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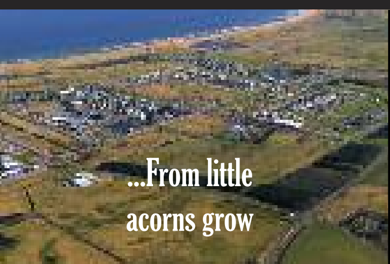
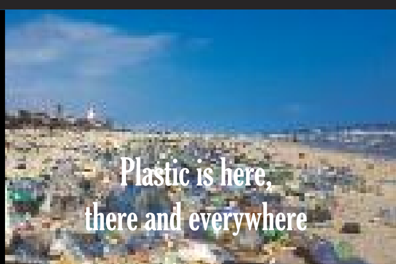
From fiery ice to sustainable aviation: the biofuel race becomes creative



...From little acorns grow

Porto Flavia: where wilderness meets design



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From fiery ice to sustainable aviation: the biofuel race becomes creative

By JEZ ABBOTT

ONE

The search for alternative fuels struck lucky off the coast of Japan recently. Under the water and below the seabed are pockets of methane, trapped in ice. Put a match to this ice back on dry land and it not only melts, it ignites. Could this be the next big break in alternative fuel technology?

Very possibly reckon several large international research programmes and multinational firms that have set sail to the seas around Japan to explore these icy blocks. If tests on this substance – called fiery ice - go well, commercial mining could start in about 12 years. Estimates suggest methane hydrates make up a third of the total carbon held in other fossil fuels such as oil, gas and coal.

And several nations, not just Japan, want to tap into the potential. The problem however is bringing the gas to the surface, scientist Carolyn Ruppel told the BBC. Ruppel, who heads up the gas hydrates project for the US Geological Survey, explains methane hydrates are too sensitive to pressure and temperature changes to conventionally mine and pipe to land. Typically they form several hundred metres beneath the seafloor where pressures are much higher and temperatures at freezing point. Removing them from these frigid atmospheres could make them break down before the methane can be harnessed. But there are ways to do it and a Japanese government-funded research programme is looking at those ways.

Japan Oil, Gas and Metals National Corporation is one of the leading research organisations in the country's national gas hydrates programme, and to date has experienced patchy success. Another trailblazer is Hawaii Natural Energy Institute, but technical translator Ai Oyama explains the biggest stumbling block is neither technical nor financial, but emotional. While some people welcome the search for fiery ice and the possibility of Japan becoming energy independent and environmentally cleaner, others fear any technique that prods or disturbs seafloor areas near tectonic plate boundaries. "In general," he says, "people just feel really scared to do anything to the ocean floor. The place is known to be unstable and where earthquakes happen."

Not just earthquakes. Extraction involves releasing a lot of methane gas suddenly into the ocean, which could potentially add vast amounts of the greenhouse gas to the atmosphere. Methane hydrate also releases water when it destabilises, which could stir sediment and fracture seabeds leading to landslips or even, some environmentalists reckon, a tsunami.
From below the sea, to above the clouds, the search for alternative fuels runs high and low. The aviation industry took a landmark step in autumn 2018 towards making commercially viable sustainable aviation fuel a reality. It is made using recycled waste industrial gases. The Boeing 747 flight - a world first – was led by Virgin Atlantic and LanzaTech and took off from Orlando.

Virgin Atlantic founder Sir Richard Branson marshalled the aircraft on its landing at London Gatwick. It followed a £410,000 (€462,000) UK government grant to test the feasibility of building a 50-million US gallon jet fuel plant in Britain. Up to 125 million gallons a year would fuel every Virgin Atlantic flight from Britain, and provide nearly one million tonnes of CO_2 savings.

LanzaTech produces next-generation 'advanced' fuels by recycling carbon-rich waste industrial gases like those produced from steel making. Ethanol from the waste gases is made into the jet fuel and other low-carbon products. Using a plentiful, affordable waste stream has a strong sustainability profile and also allows a comparable price point to current fossil jet fuel. LanzaTech has made advances in scaling up its technology and is now tantalisingly close to its first commercial plant.

Virgin Atlantic is calling on the UK government to promote carbon-capture and utilisation technologies through the kind of incentives given to earlier generations of biofuels. The EU meanwhile is well entrenched in its promotion of alternative fuels through policy and incentives. The so-called Clean Mobility Package includes an action plan for the deployment of alternative fuels infrastructure that centres on €800 million of grants to leverage loans and additional public and private investment.

Such policy drives may strike a chord with the S&D Group, a centre-left political group of socialists and democrats in the European Parliament with members from all 28 EU countries. Spokesman Ismail Ertug says 94% of Europe's transport sector depends on oil. Transport meanwhile is the only major economic sector in the EU where greenhouse gas emissions have increased since 1990.

In September 2018, the parliamentary committee on transport backed a proposal by MEP Ertug to introduce binding national targets on the deployment of alternative fuels infrastructure. Ertug who is calling for tough infrastructure targets and "sufficient" public funding, says out of roughly 800,000 charging points envisaged by 2025, just over 100,000 were currently in place.

Transport may well be the only major economic sector where greenhouse gas emissions are going up, but sections claim to be cleaning up their act. Oil giant ExxonMobil has been exploring how to turn algae into low-emission transport fuel for almost a decade. Working with Synthetic Genomics Inc, it is looking at how to scale up algae biofuels for potential commercial deployment for trucks, planes and other large transportation vessels.

In 2018, the two companies started the latest phase of their research project by farming wild algae in outdoor ponds and by 2025 they hope to have reached the technical ability to produce 10,000 barrels of algae biofuel per day. This will signal a key "engineering milestone" for large-scale production of algae biofuel, insists ExxonMobil.

Another oil titan, BP, is part of a joint venture with Du Pont called Butamax, which has developed technology to convert sugars from corn into an energy-rich biofuel known as bio-iso-butanol. Not only can it be blended with gasoline at higher

concentrations than ethanol, but it can also be transported through existing fuel pipelines and infrastructure.

BP also creates biopower to heat and light buildings from burning bagasse, the fibre that remains after crushing sugarcane stalks. In 2017 the company's three biofuel-manufacturing facilities produced around 850 gigawatt hours of low-carbon electricity – enough renewable energy to power all of those sites and export the remaining 70% to the local electricity grid.

Furthermore, the CO_2 emitted from burning bagasse is offset by the CO_2 absorbed by sugarcane during its growth.

When the Virgin Atlantic plane touched down in London, the UK's energy and clean growth minister Claire Perry hailed the kind of scientific endeavour that leads to alternative fuels for jets and homes. She also praised the exploratory drive that leads pioneers to areas such as the seas around Japan.

"Applying innovative solutions to real-world climate change challenges will help us transition to a greener, cleaner economy," she said. "We are backing this kind of outside-the-box thinking to ensure we modernise our industries and accelerate the shift to low-carbon living."

October 2018: Virgin Atlantic's Boeing 747 "Queen Of The Skies took off on the world's first commercial biofuel flight. Photo credit: Virgin Atlantic

...From little acorns grow

Could Scotland's Acorn CCS project be the start of something big?

By TOBY LOCKWOOD
ONE

Despite over ten years of trying, and numerous political initiatives at the national and EU level, carbon capture and storage (CCS) has yet to take off in Europe. This failure has variously been blamed on high costs, changeable political backing, public opposition in some countries, and the collapse of the EU's price on carbon. Whilst all of the above have played a part, it is clear that there is something uniquely challenging about launching an industry which requires an entirely new infrastructure put in place to transport and store CO_2.

Few companies are willing to invest in this infrastructure without being sure someone will pay them for the service of taking the CO_2 of their hands, and no greenhouse gas emitter will pay to capture its CO_2 without being sure it has somewhere to go. In economics, this kind of impasse is sometimes known as a coordination failure. The solution so far has been to induce large companies or consortiums to tackle the whole problem at once, but the resulting projects have largely been too complex, and too expensive for governments to back.

The Acorn CCS project in Scotland is arguably born out of a growing sense of frustration with this lack of progress, and a pragmatic desire to get something done. Unlike the ill-fated, grandiose projects that have gone before, it is small, relatively cheap, and low risk. Led by Pale Blue Dot Energy, and originating as an EU-funded international research collaboration, the idea is to reuse gas pipelines at the St Fergus gas terminal in the North-East of the country to transport CO_2 out into the North Sea. While once these pipelines were used to bring gas ashore from offshore platforms, some are now becoming redundant as the gas fields that fed them run dry. The porous rocks below the seabed which once contained so much oil and gas turn out to be just as good for holding CO_2, and have been extensively studied for exactly this purpose over the last few years.

There is a neat symmetry in reversing the historical flow of carbon – putting back as CO_2 what was once removed as natural gas. However, it is not in itself a new idea. Not far from St Fergus, the Peterhead gas power station was once a frontrunner in the UK government's £1 billion competition to fund a large CCS project, before the money was abruptly withdrawn in 2015. The CO_2 produced by this power station would have also used a repurposed pipeline to reach its final destination in an old gas field. At St Fergus there are several much smaller gas power stations, used to provide power and heat to natural gas processing facilities, which are the target of the Acorn project.

A key difference with its failed predecessor is that the scale of the CO_2 capture operations will start smaller; by collecting around a third of the existing emissions, it aims to reach around 200,000 tons of CO_2 per year. Whilst not quite the 1 million tons of annual savings that the Peterhead project had promised, this is a sizeable chunk of greenhouse gas emissions, equivalent to taking over 40,000 cars off the road. The St Fergus facility also already boasts equipment for removing the naturally occurring CO_2 found in natural gas, which could potentially be repurposed or rebuilt for the new project. Acorn hopes to start injecting CO_2 beneath the seabed in 2022, which would probably make it the first CCS success in the UK, and the first of its kind in Europe.

