CLIMATE 2020

UNA-UK

The path ahead

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BECAUSE CLIMATE JUSTICE IS GENDER JUSTICE

A changing climate affects us all but women are disproportionately at risk.

Climate action must be by, and for, women.

UN Women works with women farmers on climate-resilient agriculture to build sustainable livelihoods.

UN Women Viet Nam/Lai Dien Dam

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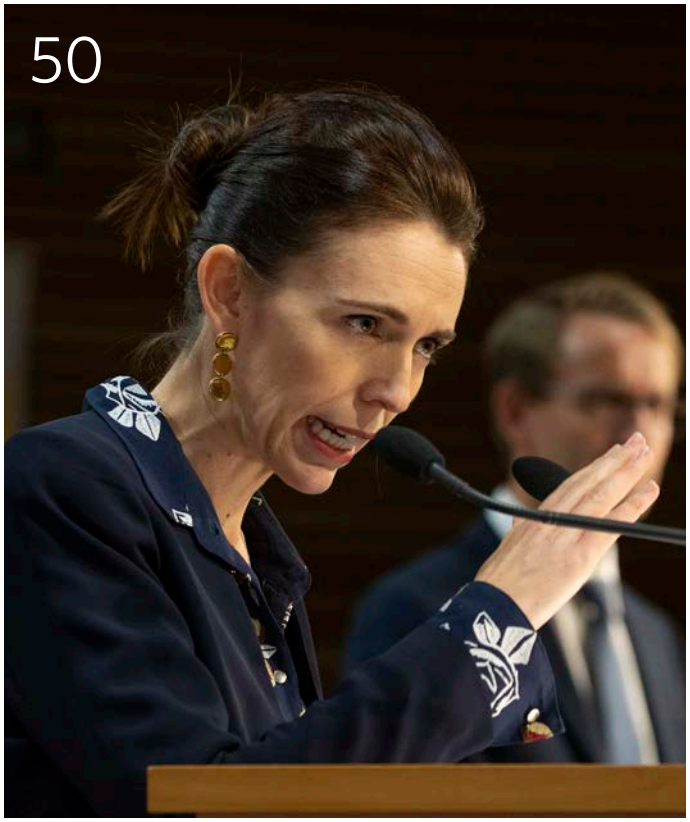
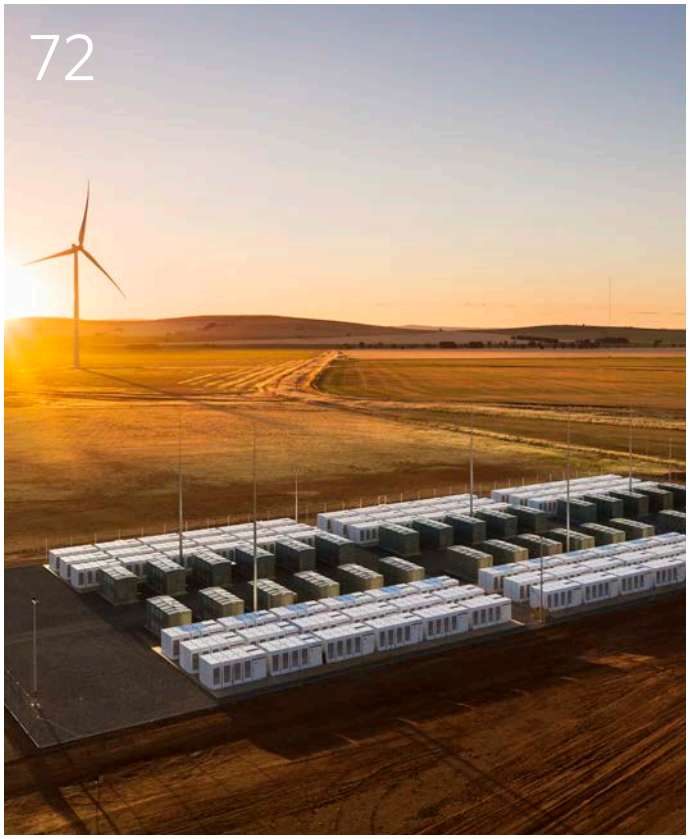
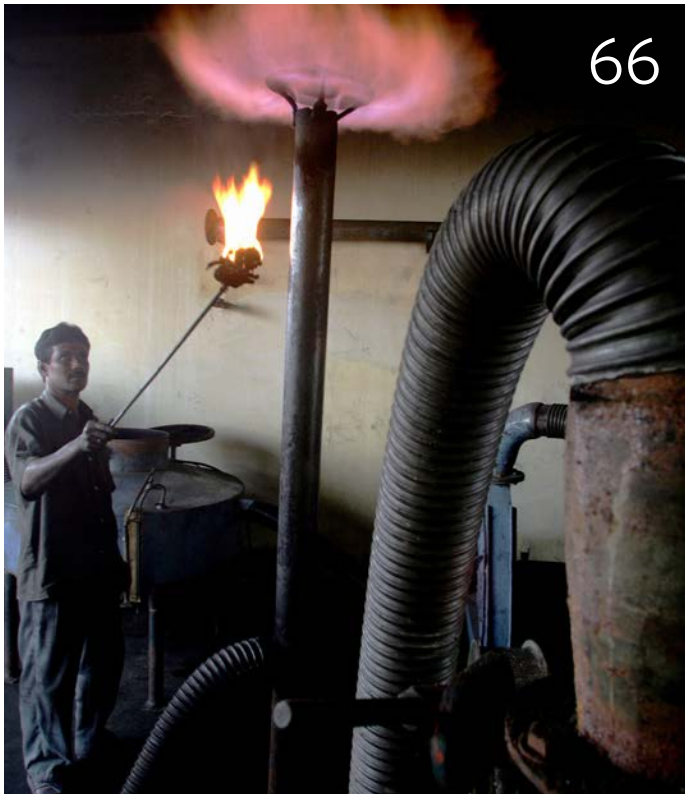




NET ZERO

FINANCE

GREY AREAS



A wake-up call

The recovery from COVID-19 should be focused on securing a sustainable, equitable and resilient future. There are six climate actions that need to underpin this recovery

◀ **Berai, Mozambique. UN Secretary-General Antonio Guterres visits a school damaged by Cyclone Idai. Cyclone Idai and Kenneth, which followed a few weeks later in spring 2019, combined to put approximately 2.2 million people in need of assistance across Madagascar, Mozambique, Malawi and Zimbabwe**

By **António Guterres**,
Secretary-General, United Nations

All eyes and energies are rightly on the COVID-19 pandemic – the biggest test the world has faced since the Second World War. The impact of the coronavirus is immediate and horrific. We must work together to save lives, ease suffering, lessen the shattering economic and social consequences and bring the disease under control.

But we must also recover better – and that means maintaining our focus on climate change. The planet's unfolding environmental crisis threatens vast devastation to lives and livelihoods. Biodiversity is in steep decline. The world's oceans are warming and filling with waste.

We must act decisively to protect people and planet from both the coronavirus and the existential threat of climate disruption. By committing now to building back better from today's tragic crisis, we can use the recovery from the effects of COVID-19 to secure a more sustainable, equitable and resilient future.

