, 28 Feb 2022

Climate breakdown is accelerating rapidly, many of the impacts will be more severe than predicted and there is only a narrow chance left of avoiding its worst ravages, the Intergovernmental Panel on Climate Change (IPCC) has said. Even at current levels, human actions in heating the climate are causing dangerous and widespread disruption, threatening devastation to swathes of the natural world and rendering many areas unliveable, according to the landmark report published on Monday.

In what some scientists termed "the bleakest warning yet", the summary report from the global authority on climate science says droughts, floods, heatwaves and other extreme weather are accelerating and wreaking increasing damage.

Allowing global temperatures to increase by more than 1.5C above pre-industrial levels, as looks likely on current trends in greenhouse gas emissions, would result in some "irreversible" impacts. These include the melting of ice caps and glaciers, and a cascading effect whereby wildfires, the die-off of trees, the drying of peatlands and the thawing of permafrost release additional carbon emissions, amplifying the warming further.

António Guterres, the UN secretary general, said: "I have seen many scientific reports in my time, but nothing like this. Today's IPCC report is an atlas of human suffering and a damning indictment of failed climate leadership."

The report says:

- Everywhere is affected, with no inhabited region escaping dire impacts from rising temperatures and increasingly extreme weather.
- About half the global population – between 3.3 billion and 3.6 billion people – live in areas "highly vulnerable" to climate change.
- Millions of people face food and water shortages owing to climate change, even at current levels of heating.
- Mass die-offs of species, from trees to corals, are already under way.
- 1.5C above pre-industrial levels constitutes a "critical level" beyond which the impacts of the climate crisis accelerate strongly and some become irreversible.
- Coastal areas around the globe, and small, low-lying islands, face inundation at temperature rises of more than 1.5C.
- Key ecosystems are losing their ability to absorb carbon dioxide, turning them from carbon sinks to carbon sources.
- Some countries have agreed to conserve 30% of the Earth's land, but conserving half may be necessary to restore the ability of natural ecosystems to cope with the damage wreaked on them.

This is the second part of the IPCC's latest assessment report, an updated, comprehensive review of global knowledge of the climate, which has been seven years in the making and draws on the peer-reviewed work of thousands of scientists. The assessment report is the sixth since the IPCC was first convened by the UN in 1988, and may be the last to be published while there is still some chance of avoiding the worst.

A first instalment, by the IPCC's working group 1 was published last August on the physical science of climate change. This second part, by working group 2, deals with the impacts of climate breakdown, sets out areas where the world is most vulnerable, and details how we can try to adapt and protect against some of the impacts. A third section, due in April, will cover ways to cut greenhouse gas emissions, and the final part, in October, will summarise these lessons for governments meeting in Egypt for the UN Cop27 climate summit.

Small islands will be among those worst affected. Walton Webson, an ambassador of Antigua and Barbuda and the chair of the Alliance of Small Island States, called the findings "cataclysmic". He urged the UN to convene a special session to consider action. "We are continuing to head for a precipice – we say our eyes are open to the risks, but when you look at global emissions, if anything we are accelerating towards the cliff edge. We are not seeing the action from the big emitters that is required to get emissions down in this critical decade – this means halving emissions by 2030 at the latest. It is clear that time is slipping away from us."

Governments in other parts of the world could help their people to adapt to some of the impacts of the climate crisis, the report says, by building flood defences, helping farmers to grow different crops, or building more resilient infrastructure. But the authors say the capacity of the world to adapt to the

impacts will diminish rapidly the further temperatures rise, quickly reaching "hard" limits beyond which adaptation would be impossible.

The climate crisis also has the power to worsen problems such as hunger, ill-health and poverty, the report makes clear. Dave Reay, the director of Edinburgh Climate Change Institute at the University of Edinburgh, said: "Like taking a wrecking ball to a set of global dominoes, climate change in the 21st century threatens to destroy the foundations of food and water security, smash onwards through the fragile structures of human and ecosystem health, and ultimately shake the very pillars of human civilisation."