1982: St Fergus gas terminal. Photo: eveningexpress.co.uk

Across the maritime border in Norway, two North Sea gas platforms have been directly reinjecting the CO_2 they remove from natural gas since 1996 and 2008, but the connection to onshore emissions is their missing link. As suggested by its name, Acorn's modest beginnings are intended to be the seed for something much larger.

The team envisage receiving CO_2 by ship from other parts of the UK, which could conveniently be brought into the deep-water port at Peterhead. In particular, there is a cluster of industrial CO_2 emitters in the Teesside area of North-East England which has long been developing CCS plans, but would require substantial new infrastructure to access suitable CO_2 storage. There is also an old gas pipeline running from St Fergus down to the Grangemouth industrial area near Edinburgh, which could be reused to run CO_2 emissions back up the country and from there out to sea. This kind of increase in volume is not expected to take place until 2025, and it will eventually require expansion of the offshore operation. With this in mind, there are plans to take on another two redundant offshore pipelines, and use other rock formations in which to store the CO_2.

An important part of the project's long-term vision is based on the expectation that hydrogen could become an important source of energy in the UK. This idea is rapidly gaining currency in climate policy worldwide, as the clean-burning gas seems to be one of the only ways in which gas grids could be decarbonised. However, it is also thought that the best way to make large quantities of hydrogen would be from natural gas, with the resulting CO_2 emissions stored by a CCS project such as Acorn. Although a complete switch to hydrogen would require some fairly major changes to our gas grid, increasing the proportion of hydrogen to around 10% could be done without too much fuss. The demand for clean hydrogen, and therefore for CCS, could soar in the coming decade.

To coincide with an international summit on CCS it hosted in Edinburgh last month, the UK government confirmed £175,000 of investment in Acorn, which will be matched by the Scottish government and will add to the existing EU funding. More good news came in the days around this announcement, as the project secured a licence to operate from the UK's Oil and Gas Authority, and a CO_2 storage lease from Crown Estate Scotland which own the rights to the North Sea assets.

Acorn may have timed it right to ride a new wave of favourable policy on CCS in the UK, launched by the technology's inclusion in the government's Clean Growth Strategy in 2017, and given further momentum by the high-profile Edinburgh meeting. Whilst sceptics will point out that CCS has been here before in the UK, backers of past projects appear to have learned from the years of failure to come up with something tailor-made to find more favour with policy makers: small, but scalable; low cost, but pioneering. This time just might be different.

Analysis: fossil-fuel emissions in 2018 increasing at fastest rate for seven years

By ZEKE HAUSFATHER
Carbon Brief

Hopes that global CO2 emissions might be nearing a peak have been dashed by preliminary data showing that output from fossil fuels and industry will grow by around 2.7% in 2018, the largest increase in seven years.

The new data, from researchers at the Global Carbon Project (GCP), is being published in Earth System Science Data Discussions and Environmental Research Letters to coincide with the UN's COP24 climate summit in Poland. The rapid increase in 2018 CO2 output from fossil fuel use and industry follows a smaller 1.6% rise in 2017. Before that, three years of flat emissions output to 2016 had raised hopes that emissions had peaked.

This year, the largest increases have occurred in China, driven by government stimulus of the construction industry. US emissions have also increased markedly in 2018, after an unusually cold winter and hot summer helped to drive up energy demand.

Continued emissions growth in 2019 "appear[s] likely", the researchers say, driven by rising oil and gas use and rapid economic growth. While some progress has been made, they add that the world has not yet reached the point where the energy system is being decarbonised fast enough to offset economic growth.

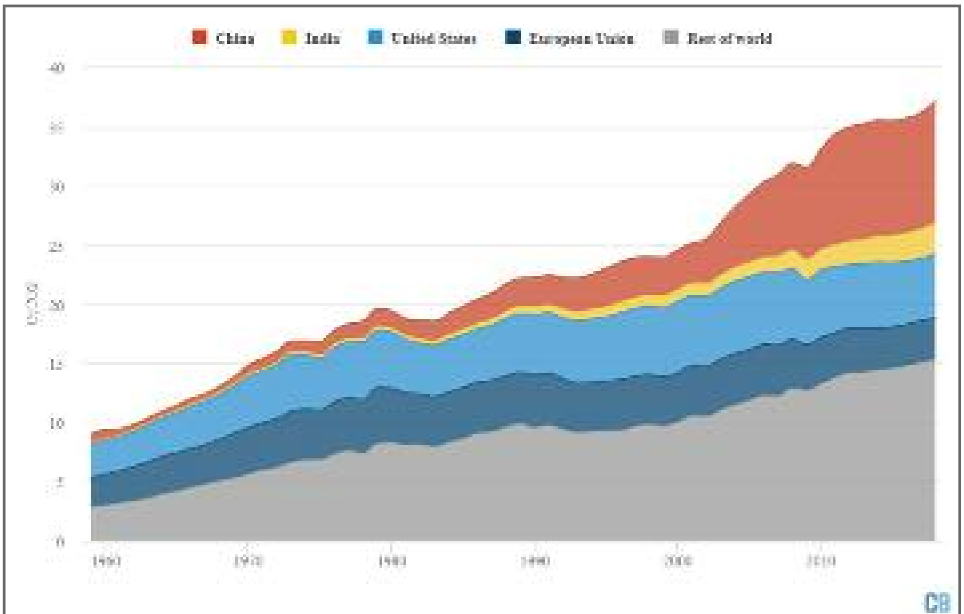
The increase in overall human-caused CO2 emissions may be smaller than the increase from fossil fuels and industry, the GCP says, up an estimated 0.7% in 2018. This is due to a reduction in land-use emissions offsetting some of the increase from fossil fuels. Nevertheless, the 2018 increase in emissions puts the world even further away from meeting its climate change goals under the Paris Agreement.

Largest increase in seven years

The GCP is a group of international researchers who assess both sources and sinks of carbon. It has published an annual global carbon budget report since 2006.

Its newly released global carbon budget for 2018 provides estimates of CO2 from fossil fuel and industry in each country, as well as global emissions from changes in land use. It also estimates how CO2 has accumulated in the atmosphere and how much was absorbed by the land and oceans.

The figure below shows global CO2 emissions from fossil fuels, divided into emissions from China (red shading), India (yellow), the US (bright blue), EU (dark blue) and the remainder of the world (grey). Emissions are expected to rise to a new high of 37.15bn tonnes of CO2 (GtCO2) in 2018, with China and the US as the two largest emitters.



Annual CO2 emissions from fossil fuels and industry by major country and rest of world from 1959-2018, in billions of tonnes of CO2 per year (GtCO2). Note that 2018 numbers are preliminary estimates. Data from the Global Carbon Project; chart by Carbon Brief using Highcharts.

After a rapid increase in global emissions of around 3% per year between 2000 and 2013, emissions only grew by 0.4% per year between 2013 and 2016. This was reversed over the last two years, with emissions growing by 1.6% in 2017 and expected to grow in 2018 by 2.7% (with an uncertainty range of between 1.8% and 3.7%).

Increases in 2018 driven largely by China

Much of the slowdown in the growth of global emissions from fossil fuels between 2014 and 2016 had been driven by a combination of reductions in the US and China, as well as relatively little growth in emissions in other countries.

However, in 2017 Chinese emissions grew, while declines in the US slowed. In 2018 China is expected to show substantial increases in emissions, with increases also expected in the US.

India's emissions increased a bit more quickly in 2018 than over the past few years, while the EU's emissions have remained relatively flat since 2014 and did not noticeably change in 2017 or 2018. The growth in emissions from the rest of the world has remained at around 0.25GtCO2 per year for the past three years.

The total emissions for each year between 2015 and 2018, and the countries that were responsible for the change in emissions, are shown in the figure below. Annual emissions for 2015, 2016, 2017 and estimates for 2018 are shown by the black bars. The coloured bars show the change in emissions between each set of years, broken down by country. Negative values show reductions in emissions, while positive values reflect emission increases. As 2018 is not yet over – and somewhat limited data is available – these projections are still subject to large uncertainties. The GCP will publish more complete 2018 numbers in early 2019 when all the data is available. However, it is clear that the rise in emissions from fossil fuels in 2018 will be the largest in quite some time.

China

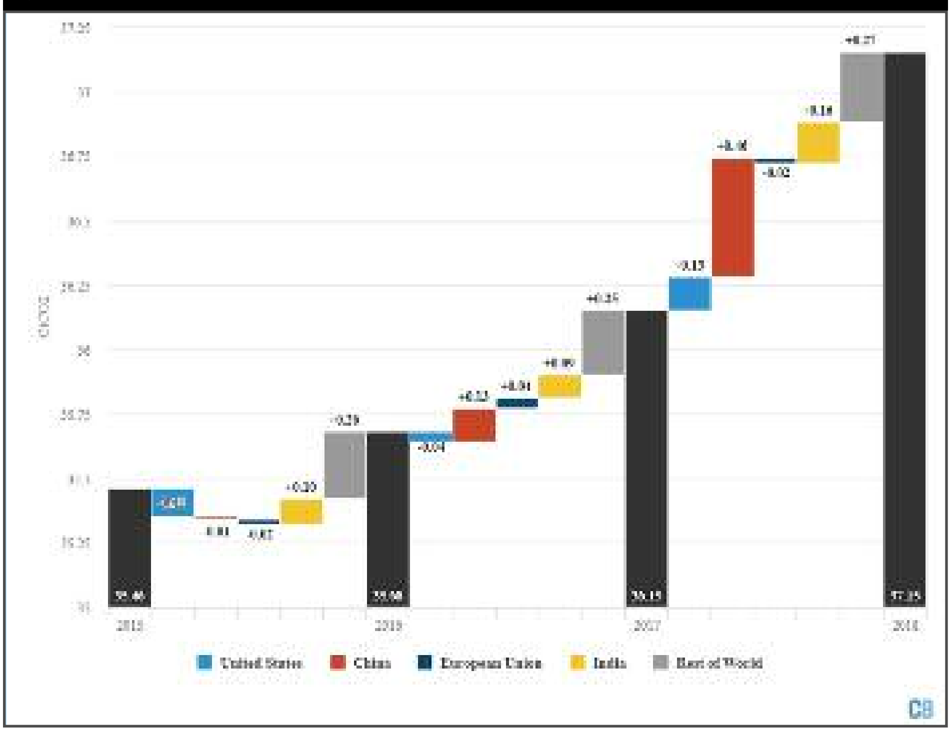
China alone was responsible for just under half the global increase in CO2 emissions in 2018. Chinese emissions are projected to grow by 4.7% in 2018, with a wide uncertainty range from 2% to 7.4%.