For that, we continue to need ambitious climate action on mitigation, adaptation and finance. We need to ensure we keep the promise of the Paris Agreement to limit global temperature rise to 1.5ºC. Despite the postponement of the next Conference of the Parties to the Framework Convention on Climate Change (COP26), we still need countries to come forward this year with enhanced nationally determined contributions and strategies to reach net zero emissions.

The COVID-19 crisis is a wake-up call. We need to turn the recovery into a real opportunity to do things right for the future. I am proposing six climate actions to shape the recovery and the work ahead.

First: as we spend huge amounts of money to recover from COVID-19, we must deliver new jobs and businesses through a clean, green transition.

Second: where taxpayers' money is used to rescue businesses, it needs to be tied to achieving green jobs and sustainable growth.

Third: fiscal firepower must drive a shift from the grey to green economy, and make societies and people more resilient

Fourth: public funds should be used to invest in the future, not the past, and flow to sustainable sectors and projects that help the environment and the climate. Fossil fuel subsidies must end, and polluters must start paying for their pollution.

Fifth: climate risks and opportunities must be incorporated into the financial system as well as all aspects of public policy making and infrastructure.

Sixth: we need to work together as an international community.

These six principles can guide us in recovering better together. Gradual approaches are no longer enough. Governments must deliver the transformational change our world needs and that people demand.

The scientific community is clear. We need to reduce greenhouse gas emissions by 45 per cent from 2010 levels by 2030, and reach net zero emissions by 2050. The main obligation rests on the main emitters. Those countries that contributed most to this crisis must lead the way.

The climate battle is a battle we can win. Technology is on our side. Scientists tell us it is not too late... All the tools and knowledge to move from the grey economy to the green economy are already available

The climate battle is a battle we can win. Technology is on our side. Scientists tell us it is not too late. Economists and asset managers tell us that climate smart investments are the key to competing and thriving in the 21st century. All the tools and knowledge to move from the grey economy to the green economy are already available.

Greenhouse gases, just like viruses, do not respect national boundaries. By working closely together we can rescue our planet and build a healthy and resilient future for people and planet alike. ●

Everything is possible

The COVID-19 crisis revealed that there was an alternative to business as usual all along

By **Fred Carver**, Head of Policy, United Nations Association – UK

We can change the way we live our lives somewhat, or have it changed for us out of all recognition. This has been the implicit or explicit message of much of the conversation around climate change in recent years. It was also the message of recent political campaigns that made a green new deal or industrial revolution the heart of their offer – and enjoyed a surge in support towards the end of the decade (although in many cases falling short of elected office).

And now, in the world's reaction to the coronavirus pandemic, we have seen both the truth of that statement and the fact that – faced with the immediate reality of such a choice – the vast majority of the populations of over 90 countries around the world have willingly chosen the former. Furthermore, by and large, those whose privilege means that they are unlikely to suffer direct and immediate consequences from such a crisis have demonstrated that they are willing to make sacrifices in solidarity with, and in order to protect, the most vulnerable communities that will be hardest hit.

Shared experience

However, it would be naïve to assume that having made such a choice in response to one crisis, it will now be straightforward to persuade the world to make it once again in response to another, and so set the world on a pathway to limit global warming to a less disruptive 1.5°C above pre-industrial levels.

For one thing, while COVID-19 – like climate change – represented an invisible threat, it moved fast enough to seem tangible and capture the public imagination. For another, limiting the spread of the new virus was something largely within our collective power and where a considerable number of us had the ability to effect the change we needed to see.

This isn't true of climate change, where the wealthiest individuals and the leaders of specific industries have dramatically more ability to curb emissions than the population at large, and where meaningful smoothing of the curve can only be achieved through government policy, not lifestyle changes.

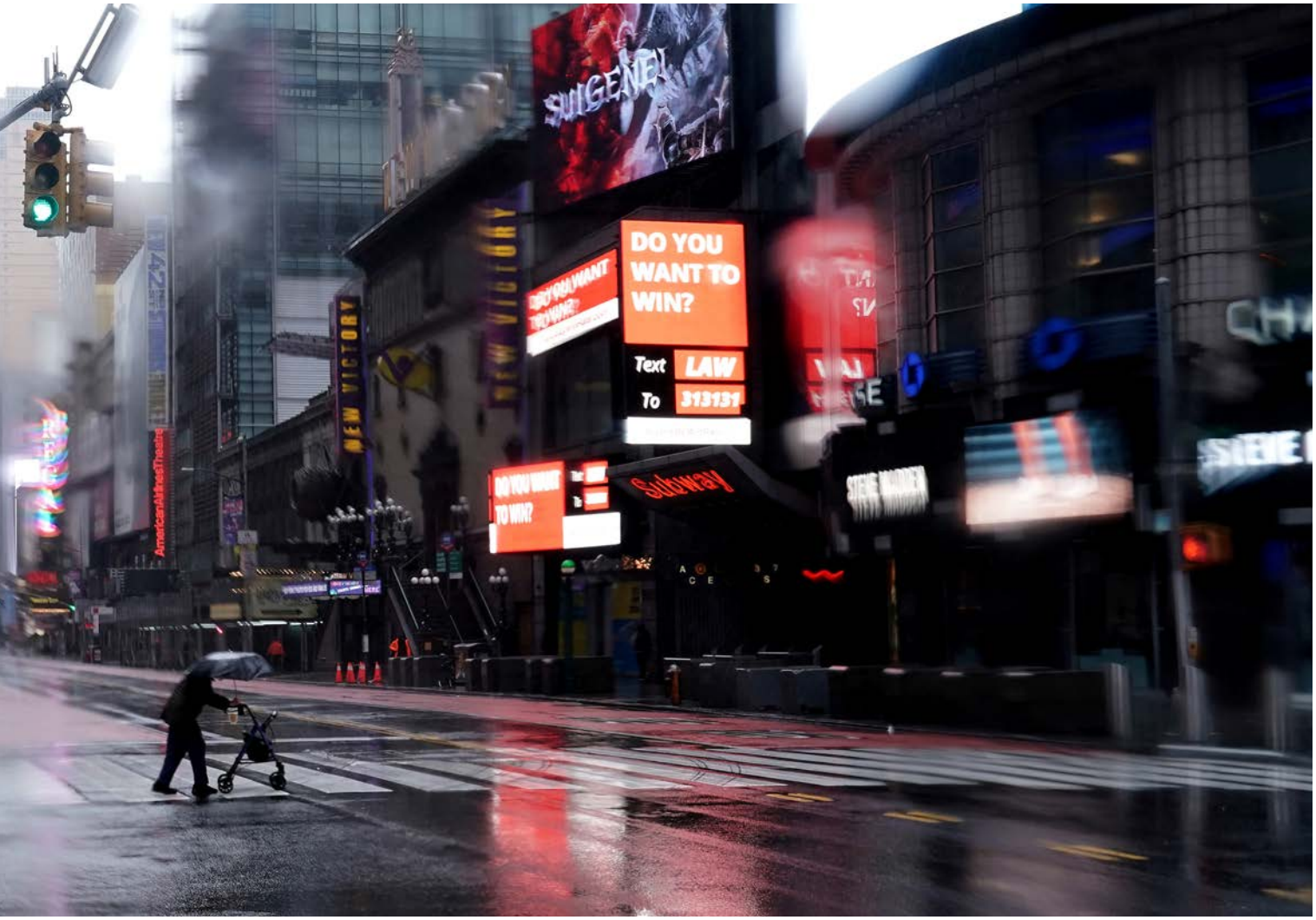
It is too early to say what the lasting effects of COVID-19 will be, and we should be wary of superficial 'hot takes'. Only time will tell whether, as we hope, the consequence will be a greater realisation of the importance of global cooperation and international mechanisms to address existential risk or, as we fear, it will be an amplification of bigoted notions of disease-causing foreigners, an impossible demand for borders impermeable to microbes, and xenophobia. Que sera sera – we can leave it to the scholars of the future to write the history of this time. Our job is to make it.

