ONE

Only Natural Energy

From Dust Bowl to Climigration

Ring out the old, ring in the new

The green and the black

Big Green Apple: forbidden fruit, no more

Wind blows, hydrogen goes

YEAR VII - NUMBER 1 - JANUARY-MARCH 2021

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Ozama River in Santo Domingo (Dominican Republic). Floods up to 20 feet occur several times a year.
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ZEROe is an Airbus concept aircraft. In the blended-wing body configuration, two hybrid hydrogen turbofan engines provide thrust. The liquid hydrogen storage tanks are stored underneath the wings. Photo credit: Airbus 2020

Ring out the old, ring in the new

GIANNI SERRA
ONE

Now is the time to plant the seeds of innovation. The pandemic has been too global and too prolonged to be considered just one of those temporary situations.

Better to forget the let's-get-back-to-2019 prayers. They are filled with hopes of bringing back the the old routine of long-haul business flights, meeting rooms packed with people more focused on reading emails on their laptops than on listening to the people next to them. The Covid-19 exposed many truths and inconvenient habits of the old normality - why waste time and energy to preserve such a monumental and senseless play? Time to change the script.

But any change brings with itself a resistance. Think of people reluctant to wear face masks despite all the evidence of its crucial role to prevent the virus from spreading. Online learning vs school lessons, office meetings vs videoconferencing, fossil fuels vs renewables, Toyota vs Tesla. The gain of some is the loss of others.

Many sectors, organisations and firms are just expecting to restart the same business they had before the pandemic. All they need is to survive this bad patch. We have airline companies bombing the market with heavily discounted deals to get enough money to lead their business model untouched out of the storm. Whereas a few forerunners are already designing new layouts of aircraft or airports, assuming the past is in the past and the future is now.

Not only aviation is at a crossroad with opposite visions and strategies. The car sector is another visible example. Akio Toyoda, the grandson of Toyota's founder Kiichiro Toyoda, is the head of the Japan Automobile Manufacturers Association. In December, the Toyota President and CEO made headlines with some comments over the intention of the Japanese government to ban combustion-engined vehicles by 2035. "Japan would run out of electricity in the summer if all cars were running on electric power. And the more EVs we build, the worse the carbon dioxide emissions get. When politicians are out there saying, 'Let's get rid of all cars using gasoline,' do they understand this?"

Call it delaying the inevitable. In Norway, the market share of electric vehicles in 2019 was already nearly 43 per cent. The price gap between gasoline-powered vehicles and electric cars is narrowing, even if not as rapidly as some expected. But when a giant refuses to accept the evidence, the only certainty is that its fall will make a more noticeable and louder impact. To win any challenge you need to recognise it first. ONE

Barh Super Thermal Power Station (India).
Photo credit: Abhinav Paulite

The green and the black

India's green power revolution cannot afford to ignore coal

TOBY LOCKWOOD

ONE

As the profound global impact of Covid-19 continues to unfold, those whose job it is to forecast the future have had to scramble for their calculators. This has proved just as true for the widely cited projections of global energy use provided by the International Energy Agency's World Energy Outlook (WEO), which saw its 2020 edition released in October.

These long-term outlooks usually feature incremental changes from one year to the next, but the central 'Stated Policies Scenario' of WEO 2020 included some major revisions, due to a combination of the Covid-induced drag on demand growth and the ongoing rise of wind and solar power. Coal power has been on the receiving end of both impacts, with the result that its trajectory to 2040 has been flipped from a modest increase to a 10% decline in total generation.

Nowhere was this reassessment more pronounced than in the numbers for India: whereas a year ago nearly an additional 190 GW of coal was expected to come online by 2040, now only around 30 GW is added in the central scenario. This is partly down to a worrying 15% downgrade in the country's electricity growth over the period, but also to the appearance of an additional 100 GW of solar power.

In January last year, the government announced an ambitious target of 450 GW of renewable energy by 2030, building on an earlier goal of 175 GW by 2022 – the vast majority of both targets consists of solar and wind power. Although both these sectors are burgeoning, only around 40 GW of both sources is currently installed, and there is clearly much work to be done. Indeed, the latest WEO sees India fall somewhat short of its 2030 ambition, before projecting a meteoric rise to 840 GW of wind and solar over the following decade.

Where do these lofty ambitions for renewables leave coal?

With over 260 GW of coal capacity in 2040, India would still boast the world's second largest coal fleet after China.

This coal power is not merely an inconvenient relic of a time where growth trumped climate goals, but an essential component of India's energy mix which is hard to replace. Owing to limited domestic natural gas reserves, gas power has never been seen as a viable option for the country, and growth in nuclear power is expected to be slow.

Coal will continue to make a vital contribution by providing back-up power, and will doubtless be required to run at full steam during evening periods of peak demand. For the time being, a coal phase out of the kind seen in Europe is simply not on the cards.

There is a risk that this diminished role for coal power will encourage neglect of a sector which still looms so large in India's future. Not all coal power is alike, and there is considerable room for improvement in India's fleet, made up largely of inefficient generating units with little in the way of pollutant controls. This capacity can either be left alone, or invested in and transformed into a cleaner, modern fleet, fit for the demands of the next two decades and beyond. While the Government of India seems willing to take on this mission, the country's thermal generating companies are currently faced with a perfect storm of challenges. Investing in new, cleaner power plants or modernising existing units is difficult when the same plants are facing a future of playing second fiddle to renewables – reduced operating hours means reduced income. Compounding this, India's electricity distribution utilities or 'discoms' are cash strapped due to highly regulated retail tariffs and huge losses within the transmission system. They are therefore not in a good position to buy coal power at a premium.

At the forefront of India's drive to clean up coal are revised emissions regulations introduced in 2015, which have required nearly all units to install costly equipment to remove harmful sulphur dioxide gas.

This equipment has long been standard for plants in Europe and North America, and in China since 2012. Although the new regulations are gradually bearing fruit, much of the industry has been slow to respond, pushing back the compliance deadline to 2022 and still looking for clarity over how their in-

Panoramic View of Hirakud Dam at Sambalpur (India).
Photo credit: Quarterback

vestment can be recouped. Accompanying regulations for nitrous oxide emissions have been successfully challenged and watered down for all but the most recently built plants. On top of this, coal plants face escalating costs from turning their output up and down in response to renewable generation.

This kind of 'flexible' operation reduces efficiency and increases operating costs, while placing increased strain on equipment which ultimately reduces its lifespan. By 2030, it is thought that around a third of the country's coal plants will have to make major shifts on a daily basis, playing havoc with hardware designed to operate continuously.

Regulators are currently grappling with how to compensate this kind of operation within India's highly regulated wholesale market. Since 2017, India's government has mandated that all new coal units should adopt more efficient 'supercritical' technology as a minimum, and a cohort of state-of-the-art 'ultrasupercritical' plants is under construction around the country.

However, given the limited need for new capacity, further use of these technologies will require a more concerted effort to close older units and replace them. At the very least, many of these inferior plants will require extensive overhauls to get them running more efficiently. Such an approach would echo China's aggressive overhaul of its dirty coal fleet in the 2000s. But investment on this scale is also a difficult prospect against the backdrop of the sector's bleak finances.

Ultimately, the extent to which India's coal fleet can be transformed into a less embarrassing partner for renewables will depend on a willingness to invest and, most importantly, cultivation of a better environment for investment in cleaner coal power.

This may be politically unpalatable, but can be seen as merely the other side of the coin in the country's drive to create its new, largely solar-powered grid.

A viable market for modernising India's coal plants must first aim to express the true value of this flexible power source to India's electricity supply; still more, it should endeavour to place a value on cleaner coal – in cleaner air, public health, and reduced carbon emissions. ONE

Big Green Apple: forbidden fruit, no more

EUSEBIO LORIA
ONE

The science behind climate change is self-evident: the burning of fossil fuels is the largest contributor to human-caused climate change. Climate change is a worldwide emergency, and national policies are essential to curb greenhouse gas emissions and implement actions and laws.

On April 22nd, 2019 – Earth Day – Bill de Blasio, New York City mayor, has announced the NYC Green New Deal, an audacious plan of $14 billion in new investments and actions that should ensure a nearly 30 per cent reduction in emissions by 2030.

The purpose is to curb both the temperature rise and the persistent opposition of die-hard fans of the fossil fuel era. In November, the US, the second-largest polluting country in the world, left the Paris climate agreement. The president-elect of the United States Joe Biden was quick to reassure everyone that Washington would rejoin the deal.

But New York City has its own agenda. On the very same day, the US left the Paris agreement, the city that never sleeps published an update on the OneNYC 2050 - Building a strong and fair city in the 21st century strategy. The report incorporates a vision of New York City three decades from now when the city will have a livable climate and a leadership role in fighting climate change both at home and abroad.

Central Park, Manhattan, New York City. Photo credit: Ajay Suresh

The launch of the OneNYC strategy in 2015 highlighted the link between climate action and inclusive growth through the introduction of equity into the city's long-term planning. Tackling climate change requires a new social agreement to invest in communities, promote an inclusive economy, support human rights defence, public health and economic prosperity for all citizens. The NYC multifaceted strategy for action is ambitious and far-reaching. It aims to achieve carbon neutrality by 2050 in an equitable way, encompassing several sectors: buildings, transport, energy, communications, water, wastewater, and waste management.

This strategy is an investment against the real threat of rising temperatures and flooding, which threaten the city's livability. In the US and in New York too, extreme heat is the number one cause of mortality related to weather conditions. Destructive storms are also dangerous: in 2012, Hurricane Sandy killed 44 people and caused $19 billion in damages. Unfortunately, extreme weather events are likely to happen more frequently. In 2018, the United Nations Intergovernmental Panel on Climate Change (IPCC) concluded that the world has as few as 12 years to keep the global temperature rise under the 1.5 degrees Celsius limit. Beyond this level of warming, the impact of climate change could be catastrophic and irreversible.

On the world's current trajectory, by the 2050s NYC will see average temperatures increase by up to 3.2 degrees Celsius. Even though NYC already has a smaller per-capita carbon footprint than any big city in the United States, the release of 1.5°C: Aligning New York City with the Paris Climate Agreement (2017), provided a plan to reach carbon neutrality - 100 per cent clean electricity resources. Key passages included the complete electrification of the city and the ban of inefficient all-glass buildings. At the time of writing, these measures are in place in more than 1600 municipal buildings. The Retrofit Accelerator and Community Retrofit programs supported the complete energy retrofit of nearly 5000 privately-owned buildings.

The city also runs the largest electric municipal fleet in the nation, with more than 1750 electric vehicles (EVs), and is on track to meet the Clean Fleet goal of 2000 EVs by 2025. New York has also experienced significant growth in solar power - since the beginning of 2014, installed solar capacity has increased sevenfold. Not only has NYC reduced emissions, but it is also now safer and more resilient, which is crucial to face the challenges ahead for the most influential metropolis of the planet. By 2050, the world's urban population will increase by 2.5 billion people. And 60% of the buildings that will exist in 2050 have not been built yet. By 2060, the total floor area of buildings will double, with most of this new construction expected in Asia and Africa. New York must lead by example. Nearly two-thirds of the industry's emissions are associated with the production and delivery of building materials - cement, steel, and a range of petrochemical-based and rubber materials. Despite the adoption of lower-carbon fuels, the substitution of cement clinker and the application of carbon capture and storage in materials production, emissions from the industry sector will keep growing.

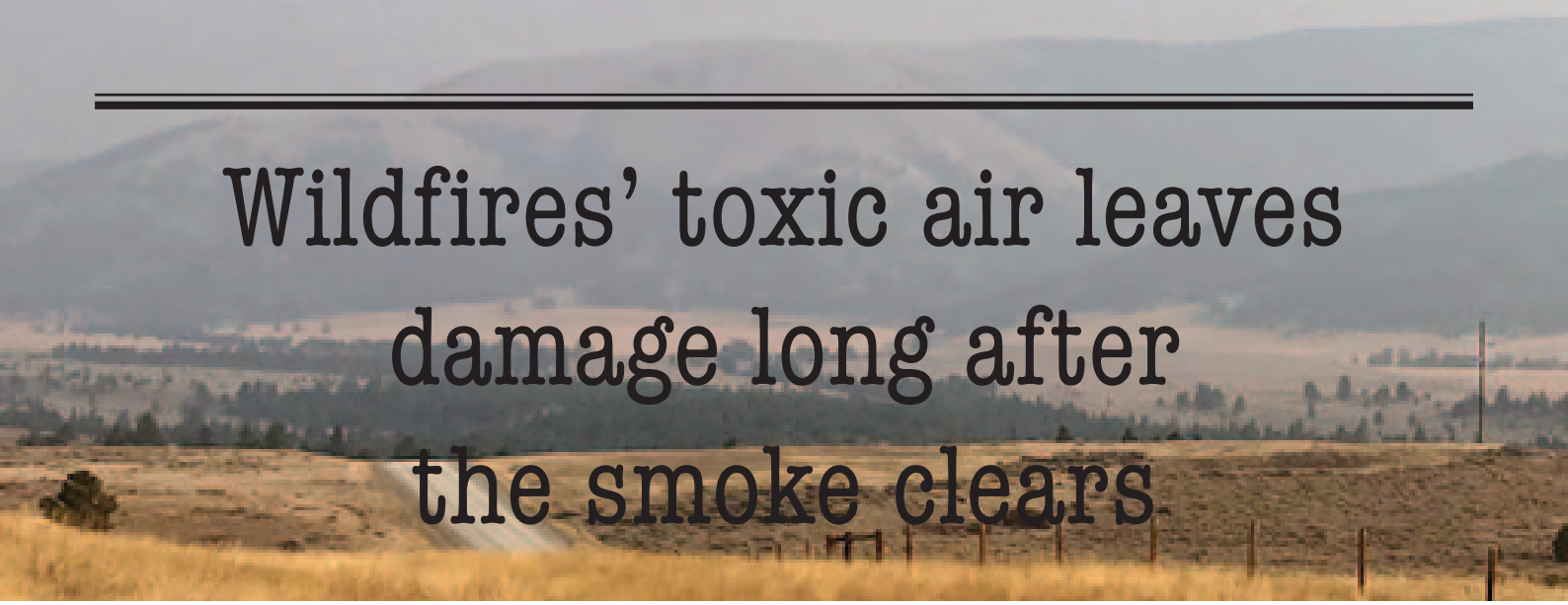
Buildings and infrastructure is the largest category identified when accounting for cumulative emissions between 2017 and 2050. We need to re-think how to build facilities and infrastructure. A whole-life-cycle approach encompasses building and infrastructure construction from planning to deconstruction. It includes interaction with the entire value chain, including investors, developers, policymakers, communities, designers, engineers and material manufacturers.