2. Coal power's sharp rebound is taking it to a new record threatening net zero goals

Extracts from IEA Press Release, 17 December 2021

After falling in 2019 and 2020, global power generation from coal is expected to jump by 9% in 2021 to an all-time high of 10,350 terawatt-hours, according to the International Energy Agency's *Coal 2021* report released on 17 December 2021. The rebound is being driven by the year's rapid economic recovery, which has pushed up electricity demand much faster than low-carbon supplies can keep up. The steep rise in natural gas prices has also increased demand for coal power by making it more cost-competitive.

Overall coal demand worldwide – including uses beyond power generation, such as cement and steel production – is forecast to grow by 6% in 2021. That increase will not take it above the record levels it reached in 2013 and 2014. But, depending on weather patterns and economic growth, overall coal demand could reach new all-time highs as soon as 2022 and remain at that level for the following two years, underscoring the need for fast and strong policy action.

"Coal is the single largest source of global carbon emissions, and this year's historically high level of coal power generation is a worrying sign of how far off track the world is in its efforts to put emissions into decline towards net zero," said IEA Executive Director Fatih Birol. "Without strong and immediate actions by governments to tackle coal emissions – in a way that is fair, affordable and secure for those affected – we will have little chance, if any at all, of limiting global warming to 1.5 °C."

In China, where more than half of global coal-fired electricity generation takes place, coal power is expected to grow by 9% in 2021 despite a deceleration at the end of the year. In India, it is forecast to grow by 12%. This would set new all-time highs in both countries, even as they roll out impressive amounts of solar and wind capacity. While coal power generation is set to increase by

almost 20% this year in the United States and the European Union, that is not enough to take it above 2019 levels. Coal use in those two markets is expected to go back into decline next year amid slow electricity demand growth and rapid expansion of renewable power.

“The pledges to reach net zero emissions made by many countries, including China and India, should have very strong implications for coal – but these are not yet visible in our near-term forecast, reflecting the major gap between ambitions and action,” said Keisuke Sadamori, Director of Energy Markets and Security at the IEA. “Asia dominates the global coal market, with China and India accounting for two-thirds of overall demand. These two economies – dependent on coal and with a combined population of almost 3 billion people – hold the key to future coal demand.”

3. How ‘super-enzymes’ that eat plastics could curb our waste problem

From an article by Michael Marshall, Observer, 5 Feb 2022

Beaches littered with plastic bottles and wrappers. Marine turtles, their stomachs filled with fragments of plastic. Plastic fishing nets dumped at sea where they can throttle unsuspecting animals. And far out in the Pacific Ocean, an expanse of water more than twice the size of France littered with plastic waste weighing at least 79,000 tonnes.

The plastic pollution problem is distressingly familiar, but many organisations are working to reduce it. Alongside familiar solutions such as recycling, a surprising ally has emerged: micro-organisms. A handful of microbes have evolved the ability to “eat” certain plastics, breaking them down into their component molecules. These tiny organisms could soon play a key role in reducing plastic waste and building a greener economy.

As a species, we make an enormous amount of plastic. In 2020, the most recent year for which we have data, 367m tonnes were produced globally, according to trade association Plastics Europe. This represented a slight decline compared with 2019, when 368m tonnes were made, but that was probably because of the Covid-19 pandemic: production had previously increased almost every year since the 1950s. A 2017 study estimated that 8.3bn tonnes of plastic had been made in total.

A huge fraction of this goes to waste. In 2016 the world generated 242m tonnes of plastic waste, according to the World Bank. Despite the popular image, only a small fraction of this ends up in the ocean – but the seas may still be absorbing more than 10m tonnes of plastic every year. As well as the dangers of the plastics themselves, they contain a lot of additives that leach out

into the water. “Over time we really don’t know what effects these have,” says Tiffany M Ramos of Roskilde University in Denmark.