> ***What previously appeared to be simply the way things were has been exposed as a political choice***

My personal experience was no doubt common to many in that it was at the same time hyper-global and hyper-local. On the one hand it has united people across the globe in a shared experience, and demonstrated the truth of the notion that our health system is only ever as strong, just as our climate is only ever as secure, as it is in its weakest places globally. The fact that we are all part of the same ecosystem, and are interconnected by far more than Zoom calls and bad internet connections, has never felt so tangible.

At the same time, day-to-day life has never felt so parochial, as our worlds shrank to a single house, or on rare occasions a nearby park and a local shop. In so doing we found more self-reliance, as many of our highest carbon activities – the commute to work, the overseas conference – turned out to be largely optional.

Community interconnections, be they in the form of mutual aid networks or the more informal ways in which – for example – our chemist set aside the last bottle of infant paracetamol for us and left it outside our front door, came to the fore. They demonstrated that a future of more local supply chains, sustainable communities,



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▲ A largely deserted Times Square, New York, US during the COVID-19 outbreak. The response to the crisis has demonstrated a previously unimaginable capacity to adapt when the threat is sufficiently tangible

and maybe even parallel power structures is perhaps not as utopian as it seemed only a couple of months ago.

Political will

Indeed, nothing seems quite as utopian as it did a couple of months ago. Seeing the Herculean efforts governments around the world have made – the trillions of dollars that have been spent, the new hospitals built in days, the overnight eradication of homelessness, the new elements of a welfare state established in just a few weeks – have demonstrated that many of our ideas of what could and could not be achieved were based on little more than the absence of sufficient political will to see it through. What previously appeared to be simply the way things were has been exposed as a political choice. To quote an inadvertent meme of my country's recent general election campaign: "everything is horribly, brutally possible".

This sense of possibility comes in the nick of time, because we've reached 2020, the year that has appeared on the front cover of our publication since the series began. It is the year that carbon emissions have to peak, the year that states' climate actions agreed under their nationally determined contributions (NDCs) to the Paris Climate Treaty start. It is the year that, as Helen Mountford argues (on page 16), there must be a step change in ambition of those NDCs if we are to have any hope of limiting global warming to 1.5°C above pre-industrial levels.

It was to be the year also where the Conference of the Parties (COP26) for the Paris Climate Treaty was to have come to the UK. COVID-19 put paid to that, and the conference will now be delayed to 2021. But COP26 was only ever to be the full stop at the end of the sentence that 2020 will write on the world's response to climate change – we still can and must deliver the substance before then. After all, another lesson of COVID-19 has been that, while international institutions, mechanisms and treaties play a vital convening, coordinating, communicating and standard-setting role, ultimately it is up to those with executive

power – largely still sovereign states – to deliver the policy changes a crisis demands.

This publication looks at those changes. Edward Barbier (page 54) talks directly about how post-COVID-19 economic recovery can be made green. Laetitia De Marez (page 24) talks about the importance of finance for the developing world. Cristina Gamboa (page 39) looks at what reducing carbon emissions means for the construction industry. Jiang Kejun (page 48) looks at the technology we already have and the technology we still need, and Sandy Verschoor (page 42) tells us how Adelaide is paying for its transition to zero carbon.

I am particularly excited by the final section, 'Grey areas', where we have attempted to look with nuance and good faith at some of the most difficult and controversial issues within the battle to mitigate and adapt to climate change. These issues include 'how clean is biomass?' (page 66), 'what role will nuclear fusion play in our future?' (page 69) and 'should we be converting waste to energy?' (page 78).

You may disagree with some of the essays in this section – I would be quite disappointed if you didn't – but I think it is important to bring these arguments into the open, and have them with evidence, rather than letting them fester.

It is vital that we keep this global conversation going, and vital that member states continue to stress their ambition and their commitment to meaningful concrete steps. Because even if we manage to smooth the climate curve, and get emissions to peak in 2020, there will still be much to debate.

We probably only have about 400 gigatons of carbon dioxide we can emit into the atmosphere and still keep to the 1.5°C pathway. That budget needs to last us for the many thousands of years it will take for our carbon cycle to heal, hence the need to reach 'net zero' as soon as possible, as Richard Black argues (on page 34). Which of us gets to emit these remaining 400 gigatons is therefore a moral question, not just an economic one.

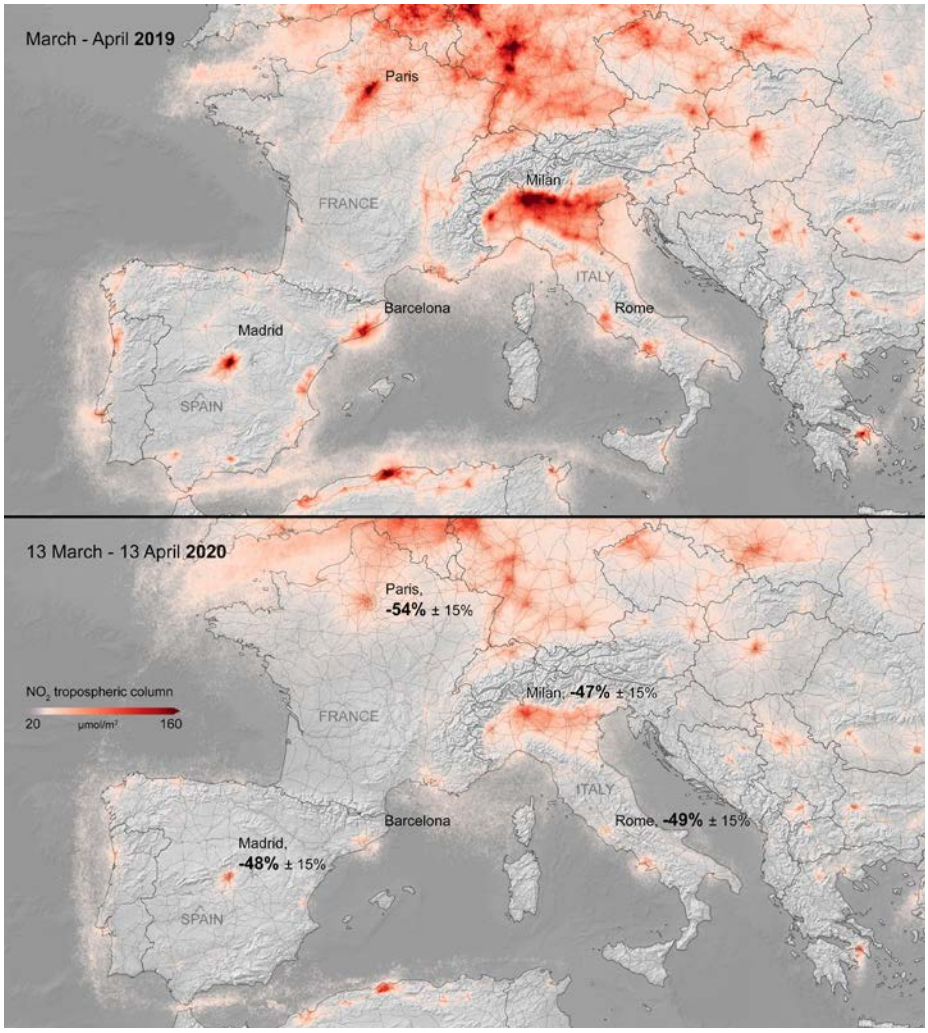
It's also a question the public and civil society at large are increasingly demanding they be given a say in. Developing countries in particular make a compelling case that the amount of carbon the developed world has emitted historically means that they've already had their ration. In September the nations of the world will adopt a political declaration on the occasion of the UN's 75th anniversary. It should tackle these issues, and extend global ambitions.