"The number one cause [of greenhouse gases] in this city is the buildings," said De Blasio. Implementing efficiency retrofits would immediately reduce multifamily energy use by 11%. Multifamily buildings emit nearly 30% of the whole building sector's greenhouse gases. Upgrading this essential part of NYC's structure will not only lower bills and harmful emissions but will also improve indoor health, comfort and well-being.

Energy auditors have assessed opportunities for building efficiency upgrades through packages of energy conservation measures (ECMs) to lower utility bills, improve living spaces and enable building decision-makers to understand the retrofit options better.

In 2019 NYC Council voted on the Climate Mobilization Act that includes the renovation of large and medium-sized buildings to reduce their emissions 40% by 2030 and 80% by 2050. Besides, the Climate Mobilization Act challenges the city to replace in-city gas-fired power plants with 500 MW battery storage systems powered by renewable sources (solar, wind and hydropower) and installation of green roofs on new residential and commercial buildings.

New York City's policy recognizes the connection between environmental and economic justice. With OneNYC 2050, New York became the first town to map its local strategy according to the Sustainable Development Goals (SDGs) and to submit a Voluntary Local Review to the United Nations. Reviving the city is a challenge within a challenge. Despite the spread of the virus, New York is leading the way in addressing the climate crisis. ONE



Wildfires' toxic air leaves damage long after the smoke clears

Forest fires had funneled hazardous air into Seeley Lake, a town of fewer than 2,000 people, for 49 days. The air quality was so bad that on some days the monitoring stations couldn't measure the extent of the pollution.

KATHERYN HOUGHTON
KHN

When researchers arrived in this town tucked in the Northern Rockies three years ago, they could still smell the smoke a day after it cleared from devastating wildfires. Their plan was to chart how long it took for people to recover from living for seven weeks surrounded by relentless smoke. They still don't know, because most residents haven't recovered. In fact, they've gotten worse.

Forest fires had funneled hazardous air into Seeley Lake, a town of fewer than 2,000 people, for 49 days. The air quality was so bad that on some days the monitoring stations couldn't measure the extent of the pollution. The intensity of the smoke and the length of time residents had been trapped in it were unprecedented, prompting county officials to issue their first evacuation orders due to smoke, not fire risk. Many people stayed. That made Seeley Lake an ideal place to track the long-term health of people inundated by wildfire pollution.

So far, researchers have found that people's lung capacity declined in the first two years after the smoke cleared. Chris Migliaccio, an immunologist with the University of Montana, and his team found the percentage of residents whose lung function sank below normal thresholds more than doubled in the first year after the fire and remained low a year after that. "There's something wrong there," Migliaccio said.

While it's long been known that smoke can be dangerous when in the thick of it — triggering asthma attacks, cardiac arrests, hospitalizations and more — the Seeley Lake research confirmed what public health experts feared: wildfire haze can have consequences long after it's gone. That doesn't bode well for the 78 million people in the western United States now confronting historic wildfires. Toxic air from fires has blanketed California and the Pacific Northwest for weeks now, causing some of the world's worst air quality.

California fires have burned roughly 2.3 million acres so far this year, and the wildfire season isn't over yet. Oregon estimates 500,000 people in the state have been under a notice to either prepare to evacuate or leave. Smoke from the West Coast blazes has drifted as far away as Europe. Extreme wildfires are predicted to become a regular occurrence due to climate change. And, as more people increasingly settle in fire-prone places, the risks increase. That's shifted wildfires from being a perennial reality for rural mountain towns to becoming an annual threat for areas across the West.

Dr. Perry Hystad, an associate professor in the College of Health and Human Sciences at Oregon State University, said the Seeley Lake research offers unique insights into wildfire smoke's impact, which until recently had largely been unexplored. He said similar studies are likely to follow because of this fire season. "This is the question that everybody is asking," Hystad said. "'I've been sitting in smoke for two weeks, how concerned should I be?'"

Migliaccio wants to know whether the lung damage he saw in Seeley Lake is reversible — or even treatable. (Think of an inhaler for asthma or other medication that prevents swollen airways.) But those discoveries will have to wait. The team hasn't been able to return to Seeley Lake this year because of the coronavirus pandemic. Migliaccio said more research is needed on whether wildfire smoke damages organs besides the lungs, and whether routine exposure makes people more susceptible to diseases. The combination of the fire season and the pandemic has spurred other questions as well, like whether heavy smoke exposure could lead to more COVID-19 deaths. A recent study showed a spike in influenza cases following major fire seasons. "Now you have the combination of flu season and COVID and the wildfires," Migliaccio said. "How are all these things going to interact come late fall or winter?"

Smoke obscures a mountain formation known as the Sleeping Giant, North of Helena, Montana (USA). Photo credit: Matt Volz/KHN

A Case Study

Seeley Lake has long known smoke. It sits in a narrow valley between vast stretches of thick forests. On a recent September day, Boyd Gossard stood on his back porch and pointed toward the mountains that were ablaze in 2017. Gossard, 80, expects to have some summer days veiled in haze. But that year, he said, he could hardly see his neighbor's house a few hundred feet away. "I've seen a lot of smoke in my career," said Gossard, who worked in timber management and served as a wildland firefighter. "But having to just live in it like this was very different. It got to you after a while."

When Missoula County health officials urged people to leave town and flee the hazardous smoke, many residents stayed close to home. Some said their jobs wouldn't let them leave. Others didn't have a place to go — or the money to get there. Health officials warned those who stayed to avoid exercising and breathing too hard, to remain inside and to follow steps to make their homes as smoke-free as possible. The health department also worked to get air filters to those who needed them most. But when flames got too close, some people had to sleep outside in campsites on the other side of town.

Understanding the Science of Smoke

One of the known dangers of smoke is particulate matter. Smaller than the width of a human hair, it can bypass a body's defenses, lodging deep into lungs. Lu Hu, an atmospheric chemist with the University of Montana, said air quality reports are based on how much of that pollution is in the air. "It's like lead; there's no safe level, but still we have a safety measure for what's allowable," Hu said. "Some things kill you fast and some things kill you slowly."

While air quality measurements can gauge the overall amount of pollution, they can't assess which specific toxins people are inhaling. Hu is collaborating with other scientists to better predict how smoke travels and what pollutants people actually breathe. He said smoke's chemistry changes based on how far it travels and what's burning, among other factors. Over the past few years, teams of researchers drove trucks along fire lines to collect smoke samples. Other scientists boarded cargo planes and flew into smoke plumes to take samples right from a fire's source. Still others stationed at a mountain lookout captured smoke drifting in from nearby fires. And ground-level machines at a Missoula site logged data over two summers.

Bob Yokelson, a longtime smoke researcher with the University of Montana, said scientists are getting closer to understanding its contents. And, he said, "it's not all bad news." Temperature and sunlight can change some pollutants over time. Some dangerous particles seem to disappear. But others, such as ozone, can increase as smoke ages. Yokelson said scientists are still a long way from determining a safe level of exposure to the 100-odd pollutants in smoke. "We can complete the circle by measuring not only what's in smoke, but measuring what's happening to the people who breathe it," Yokelson said. "That's where the future of health research on smoke is going to go."

Coping With Nowhere to Flee

In the meantime, those studying wildland smoke hope what they've learned so far can better prepare people to live in the haze when evacuation isn't an option. Joan Wollan, 82, was one of the Seeley Lake study participants. She stayed put during the 2017 fire because her house at the time sat on a border of the evacuation zone. The air made her eyes burn and her husband cough. She ordered air filters to create cleaner air inside her home, which helped.

On a recent day, the air in Wollan's new neighborhood in Missoula turned that familiar gray-orange as traces of fires from elsewhere appeared. Local health officials warned that western Montana could get hit by some of the worst air quality the state had seen since those 2017 fires. If it got bad enough, Wollan said, she'd get the filters out of storage or look for a way to get to cleaner air — "if there is someplace in Montana that isn't smoky."

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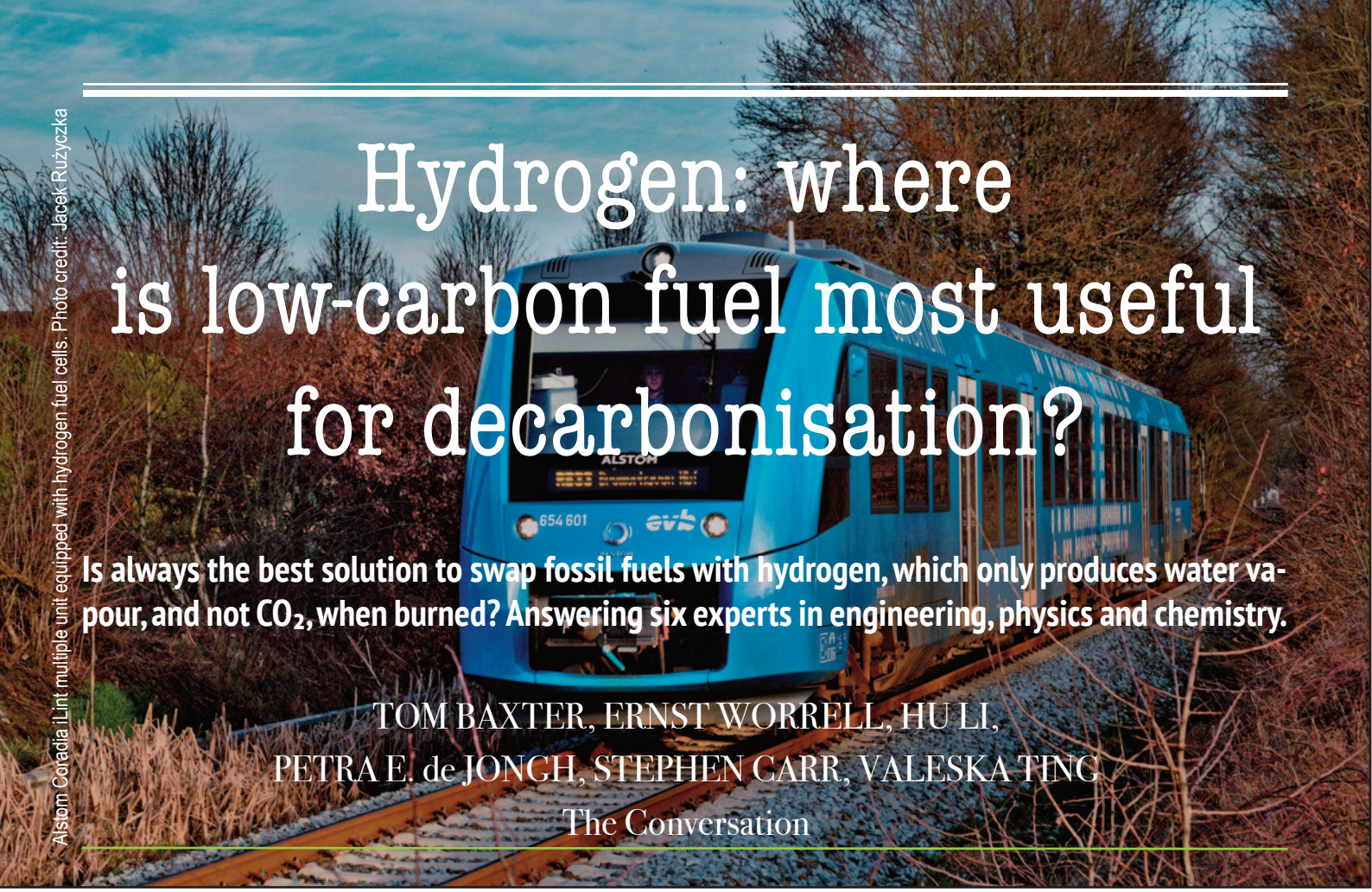

Alstom Coradia iLint multiple unit equipped with hydrogen fuel cells. Photo credit: Jacek Ruzyczka

Hydrogen: where is low-carbon fuel most useful for decarbonisation?

Is always the best solution to swap fossil fuels with hydrogen, which only produces water vapour, and not CO_2, when burned? Answering six experts in engineering, physics and chemistry.

TOM BAXTER, ERNST WORRELL, HU LI, PETRA E. de JONGH, STEPHEN CARR, VALESKA TING
The Conversation

Is hydrogen the lifeblood of a low-carbon future, or an overhyped distraction from real solutions? One thing is certain – the coal, oil and natural gas which currently power much of daily life must be phased out within coming decades. From the cars we drive to the energy that heats our homes, these fossil fuels are deeply embedded in society and the global economy. But is the best solution in all cases to swap them with hydrogen – a fuel which only produces water vapour, and not CO_2, when burned?

Answering that question are six experts in engineering, physics and chemistry.

Road and rail

Hu Li, Associate Professor of Energy Engineering, University of Leeds

Transport became the UK's largest source of greenhouse gas emissions in 2016, contributing about 28% of the country's total. Replacing the internal combustion engines of passenger cars and light-duty vehicles with batteries could accelerate the process of decarbonising road transport, but electrification isn't such a good option for heavy-duty vehicles such as lorries and buses. Compared to gasoline and diesel fuels, the energy density (measured in megajoules per kilogram) of a battery is just 1%. For a 40-tonne truck, just over four tonnes of lithium-ion battery cells are needed for a range of 800 kilometres, compared to just 220 kilograms of diesel.

With the UK government set to ban fossil fuel vehicles from 2035, hydrogen fuel cells could do much of the heavy lifting in decarbonising freight and public transport, where 80% of hydrogen demand in transport is likely to come from.

A fuel cell generates electricity through a chemical reaction between the stored hydrogen and oxygen, producing water and hot air as a byproduct. Vehicles powered by hydrogen fuel cells have a similar driving range and can be refuelled about as quickly as internal combustion engine vehicles, another reason they're useful for long-haul and heavy-duty transport.

Hydrogen fuel can be transported as liquid or compressed gas by existing natural gas pipelines, which will save millions on infrastructure and speed up its deployment. Even existing internal combustion engines can use hydrogen, but there are problems with fuel injection, reduced power output, onboard storage and emissions of nitrogen oxides (NO_x), which can react in the lower atmosphere to form ozone – a green-

house gas. The goal should be to eventually replace internal combustion engines with hydrogen fuel cells in vehicles that are too large for lithium-ion batteries. But in the meantime, blending with other fuels or using a diesel-hydrogen hybrid could help lower emissions.

It's very important to consider where the hydrogen comes from though. Hydrogen can be produced by splitting water with electricity in a process called electrolysis. If the electricity was generated by renewable sources such as solar and wind, the resulting fuel is called green hydrogen. It can be used in the form of compressed gas or liquid and converted to methane, methanol, ammonia and other synthetic liquid fuels.

But nearly all of the 27 terawatt-hours (TWh) of hydrogen currently used in the UK is produced by reforming fossil fuels, which generates nine tonnes of CO_2 for every tonne of hydrogen. This is currently the cheapest option, though some experts predict that green hydrogen will be cost-competitive by 2030. In the meantime, governments will need to ramp up the production of vehicles with hydrogen fuel cells and storage tanks and build lots of refuelling points.