Much of the rest ends up in landfills. That does not sound so bad, but a lot of it is single-use plastic, which is inherently wasteful. Making plastic requires extracting fossil fuels such as oil from the ground, with all the pollution risks that entails. Plastic manufacturing also releases greenhouse gases that contribute to global warming. A 2021 report found that the US plastics industry alone releases 232m tonnes of greenhouse gases every year, the equivalent of 116 coal-fired power plants.

The solution is not to stop using plastics altogether, because they are incredibly useful. For example, plastic bottles are far lighter than glass ones, so transporting them requires less energy and releases a smaller amount of greenhouse gases. But we do need a revolution in how we handle plastics, and this is where the micro-organisms come in.

In 2016 researchers led by microbiologist Kohei Oda of the Kyoto Institute of Technology in Japan reported a surprise discovery. Oda’s team visited a recycling site that focused on items made of polyethylene terephthalate (PET), a clear plastic that is used to make clothing fibres and drinks bottles.

Like all plastics, PET is a material made up of long string-like molecules. These are assembled from smaller molecules strung together into chains. The chemical bonds in PET chains are strong, so it is long-lasting – exactly what you do not want in a single-use plastic.

Oda’s team took samples of sediment and wastewater that were contaminated with PET, and screened them for micro-organisms that could grow on the plastic. It found a new strain of bacterium, called *Ideonella sakaiensis* 201-F6. This microbe could grow on pieces of PET. Not only that: Oda’s team reported that the bacterium could use PET as its main source of nutrients, degrading the PET in the process.

The key to this ability was a pair of enzymes made by the bacteria. Enzymes are complex molecules that can speed up chemical reactions. They are crucial to life: our digestive system relies on enzymes to break down the complex chemicals in food into simpler ones that our bodies can absorb and use. For example, our saliva contains an enzyme called amylase that breaks up the long molecules of starch found in foods such as bread.

Ideonella sakaiensis 201-F6 produces two unique enzymes. The first is a PETase that breaks the long PET molecules down into smaller molecules called MHET. A second enzyme called MHETase then goes to work, producing ethylene glycol and terephthalic acid. These two chemicals are the building blocks of PET, so *Ideonella sakaiensis* 201-F6 can completely reverse the manufacturing process that made PET.

The finding made headlines around the world, but it was not the first example of an organism that could degrade plastics. Reports of plastic-munching microbes date back to at least the early 1990s. The earliest examples were arguably less remarkable, because they could only eat plastics that were chemically flimsy or biodegradable. But by the 2000s researchers had found enzymes that could tackle tougher plastics.

A prominent researcher in this area has been Wolfgang Zimmermann of Leipzig University in Germany. His team studied enzymes called cutinases, which it obtained from bacteria such as *Thermobifida cellulosilytica*, and which could also break down PET. Lars Blank of Aachen University in Germany first heard about this in 2012. He set about creating a consortium of researchers to study plastic-eating enzymes. This became the P4SB project, which ran from 2015 to 2019. Blank has since set up a project called MIX-UP, which sees European and Chinese researchers cooperating.

By the mid-2010s plenty of plastic-degrading enzymes were known. So why did *Ideonella sakaiensis* 201-F6 cause such a stir? "The difference with the 2016 paper was this micro-organism could use the plastic as its sole energy and food source," says John McGeehan of the University of Portsmouth. "That's actually quite surprising and it kind of shows evolutionary pressure in action. If you're the first bacterium in that rubbish pile that suddenly has a taste for plastic, then you've got an unlimited food source."

Put another way, the earlier enzymes had not evolved for plastics. They evolved to break down tough chain molecules found in living things, and their ability to degrade plastic was a side-effect. In contrast, the enzymes in *Ideonella sakaiensis* 201-F6 were specialised.

Two years later McGeehan and his colleagues took things further. They produced a three-dimensional structure of the *Ideonella sakaiensis* 201-F6 PETase, shedding light on how it worked. Hoping to understand how it evolved, they tweaked the structure. To their surprise, this made the enzyme more efficient at degrading PET. Clearly, it was possible to improve the enzyme. McGeehan now wants to take that further, modifying the PETase and other such enzymes so that they can be used on an industrial scale to break down plastics that would otherwise linger in the environment. "We've got a big £6m grant from the government," he says, and they have started a specialist institute called the Centre for Enzyme Innovation.