Climate 2050

We will continue to push this agenda, and explore these questions, as we move beyond Climate 2020 and towards Climate 2050. Personally, I hope our response will mirror the experience of COVID-19 in that it will also be at the same time hyper-global and hyper-local: while the pandemic demonstrates the need for closer global cooperation, it would be a mistake to suggest that that necessarily means power should be moved upwards.

For all that COVID-19 has united the world in a shared experience, elements of that experience were extremely different from place to place. This divergence is based not so much on nationality but on much more localised economic, demographic and geographic factors – much as the impacts of climate change have been and will continue to be. Empowerment at the level of the community, and the vesting of executive authority in local decision-makers, must become the cornerstone of the new way of life we now know is not only possible but essential. ●

▼ **Images from the Copernicus Sentinel-5P satellite showing how the economic slowdown during the COVID-19 crisis has reduced emissions and improved air quality across Europe. The red areas show concentrations of nitrogen dioxide, with the major cities approximately halving emissions year on year**



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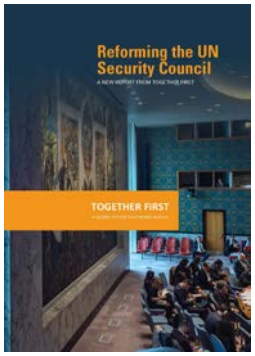
How to save the world

Written by Sam Daws, a UN expert based at Oxford University, **How to save the world** identifies 10 key barriers to implementing global solutions and the strategies for overcoming them

Rising to the challenge

Rising to the challenge highlights five vital campaigns championed by members of the Together First coalition



Reforming the UN Security Council

Written by Mona Ali Khalil, a UN legal expert, **Reforming the UN Security Council** outlines a detailed programme for reforming the UN Security Council without needing to amend the UN Charter

© UNDP Chad/Jean Damascene Hakuzimana

Focus on action

Unless we make rapid and seismic changes across all global systems, the Paris targets risk being beyond our reach. We need coordinated action now, melding efforts on climate change with those in other critical areas such as biodiversity and food security

By **Jim Skea**, Professor of Sustainable Energy, Imperial College London, and Co-chair, IPCC Working Group III (Mitigation)

The year 2021 will be another big year in the world of climate diplomacy. Governments will gather in Glasgow, Scotland for the delayed 26th Conference of the Parties (COP26) to the United Nations Framework Convention on Climate Change (UNFCCC).

There is a lot of work to be done. The COP21 Paris Agreement established three overall goals. First, to hold global warming to well below 2°C above pre-industrial levels, and to pursue efforts to limit warming to 1.5°C. Second, to increase the ability to adapt to the adverse impacts of climate change and foster resilience and low greenhouse gas (GHG) emissions development. And third, to make finance flows consistent with low-emission and climate-resilient development pathways.

◀ Planting seedlings to combat desertification in Merea, Chad. In the past 50 years, the Lake Chad Basin shrank from 25,000 to 2,000 square kilometres, jeopardising the livelihoods of 30 million people living in the surrounding regions. Most CO_2 removal techniques, on which net-zero goals depend, are found in the land sector

To support the first – the long-term temperature goal – governments also agreed to achieve a balance between emissions and sinks of GHGs arising from human activity in the second half of the 21st century. Net-zero goals by mid-century have now been adopted by many individual countries and organisations.

While the long-term temperature goal attracts the greatest attention in developed countries, the adaptation and finance goals are of equal, if not greater, importance to many developing countries. Indeed, the goals are connected. If the promise of raising $100 billion a year in financial flows from developed countries to countries vulnerable to the effects of climate change cannot be met, the trust needed to secure mitigation commitments compatible with the long-term temperature goal may be beyond reach.

Unless there is a rapid, wholesale scaling up of efforts across all these systems then the Paris Agreement goals will increasingly be beyond reach

This challenge notwithstanding, the Intergovernmental Panel on Climate Change (IPCC) has found that meeting the long-term temperature goal and achieving the net-zero goal require an immediate start to reductions in global emissions. Carbon dioxide (CO_2) emissions must fall by about 45 per cent by 2030 and be net zero by the middle of the century. But the reality is that global emissions have at best levelled off and, at worst, are still on an upward trend.

This is not to say that all is negative. Many parts of the world have been successful in bringing down power-sector emissions by backing out of coal and investing in renewable energy. This has been helped by dramatic falls in the cost of renewables, notably solar and offshore wind, which can compete with conventional fossil-fuel plants in many jurisdictions. There are also promising signs of a revolution in private transport, with electric vehicles (EVs) picking up market share in many parts of the world. Several countries now have targets for phasing out conventional internal-combustion-engine vehicles.

The problem is that clean power and EVs by themselves are not enough. Recent IPCC reports have emphasised that major changes are required in all systems – infrastructure, the built environment, industry, freight transport, aviation, shipping and, critically, the land and agricultural sectors. In these areas, there has so far been little progress. Unless there is a rapid, wholesale scaling up of efforts across all of these systems – drawing on lessons from power generation and private transport – then the Paris Agreement goals will increasingly be beyond reach.

Another essential element of a transition towards net zero is moving beyond emissions reduction to enhance and develop carbon sinks that draw CO_2 from the atmosphere. Net zero does not mean that emissions in all sectors drop to zero: it means balancing unavoidable emissions with CO_2 removal.