Prof Corinne Le Quere, director of the Tyndall Centre at the University of East Anglia and one of the lead scientists at the Global Carbon Project, tells Carbon Brief (video above) that the rise in Chinese emissions in 2018 was primarily driven by "government stimulus in the construction industry", a sector which "emits lots of CO2".Le Quéré suggests that some of this projected increase is "probably temporary", but also cautions that it is difficult to say what will happen to Chinese emissions in 2019. Early indications suggest the government is planning another multi-trillion stimulus next year.

US

The GCP projects that US CO2 emissions are likely to increase in 2018 by around 2.5% – with an uncertainty ranging from 0.5% to 4.5%. This represents a reversal after three years of consecutive emission declines.

Annual global CO2 emissions from fossil fuels (black bars) and drivers of changes between years by country (coloured bars). Negative values indicate reductions in emissions. Note that the y-axis does not start at zero. Data from the Global Carbon Project; chart by Carbon Brief using Highcharts.



Le Quere points out that a large portion of the increase in US emissions was "associated with a cold winter followed by a hot summer, both of which use a lot of energy". Power sector emissions continued to decline, with US coal consumption expected to reach a new low in 2018. However, these are somewhat offset by increases in industrial and transportation emissions driven by a growing economy.

Despite record sales of electric vehicle in the US – the total number just hit the 1m mark – there are nearly 12m more cars with internal combustion engines in the country than there were in 2008.

The GCP forecasts that US emissions will probably begin to decline again in 2019, as cheap gas, wind and solar continue to displace coal and temporary weather effects end.

European Union

EU emissions are expected to decrease by 0.7% in 2018 – with a range of -2.6% to 1.3%. While power sector emissions have continued to decrease, overall emission declines are more modest because increased use of petrol for transportation is offsetting decreased use of coal and gas for electricity generation. After this modest decline in 2018, EU emissions would have returned to much the same level as in 2014. There have been no significant changes in EU CO2 output since then.

India and the rest of the world

India and other developing countries saw emission increases in 2018, due to economic growth that is "not yet decoupled" from greenhouse gas emissions, the GCP says. India's emissions are expected to increase by 6.3% in 2018 – with a range of 4.3% to 8.3% – and the rest of the world's emissions are expected to increase by 1.8% – with a range of 0.5% to 3.0%.

Decarbonising, but too slowly

The increase in CO2 emissions from fossil fuels in 2018 leaves the world far from the trajectory needed to meet global climate goals. Yet the GCP report does contain a few proverbial silver linings. It points out that 19 countries representing 20% of the global total have significantly reduced CO2 emissions over the last decade.

As Le Quere tells Carbon Brief, "we are in a very different situation than we were in just five years ago". This is due to very large declines in coal use in the US and Europe and the rapid rise of cheap renewable energy.

Even China, which led the world in CO2 emissions increases in 2018, has much slower growth of coal use than a decade ago. There are some suggestions that global coal use may have peaked, though it is too soon to know for sure.

On the other hand, global oil and gas use is growing unabated. In particular, the world has been slow in addressing emissions from the transportation sector, as electric and other alternative-fuel vehicles have been slow in taking off. Le Quere suggests that focusing on transport, buildings and industry will be critical for ensuring future emissions reductions.

Ultimately, while progress is being made on decarbonisation, it is happening at a slower rate than the global economy is growing, particularly in developing countries. As the GCP argues:

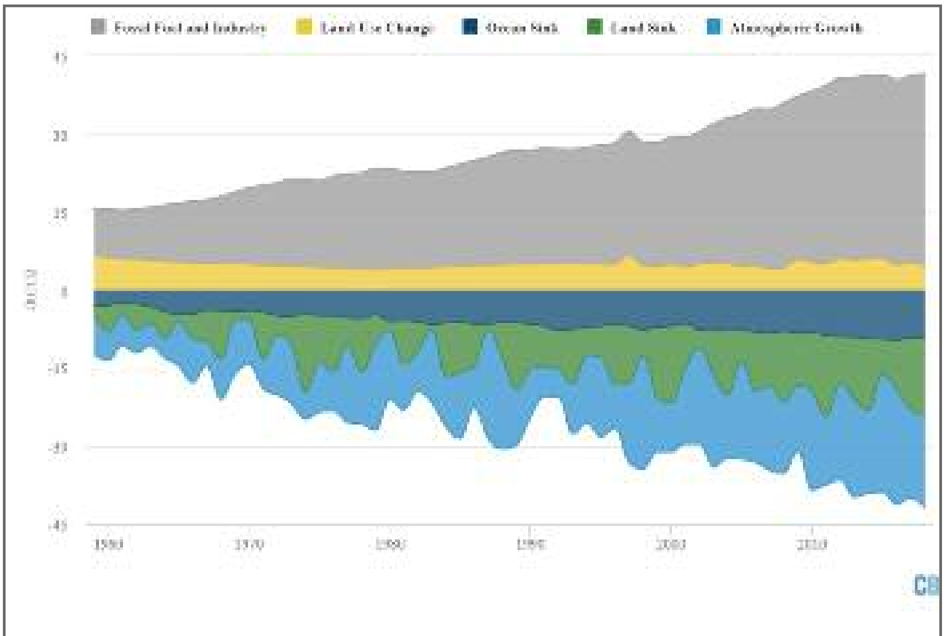
"Insufficient emission reductions in developed countries and a need for increased energy use in developing countries where per capita emissions remain far below those of wealthier nations will continue to put upward pressure on CO2 emissions. Peak emissions will occur only when total fossil CO2 emissions finally start to decline despite growth in global energy consumption, with fossil energy production replaced by rapidly growing low- or no-carbon technologies."

The global carbon budget

Every year the GCP provides an estimate of the global carbon budget. It estimates both the release and uptake of carbon including emissions from fossil fuels and industry, emissions from land-use changes, carbon taken up by the oceans and land, and changes in atmospheric concentrations of CO2.

This differs from the commonly used term "carbon budget", referring to how much emissions are left to meet a climate target, such as avoiding 1.5 or 2C of warming.

The most recent budget, including estimated values for 2018, is shown in the figure below. Values above zero represent sources of CO2 – from fossil fuels and land use – while values below zero represent "carbon sinks" that remove CO2 from the atmosphere. CO2 emissions either accumulate in the atmosphere, or are absorbed by the oceans or land vegetation.



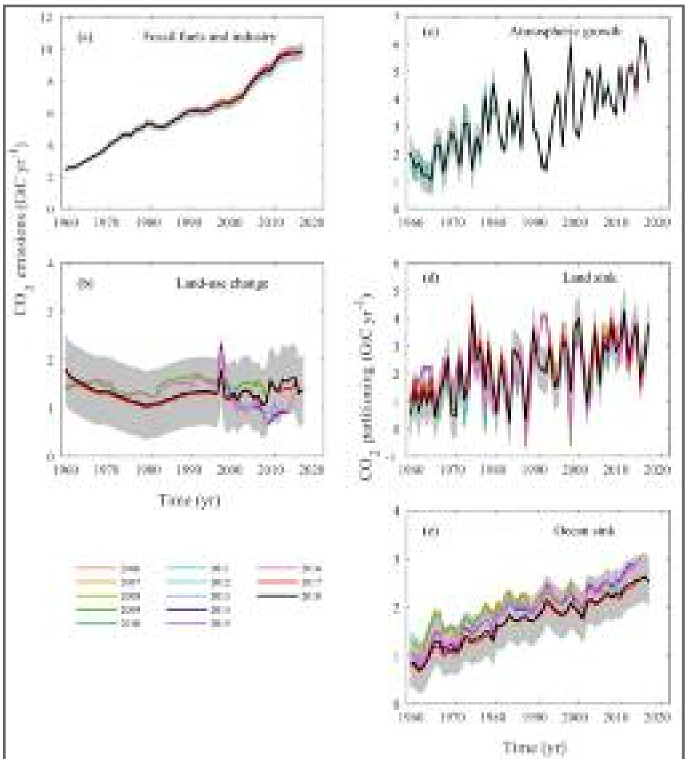
Annual global carbon budget of sources and sinks from 1959-2018. Note that the budget does not fully balance every year due to remaining uncertainties, particularly in sinks. 2018 numbers are preliminary estimates. Data from the Global Carbon Project; chart by Carbon Brief using Highcharts.