This is now bearing fruit. In 2020 McGeehan's team reported that it had linked the PETase and MHETase enzymes together. This "super-enzyme" could eat PET about six times faster than the two enzymes working separately. Other groups such as Blank's MIX-UP have produced modified enzymes of their own.

Meanwhile there is evidence that microbes all around the world are evolving similar abilities. A study published in October 2021 looked at microbial DNA from a range of habitats. In areas with high levels of plastic pollution, the researchers found that the microbes were more likely to have enzymes with plastic-degrading tendencies. In line with this, a 2020 study identified a soil bacterium that can feed on some of the components of polyurethane, which releases toxic chemicals when it breaks down.

The question now becomes: how significant a role can these enzymes really play in reducing plastic pollution? So far, most of the activity has been in universities, but some groups are attempting to commercialise the technology. The University of Portsmouth has set up Revolution Plastics, which aims to forge links between academics and industry.

The most advanced project is run by Carbios, a French biotechnology company. In September 2021 it opened a pilot plant in Clermont-Ferrand, where it will test a system for recycling PET. Carbios's system uses an enzyme that was first identified in compost, which they modified so that it worked faster and could operate at high temperatures where PET is softer.

The advantage of these enzymes is that they break down the plastic at the molecular level, so it is possible to recreate the highest-quality plastic. In contrast, other forms of recycling cause a slow decline in quality, until eventually the plastic cannot be recycled again and gets landfilled or incinerated. Enzymatic recycling, in theory at least, is truly circular.

McGeehan says: "I think in the next five years we're going to be seeing demonstration plants all over the place."

Still, there are limits to the enzymes' usefulness. Some plastics are even tougher than PET. Blank points out that the enzymes work best if the plastic has been softened by heating. That means releasing the enzymes into the environment would not do much good: they only really work in temperature-controlled reactors. So the solution to plastic in the sea remains the same as before: we have to stop releasing it in the first place.

Nevertheless, it seems likely that plastic-eating enzymes will have a role to play as societies move towards a circular economy in which everything is recycled as much as possible. In a study published in July 2021, McGeehan and his colleagues estimated how much enzymatic recycling of PET will cost. They calculate that it could compete on cost with standard manufacturing methods, which use fossil fuels as feedstock.

The key is to be savvy about where we use the enzymes, says Blank. Some plastics can be mechanically recycled, a technology that is improving rapidly, so they probably are not the best targets. Instead, he says, researchers should

go for plastics that cannot be recycled any other way – particularly if they can become substances that are otherwise expensive to make.

Ultimately, the enzymes have to be part of a revolution in the entire way we make and use plastics. It is also important for plastic products to be designed in such a way that they can easily be reused and recycled. That might mean avoiding designs that use several kinds of plastic, or fuse plastic with other materials, as these are very difficult to recycle.

4. How to store excess wind power underwater

From an article by Emma Woollacott, BBC Technology of Business reporter, 5 February 2022

With 17 new wind farm projects planned for Scotland, the UK's offshore wind power capacity is set to more than double. But what happens when the wind is blowing, the turbines are cranking out electricity and there's no demand for it? It's already a problem. In 2020, enough electricity to supply more than one million homes was wasted due to a lack of storage, according to a report by KPMG that was commissioned by the power company Drax. But one firm, which won a 2022 Best of Innovation award at the CES technology show earlier this year, believes it has the solution. Dutch startup, Ocean Grazer, has developed the Ocean Battery, which stores energy below the wind farm. When there is excess electricity the system pumps water from an underground reservoir into tough, flexible bladders that sit on the sea bed. You could think of them like big bicycle inner tubes.