Most CO_2 removal techniques are found in the land sector. Some, such as afforestation and the use of bioenergy combined with carbon capture and storage (CCS), have attracted controversy. This is because at large scale they could involve the conversion of large areas of land, with consequences for food security and biodiversity. However, if applied at more modest scales with the right crops and good management, they have an important contribution to make to the net-zero goal. And there is also a wider range of 'nature-based solutions', such as mangrove and

Also in this section

peatland restoration and re-building soil carbon through sustainable agricultural practices. Individually, none of these has the technical potential of afforestation or bioenergy with CCS, but collectively they can make a material contribution to climate-change mitigation.

This shows how climate change cannot be addressed in isolation. The landmark Rio Conference in 1992 spawned three international conventions: not only the UNFCCC, but also the UN Convention on Biological Diversity (UNCBD) and the UN Convention to Combat Desertification (UNCCD).

The IPCC's *Special Report on Climate Change and Land* highlighted the intertwined nature of the three UN Rio conventions. It identified many actions that can simultaneously mitigate climate change, halt or even reverse land degradation, and enhance biodiversity and food security. Demonstrating this interconnection, the IPCC will convene – jointly with its sister UN assessment body, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) – a shared workshop on biodiversity and climate change.

A further consideration in working towards net zero is the concept of 'just transition' – highlighted by the Polish Presidency of COP24 in 2018. This embodies the idea that the transition to net zero should be fair for all and not leave people and communities behind. It can be viewed through the lens of human rights, linking it closely to yet another UN process. Most concerns about just transition have focused on the impact that reduced demand for fossil fuels, particularly coal, could have on specific regions and communities. The use of the concept is expanding to cover a wider set of issues relating to other sectors, including land and agriculture, and to impacts on consumers and society more generally. The concept of just transition can also be applied in a positive sense to cover the potential role of the green economy in advancing high-quality employment opportunities.

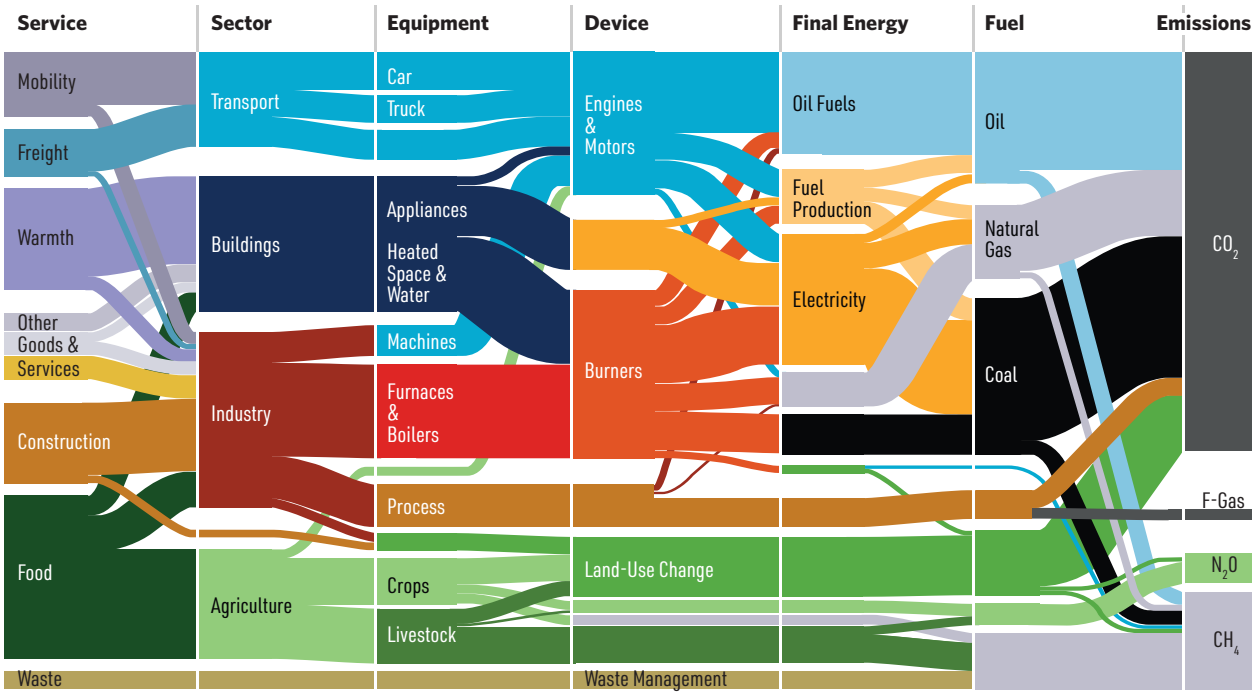
> ***The transition to net zero should be fair for all and not leave people and communities behind***

In summary, 2021 will be a critical year in terms of advancing climate action. Actions taken on the ground still fall well short of what will be required to meet the aspirations of the 2015 Paris Agreement, but there are encouraging signs that some efforts are starting to bear fruit.

Carbon is ubiquitous throughout society and concepts such as just transition help us to understand that technical fixes will not be enough. The interconnection with other environmental imperatives such as biodiversity and food security provides a further compelling case for action. For the UK, COP26 presents a unique opportunity to propel the global agenda. ●

This article is written in a personal capacity.

Piecing together sources of anthropogenic greenhouse gas emissions



Source: IPCC, Fifth Assessment Report, Working Group III

Transforming agriculture

To reduce agricultural emissions, consider the humble plant

*By **Michael Keller**, Secretary General, International Seed Federation*

Amid the accelerating climate emergency, the search continues for ways to transform agriculture, which accounts for 20 to 30 per cent of our greenhouse gas emissions. Modern agriculture faces enormous pressure to produce enough food for the world's growing population. Instead of treating agriculture as a climate culprit, we should look more closely at its contributions to a sustainable future.

Plants have evolved over millions of years to suck CO_2 from the atmosphere and convert it – with water – into carbohydrates and oxygen. This process of photosynthesis is better and cheaper than any carbon capture machine. Might our agricultural crops be part of the solution too?

Food production must adapt to the changing climate. Warmer weather will bring more pests, disease and extreme conditions, so plants must become more climate-resilient, using land and water more efficiently.

Fortunately, science and nature provide us with tools. For over a century, plant breeders have been successfully selecting, breeding and improving our plants for the benefit of farmers and society alike. The doubling of Mexican wheat yields in the 1960s, the rescue of hundreds of millions from starvation in South Asia, and the increase of European crop yields after World War II were remarkable. Today's improved varieties are even more productive, more nutritious, more resilient.

Plant breeding delivers innovations that meet the needs of farmers and consumers in terms of productivity and yield, which are essential for food security. However, with the challenge of climate change increasing, demand is moving towards more resilient varieties. With the help of the latest breeding methods, plant breeding will be more than ever part of the solution.

Some of the most exciting advances will be linked to climate mitigation. Storing more carbon in soils is one possible contribution – some plant breeders are developing varieties with a bigger root system, thus absorbing more CO_2 from the atmosphere, which is then buried in the ground for decades. The six major crops (corn, soybean, rice, wheat, cotton and rapeseed) might one day suck even more carbon from the air.

Going beyond the science

To fully unlock the potential of these innovations, we must go beyond the science.