Land-use changes, such as deforestation and fires, comprised 10.6% of total CO2 emissions in 2018, down a bit from 12.6%

in 2017. The remaining 89% of emissions came from fossil fuels and industry. Total CO2 emissions increased by about 0.7% between 2017 and 2018, driven by higher fossil-fuel emissions but lower land-use emissions.According to the GCP estimates, about 43% of CO2 emitted in 2018 accumulated in the atmosphere. The remainder was taken up by carbon sinks – 35% by the land and 23% by the ocean. Land uptake was unusually high in 2018 and one of the highest levels in the past few decades, though the cause of this is currently unclear, the authors tell Carbon Brief. Atmospheric CO2 concentration are projected to increase by 2.2 parts per million (ppm), reaching 407ppm in 2018. This increase is close to the average increase over the past decade, despite record-high emissions. This is because the return to El Nino neutral conditions and an unusally large land sink.

Updating sources and sinks

The GCP's new global carbon budget also includes updated estimates of sources and sinks based on changes in inventories and new research published since the last budget came out. The figure below, taken from the paper presenting the latest budget, shows the values used for every year from 2006 through to present.



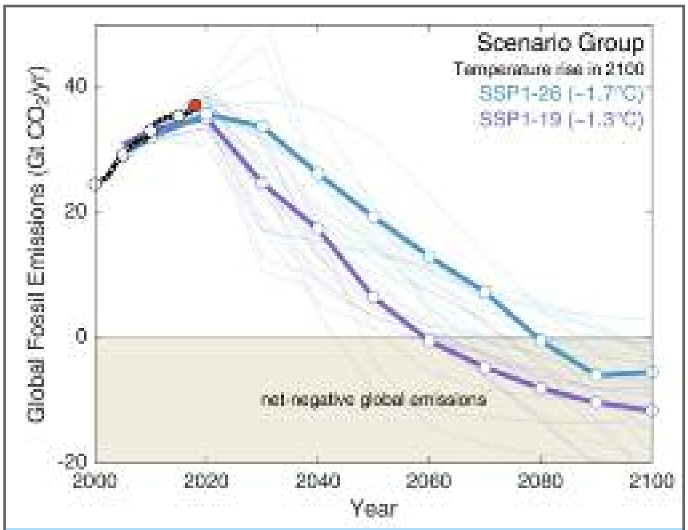
Global Carbon Project source and sink estimates in billions of tonnes of carbon (GtC) – note, not CO2 – for every Global Carbon Budget published between 2006 and 2018. Figure B4 from Le Quéré et al (2018).

Estimates of global fossil fuel and industry emissions were revised downwards by around 1.5% in recent years in the 2018 report compared to 2017, with larger declines of around 4% in Chinese emissions. This is due to a revision in the emission factors use for cement production and is particularly pronounced in China as they produce around 60% of the world's cement.

Implications for meeting Paris Agreement targets

As previously discussed by Carbon Brief, there is a growing gap between emission reduction commitments made by countries to-date and what would be required to meet the Paris Agreement targets of limiting warming to 1.5C, or well below 2C above pre-industrial levels. Every year that emissions continue to increase makes this gap larger.

The figure below shows historical fossil fuel CO2 emissions in black, with 2018 emissions as a red dot.



Historical fossil-fuel emissions (black), 2018 emissions (red), well-below 2C scenarios (RCP2.6 – blue) and below 1.5C scenarios (RCP1.9 – purple). Mitigation scenarios from integrated assessment models using shared socioeconomic pathway number one. Bold lines indicate the subset of scenarios chosen as a focus for running CMIP6 climate model simulations. Source: Figure 2 in the Jackson et al 2018

The various coloured lines show the well-below 2C scenarios (blue) and 1.5C scenarios (purple) produced by integrated assessment models in shared socioeconomic pathway number one. The thicker blue and purple lines represent the chosen "reference scenario" for each mitigation target. The increase in emissions in 2018 makes it more challenging for the world to meet its Paris Agreement goals. If emissions continue to increase over the next few years, the more ambitious mitigation targets – such as limiting warming to below 1.5C – may quickly move out of reach, at least in the absence of removal of CO2 from the atmosphere from planetary-scale deployments of as-yet-unproven negative emission technologies late in the century.

As Dr Glen Peters, a senior researcher Center for International Climate and Environmental Research (CICERO) in Oslo, says in a statement: "The rise in emissions in 2017 could be seen as a one-off, but the growth rate in 2018 is even higher, and it is becoming crystal clear the world is so far failing in its duty to steer onto a course consistent with the goals set out in the Paris Agreement in 2015."

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Better data would help crack the drought insurance problem

Public and private insurance schemes face similar challenges. Solving them requires detailed data on weather and farm outcomes.

By NEAL HUGHES
The Conversation

While drought policy raises many complex emotional, political and policy issues, it can be helpful to think of it as an insurance problem: how can we best help farmers manage climate risk?

Drought insurance has been a long-standing goal and it's easy to understand why. If viable, drought insurance markets could help farmers manage climate risk without the costs and potential side effects of government drought support.

Unfortunately, technical problems have hampered the development of drought insurance markets in Australia to date. However, there is hope that with improvements in technology and better data these problems could be solved, paving the way for a new generation of weather-based insurance products.

The missing market for drought insurance

Australia has well-functioning but limited markets for crop insurance. If hail or fire destroys a paddock, for example, an insured farmer will receive a payout for the value of the crop. But multi-peril crop insurance – which covers a wide range of adverse events including drought – has failed to thrive in Australia. The international experience has been similarly uninspiring.

Many reviews have attributed these failures to information and participation problems. Firstly, only the riskiest or most drought-prone farms may sign up for insurance (the adverse selection problem). Second, farms with insurance may put less effort into preparing for and managing drought (the moral hazard problem). Both these problems make insurance more costly to provide, resulting in higher premiums and lower uptake.

While these problems apply to all forms of insurance, they are particularly acute in agriculture, given the effects of drought will vary widely depending on farm-management decisions and detailed – and difficult to observe – farm characteristics such as the quality of land and livestock.

Subsidies are not the answer

Recently, farmers groups have called for tax breaks to promote multi-peril crop insurance. Unfortunately, while tax incentives and other subsidies may increase uptake, there is no coherent case for providing more than normal tax deductibility. In fact, such subsidies could actually cause economic harm.

Insurance premiums provide important signals to farmers, promoting preparedness and adaptation. This includes promoting careful crop-planting decisions when drought risk is high. The inglorious record of farm crop insurance in the United States shows how things can go very wrong when insurance is subsidised.
It is not surprising that previous reviews have consistently recommended against insurance subsidies, while just last year the New South Wales government rejected a similar proposal.

Index-based insurance could be a way forward

One alternative, which has been receiving increased attention in recent years, is index-based insurance. Here payouts are based on weather data rather than an assessment of actual farm damages. For example, a farmer might receive a payout if rainfall falls below an agreed threshold.

Index-based products are largely immune to the information

Sign rendered pointless by the 2007-08 Australian drought. Rawnsley park station, South Australia. Photo: Peripitus

problems that plague standard insurance: insurers don't need to spend time and money assessing each application, or monitoring farmers' behaviour. Instead, insurers must solve the technical problem of designing an accurate index.

This index needs to be sensitive to the complex effects of weather on farms. In practice, the effect of a drought depends on many things. The amount of rainfall, its timing, the temperature and many other factors all interplay. If these factors are not taken into account, drought insurance runs into a "basis risk" problem: payouts don't align with the climate risks faced by individual farms. This basis risk problem is largely why index-based weather insurance products have struggled in Australia to date.

Drought insurance could be public or private

In recent years, governments have focused on promoting private drought insurance markets. However, public schemes are also possible and exist in many other countries. A well-designed public drought insurance scheme – with premiums to cover costs – might have some advantages over private insurance. For example, governments may be better placed to absorb losses in years of severe widespread drought (although re-insurance markets might provide a way for the private sector to manage such risks).

However, public drought insurance schemes could, depending on their design, reduce demand for private insurance. This problem also extends to other forms of government drought relief: farmers may be less likely to pay for insurance if they suspect ad hoc drought assistance will be available.

Better data is essential

Ultimately, public and private insurance schemes face similar technical challenges. Solving these technical issues requires detailed data both on weather and farm outcomes.

Numerous reviews have cited data limitations as a key constraint on the Australian farm insurance sector. A recent review by ABS and ABARES highlighted the patchy and fragmented nature of existing government and industry agricultural data. There is a good case for government to support the supply of this data, similar to the National Flood Risk Information Project established following the Australian 2011 floods. Investments in data are likely to have many applications beyond insurance, including the development of improved tools to support farm decision-making.

While drought insurance schemes have had mixed success to date, there remains some hope for the future. The emergence of "big data" collected from satellites and internet-enabled devices promises to revolutionise both farm production and risk management. In time, smart products underpinned by better data might finally help us solve the challenge of drought policy.

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Plastic is here, there and everywhere

By ALICE MASILI
ONE

It had to happen sooner or later: the ocean contains plastic, the fish contain plastic, and now the plastic also arrives in the water we drink, in cooking salt, in our bodies. Plastic is everywhere. Most of it ends up in the sea, where it disintegrates into very small ones with dimensions less than 5 mm, called microplastics. Aquatic life and birds can confuse it for food, thus passing into the food chain.

The presence of microplastics in the oceans is caused by the industrial production of non-recyclable plastic. The world plastic production has increased to over 280 million tonnes. The consequence is obvious: the more plastic is used, the more it is thrown directly or indirectly into the seas: at least eight million tons a year, according to Greenpeace. There are many elements that contribute to the deterioration of plastic in the sea, from the action of ultraviolet rays, wind, waves, to microbes and high temperatures. Furthermore, the chemical additives used during the production process also contribute to prolonging its fragmentation.

It has been quantified that plastic waste from the earth makes up about 80 percent of all plastic debris found in the environment. Water treatment plants are able to trap plastics and fragments of various sizes by oxidation tanks or sewage sludge, but unfortunately, a large portion of microplastics can overcome this filtering system, reaching the sea.