Hydrogen can play a key role in decarbonising rail travel too, alongside other low-carbon fuels, such as biofuels. In the UK, 6,049 kilometres of mainline routes run on electricity – that's 38% of the total. Trains powered by hydrogen fuel cells offer a zero-emission alternative to diesel trains.

The Coradia iLint, which entered commercial service in Germany in 2018, is the world's first hydrogen-powered train. The UK recently launched mainline testing of its own hydrogen-powered train, though the UK trial aims to retrofit existing diesel trains rather than design and build entirely new ones.

Aviation

Valeska Ting, Professor of Smart Nanomaterials, University of Bristol

Of all of the sectors that we need to decarbonise, air travel is perhaps the most challenging. While cars and boats can realistically switch to batteries or hybrid technologies, the sheer weight of even the lightest batteries makes long-haul electric air travel tricky.

Single-seat concept planes such as the Solar Impulse generate their energy from the sun, but they can't generate enough based on the efficiency of current solar cells alone so must also use batteries. Other alternatives include synthetic fuels or biofuels, but these could just defer or reduce carbon emissions, rather than eliminate them altogether, as a carbon-free fuel like green hydrogen could.

Hydrogen is extremely light and contains three times more energy per kilogram than jet fuel, which is why it's traditionally used to power rockets. Companies including Airbus are already developing commercial zero-emission aircraft that run on hydrogen. This involves a radical redesign of their fleet to accommodate liquid hydrogen fuel tanks.
There are some technical challenges though. Hydrogen is a gas at room temperature, so very low temperatures and special equipment are needed to store it as a liquid. That means more weight, and subsequently, more fuel.

However, research we're doing at the Bristol Composites Institute is helping with the design of lightweight aircraft components made out of composite materials. We're also looking at nanoporous materials that behave like molecular sponges, spontaneously absorbing and storing hydrogen at high densities for onboard hydrogen storage in future aircraft designs.

France and Germany are investing billions in hydrogen-powered passenger aircraft. But while the development of these new aircraft by industry continues apace, international airports will also need to rapidly invest in infrastructure to store and deliver liquid hydrogen to refuel them. There's a risk that fleets of hydrogen aeroplanes could take off before there's a sufficient fuel supply chain to sustain them.

Heating

Tom Baxter, Honorary Senior Lecturer in Chemical Engineering, University of Aberdeen & Ernst Worrell, Professor of Energy, Resources and Technological Change, Utrecht University

If the All Party Parliamentary Group on Hydrogen's recommendations are taken up, the UK government is likely to support hydrogen as a replacement fuel for

Tehachapi Energy Storage Project at Monolith Substation, California (USA).
Photo credit: Renewableandalternativeenergy

heating buildings in its next white paper. The other option for decarbonising Britain's gas heating network is electricity. So which is likely to be a better choice – a hydrogen boiler in every home or an electric heat pump?

First there's the price of fuel to consider. When hydrogen is generated through electrolysis, between 30-40% of the original electric energy is lost.

One kilowatt-hour (kWh) of electricity in a heat pump may generate 3-5 kWh of heat, while the same kWh of electricity gets you only 0.6-0.7 kWh of heat with a hydrogen-fuelled boiler. This means that generating enough hydrogen fuel to heat a home will require electricity generated from four times as many turbines and solar panels than a heat pump.

Because heat pumps need so much less energy overall to supply the same amount of heat, the need for large amounts of stored green energy on standby is much less. Even reducing these losses with more advanced technology, hydrogen will remain relatively expensive, both in terms of energy and money. So using hydrogen to heat homes isn't cheap for consumers.

Granted, there is a higher upfront cost for installing an electric heat pump. That could be a serious drawback for cash-strapped households, though heat pumps heat a property using around a quarter of the energy of hydrogen. In time, lower fuel bills would more than cover the installation cost. Replacing natural gas with hydrogen in the UK's heating network isn't likely to be simple either. Per volume, the energy density of hydrogen gas is about one-third that of natural gas, so converting to hydrogen will not only require new boilers, but also investment in grids to increase how much fuel they can deliver. The very small size of hydrogen molecules mean they're much more prone to leaking than natural gas molecules. Ensuring that the existing gas distribution system is fit for hydrogen could prove quite costly.

In high-density housing in inner cities, district heating systems – which distribute waste heat from power plants and factories into homes – could be a better bet in a warming climate, as, like heat pumps, they can cool homes as well as heat them.

Above all, this stresses the importance of energy efficiency, what the International Energy Agency calls the first fuel in buildings. Retrofitting buildings with insulation to make them energy efficient and switching boilers for heat pumps is the most promising route for the vast majority of buildings.

Hydrogen should be reserved for applications where there are few or no alternatives. Space heating of homes and buildings, except for limited applications like in particularly old homes, is not one of them.

Electricity and energy storage

Petra de Jongh, Professor of Catalysts and Energy Storage Materials, Utrecht University

Fossil fuels have some features that seem impossible to beat. They're packed full of energy, they're easy to burn and they're compatible with most engines and generators. Producing electricity using gas, oil, or coal is cheap, and offers complete certainty about, and control over, the amount of electricity you get at any point in time. Meanwhile, how much wind or solar electricity we can generate isn't something that we enjoy a lot of control over. It's difficult to even adequately predict when the sun will shine or the wind will blow, so renewable power output fluctuates. Electricity grids can only tolerate a limited amount of fluctuation, so being able to store excess electricity for later is key to switching from fossil fuels.

Hydrogen seems ideally suited to meet this challenge. Compared to batteries, the storage capacity of hydrogen is unlimited – the electrolyser which produces it from water never fills up. Hydrogen can be converted back into electricity using a fuel cell too, though quite a bit of energy is lost in the process. Unfortunately, hydrogen is the lightest gas and so it's difficult to store and transport it. It can be liquefied or stored at very high pressures. But then there's the cost – green hydrogen is still two to three times more expensive than that produced from natural gas, and the costs are even higher if an electrolyser is only used intermittently.

Ideally, we could let hydrogen react with CO_2, either captured from the air or taken from flue gases, to produce renewable liquid fuels that are carbon-neutral, an option that we're investigating at the Debye Institute at Utrecht University.

Heavy industry

Stephen Carr, Lecturer in Energy Physics, University of South Wales

Industry is the second most polluting sector in the UK after transport, accounting for 21% of the UK's total carbon emissions. A large proportion of these emissions come from processes involving heat, whether it's firing a kiln to very high temperatures to produce cement or generating steam to use in an oven making food. Most of this heat is currently generated using natural gas, which will need to be swapped out with a zero-carbon fuel, or electricity.

Let's look in depth at one industry: ceramics manufacturing. Here, high-temperature direct heating is required, where the flame or hot gases touch the material being heated. Natural gas-fired burners are currently used for this. Biomass can generate zero-carbon heat, but biomass supplies are limited and aren't best suited to use in direct heating. Using an electric kiln would be efficient, but it would entail an overhaul of existing equipment. Generating electricity has a comparably high cost too.

Swapping natural gas with hydrogen in burners could be cheaper overall, and would require only slight changes to equipment.

The Committee on Climate Change, which advises the UK government, reports that 90 TWh of industrial fossil fuel energy per year (equivalent to the total annual consumption of Wales) could be replaced with hydrogen by 2040. Hydrogen will be the cheapest option in most cases, while for 15 TWh of industrial fossil fuel energy, hydrogen is the only suitable alternative.

Hydrogen is already used in industrial processes such as oil refining, where it's used to react with and remove unwanted sulphur compounds. Since most hydrogen currently used in the UK is derived from fossil fuels, it will be necessary to ramp up renewable energy capacity to deliver truly green hydrogen before it can replace the high-carbon fuels powering industrial processes.

The same rule applies to each of these sectors – hydrogen is only as green as the process that produced it. Green hydrogen will be part of the solution in combination with other technologies and measures, including lithium-ion batteries, and energy efficiency.

But the low-carbon fuel will be most useful in decarbonising the niches that are currently difficult for electrification to reach, such as heavy-duty vehicles and industrial furnaces

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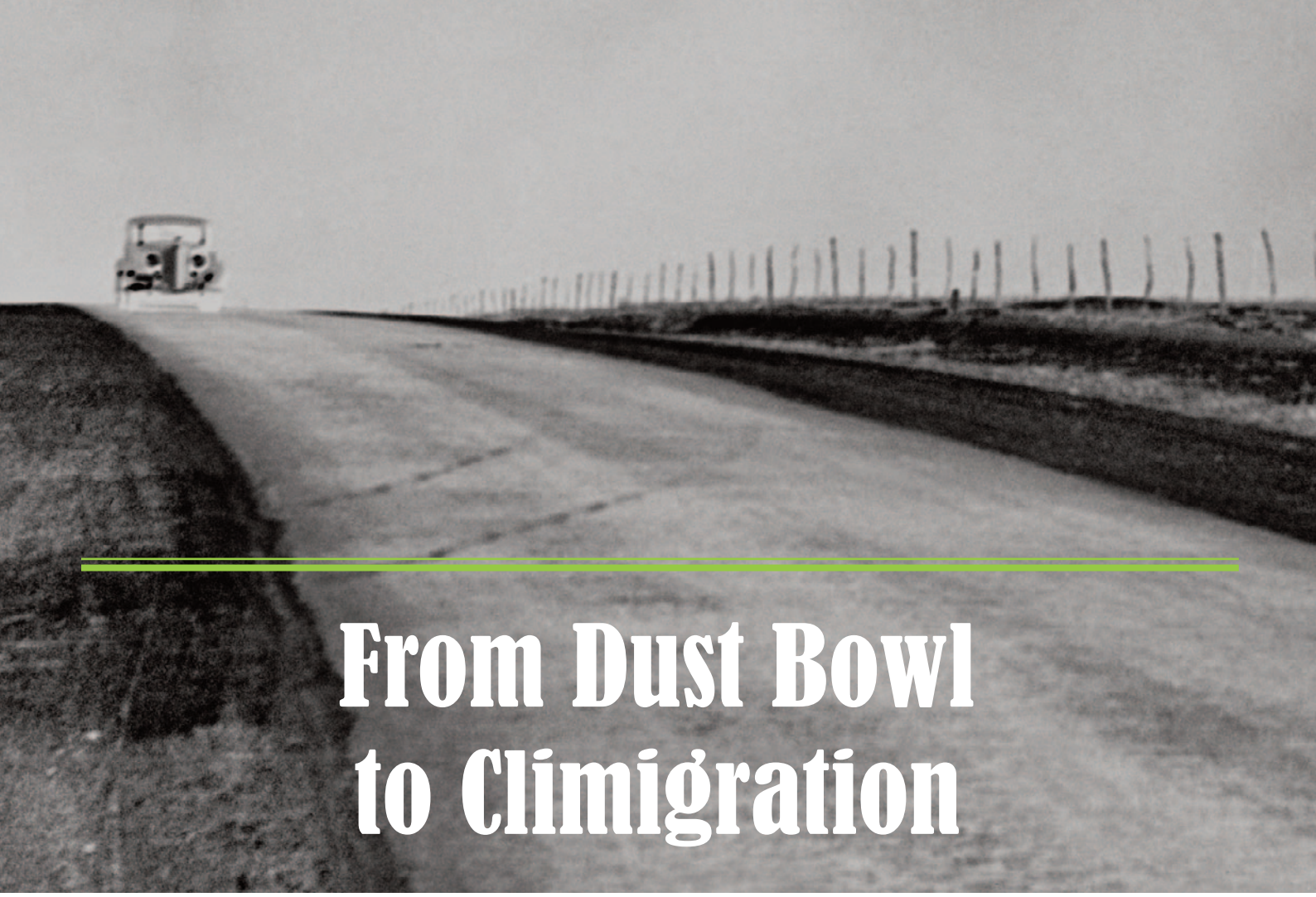

From Dust Bowl to Climigration

Worldwide climate and weather-related disasters are displacing an average of 22.5 million people yearly. In the US alone, an average of 1.2 million Americans annually had to leave their homes because of weather disasters. A journey into weather-induced migration.

LENORE HITCHLER

ONE

The *Grapes of Wrath* by John Steinbeck. *Dust Bowl Ballads* by Woody Guthrie. Hurricanes and floods in the Southeast. "When the Levee Breaks" written by an African American couple and interpreted by Led Zeppelin. Droughts and wildfires on the West Coast. What do they have in common? They are examples of catastrophic weather events and the artistic interpretations that reflect them.

Whether or not all of these weather-based phenomena are caused by climate change is debatable. However, climate change increases the number of weather calamities. In the past, weather disasters frequently led to migration, and a historical examination of weather-induced migration is valuable for understanding climate migration. To put climate migration into the proper perspective it is necessary to show its global extent. A joint report from the investigative journalism organization *ProPublica* and the *New York Times Magazine* reported that "with every degree of temperature increase, roughly a billion people will be pushed outside the zone in which humans have lived for thousands of years." This will lead to massive climate migration which is also known as climigration.

The United Nations International Organization for Migration forecasts one billion climate refugees by 2050. In 2017, researchers from Cornell University estimated 1.4 billion by 2060, and 2 billion by 2100. Abraham Lustgarten, investigative

Dust Bowl, Texas Panhandle (USA).
Photo credit: Capmo

reporter from the ProPublica study on climate migration, estimated that 162 million Americans will "most likely experience a decline in the quality of their environment" in the coming years. He added that the changes could be particularly severe for 93 million. Many of these people will become climate migrants.

The ProPublica study also estimated that by 2040, 100 million Americans will face humidity so extreme that working outside or playing school sports could cause heatstroke. Because of rising sea levels, 13 million people will have to retreat from coasts.

An article in *Environmental Research Letters* examined the loss of housing facing the poor because of rising sea levels. The authors stated that "Residents of low-lying affordable housing, who tend to be low-income persons living in old and poor quality structures, are especially vulnerable." Alaska is already being hit hard with rising sea levels. According to the New York Times, "The government has identified at least 31 Alaskan towns and cities at imminent risk of destruction."

Climigration has already begun. The Internal Displacement Monitoring Centre reported that worldwide climate and weather-related disasters are displacing an average of 22.5 million people yearly. Since 2016, in the US alone, the center reported that an average of 1.2 million Americans annually had to leave their homes because of weather disasters. United States environmental history can be examined to help us understand the effect of weather disasters and climate change. Of course, not every weather disaster is caused by climate change. For example, it is debatable if the Dust Bowl of the 1930s was caused by climate change.

However, the Dust Bowl experience is relevant to climigration because it is an example of how weather disasters can lead to migration. The Dust Bowl covered more than one hundred mil-

lion acres. Timothy Egan is the author of *The Worst Hard Time—The Untold Story of Those Who Survived the Great American Dust Bowl.* He wrote that "American meteorologists rated the Dust Bowl the number one weather event of the twentieth century … historians say it was the nation's worst prolonged environmental disaster." Drought, wind, and environmental errors contributed to the Dust Bowl.