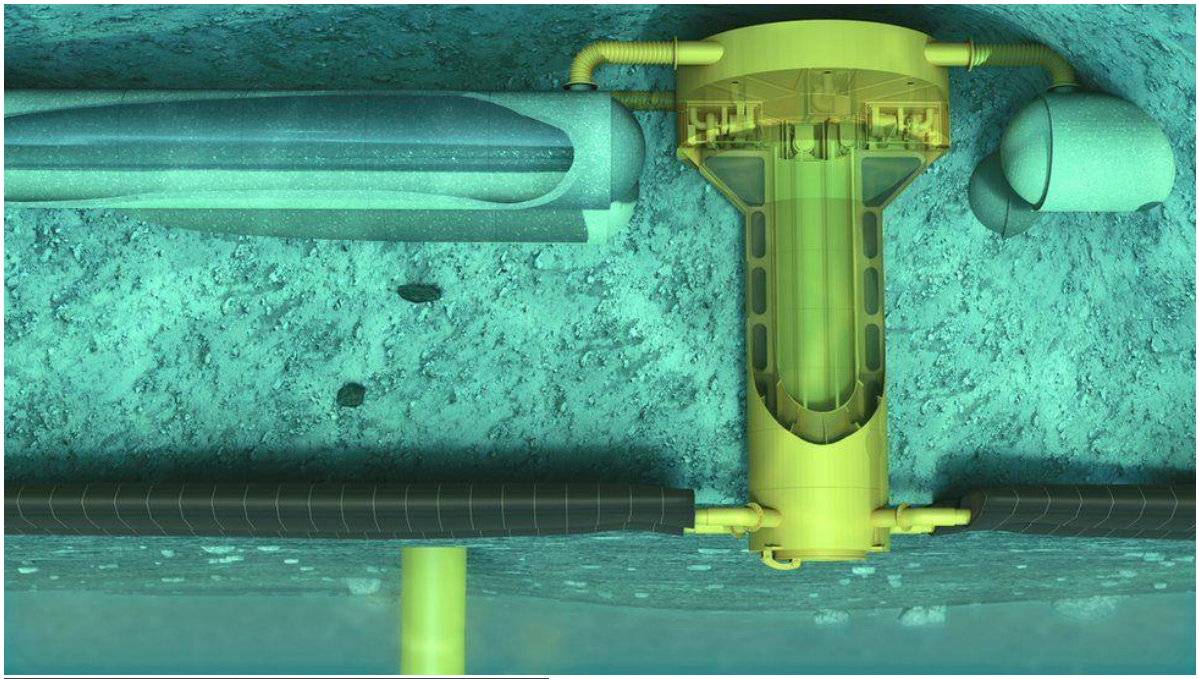

IMAGE SOURCE,OCEAN GRAZER

The water in those tubes is under pressure, so when it is released the water flows quickly and is directed through turbines, also on the sea bed, generating electricity when needed.

"The Ocean Battery, is effectively based on the same technology as hydro storage, where water is pumped back through a dam in a river, though we have transformed it into something you can deploy on the sea bed," says chief executive Frits Bliek. A protoype designed for deep water has already been tested at the port of Groningen in the Netherlands. The firm is now preparing to test a second system that has been modified for shallower water in a lake in the northern Netherlands. This should be operational next year. Many on-shore wind farms already use batteries to store extra power but there are a number of problems when it comes to using these offshore. "If you want to build a large-scale system offshore, you would also need to build a really huge platform built of sea containers and that's been found to be very, very costly. Also the lifetime of the batteries is not very long," says Mr Bliek.

While lithium-ion batteries can last for 5,000-10,000 charging cycles, the Ocean Battery can take up to a million, he says. Though the cost of storage is roughly the same, this extended life makes it much cheaper overall. "We found it can be built in shallow waters everywhere where wind farms are being built, and that's also pretty cost-effective at the end of the day," says Mr Bliek. He also thinks the technology can be used alongside solar farms, if there is a lake nearby.