According to the latest report of the United Nations Environment Program (UNEP) every square kilometre of ocean contains on average 63.320 microplastic particles, with significant regional differences. For example, in Southeast Asia the level is 27 times greater than in other areas. The Mediterranean is one of the most polluted seas in the world: 7 percent of microplastics are concentrated here globally. In addition, there are five oceanic regions (called gyres) where, due to the currents, the largest amounts of debris accumulate: 35% of these micro-

Plastic Pollution covering Accra beach (Ghana). Photo: Muntaka Chasant fragments of plastic come from the washing of our clothing; the synthetic garments, which today represent 60% of global textile consumption, release large quantities of fibres, which from the domestic discharge pass into the purifiers, contaminating the food chain. According to the FAO (United Nations Food Fund) and the International Cotton Advisory Committee, consumption of synthetic fibres increased by 300% between 1992 and 2010. At the moment there are no complete scientific data on the exact quantity of microplastics that, from our sweaters or jeans, end up in the waters of the rivers after washing. But the available data are alarming.

A research directed by Mark Browne of the University College of Dublin in 2011 showed how a single garment can release more than 1,900 microfibres in a wash. A study by the University of Plymouth published in 2016 compared different fabrics and analysed a series of washing variables. Although not having obtained clear results with respect to the type of detergent and the addition or less of fabric softener, it emerged that, from the fully synthetic garments, more microfibers are detached: on a load of 6 kilograms, in fact, garments in mixed cotton and polyester fabrics releasing almost 138 thousand fibres, against over 496 thousand of the polyester and almost 729 thousand of the acrylics. Faced with this data, some large groups of clothing are trying to remedy before Europe set some limits.

Another significant source of microplastic particles is the wear and tear of tyres, the outer part of which consists of synthetic polymers mixed with rubber and other additives. The plastic fibres, released in the environment, are transported in marine environments by the action of wind and rains. Other plastics are intentionally designed to be small. They are called microspheres and are used in many products for health and beauty. Unchanged, they pass through the waterways in the oceans and are responsible for 2% of the total fragments.

Once at sea these substances are ingested by the fauna (in particular plankton, invertebrates, fish, gulls, sharks and whales) entering the food chain. In 2015, a first study showed the presence of microplastic in fifteen different types of salt in China. But if you think that the microplastics are found only in the oceans and in the fish, you wrong. Researchers at the Medical University of Vienna and the Austrian Environmental Agency have found that microplastic particles are present in human stool samples and in the gastrointestinal area, where they can promote transmission of pathogens or harmful chemicals to our body. The research, conducted on eight subjects, showed how everyone had eaten foods wrapped in plastic materials, as well as drinking water from still plastic bottles.

The research has been opposed by some scholars, who consider the data very limited. The biologist Martin Wagner of the Norwegian University of Science and Technology has indeed stated that the scale is small and not representative, therefore not reliable. Meanwhile, politics is moving with several laws that each state has introduced to solve the problem. Since 2015, combating marine pollution is one of the objectives of sustainable development (Sustainable development goals, SDG).

In December 2015, then-President Barack Obama signed the law prohibiting the intentional addition of small plastic balls in some cosmetics, such as toothpaste and skin creams. Although this law does not include all cosmetics, it has inspired other laws around the world. In fact, the United Kingdom has introduced the same ban by extending it even on adding microplastics to all cosmetic products. Italy has banned non-biodegradable cotton buds and has recently introduced the use of biodegradable bags in all commercial activities. On this, Ireland was one of the first European countries, introducing in 2002 a tax for each bag sold. Same measure adopted by Wales, Belgium and Denmark.

During the plenary meeting of 16 January 2018 in the European Parliament in Strasbourg, the European Commission presented its strategy to combat plastic waste. It establishes that all plastics packaging in the EU will need to be recyclable by 2030, the addition of microplastics is prohibited in all products and new legislation is proposed to limit single-use plastic consumption. The goal is to increase the recourse to reuse - which today is only 30 per cent of the total in the continent - and reduce the use of microplastics.

China, the largest plastic recycler in the world, has closed its doors to the importation of plastic from the rest of the world to focus on the one produced internally.Among the countries that have banned the use of plastic bags in the world, there are many African countries such as South Africa, Eritrea, Rwanda and more recently Kenya. Even India, where the problem of plastic fuels illegal fires, has banned the production of disposable plastic for about a year. ONE

Cyber-crime is smarter than energy

Technological innovation improves efficiency, but it also makes the energy sector more vulnerable to cyber-attacks.

By EUSEBIO LORIA
ONE

With the proliferation of smart grids, smart meters, "digital coal mine" and "digital oil fields," the global energy sector is becoming increasingly interconnected, automated and digitalised.

Cybersecurity has become a critical strategic priority to succeed in the digital transformation of the energy sector. Technological innovation improves efficiency, but it also makes the energy sector more vulnerable to cyber-attacks. Soon, Artificial Intelligence –AI will be the cutting edge of cybersecurity not only to detect but also to fight back against the attacks.

Thirty years ago, the world's first cyber attack paved the way to modern cybersecurity challenges. In November 1988, Robert Tappan Morris –graduated at Harvard, with Ph.D. in computer science at Cornell University- wanted to know how big the internet was and how many devices were connected to it. So he wrote a program, launched from computer to computer, asking each machine to send a signal back to a server, just to keep count.

That program became the first of a particular type of cyber attack called "distributed denial of service, DDoS," in which large numbers of Internet-connected devices are asked to address a lot of traffic towards one specific address, overloading it so much that the system shuts down and its network connections are completely blocked. In an era with few protective software installed, the Morris worm spread quickly. It took 72 hours for researchers at Purdue and Berkeley to halt the virus. It infected tens of thousands of systems – about 10 percent of the computers on the internet. The power industry is now entering a new age, the digital transformation age in the energy sector, which looks increasingly in danger of new "energy worms."

The ways we generate and use energy are changing, so that power systems are evolving and digital and software-based technologies are becoming central to keep the electric grid balanced and to enable connectivity and controllability, creating an "intelligent Internet of Energy."

Digitalisation is set to make energy systems more connected, intelligent, efficient, reliable and sustainable. Data is the new raw material of the power sector that can enforce a quicker access to pieces of information and also enable a faster decision-making process to optimize power systems exploitation. Data are growing at an exponential rate – internet traffic has tripled in only the past five years and around 90% of the data in the world today have been created in the last two years.

Christoph Frei, Secretary General of the World Energy Council, said: "What makes cyber threats so dangerous is that they can go unnoticed until the full extent of the damage surfaces, from stolen data and power outages to destruction of physical assets and great financial loss. Over the coming years, we expect cyber risks to increase further and change the way we think about integrated infrastructure and supply chain management."

Incident	Description
Usa, 2003*	'S lammer' was the fastest computer worm in history. In 2003 it attacked the private network at an idle nuclear power plant in Ohio, disabling a safety monitoring system for 5 hours. Five other utilities werw also affected
Shamoon 1 and 2 (Saudi Arabia, 2012 and 2016)**	"Shamoon 1" virus carried out cyber-sabotage and destroyed over 30 000 computers at Saudi Aramco.
Usa, 2012*	A US power utility's ICS was infected with the Mariposa virus when a 3rd-party technician used an infected USB drive to upload software to the systems. The virus resulted in downtime for the systems and delayed plant restart by approximately 3 weeks.
Netherlands, 2012*	A 17-year-old was arrested for breaching hundreds of servers. The servers were maintained by a telecommunications company providing smart-meter services to utilities.
Usa & Canada, 2013-2015*	This attack on a company that operates over 50 power plants in the US and Canada began through information stolen from a contractor. Hackers were able to steal critical power plant designs and system passwords.
South Korea, 2015*	Korea Hydro and Nuclear Power Co. Suffered a series of attacks aimed at causing nuclear reactors to malfunction. The attack only succeded in leaking non-classified documents.
Australia, 2015*	Hackers attacked Maitland office of the Department of Resources and Energy in New South Wales. The hackers may have been interested in the department's current projects, or may have viewed as a weak link to access more highly classified government information.
Western Ukraine power grid (2015)**	The first confirmed cyber-attack specifically against an electricity network.
Israel, 2016*	An employee of the Electricity Authority fell for a phishing attack, which infected a number of computers on the network with malware. The power grid was not affected but it took two days for the Authority to resume normal operation.
The Mirai Botnet (2016)**	"Mirai" malware exploited low security in connected smart devices, such as cameras, to use a botnet to deliver the largest DoS attack to date. This attack did not target or impact energy infrastructure, but illustrates the vulnerability of the Internet of Things (IoT).
Industroyer/Crash Override (Ukraine, December 2016 – reported May 2017)**	A second brief but significant attack on the Ukrainian electricity system, thought to have been a test run for malware "Industroyer" (also known as "Crash Override"). This was an example of a cyber intrusion into the control systems of critical infrastructure.
Nuclear plant spear phishing attack (US, 2017)**	This incident occurred in the United States. It used targeted email messages containing fake Microsoft Word résumés for engineering jobs, potentially exposing recipients' credentials for the control engineering network. The hackers also compromised legitimate external websites that they knew their victims frequented (known as a watering hole attack).
WannaCry (2017)**	"WannaCry" ransomware hit hundreds of thousands of computers in thousands of organisations in some 150 countries. These attacks did not target energy infrastructure, but several energy companies reported problems. In China, over 20 000 China National Petroleum Corporation (CNPC) petrol stations went offline.

*Sources: * World Economic Forum "Road to resilience: Managing cyber risks", 2016*
*** IEA Internationl Energy Agency, "Digitalization and Energy", 2017*

The electricity sector is the heart of digital transformation.