Farmers had significantly changed the ecology of the plains which had been perfectly suited to the environment. Bison withstood 110 degrees Fahrenheit in the summer and 30 degrees below zero Fahrenheit in the winter. Bison were deliberately slaughtered. Instead, farmers raised cattle, which are not as appropriate for the harsh conditions of the plains. Native prairie grasses had held the soil in place and were drought resistant. Tall grasses had roots going down six feet enabling them to locate moisture. Instead of retaining bison and prairie grasses, farmers plowed the ground to raise grains to feed cattle and humans resulting in soil erosion. Thus, farmers destroyed the soil to grow corn and wheat which were not even suitable to the hot, dry environment and these crops perished during the drought.

Massive winds blew the eroded topsoil away. It is estimated that more than 80 million acres were stripped of topsoil. The harsh conditions of the Dust Bowl led 2.5 million to migrate according to an article in the journal *Rural Migration News* published by the University of California-Davis.

Besides increasing temperatures, climate change increases the number and severity of droughts. In California, between 2012 and 2016, an estimated 150 million trees perished during the severe drought. California's temperature has increased by three degrees Fahrenheit. High temperatures dry out dead trees, leaves and other organic matter, providing fuel for fires. Additionally, higher fall temperatures and less rainfall lead to a 20% increase in the number of days in the fire season. Thus, the western fire season increased by at least 84 days since the 1970s. The risk for wildfires is increased by climate change-induced early melting of snowpacks. Over 70% of areas burned in forest fires between 1970 and 2012 occurred in years where the winter snows disappeared early.

Wildfires also lead to increased threats to survivor's mental health.

Environmental epidemiologist Irva Hertz-Picciotto from the University of California-Davis studied the psychological consequences of the Tubbs Fire of 2017. She found that approximately 60% of survivors reported experiencing at least one mental health symptom, such as trouble sleeping heightened anxiety, loss of appetite or depression. Some also reported a change in their use of alcohol and drugs. About 20% experienced four or more of these symptoms because of the wildfire.

The 2020 wildfires burned approximately five million acres. These wildfires put around 2.5 million homes at risk. The ProPublica report stated that by 2040 at least 28 million Americans will be threatened by megafires which will also increase climigration.

Besides increasing droughts and wildfires, climate change can also dramatically increase rainfall. This frequently results in more extreme flooding. The Mississippi Flood of 1927 was probably not caused by climate change. It occurred after many months of torrential rain throughout the area surrounding both the tributaries and the river itself. This area covers more than 40% of the US and includes parts of 31 states. The area that drains into the Mississippi extends from Canada to the Gulf of Mexico and New York west to Idaho and New Mexico.

Although historians have written about it, the public is not as familiar with the Mississippi Flood of 1927 as it is with Dust Bowl. *Backwater Blues—The Mississippi Flood of 1927 in the African American Imagination* was written by history professor Richard M. Mizelle Jr. He wrote that the flood "was a slow-moving disaster that built up to a crescendo over time as levee after levee began to fail during the spring." Journalist John Barry, author of *Rising Tide—The Great Mississippi Flood of 1927 and How It Changed America* stated that there were one million flood victims.

Professor Susan Scott Parrish, author of *The Flood Year 1927*, wrote that the lower Mississippi Valley flood covered 27,000 square miles in seven states, and approximately 637,000 lost their homes, of

Jackson Street, washed out in aftermath of 1955 Connecticut floods in Holyoke, Massachusetts, USA). Photo credit: US NARA/ U.S. Army Corp of Engineers

which approximately 555,000 were racial or ethnic minorities. Like the Dust Bowl tragedy, the magnitude of the damage of the Mississippi flood of 1927 was amplified by man-made environmental errors. From their first arrival, white farmers made poor decisions. Native Americans had told the first European explorers that the river flooded every fourteen years, yet they developed the vulnerable riverfront anyway.

Parrish wrote that the flood was "the product of environmental practices in the upper part of the watershed: deforestation of the upper Midwest, mowing under of prairie grasses to the west, industrial growth of corn and wheat, and drainage of wetlands. Without trees, grasses, deep roots, and wetlands, the denuded soil of the watershed could not do its ancient work of absorbing and stalling water after seasons of intense snow and rain."

During the aftermath of the flood, Caucasians fared much better than African Americans. Whites were given refuge at indoor facilities, such as downtown department stores and hotels. They were provided both meat and a higher quality of food than blacks. Whites received new clothes first, and their children received healthcare before black children. African Americans were forced to live in outdoor camps. Mizelle wrote that in Greenville, Mississippi, "Every black family, single man, woman, and child, had to be vouched for by a local white person to receive food and shelter, without exception." The food and shelter that they received was inadequate, and they were forced to sleep on the ground. According to Red Cross official policy, flood relief was supposed to go directly to tenants and sharecroppers and not to landlords. However, some landlords took control over the rations, and some even charged their tenants for them. Men were forced to repair broken levees and clean polluted cities.

J. Winston Harrington, investigative journalist, wrote that "Clean-up squads are now working in the white sections of the city keeping the streets and alleys in sanitary conditions, while sections of the city where our people live are used as dumping grounds for disease-breeding trash from the white sections." One sign read "refugee labor is free to all white men." A report from the Colo-

red Advisory Committee detailed "fearful black tenants scared of being whipped by white planters who stole refugees' supplies."

Just as The Grapes of Wrath and folk ballads were written about the Dust Bowl, novelists and song writers wrote about the flood. William Faulkner wrote about it in several of his novels. He showed the relationship between the environment and the white power structure in *Go Down Moses*. Faulkner wrote "This land which man has deswamped and denuded and derivered in two generations so that white men can own plantations."

The African American author, Richard Wright, wrote two short flood stories. Many blues songs were written about the flood, including "Back Water Blues" by Bessie Smith. The original version of "When the Levee Breaks" was written by Kansas Joe and Memphis Minnie. Other blues songs about the flood include "Greenville Levee Blues," "Broken Levee Blues," and "The Flood Blues." The Mississippi Flood was a catastrophe for African Americans. Unlike the literary heritage from the Dust Bowl, the only mainstream cultural remnant of the flood is "When the Levee Breaks" by Led Zeppelin, and how many listeners know the origin of the song?

The flood did not just affect the South. Many African Americans migrated to such cities as New York, and Detroit. Almost half ended up in Chicago, which is ironic as Chicago might have contributed to the disaster.
According to journalist Ron Grossman, the *Chicago Tribune* reported that a Toronto meteorologist stated that if water from Lake Michigan had not been diverted through the Chicago Drainage Canal to the Mississippi, the "toll of life and property would have been very much less severe."

Climate change will also strengthen the destructive power of hurricanes. Warmer ocean water temperatures increase both the number and intensity of them. The Clausius-Clapeyron equation shows that for every single degree Celsius (1.8 degrees Fahrenheit) of warming, the atmosphere can hold 7% more moisture. This increased moisture leads to exponentially more destructive storms. Even though Hurricane Katrina may not have been caused by climate change, it is an example of how hurricanes damage the environment and survivors. It wreaked havoc on 55,600 square miles along the Gulf Coast and left than one million residents homeless. Hurricane Karina particularly battered the poor and racial minorities, especially children.

Lori Peck, a sociologist at the Center for Disaster and Risk Analysis at Colorado State University, found that poorer children were more likely to be exposed to Katrina's floodwaters. This led to "challenges concentrating in schools, higher anxiety levels, and more behavioral problems."

Researchers at the National Center for Disaster Preparedness, part of the Mailman School of Public Health at Columbia University, found that evacuated children were more than four times more likely than the average child to show symptoms of serious emotional disturbance. To fully understand the suffering caused by climate change-induced weather disasters is almost impossible.

Survivors mourn all that they lost including friends and loved ones. Lifelong places of worship and graveyards of loved ones may be destroyed and gone forever. Survivors will no longer be able to cherish lost or ruined family heirlooms and a lifetime collection of mementos. Members of racial minorities and the poor have added burdens as they are always hit particularly hard, and they have fewer financial resources to help them rebuild their lives.

Thus, climate migrators lose almost everything and then have to build a new life in a new location. Family members and friends may never be seen again. Many relocators face discrimination and prejudice.

Both their physical and mental health suffer. Also, the receiving communities face providing for new students, housing, health services, and employment. Fortunately, being cognizant of all these consequences and ramifications can spur us on to work harder to slow down climate change and lesson the need for climate migration. ONE

Poland & St. Claude Avenues in New Orleans (USA) after Hurricane Katrina.
Photo credit: ioerror

The plastic myth and the misunderstood triangle

Of all the plastic we've ever produced, only 9% has been recycled. So what happened to all that plastic you've put in the recycling bin over the years?

KATE RAYNES-GOLDIE

Particle

Of all the plastic we've ever produced, only 9% has been recycled. So what happened to all that plastic you've put in the recycling bin over the years?

Hands up if you grew up thinking that recycling plastic waste is key to saving the environment. It turns out that for decades the recyclability of plastics was grossly oversold by the plastics industry.

The creation of this recycling 'myth' is why, despite 30 years of being diligent recyclers, we have things like the Great Pacific Garbage Patch. In fact, we've only recycled 9% of all the plastics we've ever produced. and, our use of plastics is still increasing every year. The reality of the situation is that recycling plastics is actually really hard and expensive.

Triangle of mistruths

The myth created around plastic recycling has been one of simplicity. We look for the familiar triangle arrows, then pop the waste in the recycling bin so it can be reused. But the true purpose of those triangles has been misunderstood by the general public ever since their invention in the 1980s.

These triangles were actually created by the plastics industry and, according to a report provided to them in July 1993, were creating "unrealistic expectations" about what could be recycled. But they decided to keep using the codes. Which is why many people still believe that these triangular symbols (also known as a resin identifier code or RIC) means something is recyclable. But according to the American Society for Testing and Materials International (ASTM) – which controls the RIC system – the numbered triangles "are not recycle codes".

In fact, they weren't created for the general public at all. They were made for the post-consumer plastic industry. In other words, the symbols make it easier to sort the different types of plastics, some of which cannot be recycled – depending on the recycling facility.

"Unfortunately, just placing your plastic into the recycling bin doesn't mean it will get recycled," says Lara Camilla Pinho. She is an architect and lecturer at the UWA School of Design who is researching novel uses of plastic waste. "The recycling system is complicated and often dictated by market demand. Not all plastic is recyclable. We cannot recycle plastic bags or straws for example."

Behind the scenes

So, what makes recycling plastics so difficult? "Essentially, there are two types of plastics – thermoplastics and thermosets. While thermoplastics can be re-melted and re-molded, thermosets contain cross-linked polymers that cannot be separated meaning they cannot be recycled," says Lara. "Even thermoplastics have a limit to the amount of times we can recycle them, as each time they are recycled they downgrade in quality." Even when plastics are recyclable, it is often more costly than simply making new plastics.

Sugar, seaweed and mushrooms

If the conventional recycling system isn't working, what else can we do with all the plastic we've created? Lara is looking for ways to add value to recycled plastics such as using it in the design and development of architectural products. She hopes to use these architectural products to help underserved communities that are disproportionately affected by plastic waste. In addition to recycling, we also need to find ways to reduce our use of virgin petroleum-based plastics. Bioplastic is one such product that has been getting a lot of hype over the last few years. And although they're better than petroleum-based plastics, bioplastics also come with their own set of challenges.

"There are already a lot of bio-based alternatives to plastic, such as bagasse – a byproduct of sugar cane processing," says Lara. Mycelium, a type of fungi we most often associate with mushrooms, are also providing an interesting plastic alternative. "In the field of architecture, mycelium is starting to be used as an alternative to plastic insulation, but also as compostable packaging and bricks," says Lara. "The bricks take around five days to make and are strong, durable, water resistant and compostable at the end of their use.

"Hy-Fi Tower, created by The Living, is an example of a building made from these bricks. And finally, there's seaweed. "[Seaweed is] cheap and can reproduce itself quickly without fertilisers. In architecture, there is use for seaweed as an alternative to plastic insulation but also as cladding," says Lara.

More money, more problems

While all these alternatives are great, the main cause of our plastic dilemma is not scientific or technological, but economic. As long as it remains cheaper to create new plastics from fossil fuels rather than from bioplastics or from recycling, we're going to be stuck with plastic garbage islands floating in our oceans. The true cost to our health and our environment has yet to be included in the equation. But once it is, maybe that is when the real shift will happen.

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Photo credit: Michal Maňas

China's new carbon neutrality pledge: what next?

Experts react to President Xi's statement that China will up its climate ambition by striving for carbon neutrality by 2060

China Dialogue

In a virtual address to the 75th UN General Assembly on 22 September, Chinese President Xi Jinping said China would deliver a stronger emissions reduction target, peak emissions before 2030 and strive to reach carbon neutrality before 2060.

These pledges are a significant step forward in climate ambition from the world's largest carbon emitter and second largest economy. Xi's commitment came a week after the EU-China leaders meeting where the EU pressed China to commit to setting a goal of climate neutrality. In her State of the Union address on 16 September, European Commission President Ursula von der Leyen also proposed to raise the EU's 2030 climate target by end of the year.

All governments are required to deliver tougher climate targets under the Paris Agreement ahead of the next climate talks in Glasgow, UK, known as COP26, which were delayed until 2021 because of Covid-19. With commitments from the EU and China, well over a third of global emissions will be covered by new, tougher targets.

If China achieves its aim of reaching carbon neutrality before 2060 then it would lower global warming projections by around 0.2 to 0.3C, according to analysis by the Climate Action Tracker, which measures government commitments on climate against the Paris Agreement goals.

China Dialogue asked a group of climate experts how China's new pledges would contribute to the Paris Agreement goal of keeping global warming well under 2C and what they mean for China's transition toward a low-carbon economy.

Xie Zhenhua, Special Advisor on Climate Change Affairs of China, Ministry of Ecology and Environment; President of the Institute of Climate Change and Sustainable Development of Tsinghua University

China's commitment of carbon neutrality before 2060 goes beyond the 2065-2070 global carbon neutrality schedule under the Paris Agreement 2C scenario. This bold target may move global carbon neutrality ahead by 5-10 years. It will also play a key role in promoting stronger global climate governance. China is actively following the global trend of green and low-carbon recovery by setting forth a clear, strong carbon peak and carbon neutrality targets. Given the current international economic and political dynamics, the global community must come together to further the global climate agenda by incorporating concrete goals into a green post-pandemic recovery pathway.