Dr Gavin Harper, Faraday Institution research fellow at Birmingham University, says the future of energy storage is likely to involve a mix of different techniques. "Different energy storage technologies are suitable for storing energy on different time scales. Some are better suited for very fast responsive energy storage and others are suited to longer-term energy storage." "One of the real advantages with this type of technology is it eliminates the use of critical materials - for example, cobalt, nickel and lithium - which are key technology metals used in the manufacture of lithium-ion batteries." Such materials are expensive and in short supply.

But there are concerns about the financial viability of the system, says reader in energy systems and policy, Dr Jonathan Radcliffe, who is also at Birmingham University. "In principle, the technology is aiming to store large amounts of energy over periods of many hours, days or weeks. The problem that a lot of energy storage technologies face is that the value of storing energy at that scale is not high in the current market, so it would take a long time to pay back."

Land-based battery storage is more useful to power firms as it can be used to handle other problems with the grid, such as when power lines are near their limits, he says. "Those applications are quite highly valued and need storage

over short periods of time, so quite a few projects are proving to be commercial."

5. Reasons to be hopeful: the climate solutions available now

From an article by Damian Carrington, environment editor, and Guardian reporters, 31 Oct 2021

The climate emergency is the biggest threat to civilisation we have ever faced. But there is good news: we already have every tool we need to beat it. The challenge is not identifying the solutions, but rolling them out with great speed.

Some key sectors are already racing ahead, such as electric cars. They are already cheaper to own and run in many places – and when the purchase prices equal those of fossil-fueled vehicles in the next few years, a runaway tipping point will be reached.

Electricity from renewables is now the cheapest form of power in most places, sometimes even cheaper than continuing to run existing coal plants. There's a long way to go to meet the world's huge energy demand, but the plummeting costs of batteries and other storage technologies bodes well.

And many big companies are realising that a failure to invest will be far more expensive as the impacts of global heating destroy economies. Even some of the biggest polluters, such as cement and steel, have seen the green writing on the wall.

Buildings are big emitters but the solution – improved energy efficiency – is simple to achieve and saves the occupants money, particularly with the cost of installing technology such as heat pumps expected to fall.

Stopping the razing of forests requires no technology at all, but it does require government action. While progress is poor – and Bolsonaro's Brazil is going backwards – countries such as Indonesia have shown regulatory action can be effective. Protecting and restoring forests, particularly by empowering indigenous people, is a potent tool.

Recognition of the role food and farming play in driving global heating is high, and the solutions, from alternatives to meat to regenerative farming, are starting to grow. As with fossil fuels, ending vast and harmful subsidies is key, and there are glimmers of hope here, too.

The real fuel for the green transition is a combination of those most valuable and intangible of commodities: political will and skill. The supply is being increased by demands for action from youth strikers to chief executives, and

must be used to face down powerful vested interests, such as the fossil fuel, aviation and cattle industries.

Transport

Responsible for 14-28% of global greenhouse gas emissions, transport has been slow to decarbonise, and faces particular challenges in areas such as long-haul flight. But technical solutions are available, if the will, public policy and spending are there, too. Electric cars are the most obvious: petrol and diesel vehicles will barely be produced in Europe within the decade. EV sales are accelerating everywhere, with the likes of Norway well past the tipping point, and cheaper electric vehicles coming from China have cut the fumes from buses. Meanwhile, combustion engines are ever more efficient and less polluting.

Bike and scooter schemes are growing rapidly as cities around the world embrace electric micromobility. Far cleaner ships for global freight are coming. The potential of hydrogen is growing, for cleaner trains where electrification is impractical, to be followed by ships and even, one day, planes. Manufacturers expect short-haul electric aircraft much sooner. Most of all, the pandemic has shown that a world without hypermobility is possible – and that many people will accept, or even embrace, a life where they commute and travel less.

Deforestation

Deforestation and land use change are the second-largest source of human-caused greenhouse gas emissions. The destruction of the world's forests has continued at a relentless pace during the pandemic, with millions of hectares lost, driven by land-clearing in the Brazilian Amazon.