Traditionally, electricity is generated in large power plants, distributed through transmission and distribution networks and flowing one-way to end users in the residential, commercial, industrial and transport sectors. These nuclear, coal, or oil centralised plants are particularly at risk due to the "domino effect."

Nowadays, energy flows are multi-directional, distributed in intermittent renewable plants and linked to individual energy-production or consuming units– ranging from electric vehicles (EVs) to wind farms and rooftop solar systems. Government policies will play a vital role in helping to set up a more secure, more sustainable, and smarter energy future.

Is digitalisation making the energy system more vulnerable? To date, the breakages caused to energy systems by cyber-attacks have been relatively few. However, cyber-attacks are becoming more accessible and cheaper, as the digitalized devices are catching on.

The growth of the Internet of Things (IoT) is increasing the potential "cyber-attack action-range" in energy systems and as a consequence "digital resilience" needs to be included in technology research and development efforts as well as into policy strategy and markets.

What does it mean to be security resilient?

Digital energy security is ensured by a system both flexible and stable. To date, the U.S. National Institute of Standards and Technology (NIST) has identified around 60,000 cyber-vulnerabilities. New threats are discovered every day.

A recent report published by the World Energy Council reveals that oil and gas industries alone spend nearly USD 1.9 billion a year on cybersecurity. The number of connected IoT devices has to grow from 8.4 billion in 2017 to over 20 billion by 2020. Globally, the cost of a cybercrime "to be done" will reach 2 trillion US$ by the end of 2019.

How digitalisation impacts the energy sectors?

Global investment in digital electricity devices, infrastructures and software has grown by over 20% annually since 2014. The most revolutionary changes from digitalisation could be seen in road transport. Automated, Connected, Electric and Shared (ACES) mobility will play a key role in our future, reducing road's energy use by 20-25%.

Electricity use in buildings is also set to nearly double its figures - from 11 petawatt hours (PWh) in 2014 to around 20 PWh in 2040. Cumulative energy savings over the period to 2040 would amount to 65 PWh – equal to the total final energy consumed in non-OECD countries in 2015.

Digital technologies have also had an impact in the manufacturing industry. Technologies such as industrial robots and 3D printing are becoming standard practice in specific industrial applications. Deployment of industrial robots is expected to continue to grow rapidly, with the total number of robots rising from around 1.6 million units at the end of 2015 to just under 2.6 million at the end of 2019.

Digital technologies are being used throughout the coal supply chain to reduce production and maintenance costs and enhance workers' safety. Examples include automated systems, robotic mining, remote mining, and the use of global positioning system (GPS) and geographic information system (GIS) tools.

In the long term, one of the most important potential benefits of digitalisation in the power sector is the possibility of extending the operational lifetime of power plants and network components, improving maintenance. The digital world is made for and by a digital brain.

Can cyber-security be smarter than the digital brain?

Cyber resilience in the energy industry is not an option. It is not just about preventing and minimizing risk; it is about delivering a higher quality product and more reliable service. The energy sector is evolving rapidily, and its cybersecurity has to grow at the same speed.

More and more companies are turning to cyber Artificial Intelligence. By deploying AI solutions across energy networks, it is possible to detect and defeat an attack before it becomes serious. There are no alternatives.

A very high amount of data signals a less resilient energy sector. A loss of information is a concern, but an electrical failure can be a disaster for the society. Energy companies are already aware of that. Shortly all of us will be aware too.

Porto Flavia: where wilderness meets design

Photo: ONE

"This is not a coal mine but a sea harbour," this is how the Sardinian Geopark guides typically introduce Porto Flavia to tourists and visitors. The site has so many virtues and strong points that there is no need to add anything else.

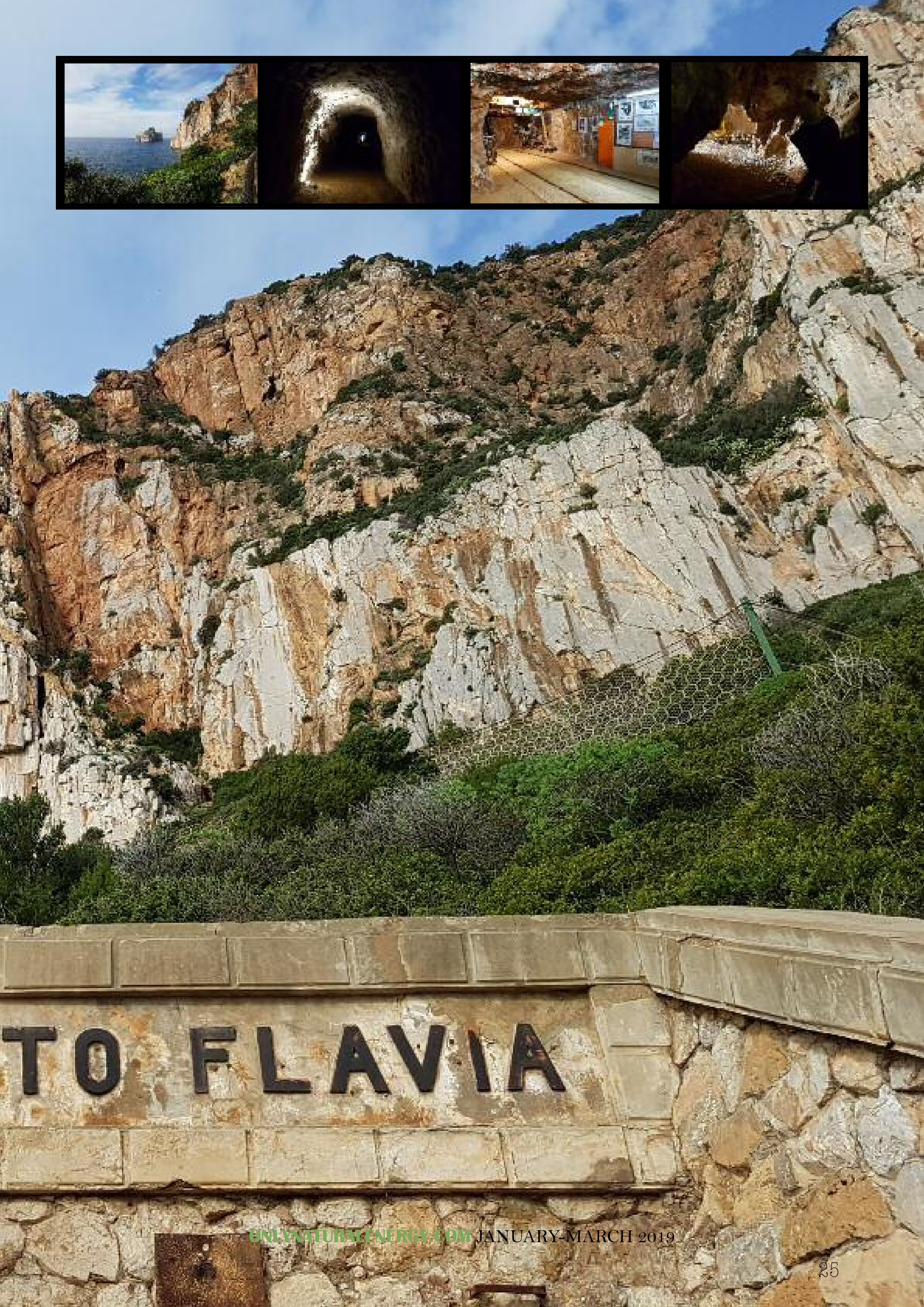
Porto Flavia is a rare combination of [natural] beauty with brains. Rare indeed. Hardly you can find another place which happens to be revered as a monument to the coal industry heritage and also as a totem of uncontaminated nature and a symbol of the human talent in the designing and engineering fields.

Built in two years, between 1922 and 1924, in the South-West coast of Sardinia, next to the now abandoned Masua village, Porto Flavia it was the solution provided by the Italian engineer Cesare Vercelli to the mining companies' request to ensure quicker and safer ways to load boats with the mineral extracted in the Sulcis area. Vercelli explored the coastline, studied local winds and tide and found the right spot just opposite the Pan di Zucchero cliff, which could act as a natural shelter capable to protect ships from the dominant Mistral wind and allow a quicker and safer loading activity, just as required.

Finding the right location was decisive but only half of the task. The second part involved the designing of two 2,000 ft tunnels, linked between themselves by nine vertical reservoirs. The two tunnels were the missing link between the railway and the sea - the mineral carried by trains was unloaded by gravity from the upper cave to reach the 52 ft conveyor belt in the lower tunnel that would load the coal directly on the ship.

Virtually inactive since the 60s, it has become a UNESCO-protected site and one of the most appreciated destinations amongst industrial archeology tourists. Flavia was the name of Cesare Vercelli's daughter, born a few weeks before the harbour opening. ONE

Photo: ONE


TO FLAVIA

Next-gen Nukes

Scores of nuclear startups are aiming to solve the problems that plague nuclear power.

By NATHANAEL JOHNSON
Grist.org

Isar Nuclear Power Plant at night. Photo: Bjoern Schwarz

Back in 2009, Simon Irish, an investment manager in New York, found the kind of opportunity that he thought could transform the world while — in the process — transforming dollars into riches.

Irish saw that countries around the globe needed to build a boggling amount of clean-power projects to replace their fossil fuel infrastructure, while also providing enough energy for rising demand from China, India, and other rapidly growing countries. He realized that it would be very hard for renewables, which depend on the wind blowing and the sun shining, to do everything. And he knew that nuclear power, the only existing form of clean energy that could fill the gaps, was too expensive to compete with oil and gas.

But then, at a conference in 2011, he met an engineer with an innovative design for a nuclear reactor cooled by molten salt. If it worked, Irish figured, it could not only solve the problems with aging nuclear power, but also provide a realistic path to dropping fossil fuels. "The question was, 'Can we do better than the conventional reactors that were commercialized 60 years ago?" Irish recalled. "And the answer was, 'Absolutely.'"