Zou Ji, President of Energy Foundation China

President Xi Jinping's new vision shows that China's climate targets are highly embedded into its modernisation goals. In 2020, China will embark on a new journey of modernisation as new plans and blueprints unfold. It is a necessity for the country to increase investment in climate security as well as other forms of "natural capital", and to create a new economic growth engine through the ongoing low carbon transition, as the country strives to accelerate sustainable development and benefit people from China and the world on this journey. Such action will also be China's outstanding contribution to the Paris Agreement goals and global governance as a responsible global power. A thousand miles begins with a single step. To honour President Xi's new climate pledges, the first imperative for China is to set up more ambitious climate targets in

the 14th Five-Year Plan (2021-2025). This includes a carbon cap – requiring coal to be below 50% in the primary energy mix by 2025 and the acceleration of structural changes in energy production and consumption. China should also formulate nationnal, provincial, and local peaking plans as soon as possible, as well as long-term decarbonisation roadmaps that are economically and technically viable.

Hu Min, Executive Director at Innovative Green Development Program (iGDP)

The pledges send a strong, long-term political signal for China's low-carbon transition. The announcement was made a week after the EU-China leaders' virtual meeting, reflecting both sides' determination to cooperate on climate action.
We can expect that more concrete implementation plans will be released soon, and it's looking hopeful that more regional and local governments in China will bring out their plans to achieve carbon neutrality. Nevertheless, to achieve carbon neutrality by 2060 is not an easy task, it requires major technological breakthroughs and large-scale investments, which can only be secured by strong policies and implementation plans.

Zhang Shuwei, Director at Draworld Environment Research Center

China's commitment to reach carbon neutrality by 2060 comes at a critical moment when the world is in much need of more ambitious climate goals. The pledge is highly consistent with the 2 degree-deep reductions pathway and reflects China's responsibility as a major power. This will undoubtedly inject important momentum to global climate action.
Achieving carbon neutrality by 2060 means that China will have 30 years for continuous and rapid emissions cuts, after it reaches the emissions peak by around 2030. It will pose a significant impact for the transition of many sectors, including energy, transportation, industry, construction, and agriculture. We expect the introduction of specific policy tools, such as carbon pricing to realise the goals. The rapid transformation process must be fair and manageable.

Joanna Lewis, Associate Professor and Director, Science, Technology and International Affairs, Georgetown University

Almost all of China's climate and energy targets in recent years have been met or exceeded, so anything President Xi Jinping announces in such a public forum is not just symbolic. The carbon neutrality goal is a big deal coming from China – even just the mention of it because of what it implies. The timing of the announcement may be a sign that China is anticipating a call for scaled up climate action if Democratic nominee Joe Biden is elected in the November US election. China is likely trying to get out in front of any US pressure or demands, while simultaneously appeasing the European Union, which has been pushing for such a goal bilaterally for some time.

Jonna Nyman, Lecturer in International Politics, University of Sheffield

Xi Jinping's announcement of the aim to achieve carbon neutrality by 2060 is a welcome indication of China's commitment to carbon reduction. It is also a positive signal to the global community hoping for a constructive partner in the global effort to deal with climate change.
That said, the statement remains fuzzy on detail. I look forward to seeing how the carbon neutrality pledge will be translated specifically into policies and targets as part of China's Covid-19 recovery and upcoming 14th Five Year Plan, which will set out key targets for 2021-2025. To achieve carbon neutrality by 2060, China needs clear policies and targets that

shift the focus away from fossil fuels – and particularly coal – towards renewable energy. China's coronavirus recovery has so far favoured fossil fuels over clean energy. If taken seriously, this new announcement will indicate a significant near-term shift in focus.

Barbara Finamore, Senior Strategic Director, Asia, Natural Resources Defense Council (NRDC)
China's commitments to scale up its Paris Agreement pledges and aim to become carbon neutral by 2060 put pressure on the United States to restore its own climate leadership. An ambitious US 2030 target codified in a new nationally determined contribution (NDC), an unambiguous commitment to reach net-zero greenhouse gas emissions no later than 2050, and a strong policy framework to meet those targets will be essential. Moreover, in a time of rising US-China tensions, it might seem implausible or even unwise to call upon the two countries to work together to tackle our global climate emergency. But it is in the vital national interest of both the United States and China to align their efforts to rise to this unprecedented challenge.

Judith Shapiro, Co-author with Yifei Li, China Goes Green: Coercive Environmentalism for a Troubled Planet
China's new climate pledge is commendable. At a moment when the international community seems paralysed on the issue, China's leadership seems to understand the risks both to global infrastructure and China's own well-being, as severe weather events, melting glaciers, and sea level rise threaten domestic security and government legitimacy. The commitment to carbon reduction should help China achieve a double win and help to reduce the ground-level air pollution that so threatens public health. That said, China's commitments to ecological civilization and other "going green" initiatives must be implemented in such a way that they do not mask other state goals such as the collection of data about individuals and the administrative reordering and relocations of border area populations. The use of target-setting, crackdowns and behaviour modification campaigns can fail to garner public support and doom these initiatives in the long run.

Michal Meidan, Director of the China Energy Programme at the Oxford Institute for Energy Studies (OIES)
China's carbon neutrality pledge is nothing short of momentous, and in the context of an ongoing expansion of coal-fired power generation capacity within China, gives cause for cautious optimism. The devil is, of course, in the detail, but reaching this goal would require a fundamental change in how China develops its economy and consumes energy, which in turn, requires a shake-up of existing industrial complexes and political power groups. There will, therefore, be losers. The fossil fuels industry, currently a powerful stakeholder in China, will need to adapt to a changed reality and create new areas for growth as its share of the energy mix will have to shrink.

Beijing (China). Photo credit: Picrazy2

Whether the upcoming 14th Five Year Plan will kick-start that process remains to be seen. There is no doubt, however, that China's focus on innovation, as part of the "dual circulation strategy" to foster economic self-reliance, lays the foundation for accelerated innovation in key technologies underpinning the global energy transition. But the dual circulation strategy was born from a need to insulate China in an increasingly de-globalised world, and will likely be executed with a large dose of administrative measures. Companies and governments around the world will also have to make sure they too can play a role in China's transformation.

Ranping Song, Developing Country Climate Action Manager, World Resources Institute (WRI)

China will become richer and healthier in the pursuit of a zero-carbon economy. A forthcoming WRI analysis shows that realising carbon neutrality would require additional capital investment across multiple sectors, particularly energy, but the savings in fuel as well as operation and maintenance costs would quickly make up the difference. As a result, such policies can achieve positive financial benefits as early as 2023, even before factoring in social benefits such as health impacts. Realising carbon neutrality would save as many as 1.8 million people from premature death in the year 2050 alone. After incorporating the health benefits, China would create a net benefit of US$11 trillion before 2050 when compared with current policies, at a discount rate of 8%. Similarly, Cambridge Econometrics finds that China can raise its GDP by as much as 5% later this decade by implementing the new pledge.

Thom Woodroof, Senior Advisor on Multilateral Affairs to the President of the Asia Society Policy Institute and a former climate diplomat

President Xi's announcements are a game changer. For the first time, there is now a long-term trajectory for decarbonisation in China and their commitment to enhance their 2030 pledge under the Paris Agreement will put pressure on other major emitters to do the same. That said, a Biden administration will likely expect that China would do more in the short term given its peaking date was only part of its Paris pledge, and that it would increasingly take steps to reach carbon neutrality closer to 2050 as both the science demands and Biden himself has committed the US to do. For example, Biden has highlighted the need for action on China's coal use domestically and its coal financing as part of the Belt and Road Initiative (BRI). While these announcements were smartly timed with respect to the US election, they are more importantly an implicit acknowledgement that China understands the geopolitical importance of its continued climate leadership. They also lay a strong foundation for a hopeful return to US–China climate cooperation under a new US administration, which will be in China's interests given the strength of Biden's own platform.

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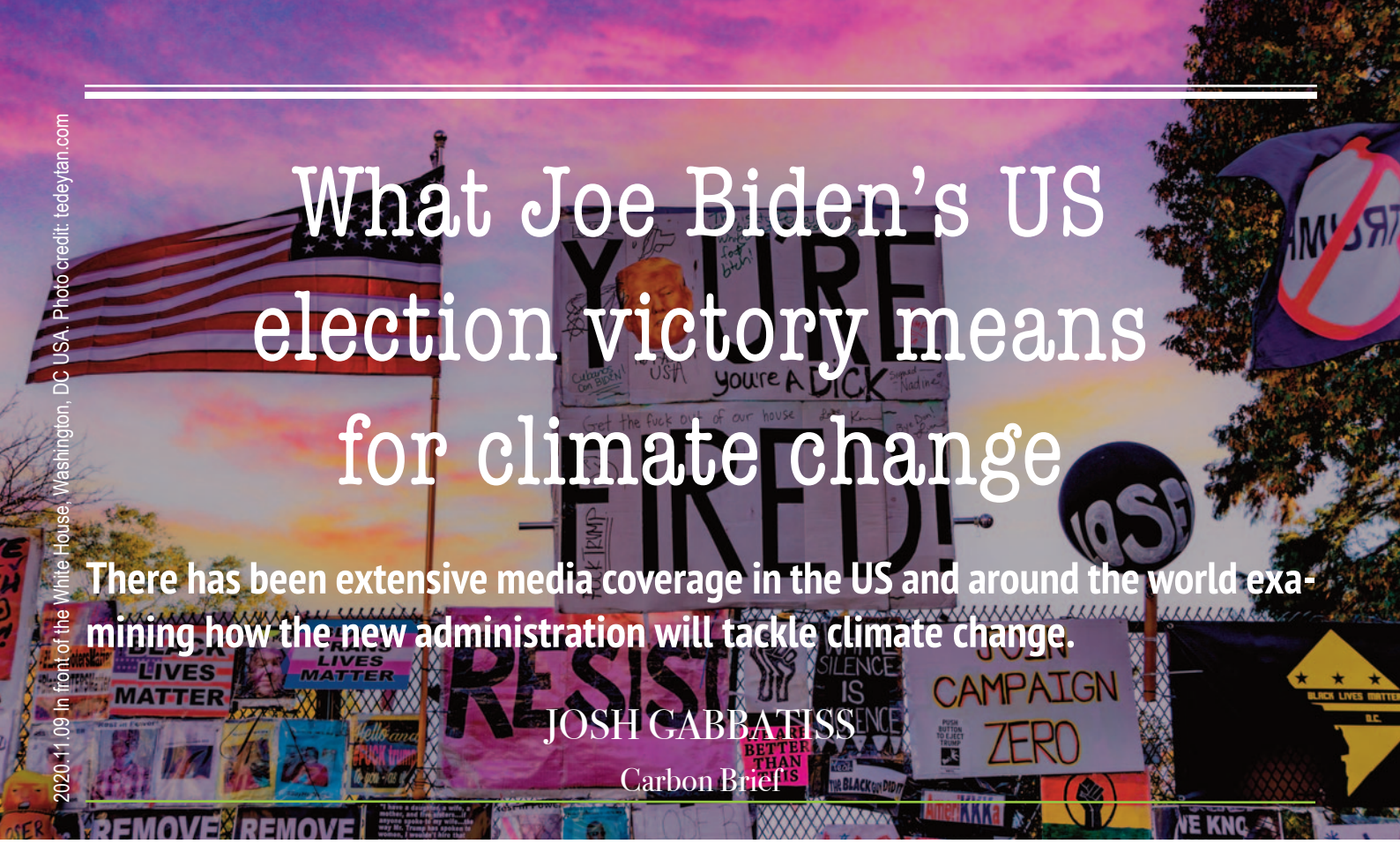


2020.11.09 In front of the White House, Washington, DC USA. Photo credit: tedeytan.com

What Joe Biden's US election victory means for climate change

There has been extensive media coverage in the US and around the world examining how the new administration will tackle climate change.

JOSH GABBATISS
Carbon Brief

Joe Biden's US election victory has been hailed as a significant turning point in US policy on everything from racial injustice to the Covid-19 pandemic. But there are few areas where the president-elect differs from his predecessor more than climate change, a topic that was seen as a key election issue.

After four years of environmental policy rollbacks, support for fossil fuels and retreat from the international community under Donald Trump, many now hope the president-elect and vice president-elect Kamala Harris will encourage the US to be a climate leader. There has been extensive media coverage in the US and around the world examining how the new administration will tackle climate change.

Below, Carbon Brief summarises how Biden's win has been covered in the context of climate change.

How will a Biden presidency impact climate action?

Biden's win came after an intense few days of speculation during which votes were counted in a handful of tightly contested states.

Vox was one of the first outlets to report Biden to be the winner, based on an announcement by election analysts at *Decision Desk*, which concluded on 6 November that the Democrat had won in Pennsylvania, thus securing the required 270 electoral votes. The US-based news outlet was quick to emphasise Biden's climate pledges, noting he had committed to a "massive spending programme" to address it.

Other news desks and television networks called the election result as the weekend progressed, with the *Associated Press (AP)* making a call on 7 November. It subsequently covered Biden's victory speech, in which he declared a desire "not to divide, but to unify".

In the full speech, of which Vox published a transcript, Biden said the US had been called upon "to marshal the forces of science and forces of hope in the great battles of our time", including "the battle to save our planet by getting climate under control".

In its coverage, *Climate Home News* said that "Biden is heading to the White House with a promise to overturn four years of US retreat on climate action". It noted that he had been elected on "the most ambitious climate platform ever presented by a presidential candidate", including $2tn of clean energy spending. (Carbon Brief has an election trac-

ker that includes details of Biden's climate policies.)

The article also stated that Biden will govern with Kamala Harris as his vice president, who has "a track record of suing oil companies as former attorney general of California". The Biden-Harris transition team has already published its climate plan on its new website.

Bloomberg said that, for the first time in history, Biden could take a "clear climate mandate" into the White House, with "robust popular support for climate action, borne out in polling data and election results from a hard-fought campaign".

Climate Action Tracker released new analysis following Biden's victory that was picked up by many outlets, including the *Guardian*. It concluded that, if the president-elect's plans come to fruition, the result "could reduce global heating by about 0.1C, bringing the goals of the Paris Agreement 'within striking distance'".

One of the key actions proposed by Biden in his platform (the US term for a manifesto) was re-joining the Paris Agreement – and *Axios* examined the need for the US to update its climate pledge when it does so: "Given the long odds of moving a big climate bill through congress, Biden's diplomatic leverage will depend on showing other policies will breathe life into the new pledge... Options include stimulus provisions; tariffs on carbon-intensive goods."

Writing for *Foreign Policy*, Jason Bordoff noted that re-joining the Paris Agreement "is necessary, but far from sufficient". He proposed various other measures, including collaboration on clean energy trade and innovation, leading an agreement to curb methane emissions and finalising another to phase down hydrofluorocarbons.

A piece in the *New York Times* put forward nine actions the Biden administration could take to address climate early on, noting that the "first 100 days of the Biden administration are likely to see a flurry of executive actions on climate change".
Among these proposals were making climate action part of Covid-19 relief, signing executive orders to cut emissions and revising rules on fossil fuel production. *The Los Angeles Times* highlighted the importance of reinstating "tough nationwide rules for auto emissions and mileage standards that were put in place under the Obama administration".