But there are reasons for hope. Indonesia and Malaysia, once global hotspots of deforestation, have experienced significant falls in recent years, the result of increased restrictions on palm oil plantations. However, the 2000s soy moratorium in Brazil shows these trends are reversible. Finally, there is a growing recognition of the importance of indigenous communities to protecting the world's forests and biodiversity. In the face of racism and targeted violence, a growing number of studies and reports show they are the best guardians of the forest. Empowering those communities will be vital to ending deforestation.

Technology

Emissions from technology companies, including direct emissions, emissions from electricity use and other operations such as manufacturing, account for 0.3% of global carbon emissions, while emissions from cryptocurrencies is a huge emerging issue.

Mining – the process in which a bitcoin is awarded to a computer that solves a complex series of algorithms – is a deeply energy-intensive process and only gets more energy-intensive as the algorithms grow more complex. But new mining methods are lighter, environmentally. A system called “proof of stake” has a 99% lower carbon footprint.

Scrutiny of the whole sector is increasing, spearheaded by tech workers who walked out in their hundreds to join climate change marches in 2019. The companies have pledged to do better: Amazon aims to be net zero carbon by 2040 and powered with 100% renewable energy by 2025. Facebook has a target of net zero emissions for its entire supply chain by 2030 and Microsoft has pledged to become carbon negative by 2030. Apple has committed to become carbon-neutral across its whole supply chain by 2030.

They’re still falling short when it comes to delivering, but employee groups continue to push.

Business

For decades Exxon Mobil has arguably been corporate America’s biggest climate change denier. But this year, the activist investor Engine No 1 won three seats on the company’s board with an agenda to force the company to finally acknowledge and confront the climate crisis.

Across corporate America and all around the world there are signs of change. The Federal Reserve, the world’s most powerful central bank, is beefing up its climate team. BlackRock, the world’s biggest investor, has made environmental sustainability a core goal for the company. According to BlackRock, failure to tackle climate change is simply bad for business.

Electricity

The rocketing global market price for gas has ripped through world economies, forcing factories to close, triggering blackouts in China, and threatening to cool the global economic recovery from the Covid-19 pandemic. But it has also spelled out a clear economic case for governments to redouble their efforts in developing homegrown, low-carbon electricity systems.

The precipitous fall in the price of wind and solar energy has helped to incentivise fresh investments in electricity vehicles and energy storage technologies, such as batteries, where costs are plummeting too. Soon, wind and solar power will help to produce green hydrogen, which can be stored over long periods of time to generate electricity during days that are a little less bright or breezy.

Buildings

The built environment is one of our biggest polluters, responsible for about 40% of global carbon emissions.

Over the past two decades, the carbon footprint of buildings "in use" has been greatly reduced by energy-saving technologies – better insulation, triple-glazing, and on-site renewables such as solar panels and ground-source heat pumps. On heat pumps, Norway, through a mixture of grants and high electricity prices, has installed more than 600 heat pumps for every 1,000 households.

As national energy grids are decarbonising, the focus is shifting to reducing the "embodied energy" of materials – which can account for up to three-quarters of a building's emissions over its lifespan – for example by reducing the amount of concrete and steel in favour of timber.

There is also a growing movement to prioritise refurbishment and reuse over demolition, driven by the realisation that the most sustainable buildings are the ones that already exist.

Food and farming

The hoofprint of the global livestock industry is a significant one, accounting for about 14% of total annual greenhouse gas emissions. But it is increasingly recognised and accepted by national governments. New Zealand now has a legal commitment to reduce methane emissions from agriculture by 10% by 2030, while Denmark has passed a legally binding target to reduce climate emissions from the agricultural sector by 55% by 2030.

While global meat production is increasing, there is a growing shift towards fish and poultry, which have a comparatively lower emissions footprint than red meats. The food industry is also developing a range of lower-carbon products using plant-based proteins such as soy and pea, and insect and lab-grown meat alternatives.