First, as a society, we need full and open discussions about innovation in general – particularly the latest breeding methods and the products that emerge from them. How do we ensure their safe and effective application? And how do we reassure regulators and society alike? For its part, ISF will continue to support a constructive dialogue around plant breeding and how it contributes to a safe, nutritious and diverse supply of food and feed.

Second, we must create the right enabling environment for breeders to deliver innovation to farmers. Breeding new varieties depends on full access to the genetic materials that may hold solutions for the future. Genetic resources must be shared and biodiversity conserved. The IP system must be balanced and efficient. The UPOV convention's continued promotion is a necessity wherever IP systems consistent with it are not yet in place or not properly enforced.

Third, and arguably most important, how do we share access to the latest breeding methods, new varieties and innovations with developing countries? The vast majority of the world's farmers are in developing countries and will suffer most from climate change. Access to a wider choice of improved seeds will help them to overcome the many climate obstacles they face. Our public and private sectors must work together, building trust, coordinating investment and developing a shared vision. Together we will succeed.

Whatever ideas and actions will finally emerge in the battle to beat our changing climate, plants offer important solutions. ■

ISF International Seed Federation
Seed is Life

UNA-UK thanks the International Seed Federation for its generous support for this publication

Raising climate ambition in the time of COVID-19

Enhanced nationally determined contributions can forge the way towards a more inclusive, resilient and sustainable world after COVID-19 – and the world's major emitters should lead the way

By **Helen Mountford**, Vice President, Climate & Economics, World Resources Institute

The COVID-19 pandemic has given rise to one of the most challenging global crises of our time, already resulting in a tragic loss of lives and livelihoods for so many around the world as I write in April 2020. It is a poignant reminder of how our societies and economies are so deeply vulnerable. A health pandemic, like climate change, can affect anyone. However, we know that the poor and marginalised will suffer the most.

COVID-19 is a threat multiplier and underscores the urgency of building resilience not only to pandemics but also to other systemic risks such as climate change and ecosystem destruction. Now is the time to identify approaches that will help us 'build back better' following the pandemic, in a way that delivers the jobs and growth opportunities we so desperately need in the short term, but also reduces the risk from other such crises in the future.

The second wave of responses to COVID-19 will focus on stimulating or reflating the economy. These will have more impact on climate action

Making investments count

In the coming weeks and months, governments and international finance institutions are expected to mobilise unprecedented funds – potentially as much as $10 trillion or more – to tackle and then recover from the COVID-19 crisis. Following these massive investments, budgets will likely be very tight for the coming years if not the next decade. So, we need to make these investments count.

The first wave of immediate response from governments and international financial institutions to the COVID-19 pandemic are focused on emergency measures to stop the spread of the virus and protect the people and communities most vulnerable to it, whether from the virus itself or income and job losses as economies grind to a halt. This is the first priority.

Most of these measures have no direct link to climate action. The exceptions are potential bail-outs for high-carbon industries, such as the oil and gas sector or airlines, or calls in some countries to loosen environmental regulations. But we should not boost growth coming out of one health crisis by exacerbating others, including air pollution – which already kills more than seven million people worldwide annually – and the climate crisis.

The second wave of responses to COVID-19 will focus on stimulating or reflating the economy. These will have more impact on climate action – either positive or negative. One element is likely

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▲ Against the backdrop of Duvha coal-fired power station in the Witbank region of South Africa, women from a nearby settlement collect free coal. At COP 25, South Africa pledged to decommission its old coal-fired power stations

to be the investment of trillions of dollars in large, shovel-ready infrastructure projects to boost demand and jobs. These investments could simply restore the high-carbon, vulnerable and unequal economies of today, or they could help accelerate the transition to more inclusive, low-carbon and resilient economies. The types of infrastructure investment chosen will be critical.

There is evidence from the 2008-09 economic recovery packages that well-targeted green stimulus measures generated more jobs and better growth than alternatives in some cases, and there

are good reasons to believe they would be even more promising today given technological advances and increasing cost-competitiveness. For example, of the 2009 stimulus funds used in the US, it was found that one billion dollars spent on public transit infrastructure projects created almost double the job-hours of the same level of investment in highways.

The 2009 American Recovery and Investment Act was also the largest clean energy investment in US history, providing more than $90 billion in clean-energy investments and tax incentives, leveraging approximately $150 billion in private and other capital, and supporting 900,000 job-years in clean-energy fields from 2009 to 2015. It jump-started a major scale-up of the American wind and solar industries, which are now directly competitive with fossil fuel power plants.

Korea was the country that invested the most – about 80 per cent – of its 2008-09 stimulus in green measures, and it was also one of the OECD countries to rebound the quickest after the crisis.

In the second wave of response measures, governments may also look to re-align fiscal policies to stimulate growth and jobs. This is an opportunity to reform environmentally harmful and inequitable subsidies, replacing them with more direct payments that support the incomes of vulnerable workers or communities while reducing government outlays.

Current low oil prices mean that fossil fuel subsidy reforms or use of carbon or energy taxes would have little impact on household expenditures, and the revenues raised could easily offset any impacts and still have funds left for other pressing public priorities.

This is a moment to look at options to shift taxes away from things that we want to encourage, like employment, and towards those we don't, like pollution. Phasing out the over $400 billion per year in subsidies to fossil fuel use is one opportunity, another is to join the 77 countries, states or cities now applying a price on carbon globally, covering about 20 per cent of global emissions. Both approaches can raise funds for cash-strapped governments, be done in a way that ensures low-income and vulnerable households are better off, and would allow countries to step up their climate ambition.

Increasing efforts

Given the unfolding COVID-19 crisis, the COP26 UN climate negotiations have been postponed from November 2020 until 2021. This was not an easy decision, but it was the right one. However, while these meetings may be delayed, the urgency of tackling the global climate crisis is only clearer today.

In some ways, it is not surprising that those most vulnerable to the climate crisis woke up first and have emerged as the true leaders. As of early April 2020, 106 countries have committed to enhance their climate ambition in 2020 – primarily small and medium-sized economies, including many climate-vulnerable, developing nations. In April, Chile joined six other countries in releasing its updated national climate commitment, reflecting significant progress towards a prosperous and safer future. This will be a critical part of its broader economic recovery from COVID-19 and its continued efforts to address inequalities.

However, the hard truth is that the 106 countries leading the charge cannot achieve what is needed alone. Together these countries represent just 17.8 per cent of global emissions. So even with the greatest ambition, they cannot move the needle enough on global emissions. Major emitting countries must stop equivocating, join this growing movement, and step up their efforts to address the global climate crisis as they build back their economies following the COVID-19 crisis.

Promising signals

There are promising signals emerging from some major economies. The European Council has released official statements linking the pandemic response to the green agenda, delivering a mandate to factor the 'green transition' into its response. This builds on the European Commission's release of a European Green Deal in December 2019, which puts forward a vision of a prosperous, fair and resource-efficient economy.

In South Korea, the ruling party has tackled the COVID-19 and climate crises simultaneously and with equally high ambition, with an impressive response to the pandemic and also announcing new plans to set a net-zero emissions goal, including shifting away from financing for coal and instead promoting renewable energy.