The *Boston Globe* published a comment piece by Dr Leah Stokes from the University of California, Santa Barbara, who said: "With Joe Biden and Kamala Harris running the executive branch, we can ensure that government spending is greened across the board."

A Twitter thread by *Politico* journalist Mike Grunwald attracted many replies from experts suggesting potential climate action that could happen "right away". Another focus identified by veteran US climate scientist Ben Santer in an open letter to Biden in *Scientific American* is restoring public trust in science and scientists after four years of the Trump administration: "You must rebuild public trust in the scientific impartiality of the Environmental Protection Agency (EPA), the National Oceanic and Atmospheric Administration, the Department of Energy, the Centers for Disease Control and many other federal agencies with scientific remits."

According to *InsideClimate News,* climate activists in the US have already said they will "push the new president for aggressive action on climate" where necessary.

Adam Vaughan in *New Scientist* noted that in the TV debates Biden said he would "transition from the oil industry" and "promised to end new drill leases for public land and water, which would have a big impact offshore". However, Biden has drawn criticism from some in the climate community for not coming out firmly enough against fracking.

A piece in *Forbes* by Michael Lynch concluded that, despite pressure from the "progressive/left" of the Democratic party, "on the big questions that affect the petroleum industry – fracking, pipeline construction, carbon taxes – the administration seems unlikely to act to their detriment, at least initially".

The Independent reported that while the Trump team has refused to cooperate, Biden has announced his transition

Happening outside the White House, Washington DC (USA).
Photo credit: Ted Eytan

teams, including the people overseeing transfer of power at federal environmental and energy agencies. The piece noted that the transition "may be a bumpy one", as some team members have histories of publicly condemning and even launching lawsuits against the current administration over its rollbacks of environmental regulations. *The New York Times* included more details of Biden's team.

Bloomberg founder and former Democratic presidential candidate Michael Bloomberg has offered his views on the "bold approach" Biden should take to climate change, emphasising the importance of actions taken independently of Congress and a focus throughout government.

A feature in the *Washington Post* suggested that this is indeed the approach that Biden will take. It cited a "300-page blueprint" put together by former Obama administration officials and experts layingout what the president needs to do beyond reversing Trump administration policies, while "avoiding some of the pitfalls that hampered president Barack Obama".

Among the proposed measures were creating a White House National Climate Council, establishing a "carbon bank" that could pay landowners to store carbon, pushing vehicle electrification through the transport department and developing a Treasury climate policy that promotes emissions cuts through tax, budget and regulatory policies.

The end of the Trump era

Donald Trump's presidency has been characterised by what *Climate Home News* referred to as "a four-year assault on environmental protections", something that many media outlets have emphasised in their coverage of Biden's victory.

The *Financial Times* said that "president-elect Joe Biden will take office with a plan to adopt tough new climate targets for the US and reverse many of the environmental actions of the Trump administration".

A feature in *Nature* stated that "scientists the world over are breathing a collective sigh of relief...The new president has the opportunity to reverse four years of anti-science policies –but he has a hard road ahead as he inherits a nation divided."

The *New York Times* climate change reporter Coral Davenport reflected on what she calls Trump's "most profound legacy", namely his impact on climate change: President-elect Joseph R Biden Jr will use the next four years to try to restore the environmental policies that his predecessor has methodically blown up."

However, she wrote that while air and water regulations dismantled by the Trump administration could be reversed, restoring "clarity" to ecosystems, the impact of greenhouse gas emissions released into the atmosphere would have a long-lasting impact.

BusinessGreen editor James Murray also considered what the end of a Trump presidency would mean for the environment in a piece titled "a victory for the climate": "And just like that, a modicum of sanity was restored. The world's

most powerful office is set to be held by a dignified man who accepts climate change is the gravest long-term threat faced by human civilisation and a canny politician determined to do something about it."

What could stand in Biden's way?

Despite Biden's success, the positive mood of some of the media commentary has been tempered somewhat by what *Climate Home News* called the Democrats' "disappointing performance" in the Senate race. Control of the Senate is expected to come down to two run-offs in the state of Georgia in early January, the news website stated.

According to the *Washington Post*, "some of Biden's most sweeping programs will encounter stiff resistance from senate Republicans and conservative attorneys general", specifically referencing his climate plans. Unless the Democrats are successful in Georgia, the president-elect will have to rely on "a combination of executive actions and more-modest congressional deals to advance his agenda," the newspaper reported.

Besides the difficulty of passing any new climate legislation, BuzzFeed noted that a Republican senate "could also drag its feet on confirming key Biden administration officials, including cabinet members and the administrator of the EPA".

A comment piece in the *Daily Telegraph* by Garry White, titled "Big Oil rejoice, the green revolution has been delayed", citing the Democrat's failure to take control of the Senate.

However, not all of the coverage was negative. An article in *MIT Technology Review* ran through what Biden will and will not be able to do stated:"A Biden administration would also be likely to quickly remove the roster of climate deniers, fossil-fuel lobbyists and oil executives that Trump placed in positions of power throughout federal agencies; end the suppression of scientific reports; and restore the federal government's reliance on scientists and other experts to make critical decisions on climate change."

In an article for *Bloomberg*, Gernot Wagner wrote that it would be important for Biden to approach any Covid-19 economic stimulus packages through a "climate lens" as there will be few other opportunities granted to spend in this way.

David Roberts in *Vox* said that Biden will still be able to make "enormous progress in four years – especially if he is fearless in his use of executive powers, willing to shrug off the inevitable scolding from Republicans and pundits". He concluded: "Republican climate intransigence is not a problem Biden can solve."

This sentiment was echoed by John Podesta, former climate adviser to Barack Obama, in a piece for *Bloomberg*, in which he is quoted as saying "we just don't have enough time" to try and foster bipartisan support on these issues.

What has the international response been?

Biden's climate platform set out his plan to lead internationally on climate change, stating that he would "lead an effort to get every major country to ramp up the ambition" of their targets.

In a piece examining how the president-elect plans to tackle climate change, *BBC News* environment correspondent Matt McGrath emphasised the importance of US leadership in the process of UN climate negotiations.

Climate Home News noted that Biden has promised to expose "climate outlaws" – nations that are failing to meet their Paris Agreement commitments or otherwise undermining global climate action. The publication also lists "a number of nations could soon be feeling the heat", including Australia, Brazil, China and Indonesia.

The Independent has a roundup of how world leaders responded to Biden's victory, noting that many of them emphasised the need for climate action in their messages. *Bloomberg* journalist Akshat Rathi made a Twitter thread recording such sentiments.

EurActiv reported that the "European Commission and senior EU lawmakers said they stood ready to intensify dialogue with the US on climate change, listing car CO_2 limits and green finance among areas where 'real transatlantic cooperation' is again possible after the four-year 'Trump parenthesis'".

In Australia, where the Coalition government led by Scott Morrison has faced criticism for its lack of action to address climate change, several commentators reflected on what Biden's victory would mean for the nation's leaders. *The Australian Financial Review* noted that, while the prime minister was under pressure to set more ambitious emissions targets in light of Biden's victory, Morrison said he will "hold his ground on climate change policy".

A piece in the *Guardian* written by Australian climate scientist Bill Hare described his country as "increasingly isolated as the world heads to net-zero emissions".

Meanwhile, analysis by Aaron Wherry in Canada's *CBC News* came under the headline: "The Biden presidency could change the terms of the climate debate in Canada".

The article stated that a potential "second demise" of the Keystone XL pipeline under Biden would "put new pressure" on the Canadian government to address its oil and gas industry. "American action on climate change also would increase pressure on [prime minister Justin] Trudeau's Liberals to fulfil their own promises – and perhaps even move faster," the piece added.

In "an early sign of Biden's intent to stitch climate into his foreign policy posture", *Axios* reported that Biden had discussed climate change in his first calls with the leaders of the UK, Ireland, France and Germany.

The pieces added that Trudeau said after his call with Biden that they were ready to "tackle the challenges and opportunities facing our two countries – including climate change and Covid-19".

The Guardian reported that the Australian prime minister told journalists he had discussed the similarity of the US and Australia's "policies on emissions reduction technology" on his phone call.

What does Biden's victory mean for the UK and COP26?

This year's UN climate summit, COP26, was originally set to coincide with the US election, but ended up being delayed due to the Covid-19 pandemic.
The delay has given countries more time to prepare revised climate strategies, not least the UK, where the event is set to take place next year.

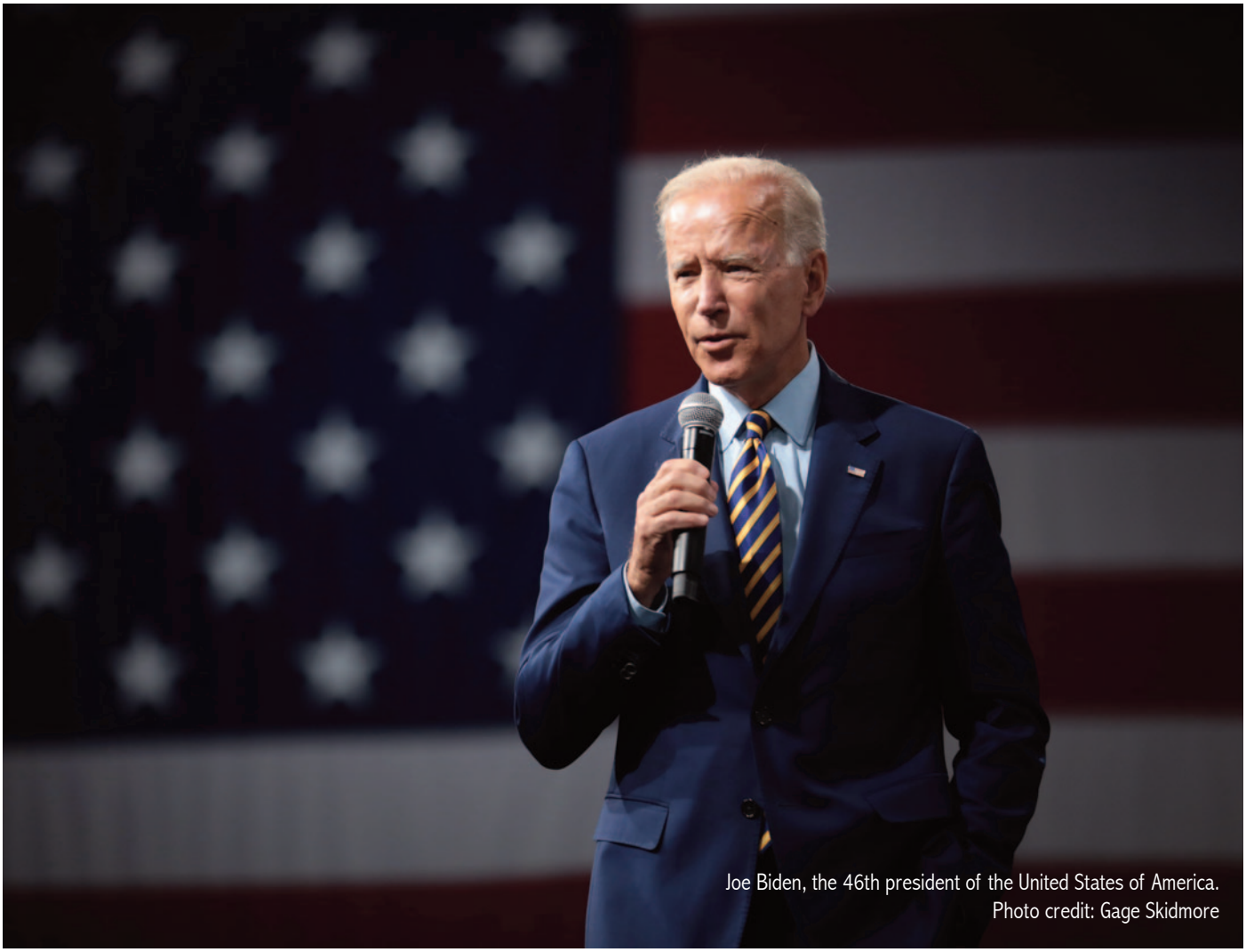
Matt McGrath for *BBC News* wrote: "With China, Japan and South Korea having set long-term goals to cut carbon, expectations are rising that the UN's COP26 climate summit, which convenes in Glasgow in November 2021, may turn out to be a success".
Writing in the *Times*, James Forsyth – political editor of the *Spectator* – wrote that "perhaps Britain's biggest win from a Biden presidency will be greater cooperation over climate change".

UK prime minister Boris Johnson is quoted by *AP* as saying: "I think now with president Biden in the White House in Washington, we have the real prospect of American global leadership in tackling climate change." AP described Johnson's remarks as "an implicit criticism of Trump".

Several publications focus on the perception that Biden supposedly has a low opinion of the British prime minister due to derogatory remarks he once made about Barack Obama, as well as the idea that climate could be a way of bridging the divide. *AFP* noted that Biden has described Johnson as "physical and emotional clone" of Trump.

According to Emma Gatten, the *Daily Telegraph*'s environment editor: "Climate change could prove the government's best in-road to the new Biden administration and help dispel the incoming president's impression that Boris Johnson is a Trump 'clone'."
Gatten added that the UK will be hoping to "pull off a diplomatic victory" by securing new commitments on meeting the goals of the Paris Agreement and that Johnson will have to persuade the US that his nation is "still a leader in this arena".

In an analysis of the two nations' future relationships, Daisy



Joe Biden, the 46th president of the United States of America.
Photo credit: Gage Skidmore

Dunne, the *Independent*'s climate correspondent, quoted Nick Mabey, the founder of climate thinktank E3G, saying "obviously the UK has the problem of the legacy with the relationship with Trump".

An editorial in the *Times* echoed these sentiments, noting that the UK government would also need to come forward with an effective climate strategy of its own both to "deepen the transatlantic alliance" and "secure a new global climate deal".

The editorial also noted that the "first test" would be a speech Johnson is set to give on how the government intends to meet its own climate targets: "It is vital that this goes beyond talk of technological moonshots and sets out the hard choices that lie ahead. What is more, a global climate deal will not negotiate itself. If Mr Johnson is to make the most of his diplomatic opportunity he should waste no further time in allocating all the diplomatic resources necessary to ensure that COP26 is a triumph."

The UK's opposition Labour party has also weighed in on the election's significance for climate action. According to the *Guardian*, "Labour is urging the government to seize on Joe Biden's presidency to redouble Britain's efforts to tackle the climate crisis by bringing forward a multibillion pound 'green recovery' plan in the run-up to next year's COP26 summit in Glasgow".

The article quoted Ed Milliband, the shadow business secretary and former Labour leader, who said the UK should bring forward its Covid-19 "green recovery" and use the "power of example" in light of Biden's victory. Current Labour leader Keir Starmer wrote an opinion piece for the *Guardian* urging the government to "seize the moment" ahead of COP26.