Manufacturing

Decarbonising the manufacturing of every product needed by a modern economy is a vast and varied task. Some sectors are well on their way. For instance, Apple, the world's third-largest maker of mobile phones by volume, has pledged to produce net zero carbon throughout its supply chain by 2030.

For many others, advances in efficiency of factories and their products will be accelerated by machine learning and other artificial intelligence technologies that are still in their infancy. There are even hopeful signs in some of the

hardest sectors to decarbonise, such as plans by Volvo to replace coal with hydrogen in the steel it uses in cars.

One of the greatest reasons for optimism is manufacturers' increasing awareness of circular design principles. Making products easier to recycle from the start will help to cut emissions from fresh resource extraction– although a bigger question remains as to whether rich societies can reduce consumption, the most obvious way to cut emissions.

6.Nuclear fusion heat record a 'huge step' in quest for new energy source

From an article by Ian Sample Science editor, @iansample, Guardian website, 9 Feb 2022

The prospect of harnessing the power of the stars has moved a step closer to reality after scientists set a new record for the amount of energy released in a sustained fusion reaction. Researchers at the Joint European Torus (JET), a fusion experiment in Oxfordshire, generated 59 megajoules of heat – equivalent to about 14kg of TNT – during a five-second burst of fusion, more than doubling the previous record of 21.7 megajoules set in 1997 by the same facility.

The feat announced on Wednesday follows more than two decades of tests and refinements at the Culham Centre for Fusion Energy and has been hailed as a "major milestone" on the road to fusion becoming a viable and sustainable low-carbon energy source. "These landmark results have taken us a huge step closer to conquering one of the biggest scientific and engineering challenges of them all," said Prof Ian Chapman, the chief executive of the UK Atomic Energy Authority. "It's clear we must make significant changes to address the effects of climate change, and fusion offers so much potential."

The doughnut-shaped JET is built to contain plasmas, or highly ionised gases, which are heated to 150m degrees Celsius, 10 times hotter than the centre of the sun. At such extreme temperatures, atomic nuclei can fuse together to form new elements and release vast amounts of energy. The same fusion reactions power the sun, but at considerably lower temperatures, because stars have gravity to lend a hand.

Experiments at JET have focused on whether fusion is feasible with a fuel based on two isotopes of hydrogen known as deuterium and tritium which combine to form helium gas. The latest results suggest that it is and provide crucial confirmation for Iter, a larger fusion project being built in the south of France. Iter is scheduled to start burning deuterium-tritium fuel in 2035 and ultimately generate more heat than is needed to keep its plasma at high temperature.

If all goes well with Iter, the next step is to build a European demonstration power plant that produces more electricity than it uses and is hooked up to the grid. The prospect of fusion energy is deeply attractive because it does not release greenhouse gases and 1kg of fusion fuel contains about 10m times as much energy as 1kg of coal, oil or gas.

While deuterium is abundantly available in sea water, tritium is extremely rare and produced in nuclear reactors. Future fusion plants – Iter included – are expected to make their own tritium fuel by using high-energy neutrons, released when deuterium and tritium fuse, to split the common metal lithium into tritium and helium.

Dr Mark Wenman, a reader in nuclear materials at Imperial College London, said that while the experiment released fusion energy for only five seconds, it proved that the fuel could be burned in a sustainable manner. “It’s been a while since they have produced a record like this and it’s a major milestone on the way to proving that fusion’s a viable and sustainable energy source for the future. “Five seconds doesn’t sound like much, but if you can burn it for five seconds, presumably you could keep it stable and keep it burning for many minutes, hours, or days, which is what you are going to need for a proper fusion power plant. It’s the proof of that concept that they have achieved,” he said.

Prof Ian Fells, the emeritus professor of energy conversion at the University of Newcastle, said the record-breaking release of fusion energy was “a landmark” in fusion research. “Now it is up to the engineers to translate this into carbon-free electricity and mitigate the problem of climate change,” he added.

Ross Rutherford

ESR Newsletter Editor

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