In Indonesia, the potential for a broader shift to a low-carbon and resilient development path is clear. Indonesia's Planning Ministry launched a *Low Carbon Development* report in early 2019 that identified a sustainable growth path that will deliver higher annual GDP growth than business as usual, from the very first year, and provide a more rapid reduction in poverty together with more than 15 million additional green jobs in 2045, while also reducing emissions faster than their current NDC. This is an opportunity to reflect this stronger, more inclusive, low-carbon and resilient growth path as they build back following the COVID-19 pandemic and economic crisis.

Now is the time for transformative climate action – and major economies can and should take a lead. We have the tools and solutions available to make the shifts needed – and they can benefit people and economies in the global response to the COVID-19 pandemic, and beyond. This action must put people at the centre, in a way that can deliver a safer, more inclusive, and more resilient world for all. ●

This is a moment to look at options to shift taxes away from things that we want to encourage, like employment, and towards those we don't, like pollution

Are countries implementing enough policies to meet their NDCs?

Climate Action Tracker December **2019 update**	CAT **Paris commitment rating**	Will policies **meet the target?**
The Gambia	1.5°C PARIS AGREEMENT COMPATIBLE	YES
Morocco	1.5°C PARIS AGREEMENT COMPATIBLE	CLOSE
India	2°C COMPATIBLE	YES
Kenya	2°C COMPATIBLE	YES
Bhutan	2°C COMPATIBLE	CLOSE
Ethiopia	2°C COMPATIBLE	CLOSE
Costa Rica	2°C COMPATIBLE	NO
Philippines	2°C COMPATIBLE	NO
Peru	INSUFFICIENT	YES
EU	INSUFFICIENT	CLOSE
Australia	INSUFFICIENT	NO
Brazil	INSUFFICIENT	NO
Canada	INSUFFICIENT	NO
Kazakhstan	INSUFFICIENT	NO
Mexico	INSUFFICIENT	NO
New Zealand	INSUFFICIENT	NO
Norway	INSUFFICIENT	NO
Switzerland	INSUFFICIENT	NO
UK	INSUFFICIENT	NO
Chile	HIGHLY INSUFFICIENT	YES
China	HIGHLY INSUFFICIENT	YES
Indonesia	HIGHLY INSUFFICIENT	YES
Singapore	HIGHLY INSUFFICIENT	YES
South Africa	HIGHLY INSUFFICIENT	YES
UAE	HIGHLY INSUFFICIENT	YES
Japan	HIGHLY INSUFFICIENT	CLOSE
Argentina	HIGHLY INSUFFICIENT	NO
Germany	HIGHLY INSUFFICIENT	NO
South Korea	HIGHLY INSUFFICIENT	NO
Russian Federation	CRITICALLY INSUFFICIENT	YES
Turkey	CRITICALLY INSUFFICIENT	YES
Ukraine	CRITICALLY INSUFFICIENT	YES
Viet Nam	CRITICALLY INSUFFICIENT	YES
Saudi Arabia	CRITICALLY INSUFFICIENT	CLOSE
USA	CRITICALLY INSUFFICIENT*	NO
Nepal	NOT RATED	

*The CAT's rating for the USA is "Critically Insufficient" based on the Trump administration's decision to withdraw from the Paris Agreement.

Source: Climate Action Tracker, December 2019 Global Update

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No time for fatalism

The level of ambition formulated by current climate policies as part of the Paris Climate process falls woefully short of what is required to put us on a 1.5°C or 2°C pathway. However, the technology exists and many of the societal transformations are already taking place. Rather than fatalism, we can scale up our ambition both inside and outside the Paris process

By **Detlef van Vuuren**, Professor at Utrecht University and Senior Researcher, Department of Climate, Air and Energy, PBL Netherlands Environmental Assessment Agency

The results from the intensive climate negotiations in Madrid (COP25) in December 2019 have been generally summarised as disappointing. This is despite the summit having a relatively modest agenda to begin with. The young climate activist Greta Thunberg, for instance, responded to the COP25 results by warning: "Our leaders are not behaving as though we were in an emergency."

Clearly, a lot has happened since the Madrid climate summit, and the world is now facing the acute health crisis caused by COVID-19. But the long-term climate challenge still remains, and after Madrid a critical question is whether we have now indeed fallen critically behind the timeline for addressing the climate crisis.

In this context, we need to realise that COP25 was just one small step on the decarbonisation journey that will take several decades and was agreed on at Paris in 2015. Then, world leaders agreed to focus international climate policy on keeping the increase in global mean temperature to well below 2°C and, preferably, to within 1.5°C. The international community was able to achieve this consensus because the actual measures were left to voluntary contributions by individual countries (the nationally determined contributions or NDCs). This voluntary approach was chosen because of the previous experience of using binding targets: nearly impossible to set and impossible to enforce.

◀ The plenary session at COP25 in Madrid, Spain. Greta Thunberg has played a major role in energising and giving a voice to grass-roots climate activism globally

A critical question is whether we have now fallen critically behind the timeline for addressing the climate crisis

The two faces of Paris

This approach, however, has turned the Paris Agreement into a 'Janus head' – one with two different faces. On the one side, it sets a clear pathway and framework for international climate policy. More importantly, it serves as a source of inspiration for taking action – for countries, companies and individuals. On the other side, it is relatively toothless in its ability to enforce action.

It is hardly encouraging that, since 2015, global greenhouse gas (GHG) emissions have been increasing further – to a record high of 42 Gt CO_2 in 2019. Clearly, the COVID-19 crisis will have a clear impact on emissions in 2020 – but without further action, it is not likely to lead to a more permanent transition. In that context, it is important to realise that the sum of all the submitted NDCs in 2019 were still projected to lead to an emission reduction well below what is needed to limit temperature rise to less than 2°C, let alone 1.5°C.

Model studies suggest that an optimal pathway towards implementing the Paris goals should be one that leads to a reduction in GHG emissions of at least 40 to 50 per cent by 2030, relative to the current trend (even with accepting the need for negative emissions in the long run). Yet all the NDCs combined only add up to a 17 per cent reduction in GHGs.

Even worse, the policies that countries are actually implementing seem to be barely sufficient to achieve a third of that 17 per cent. Five years on from Paris, it is clear that the policy community is scarcely on the way. But the world is already close to breaching the emission thresholds of the Paris targets, emitting about one half of the carbon budget for the 1.5°C target. At 2019 emission levels, we will exceed this carbon budget in the next 10 years. For the 2°C target, the budget is larger. But to achieve even that target, the world economy would need to become carbon-neutral within three to four decades.

The need for speed

The negotiators in Paris obviously foresaw that countries would not immediately put all their cards on the table and promise the most ambitious reductions. That is why they devised a process whereby every five years countries would be able to revise their promised contributions on the basis of scientific information. This process is called the 'global stocktake'. However, the ongoing negotiations strongly suggest that

the urgency of speeding up the stocktaking process is not high enough on world leaders' list of priorities.

The science shows that the world must urgently cut global emissions from their current high levels from 2020 onwards – certainly for meeting the 1.5°C target but also for the 2°C pathway. Yet negotiators are slowly working towards a first stocktake only in 2023 to see whether the NDCs are compatible with achieving the global goals. There is also little to suggest from the negotiations that countries will massively increase their ambition levels in the new NDCs they submit this year or before 2023.