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Climate literacy is essential for effective change

We don't need everyone to become carbon-computing experts, but we need to make it easier to understand basic climate science and emissions reductions.

SARAH LAZAROVIC

Yes Magazine

We know less than we think we know about climate. And we know even less than that about our carbon footprint. This doesn't mean we're all idiots. Instead, it means that we live in a world where this information isn't widely available, or particularly well-conveyed. This needs to change. Quickly.

We don't need everyone to become carbon-computing experts, but we do need to make it easier to understand the basics of climate science and emissions reductions, in the hopes that people will be empowered and inspired to take climate action.

What We Don't Know

The fancy term for thinking we know more than we do is overconfidence bias. In the case of climate, a new VICE study finds that we overestimate our knowledge significantly. The study revealed that "67% of adults around the world said they had a good understanding of climate change terms, but when asked to choose the best definition of those terms, only 41% of adults chose answers that showed they knew what they were talking about." It seems our knowledge of basic climate change is, well, not so hot.

Which is why it's no surprise that a new University of British Columbia study finds that North Americans don't know much about what causes emissions either. In fact, we are surprisingly off the mark when asked to make trade-offs (nope, the emissions from a transatlantic flight cannot be mitigated by picking up litter). Carbon numeracy, or people's knowledge of the carbon impacts of goods and services, is a remarkably under-researched area. The good news is that we're starting to learn about how much we don't know. "People have very incorrect ideas of what's effective and what's not," says Jiaying Zhao, an associate professor of psychology at UBC, and one of the study's co-authors.

Why We Don't Know

There are lots of reasons why we don't know nearly enough about climate change and carbon emissions. The consensus on climate science grows stronger by the day but has only existed for a few generations, and is still highly politicized. And the science is complicated, especially when we're not formally taught about climate change with any great breadth or consistency across our formal education.

In some areas, the public has been well-educated, as is the case with the benefits of electric vehicles versus gas vehicles. In other areas, we've been fed a lot of misinformation, such as the overstated benefits of recycling that actually have minimal effect on our emissions reductions. What's more, numbers are communicated in ways that have no relevance to the average individual who doesn't talk in megatonnes. Better to say that a transatlantic flight is roughly equivalent to the emissions that an average person in The Global North produces in an entire year.

Another key reason all this is so difficult is that it's impossible to know the carbon footprint of most of the stuff we buy. Climate impacts are much more complicated than calories or personal finances, because they require an understanding of energy, agriculture, and fuel efficiency.

Why It Matters

All of this is so important because you can't measure what you don't understand. It's hard to care about climate and know what actions to take or advocate for if we don't know what emissions are or what we can do about them.

What We Can Do

We have lots of ways to improve basic climate knowledge

and carbon numeracy. But we should focus on the arenas in which people's knowledge gaps are the largest: What is climate change, and what are the best things to do to stop it? Upstream policy interventions are essential, but people need to understand the basics to care enough to advocate for those important interventions.

Quick Tips for Climate Shifts

The message isn't austerity. It's that we need to be smarter. "We don't have to become calculators," says Shahzeen Attari, an associate professor in the school of public and environmental affairs at Indiana University Bloomington. "We just need to know the most effective things we can do and go out and do them."

We should be doing the things that get the most bang for our buck. Right now, we're spending lots of effort on the wrong things. Simple heuristics or shortcuts can help people focus on the most important things to reduce their footprints, starting with how we travel, then moving on to how we power our homes and what we eat.

Design and photo credit: sarahl.com

Label This

We should really slap carbon labels on everything. There's no excuse for not providing people with what should be one of the most important metrics in determining what they buy. Recent polling by Canadian climate policy institute Clean Prosperity suggests 71% of Canadians would like to see these labels on their products. Another recent study by Globescan, a research consultancy, finds that people overwhelmingly want to live sustainable lifestyles but need concrete information to support their efforts.

As technology makes it easier and easier to calculate a product's emissions, the industry complaint that figuring out how to do this is untenable or expensive no longer holds water. Large manufactures track and manage every aspect of their supply chain. (It's why they can do things such as get rid of unsustainable suppliers, as the Mars candy company did with palm oil). Calculating emissions along the way is increasingly becoming the cost of doing business. A few big manufacturers, including Unilever, have already committed to doing so. How companies label will also help people understand and quantify their emissions.

Carbon Trust, a leading U.K. carbon footprint labeler, suggests language like "this product is X times lower than the market standard." Companies can also share emissions info by representing it with visual metaphor. For example, trying to visually quantify emissions in ways that people understand, such as traffic lights or a simple scale of 1 to 10. In this way, labels can fulfill their responsibility to disclose, while also helping improve carbon numeracy for consumers.

"I think we should label all the things we buy, so all consumer products going from a sandwich to a car to a flight we book," says University of British Columbia's Zhao. "That doesn't necessarily mean you can influence actions, but the hope is that consumers would become more aware, and they will make different choices if they can."

That said, Indiana University's Attari cautions that labels are not the only solution. "Given our limited time and attention, people need to know the things to do as individuals, and as political actors. That includes things like voting, protesting, and voting with your wallet."

Put a Price it

A partner recommendation to carbon labeling products is putting a price on carbon itself, in the form of a carbon tax. A carbon tax means the cost of the good or service will automatically reflect the emissions required to produce it. And in a world with far too much information to consume already, this seems the wisest, fairest, and easiest course of action. By pricing carbon, the cost of the good or service gives us important information about its emissions intensity.

Together, labeling and taxing go a long way towards informing the consumer of the true cost of emissions. It's about transparency and clarity. And you know, saving humanity. Of course, we need a whole whack of other solutions, too. But to mobilize people in support of our most imminent existential threat, we should use the simplest, quickest tools to bring the world up to a modest degree of carbon fluency. There isn't time for anything less.

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Are forests the new coal? Global alarm sounds as biomass burning surges

Though current science has shown that burning the world's forests to make electricity is disastrous for biodiversity, generates more emissions than coal, and isn't carbon neutral, a UN policy established in the 1997 Kyoto Protocol erroneously counts energy produced from forest biomass as carbon neutral.

JUSTIN CATANOSO

Mongabay

The forest biomass industry is sprawling and spreading globally — rapidly growing in size, scale, revenue, and political influence — even as forest ecologists and climatologists warn that the industry is putting the planet's temperate and tropical forests at risk, and aggressively lobbying governments against using wood pellets as a "renewable energy" alternative to burning coal.

"We have repeatedly pointed out that… the large-scale substitution of coal by forest biomass [to produce electricity] will accelerate climate warming, and will increase the risks of overshooting Paris [Climate Agreement] targets," Michael Norton, environmental director of the Science Advisory Council of the European Academies, said in a December 2019 statement issued to European Union countries.

"The reason is simple: when the forest is harvested and used for bioenergy, all the carbon in the biomass enters the atmosphere very quickly, but it will not be reabsorbed by new trees for decades. This is not compatible with the need to tackle the climate crisis urgently," said Norton.

As the forest biomass industry expands rapidly in the U.S., Canada, Russia, Vietnam and Eastern Europe, so too does the threat to untold acres of natural forests and their biodiverse ecosystems needed for carbon sequestration and climate change mitigation in those same nations and regions, even as global warming is poised to set punishing new records in 2020.

"Our two biggest global environmental challenges — climate change and biodiversity loss — are inextricably linked, so keeping forests standing must be a priority of all governments," said Natural Resource Defense Council Senior Advocate Sasha Stashwick, in an interview with BioEnergy Insight.

"Much of the wood burned in UK power plants is cut down and shipped from ecologically sensitive forests in the U.S. Southeast. Those forests are efficient and powerful carbon-capture systems and support unique wildlife found nowhere else in the world," said Stashwick. But they can't serve that important purpose if the trees are cut and turned into wood pellets, and don't grow back for decades.

Biomass industry in full boom

With one possible exception in the Netherlands — where wood pellet burning is under examination as policy — today's forest biomass industry is both refuting and shrugging off its environmental critics, and appears to be on a roll. That's lar-

IOI Sandakan Biomass Power Plant (Malaysia).
Photo credit: CEphoto, Uwe Aranas

gely thanks to the so-called United Nations carbon accounting loophole that designates the burning of forests to generate electricity as carbon-neutral, despite recent hard science that shows otherwise.

Consider these news items, most published in just the past few months, sampling the industry's explosive growth:

* U.S. wood pellet exports have more than tripled, from 1.9 million metric tons in 2012 to about 6.9 million metric tons in 2019; the first five months of 2020 outpaced the first five months of last year, according to Forisk Consulting, which analyzes the industry.

* Pellet maker Pinnacle Renewable Energy had a record second quarter (April-June 2020) for production and sales of forest biomass from British Columbia and Alberta, Canada. The company sold 620,000 metric tons of wood pellets for export during the three-month period, up 21% over the previous quarter, and up 30% when compared to the second quarter of 2019, according to public filings.

* Maryland-based Enviva, publicly traded and the world's largest producer of industrial-use wood pellets, spent $175 million to purchase its ninth plant in the U.S. Southeast. Two more plants are under construction in Alabama and Mississippi and promise to be the largest pellet-producing facilities on earth. Eniva's pellets are bound for burning at converted coal plants mostly in the UK, but increasingly Japan and South Korea.

* North Carolina, the largest pellet-producing state in the U.S. Southeast, just approved its fifth plant, this one in Robeson County, which already has a large Enviva plant; all pellets are exported. Despite opposition from the public and environmental groups, the NC Department of Environmental Quality (DEQ) issued a permit to UK-based Active Renewable Energy Power, even as DEQ pledges to never use biomass to make energy for North Carolina.

* UK-based Drax, the world's largest user of wood pellets for energy production, has had a booming first half of 2020. It reported a win-win for investors with biomass energy generation up 16% over the first half of 2019. Also, production at its own pellet-making plants in the U.S. Southeast is up 15% over 2019, with costs down 9%. Drax continues to enjoy more than $1 billion annually in government subsidies because biomass is technically deemed a carbon-neutral energy source on par with wind and solar.

*Subsidies for biomass energy generation are so great in South Korea that – as in the UK and EU – the Asian nation is reducing investments that would otherwise go to truly renewable energy sources like wind and solar, according to a new study. Russia and the U.S. are supplying South Korea with pellets, but so too is Vietnam, Indonesia and Malaysia, whose biodiverse rainforests are already under extreme pressure from agribusiness and mining.

* Japan, the world's third-largest economy, must import nearly all its energy since the Fukishima nuclear disaster in 2011. To

Tillamook state forest (Oregon, USA).
Photo credit: Tiger635

meet that need, it is converting more than 20 coal-fired power plants to co-fire with wood pellets and coal until a complete transition to pellets can be made. Vietnam, relatively new to pellet production, will likely clear cut thousands of acres of rainforest to meet Japan's surging biomass demand. Pellet makers in Canada and the U.S. are also gearing up to meet Japan's soaring demand.

* According to financial forecasters, global revenue for solid biomass is projected to nearly double from $221.7 billion in 2019, to $425.8 billion by 2027. Much of those profits will come from harvesting and burning trees – along with the spewing of carbon into the atmosphere, while meeting Paris Agreement national carbon targets on paper.

Biomass defense and carbon loophole

Forest experts have argued for a decade that the biomass industry is the beneficiary of a flaw in the 1997 Kyoto Protocol that classified forest biomass burning as a renewable energy source equivalent to zero-carbon wind and solar.

The reasoning then was that the carbon released by burning wood pellets would be offset by the replanting of new trees – partly true, but with a huge caveat. Studies have shown that carbon neutrality, if enough new trees are planted to replace those pelletized, takes 50-100 years – a timeframe far too long given the accelerating pace of climate change. The UN itself says we have just ten years to make drastic emissions cuts or face catastrophic global warming impacts.

But today, with the UN's full blessing, countries continue burning forest biomass without needing to count the actual carbon emissions produced against their Paris Agreement carbon reduction pledges, thus giving a false, on-paper-only accounting of reductions.

Studies have shown that biomass actually pollutes more than coal because more biomass is needed using wood pellets to generate the same amount of energy as coal. The biomass industry argues that its critics have it all wrong. In public hearings, statements and scientific reports of their own, the industry stresses that it is a green climate-friendly alternative to burning coal. The companies argue, for example, that they do not clear cut forests, but rather "manage" harvests in such a way that carbon sequestration is undisturbed, even as forest advocates tracking those same harvesting methods tell a far different story.

"While our industry welcomes robust scrutiny and debate on the issues," said Seth Ginther, executive director of the U.S. Industrial Pellet Association, in a statement, "it's important for us to recognize and acknowledge that we have reached a tipping point where the overwhelming data, evidence and peer reviewed research points to the fact that sustainable biomass

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is part of the climate change solution." With EU countries required by law to reduce their carbon emissions annually, Ginther's pro-biomass advocacy position appears to hold sway — not the contrary view held by forest ecologists and environmentalists. Nearly 60% of renewable energy generated in the EU today comes not from wind or solar, but from burning biomass, mostly using wood pellets made out of whole trees and lumber waste.

Pushback in the Netherlands

In early July, environmentalists met with some success In their advocacy against biomass. The independent Dutch Social Economic Council (SER), made up of business leaders, academics and NGOs, recommended to the Dutch Parliament that it phase out the use of biomass for electricity and heat generation. The Netherlands gets 61% of its renewable energy from biomass. SER recommended that biomass still be used, though in smaller quantities for the production of innovative chemicals, bio-plastics and bio-concrete, instead of using fossil fuels for those limited purposes. The Dutch government will decide this fall how, or if, to incorporate these recommendations into its climate change mitigations laws. Those laws call for carbon emission reductions of 49% by 2030. Almuth Ernsting, with Biofuels Watch in Scotland, has been lobbying against biomass in the EU for 10 years. She called the SER solution an imperfect compromise, but told Mongabay, "If the Dutch government accepts the recommendations and implements them, that would send a really strong signal to other EU nations [on biomass]. The Netherlands is one of the big players within the EU and internationally. If [the SER report] gets translated into meaningful policy change, it will make a huge difference."

That difference could save forests in Eastern Europe, according to Martin Luiga of Forest Aid Estonia: "Logging rates in Estonia are far too high to protect the climate. Most of our endangered species are forest-dwelling species, and there is widespread public concern about the intensity of logging. Nonetheless, the prevailing political mood is to further increase the harvesting volumes. Reducing demand for pellets would greatly help the situation and thereby protect Estonian forests."

A RED review?