Irish was so convinced that this new reactor was a great investment that he bet his career on it. Nearly a decade later, Irish is the CEO of New York City-based Terrestrial Energy, a company that expects to have a molten-salt reactor online before 2030. Terrestrial is far from alone.

Dozens of nuclear startups are popping up around the country, aiming to solve the well-known problems with nuclear power — radioactive waste, meltdowns, weapons proliferation, and high costs.

There are reactors that burn nuclear waste. There are reactors designed to destroy isotopes that could be made into weapons. There are small reactors that could be built inexpensively in factories. So many ideas! To former Secretary of Energy Ernest Moniz, an advisor to Terrestrial, it feels as if something new is underway. "I have never seen this kind of innovation in the sector," he said. "It's really exciting."

Other reactors, like Terrestrial's molten-salt-cooled design, automatically cool down if they get too hot. Water flows through conventional reactors to keep them from overheating, but if something halts this flow — like the earthquake and tsunami in Fukushima — the water boils off, leaving nothing to stop a meltdown.

Unlike water, salt wouldn't boil off, so even if operators switched off safety systems and walked away, the salts would keep cooling the system, Irish said. Salts heat up and expand, pushing uranium atoms apart and slowing down the reaction (the farther apart the uranium atoms, the less likely a flying neutron will split them apart, triggering the next link in the chain reaction).

"It's like your pot on the stove when you are boiling pasta," Irish said. No matter how hot your stove, your pasta will never get hotter than 212 degrees Fahrenheit unless the water boils off. Until it's gone, the water is just circulating and dissipating heat. When you replace water with liquid salt, however, you have to get to 2,500 degrees Fahrenheit before your coolant starts to evaporate.This stuff can sound like science fiction — but it's real. Russia has been producing electricity from an advanced reactor that burns up radioactive waste since 2016.

China has built a "pebble bed" reactor that keeps radioactive elements locked inside cue ball-sized graphite spheres.
In 2015, to keep track of the startups and public-sector projects working on trying to provide low-carbon energy with safer, cheaper, and cleaner nuclear power, the centrist think tank, Third Way, started mapping all of the advanced nuke projects across the country. There were 48 dots on the first map, and now there are 75, spreading like a candy-colored case of measles.

"In terms of the number of projects, the number of people working on it, and the amount of private financing, there isn't anything to compare it to unless you go back to the 1960s," said Ryan Fitzpatrick who works on clean energy for Third Way. Back then, just after Walt Disney released the film "Our Friend the Atom" promoting nuclear energy, when the futuristic notion of electricity "too cheap to meter" seemed plausible, electric utilities had plans to build hundreds of reactors across the United States.

Why is this all happening now? After all, scientists have been working on these alternative types of reactors since the beginning of the Cold War, yet they've never caught on. The history of advanced reactors is littered with the carcasses of failed attempts. A salt-cooled reactor first ran successfully back in

A recent study from the Energy Innovation Reform Project estimated that the latest batch of nuclear startups could deliver electricity somewhere between $36-90 a megawatt hour. That's competitive with any power plant that runs on natural gas (which runs between $42-78).

1954, but the United States opted to specialize in water-cooled reactors and defunded other designs. But something fundamental has changed: Previously, there was no reason for a nuclear company to pony up the billion dollars needed to get a new design through the federal regulatory process because conventional reactors were profitable. That's not true anymore.

"For the first time in half a century, the incumbent nuclear players are in financial distress," Irish said.

Recently, the United States' bet on conventional water-cooled reactors has been going bad in very expensive ways. In 2012, South Carolina Electric & Gas got permission to build two huge conventional reactors to generate 2,200 megawatts, enough to power 1.8 million homes, promising to have them up and running sometime in 2018. Electricity users saw their bills jump 18 percent to pay for the construction, which soon ran into delays. Last year, after sinking $9 billion into the project, the utility gave up.

"The most recent builds in the United States have been a disaster, largely due to poor on-sight construction practices," said John Parsons, codirector of MIT's Low-Carbon Energy Center for Advanced Nuclear Energy Systems.

Similar stories have played out abroad. In Finland, construction of a new reactor at the Olkiluoto power plant is eight years behind schedule and $6.5 billion over budget. In response, these nuclear startups are designing their businesses to avoid horrible cost overruns. Many have plans to build standardized reactor parts in a factory, then put them together like Legos at the construction site. "If you can move construction to the factory you can drive costs down significantly," Parsons said.

New reactors could also reduce costs by being safer. Conventional reactors have a fundamental risk of meltdown, largely because they were designed to power submarines. It's easy to cool a reactor with water when it's in a submarine, underwater, but when we lifted these reactors onto land, we had to start pumping water up to cool them, Irish explained. "That pumping system can never, ever break, or you get a Fukushima. You need safety system on top of safety system, redundancy on top of redundancy."

Oklo, a Silicon Valley startup, based its reactor design on a prototype that isn't susceptible to meltdowns. "When engineers shut off all the cooling systems, it cooled itself and then started back up and was running normally later that day," said Caroline Cochran, Oklo's cofounder. If these safer reactors don't require all those backup cooling systems and concrete containment domes, companies can build plants for much less money. Technologies often fail for a long time before succeeding: 45 years of tinkering passed between the first electric light and Thomas Edison's patent for an incandescent bulb. It can take decades for the engineering to catch up to the idea. Others have tried seemingly every idea for advanced nuclear in the past, Parsons said. "But science has moved forward," he said. "You have much better materials than you did a few decades ago. That makes it believable these things could work."

A recent study from the nonprofit Energy Innovation Reform Project estimated that the latest batch of nuclear startups could deliver electricity somewhere between $36 and $90 a megawatt hour. That's competitive with any power plant that runs on natural gas (which runs between $42 to $78), and would provide a viable alternative to fossil fuels.

In a best-case scenario, nuclear power could be even cheaper. There are projections a study like this can make based on, say, an improved design that cuts construction costs, but it can't anticipate revolutionary advances.

"Hopefully these designers will come up with much more radical reductions in cost — you would like energy to be more accessible to a billion more people — so that nuclear becomes a cheap alternative that can beat natural gas even if there's no carbon price," Parsons said. "That's just a hope, but that's what entrepreneurs are supposed to do."

Matthew Bunn, a nuclear expert at Harvard, said that if nuclear power is going to play a role in fighting climate change, these advanced nuclear companies will have to scale up insanely fast. "To supply a tenth of the clean energy we need by 2050, we have to add 30 gigawatts to the grid every year," he said. That means the world would have to build 10 times as much nuclear power as it was before the Fukushima disaster in 2011. Is that even realistic? "I think we ought to be trying — I'm not optimistic," Bunn said, noting that the pace at which we'd need to build solar and wind to quit fossil fuels is just as daunting. Big barriers remain in the way of a nuclear renaissance.

It takes years to test prototypes and get approval from federal regulators before a company can even start construction. "In order for advanced nuclear technologies to play a role in deep decarbonization over the next several decades," the United States would need to overhaul the way it's rolling out the technology, according to a study published earlier this month in the Proceedings of the National Academy of Sciences.

Experts point to many of the same steps to give advanced nuclear a fighting chance: Making regulations more friendly to innovation, instead of favoring conventional reactors. Creating incentives to reward utilities for buying low-carbon power. And a lot more funding. The people behind the new crop of nuclear companies think they can get to market much faster with the right help. Oklo is shooting to have a commercial reactor online before 2025.

"Can we decarbonize quickly with nuclear? France did it, it can be done," Cochran from Oklo said. "Our reactors are 500 times smaller than the [latest conventional reactors], they have all these inherent safety characteristics, and they can consume nuclear waste. Will our application process be any shorter?".

Lowering these barriers would be cheaper than letting the government pick one promising idea and coddle it like a privileged child, which is the way we've treated conventional nuclear in the past, said Jessica Lovering, who studies nuclear power at the Breakthrough Institute, a pro-technology environmental think tank."We could pick one idea, spend a lot of money helping it become commercial, and then subsidize every project for even more money," Lovering said. "Or, we could invest a much smaller amount of money across the entire innovation system."

Still, it could easily take the advanced nuclear projects 30 years to get through regulatory review, fix the unexpected problems that crop up along the way, and prove that they can compete, said Dan Kammen, who studies clean energy at the University of California Berkeley. And by then Kammen thinks there will be other options in competition: Electric storage is getting better, and fusion could have a breakthrough.

"Ultimately on a planet with 10 billion people, some amount of large, convenient, affordable, safe baseload power — like we get from nuclear fission, or fusion — would be just hugely beneficial," Kammen said. "There are other competitors in view on the straight solar side that 10 years ago sounded like science fiction — space-based solar, transparent solar films on every window. That world works, too."

At this point in history, everything is a longshot. We've got to completely replace our energy system on the fly. To do that, people are planting a lot of different seeds. It's still a long time until harvest, but we're seeing a flush of new sprouts from the advanced nuclear section of the garden. This new flush of nuclear possibility has excited young people who see nuclear as a way to shift away from fossil fuels. College students are gravitating toward nuclear engineering. The number of students studying the subject cratered when the nuclear industry collapsed in the late 1970s (the Three Mile Island accident in 1979 didn't help), but it has been creeping steadily higher since the early 2000s. Some of those students are going on to start their own advanced nuclear companies. David Schumacher, a documentary filmmaker, met some of these young people and became so infected with their enthusiasm that he made a documentary about them, The New Fire, which came out last year.