Rita Frost, campaigns director with the North Carolina, USA-based Dogwood Alliance, a forest-protection NGO, has likewise focused her efforts on shifting the Netherlands position on biomass. That includes targeting the EU's Renewable Energy Directive (RED), which states that burning wood pellets is carbon neutral and a legitimate way to reduce carbon emissions. "It goes back to the problem with the RED and the belief that there is [such a thing as] sustainable biomass," Frost told Mongabay. "The industry has used that argument effectively in Sweden, Finland and the Netherlands, which have intensive forestry management practices. And when [those governments] look at the [wood pellet] supply coming from the U.S., they figure it must be okay. But with our work, and the work in the Baltic states, the picture is much different on the ground, where we have documented the extensive loss of forests."

Environmental advocates have won some smaller victories in the past few years — prevailing on the UK to cap subsidies and expansion of its massive Drax pellet burning plant, while also seeing the EU put some new biomass plants on hold. Also, as a matter of UK policy, subsidies to Drax for burning biomass, having started in 2007, are now set to end in 2027 unless the company successfully lobbies for an extension. Fourteen EU countries presently provide subsidies for bioenergy, but it's unclear how long such taxpayer support will remain in place, according to research by the Natural Resources Defense Council (NRDC), an NGO. Ultimately, biomass critics acknowledge that real change depends on the EU revising its Renewable Energy Directive (RED) and closing the carbon neutrality loophole. At the UN climate summit in Madrid last December, Franz Timmermans, executive vice president of the EU and a Dutch politician, told Mongabay that RED's current biomass position needed to be reviewed because of recent scientific studies, perhaps in 2021. "The issue of biofuels needs to be looked at very carefully," Timmermans said in Madrid. "We have to make sure that what we do with biofuels is sustainable and does not do more harm than that it does good."

Almuth with BioFuels Watch said she was encouraged by Timmermans' comment, but stressed that much more work on the part of scientists and environmentalists is needed to shift public opinion and create political will in the face of a biomass industry steadily growing larger, wealthier and more influential. "Any legal change to the RED would require the support of the majority of [EU] member states, or 15 or 27 countries," Almuth said. "It will take a lot of awareness raising and campaigning to make that possible. That's why the upcoming debate and political arguments coming this fall in the Netherlands over biomass and carbon neutrality is so important.

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Warmer climate and Arctic sea ice in a veritable suicide pact

Their 'death spiral' is a vicious melting-warming feedback, leading to more melting of snow and ice and still more warming, an ongoing cycle.

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Think of it as a suicide pact on ice – global warming and Arctic sea ice in a mutually destructive relationship. Earth's rising temperatures melt Arctic snow and ice, which, as the reflective surface cover disappears, reveals the dark land and ocean surface beneath. That darkening surface causes the Arctic to absorb more sunlight and therefore to warm faster … which in turn leads to more melting of snow and ice, ergo resulting in more warming. Scientists refer to Earth's surface reflectivity as its "albedo," and to the vicious Arctic melting-warming cycle as a "feedback." One action precipitates and reinforces another, in this case with Arctic warming and ice loss each accelerating the other. As a result, the Arctic is warming three times faster than the global average and its sea ice is quickly melting away. In summers between 1979 and 2012, Arctic sea ice had lost half its surface area and three-quarters of its volume. Some climate scientists described this rapid decline as the "Arctic sea ice death spiral."

But then came the unexpected – the ice death spiral froze. The years 2014 through 2020 have been the seven hottest ever recorded on Earth, with the resulting heat fueling monster hurricanes in the Gulf of Mexico and record wildfires in the western U.S. and Australia. "Ever since the record-smashing summer of 2012, Arctic scientists have watched melt seasons unfold with bated breath: Will this year break the record again? Will this year bring the long-anticipated sea-ice-free summer?" said climate scientist Jennifer Francis of the Woodwell Climate Research Center. "And almost every August, the rate of ice loss came to a screeching halt, averting a new record minimum. But why?"

Defying both the heat and scientists' expectations, the record minimum set in September 2012 still stands, as illustrated in graphic artist Andy Lee Robinson's video [titled "Arctic Sea Ice Minimum Volumes 1979-2020", available on You Tube.]

What froze the death spiral?

Francis and her co-author Bingyi Wu of Fudan University in Shanghai have a theory that the rapid warming in the Arctic prompted a change in the polar jet stream, the narrow band of strong wind circling the region; they theorize that this change helped preserve some sea ice. Their new study in Environmental Research Letters notes that the winter and spring sea ice extent reached record low levels nearly every year since 2012 … but then the trajectory took a sharp turn late into the summer season, with the loss curbing early and therefore avoiding setting a new record low annual minimum in September. Francis and Wu identified a common pattern in atmospheric air circulations during many of the summers since 2012: Low-pressure systems would develop in the Arctic, forming clouds that kept temperatures cool by blocking sunlight and generating winds that spread out the remaining ice. These weather systems lingered because a split in the jet stream trapped them in light winds that failed to move them along. When the jet stream air current slows down, much like a slow water current in a river, it develops a meandering wavy pattern rather than a strong straight path. The authors suggest that the decline in northern latitude snow cover and Arctic sea ice resulting from global warming may be contributing to more frequent wavy jet stream events. The temperature difference between the cold Arctic and warmer lower latitudes creates a force that propels the atmospheric air currents. The rapid warming of the Arctic, due largely to its increased absorption of sunlight resulting from the melting of reflective snow and ice, is decreasing the temperature difference between that region and lower

latitudes. This in turn has weakened the force on the jet stream, leading to more slow meandering air currents. The melting Arctic may be slowing its own decline by allowing more low-pressure cloudy weather systems to linger in the summer.

But it may only have delayed, not stopped the spiral…

The study finds that these recent atmospheric patterns resemble those identified in a 2018 study led by Michael Mann of Penn State University. "This is a fascinating article, drawing a new linkage between seemingly disparate climate change impacts," Mann, not personally involved in the Francis/Wu work, wrote via email. "Jennifer Francis has been doing very innovative work for years now looking at the relationship between amplified Arctic warming and the behavior of the Northern Hemisphere jet stream," he wrote.

"In this new article, Francis and Wu demonstrate that a climate change impact my co-authors and I have investigated previously, known as 'planetary wave resonance,' which is responsible for many of the extreme summer weather events we've seen in recent years, may also explain why the rate of decline in Arctic sea ice has decreased a bit in recent years. A little bit of good news, perhaps, given the otherwise bleak outlook for the Arctic as we continue to warm the planet."

As Mann hinted, this jet stream effect can only delay the inevitable Arctic sea ice death spiral because the melting effect of ever-rising temperatures can be held in check only for so long. In fact, Francis and Wu noted that the wind pattern that causes abrupt Arctic cooling didn't occur in the summers of 2019 and 2020, and the sea ice minimum record was nearly broken in both years. Another new study published in Nature Climate Change used the latest generation of climate models to simulate Arctic sea ice during the warm period 120,000 years ago before the last ice age. The simulations showed that during that era, the Arctic was very likely ice-free in the summer. The team also ran model simulations for the future and found that summer Arctic sea ice likely will be gone between about 2030 and 2050.

And what happens in the Arctic doesn't just stay there

Hungry polar bears facing a shrinking hunting range are not the only ones affected by the rapid melting of ice and snow in the Arctic. A growing body of scientific research suggests that while changes in the jet stream may have temporarily slowed the death spiral, they also have contributed to extreme heat, fires, drought, and floods in regions across the northern hemisphere. The summer cloudy low-pressure Arctic systems, for instance, aren't the only types of weather events made more frequent by the increasingly wavy jet stream. Francis and Wu found that conversely, high pressure systems have tended to develop at the same time in Canada, east Asia, Scandinavia, and the north Pacific Ocean, leading to frequent summer heatwaves in those regions. In addition, a 2017 study in Nature Communications, lead authors Ivana Cvijanovic and Benjamin Santer, then with Lawrence Livermore National Laboratory, found that the Arctic sea ice decline will lead to more high-pressure ridges loitering off the coast of California. This type of persistent high-pressure system developed in the winters of 2012-2015, diverting rain systems to the north of the state, causing dry conditions that contributed to California's most intense drought in over a millennium.

The 2018 study by Mann and colleagues noted also that other recent extreme weather events influenced by the wavy jet stream include the deadly 2003 European heat wave, 2010 wildfires in Russia and floods in Pakistan, and a 2011 heat wave and drought in Oklahoma and Texas.

In 2018, prominent jet stream waves coincided with high-pressure systems causing intense heat in Scandinavia, central Europe, and California (contributing to the state's then-record wildfire season), and also with flooding in the eastern U.S. And in a 2018 paper in Nature, James Kossin of the National Oceanic and Atmospheric Administration found that hurricanes have slowed by 10% since 1950. That's important because slower hurricanes wreak more flooding and destruction on the regions they strike. This hurricane slowing may also be a result of the increasingly wavy jet stream, an issue still a subject of ongoing scientific research. As for the "surprise" of the recent lull in the death spiral, Francis in her formal statement about her and Wu's study commented, "Accumulating greenhouse gases affect the Earth's climate in sometimes unforeseen, counter-intuitive ways."

"We must do everything in our power to reduce emissions of greenhouse gases, accelerate efforts to remove carbon from the atmosphere, and prepare for more surprises ahead," Francis said.

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Wind blows, hydrogen goes

ALICE MASILI
ONE

The future of travel will not only belong to battery-powered vehicles. Climate-neutral synthetic fuels are another promising option, and the focus of a pioneering new plant. The "Haru Oni" pilot project is expected to go into operation by 2022 in Magallanes province in Chile. It will be the largest green hydrogen plant of its kind in Latin America.

The project lines up Siemens Energy, Porsche, Enel Green Power Chile, the Chilean electricity company AME and the Chilean oil company ENAP. This broad partnership plans to use green hydrogen to produce 130,000 litres of transport fuel, known as 'e-fuel' due to being ultimately derived from green electricity.

The capacity should increase to approximately 55 million litres of e-fuel per year by 2024 and around 550 million litres by 2026. Porsche will also be the first customer, using the e-fuel both for its motorsport and passenger cars sectors.

The electrification of the automobile sector is undoubtedly a significant step forward in the fight against climate change. Nevertheless, synthetic fuels can also be part of the solution, especially for luxury cars, sports models, and generally for production lines that do not cater for a large number of customers. Synthetic fuels include many variants - from ethanol, already adopted in South America, to gasoline derived from second generation biomass, and to those obtained from green hydrogen.

These climate-neutral fuels are suitable for combustion engines and plug-in hybrids and can use the existing network of filling stations - a great advantage, considering

Magallanes and Chile flags in Punta Arenas (Chile).
Photo credit: Breathe

the massive investments required to complete the transition towards a fully electric system. The interests of carmakers, keen to keep alive the production of combustion engines, gearboxes and mechanical drives, are shared with oil and petrochemical companies looking for a solution that keeps them in play in a decarbonised world.

These are the reasons that prompted the sports car maker Porsche to take part in the development and construction of the Haru Oni plant.

The wide availability of energy from renewable sources was indispensable for the project. The excellent and abundant wind conditions in southern Chile provide just what is needed to ensure the production of a climate-neutral fuel. Siemens Energy's proton-exchange membrane electrolysers will convert the energy supplied by wind turbines into hydrogen. Subsequently, the CO2 filtered from the air will be combined with hydrogen to form synthetic methanol ("renewable methanol"). Finally, the methanol will be converted to gasoline, using MTG (methanol-to-gasoline) technology provided by Exxon Mobil.

The Haru Oni project, also known as HIF, Highly Innovative Fuels, received 8 million euros from the German Ministry of Economic Affairs and Energy, as part of the national hydrogen strategy. "We know we won't be able to cover our national demand out of domestic production alone and will need international partnerships. So I'm very pleased to see that Siemens Energy and Porsche are developing production capacity in other countries, along with importing structures, for green hydrogen and its daughter products. Thanks to German know-how, for the first time in the world innovation from the laboratory, will now be applied in an integrated, commercial plant", Germany Economy Minister Peter Altmaier said.

The transport and industry sectors are together responsible for 45% of the world's CO2 emissions. The decarbonisation of transport and industry is much more complicated than in the energy sector, as it brings into play more actors and more diverse situations.

In Europe, cars are responsible for around 12% of the region's CO2 emissions. This is why the European Union has introduced CO2 emission performance standards for new passenger cars and new vans for 2025 and 2030, and also decided to gradually incorporate road traffic and the construction sector into its emissions trading scheme. Encouraging eco-innovation of all kinds is the priority. .

Photo credit: Alex Proimos

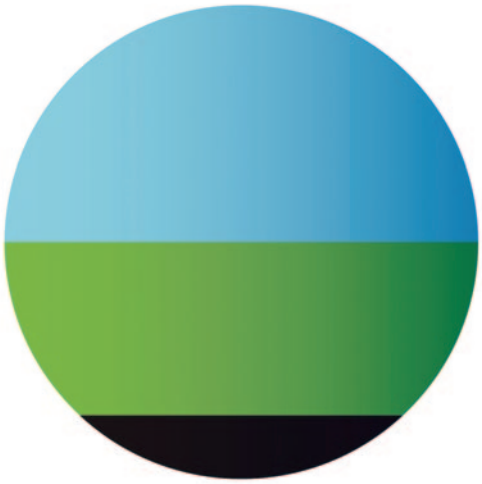
NAVAJO GENERATING STATION

A triple fraud. The leasing, the compensation, the ending. The story of the Navajo Generating Station is also the story of the Native Americans tricky relationship with mining industry corporations. In the Sixties, the Peabody Energy company obtained from the Hopi Tribe and the Navajo Nation the leases to mine in Kayenta and built a power plant in Page, Arizona (USA). The Navajo Generating Station had three 236-meter tall flue gas stacks, the most iconic part of three identical 750 MW steam electric generating units. It provided electricity to Arizona, Nevada, and California.

The Navajo Nation and the Hopi Tribe reward was a 3.3 per cent royalty. A terrible deal that had an explanation - the attorney representing the Hopi Tribe was on Peabody's payroll. Later they found out the scam, fought back and managed to negotiate better contractual terms. But no compensation could match the suffering for the Hopi families' forced relocation and also for the destruction of several ancestral shrines. The plant had nearly 600 employees - ninety per cent were Native Americans. Natural-gas-fired electricity was a cheaper option than coal and in the owners decided to close the plant. The Navajo Nation tried to buy the facility then asked for the Federal government intervention. Neither actions could prevent the closing down on November 18, 2019. Thirteen months later the three towering smokestacks at the Navajo Generating Station were demolished in a controlled explosion.

After the explosion, members of the Navajo Nation and Hopi tribe released a statement, saying, "It marks the close of a painful chapter for thousands of Navajo and Hopi whose lives and families have been impacted by coal. Until it closed last November, the 2,400 MW power plant generated electricity for Phoenix, Tucson, Las Vegas, Los Angeles and other cities, insultingly bypassing Navajo and Hopi homes and businesses. The plant also pumped the massive amounts of water that has allowed Phoenix to grow into the fifth largest city in America, all while thousands of Navajo and Hopi homes also lack access to running water." A landmark is gone, the wounds are not. ONE

SOTACARBO



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