"They are truly idealistic young people trying to save the planet by doing something really important but really unpopular," Schumacher said. "They could be making a lot of money elsewhere, but instead they are starting these nuclear companies, knowing they are going to be maligned."
It's a feeling Simon Irish, at Terrestrial Energy, is familiar with. "The views on nuclear are so negative," he said. "The great win is simply to persuade busy people to listen."

While Terrestrial battles public opinion, Irish said his company has been hitting every milestone on time. Canadian regulators announced last year that Terrestrial had completed the initial stage of its design review — the first step toward approval in that country. Irish has already selected sites in Ontario where Terrestrial could build the first reactors. Although Irish was mum on Terrestrial's other milestones, he did describe an experience that he said gives him more confidence in the company's prospects than any of its other accomplishments so far.

Last August, he found himself in the office of a prominent New York investor, a major contributor to environmental organizations. Getting the meeting had been a challenge — again because of the controversy around nuclear. But by the end, Irish had convinced the businessman that renewables and nuclear could not just coexist but compliment each other.

In Irish's telling, he was in the middle of explaining Terrestrial's reactor design when the man stopped him and said, "'Hold on, this can deliver heat! The industrial sector needs heat, and wind and solar aren't making any dent in that at all.'

"As far as he was concerned," Irish said, "this was the great missing piece."

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Photo: Lifeline Energy.org

Is clean energy funding from the UN's green climate fund and other sources going where it's needed most?

By JOHN VIDAL

Ensia

Most of rural Africa still has no electricity, and tens of millions of families must cook on open fires and light their homes with candles or a kerosene lamps. But change is coming, at least in several hundred villages in southern Zambia.

Project FP080 is a US$154 million scheme intended to benefit 300,000 people and avoid emissions of 4 million metric tons (4.4 million tons) of carbon dioxide by connecting villages to a series of new solar and hydropower plants within five years. It should also mean children will have a better chance to pass their exams because they can study in the evenings, houses will be less likely to catch fire, and there will be more chance of economic development.

Project FP080 is one of the 93 clean energy and climate adaptation schemes so far approved by the United Nations' Green Climate Fund (GCF), a financial mechanism set up in 2010 to collect and distribute the projected US$100 billion per year that rich countries have pledged to developing countries to help them mitigate and adapt to climate change.

Approved in March 2018 by the GCF board, FP080 brings together public and private money from multilateral development banks, European and African energy companies, national pension funds, and the Zambian government. Some of the money is in the form of grants. The rest is in a complex mix of loans, bonds, equity and guarantees. The GCF is one of the great new hopes for the world's poorest countries to be able to access money for clean energy. It had a slow and torrid start, with rich countries backsliding on their pledges to fund it and poor countries bitterly complaining that international banks control the funds for their own profit.

Last year U.S. President Donald Trump canceled US$2 billion of the US$3 billion promised to the GCF by former President Barack Obama. More recently, Australia, too, has chosen not to contribute. ill, today the GCF says it is increasing the number of projects it is backing and is speeding up assessment of new applications."We now have 93 projects, worth US$4.6 billion. Thirty-nine projects, worth US$1.6 billion in GCF resources, are under implementation, and we expect to have disbursed around US$483 million by the end of the year," says Simon Wilson, head of communication in the external affairs division of the Korea-based operation. "Demand for climate finance already exceeds supply, and disbursement of funds for energy projects is expected to pick up quickly over the next few years."

But are funds going where they're needed most? And what types of energy projects are they encouraging? The answers to those questions will play a big role in determining the resilience and climate impacts of energy development in emerging economies.

Least Developed, Least Funded

In theory, there has never been a better time for developing countries to install clean energy. In addition to the GCF, the African, Asian and American development banks; the European Bank for Reconstruction and Development (EBRDF); the European Investment Bank and the World Bank Group have all said they intend to significantly increase their green energy financing, offering developing countries cheap loans and grants. Many donor countries have also pledged to help poorer nations switch to clean energy. But as diplomats and NGOs from some 190 countries will hear at the U.N. climate summit in Katowice, Poland, in December, the reality is that the new streams of public climate finance like the GCF are not nearly enough to meet the demand for clean energy infrastructure. That means a need to fund clean energy projects from the private sector — where commercial banks, motivated by profit, are loath to provide money to developing countries for what they consider risky projects.

"For a [clean energy] proposal to be accepted by a bank, it needs hard data and a wealth of detail," says Nathan Rive, a climate change specialist with the Asian development bank. "However, in many developing countries data on energy and emissions is sparse, unavailable or unreliable, making detailed project-specific climate assessments difficult. Other countries do not have adequate monitoring or evaluation systems to keep track of projects."

The resulting bias toward more developed countries is stark. Of the roughly US$333 billion estimated by financial research group Bloomberg NEF to have been invested worldwide in renewable energy in 2017, nearly US$280 billion went to China, the U.S., Canada, Europe, Japan and Australia. A handful of middle income countries like Mexico and South Korea. India, Brazil and Egypt absorbed a further US$28 billion. The remaining countries attracted just about US$25 billion among them, despite having over one-third of the world's population.

In fact, consultants working with ministers and banks to raise clean energy finance say the world's 47 least developed countries and the 39 small island developing states are barely on the financial map. "There are major challenges in reaching least developed countries (LDCs) and small island developing states (SIDs), due to a lack of sophisticated capital. As a result of this …. renewable energy projects tend to be located in middle-income countries," says Virginie Fayolle, a senior economist who leads climate finance at Acclimatise, a U.K.-based consultancy which has advised the governments of Swaziland, Bangladesh, Guyana and other developing countries on how to access climate finance.

Infrastructure Challenges

The nature of energy infrastructure needs affects willingness to invest as well. Developing countries require a higher level of investment in infrastructure, such as small-scale, off-grid and decentralized projects, to reach more remote populations, says Ming Yang, a senior climate change specialist at the Global Environment Facility (GEF), which has provided more money for small-scale electrification in developing countries than any other funder in the past 30 years. Between October 1991 and August 2017, the GEF granted US$1.19 billion to 254 renewable energy projects. Of these, 43 percent are microgrids, mini-grids or decentralized, says Yang. The problem, he says, is that financing clean energy for the poorest is getting harder, and new technology systems and financial instruments are needed. "Electric companies and energy suppliers [may] defer expanding access to economically disadvantaged areas because it is not perceived as financially viable," says Yang.

"National planners [in developing countries] hesitate to promote renewable energy–based micro-grids because they are thought relatively more expensive than fossil-fuel energy technologies. For a variety of social and political reasons, government agencies also give higher priority for expanding access for urban, rather than rural, areas."

Wilson says over 40 percent of the GCF's projects are micro- or small-scale investments of under US$250,000, and there is no preference for large projects over smaller ones. But Neha Rai, a senior researcher at London-based International Institute for Environment and Development (IIED) says little of international climate money is funding decentralized energy. "Of the US$14 billion approved so far for climate finance, about 40 percent, or US$5.6 billion, has been marked for energy projects. But only 3 percent (US$475 million) has been allocated for decentralized energy. That is the equivalent of just US$51 million a year between 2006 and 2015, the period for which data on clean energy finance is available," she says.

Climate Catch-22

Ironically, climate change may be making it even harder for developing countries to raise money for renewable energy projects. Particularly vulnerable ones, such as Bangladesh and small island states, must pay more to borrow because climate change is regarded by banks as an extra financial risk, according to a new U.N. Environment Programme–backed study. Researchers who examined the financial data of 48 developing countries, including Bangladesh, Guatemala, Kenya and Vietnam, found that vulnerable countries have had to pay an extra US$62 billion for capital over the past 10 years. "Climate vulnerability has already raised the average cost of borrowing to developing countries through higher interest rates. We expect the additional interest payments attributable to climate vulnerability to increase to between US$146 and US$188 billion over the next decade," says Charles Donovan, director of the Centre for Climate Finance at Imperial College Business School.

Solutions

lWithout more clean energy funding, say non-government groups including Third World Network, U.S. Climate Action Network and Greenpeace International, it's unlikely that most developing countries will be able to meet their commitments made in Paris in 2015 to reduce CO2 emissions, adapt to climate change and meet the U.N. goal of providing electricity to the 1 billion people presently without it.

"The problem is not that there is not enough money. It is lack of political will. There is definitely institutional bias against poor countries when it comes to sustainable energy," says Lidy Nacpil, coordinator of the Asian Peoples' Movement on Debt and Development (APMDD)."We see renewable energy as a public good and say that governments and international financial institutions should use public funds not to guarantee and absorb the risks of the private sector, but to take the lead in developing democratic renewable energy systems."

Developing countries must fight for every dollar of climate cash. Larger ones, like Bangladesh and Ethiopia, have the human resources and technical data to convince the funding bodies of their case. Egypt has been one of the most successful countries to access money for clean energy projects, thanks to government commitment to economic reforms and its potential for wind and solar. By 2019, 37 square kilometers (14 square miles) of desert near the village of Benban, outside Aswan, should be covered with solar panels — potentially one of the world's largest solar parks.

Yasmin Fouad, environment minister of Egypt, is cautiously optimistic. "It's never been easy for countries like Egypt to raise money for clean energy," she says. "But we now have three projects with the GCF and will be submitting more. It's not easier to raise the money, but we can say the situation is getting a bit better."

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Photo credit: Discovod

SAO DOMINGOS

The São Domingos Mine is an abandoned open-pit mine in Alentejo's Corte do Pinto, the first place in Portugal to have electric lighting.

The Romans mined in the São Domingos area for gold and silver for about four centuries, and mining stopped in AD 439 when they the Roman domination ended.

In 1857 the Italian explorer Nicola Biava claimed mining rights for the site, which became strategic due to the growing international demand for copper. The mining concession went to the Mason&Barry mining company. The most visible sign of those years under English control is the British cemetery still in place, where managers and workers are buried. The mine was closed in 1966. ONE

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