Building on recent achievements

Does this mean we must concede to fatalism? Clearly, that would not help, and I believe there is a better – and viable – path to take. Studies have shown that there are many possibilities for taking additional measures to reduce emissions within or outside the official UN process. For example, to avoid losing more time, countries could tighten up their emissions-reduction commitments as part of an 'informal' stocktake process running towards 2023.

Over the last decade, there have been notable successes that we can build upon. Technological progress has led to impressive cost reductions in renewable energy, as well as rapid improvements in electricity storage and electric vehicles. As a result, it is far easier now to imagine how we can decarbonise particular sectors for relatively little cost than it was, say, 10 years ago. And just as important is the dramatic increase in awareness of the need for action among citizens and companies. These two factors – technological progress and increased awareness – provide a clear platform for reducing emissions.

Achieving the Paris goals

In the longer term, we will need to realise a fundamental transformation of the energy system, as well as a deep reduction of land-based emissions. Model studies have shown that there are, in fact, multiple pathways that could lead to achieving this. These pathways are focused on rapidly increasing the efficiency of current energy use – in transport, industry and the built environment.

A second key element is that they must realise the potential of moving towards a carbon-free power system. This strategy can be combined with rapid electrification – as far as possible – in all end-use sectors: transport, heating and cooling, and some parts of industry. It will also be preferable to reduce non-CO_2 sources of GHGs such as methane, nitrous oxide and particulate matter. Doing so will generate immediate benefits for both the climate and air quality.

Finally, the models show that, while some pathways are predicated upon long-term CO_2 removal (for example, through massive reforestation), others rely on more rapid short-term action or lifestyle changes. For instance, moving consumption of meat towards levels consistent with health recommendations can be extremely effective in reducing non-CO_2 emissions that are otherwise difficult to abate.

The leadership of a number of countries and other relevant actors... could yet make Paris a success

Taking everything together we see that it is possible to achieve substantial reductions in GHGs by 2030 and reach net-zero GHG emissions globally around 2050 – or earlier in most industrialised countries. The studies also show that although such transformation would require a major shift in investments, overall macro-economic costs (in terms of GDP) would be limited. In the long run, these costs would certainly outweigh the costs of climate impacts.

A call for front runners

As indicated in the introduction, it is clear that governments are now focused on the acute COVID-19 crisis. But the long-term challenges will also have to be addressed again at some point. This will not be easy, as clearly the economic consequences of the COVID-19 crisis will imply that many governments will have other priorities even if the health crisis is resolved.

At the same time, however, possible investment programmes to revive the economy could also form an opportunity if aligned with the Paris Agreement. And we can possibly also learn from some experiences in organising an effective response.

Implementing climate policy will require all parties to take a stand. But we know from the historic examples of renewable energy and electric mobility that sometimes it needs only a few front runners to start a trend. And, in fact, a considerable group of countries – including the UK, France and Germany – have already shown that they can reduce emissions while continuing economic growth.

The recent ambition of the new European Commission to present the European Green Deal could become another example of 'taking a stand'. Although the target (50 per cent GHG reduction by 2030, climate-neutral by 2050) seems not sufficient for the goal of limiting the global temperature increase to 1.5°C, it does fit the 2°C target. The objective certainly conveys the required scale of transformation.

Pursuing and achieving this goal also has other benefits. It reduces EU dependence on fossil fuel imports from Russia and the Middle East. It reduces air pollution and provides an incentive for technological development. The leadership of a number of countries and other relevant actors such as industry and consumer groups – not at the negotiating table but through formulating and implementing policy – could yet make Paris a success.

The near future will be critical. Despite all short-term priorities, we cannot lose sight of the long-term future either. The need to take firm steps as part of a long-term transition remains as important as ever. Ideally, enough countries will have the courage of their convictions in the run-up to the new climate summit, in 2021 or as soon as possible. Steps are needed if we are to achieve the Paris goals within the agreed timeframe. There is indeed no time for fatalism. ●

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Finance for the most vulnerable

A decade on from its creation, how successful is the Green Climate Fund in translating finance from rich countries into climate action for the most vulnerable?

By **Laetitia De Marez**, Head of Implementation Strategies, Director of Climate Analytics (CA) New York

The year 2020 has been dubbed a climate 'super year'. All signatories of the Paris Agreement are requested to revise the (currently insufficient) ambition of their pledges to achieve the Paris goals, known as nationally determined contributions or NDCs. Though the COVID-19 pandemic has created immense disruption worldwide, and caused major international climate meetings and negotiations to be postponed, many developing countries continue to work towards developing new and stronger NDCs that will help limit global warming and increase their populations' resilience.

A key condition in these countries' efforts to transition to low-carbon and resilient economies will be access to financial support, as recognised in the international climate policy framework. In 2010, developed countries agreed to a goal of jointly mobilising $100 billion per year by 2020 to help developing countries reduce emissions and adapt to the impacts of unavoidable climate change. While this $100 billion will flow through a variety of channels, one key conduit is the Green Climate Fund (GCF). Established in 2010, the GCF aimed to rebuild trust between developed and developing countries after they collectively failed to adopt an encompassing global climate agreement at the previous year's Copenhagen Climate Summit.

In its initial round of fundraising in 2014, the GCF received pledges of approximately $10 billion. While well short of target requirements, the mobilisation of these funds sent a strong signal and contributed to the adoption of the Paris Agreement in 2015.

Since its inception, the GCF has been different from existing international financing institutions (IFIs) such as the multilateral development banks or the Global Environment Facility. For one, while other IFIs have a range of developmental and environmental focus areas, the GCF is solely focused on climate action.

Furthermore, unlike traditional official development assistance, which is only eligible to countries below a certain per capita income threshold, GCF support is available to all developing countries that are parties to the United Nations Framework Convention on Climate Change.

Finally, while governance of other IFIs tends to be dominated by donors, the GCF Board features equal representation of developed and developing countries.

The GCF further seeks to correct previous imbalances in the provision of international climate finance. To prevent the poorest and most vulnerable countries from being overlooked in the provision of support, the GCF has specific goals for providing adaptation finance to these countries. It has adopted a number of modalities and procedures to improve these countries' access to GCF funds. It is also the only climate fund mandated to strive for an equal split of its resources provided between mitigation and adaptation.

The GCF further complements other sources of finance by maintaining a higher risk appetite, which allows it to de-risk potentially transformational climate investments for other financiers and private investors.

In addition to, and by function of, its role as a central provider of climate finance, the GCF is also expected to make a critical norm-setting contribution to the international climate finance landscape. First, the Fund put at the centre of its operation the principle of country ownership, bringing to scale a relatively recent business model responsive to recipient countries' needs. The GCF even allows countries to access resources directly through their national agencies, provided these agencies meet international standards.

From its inception, the GCF was designed to strongly interface with the private sector – both at a global level and within developing countries. It does so by offering a wide range of financial instruments to help mobilise domestic capital, de-risk investments, accredit private entities to serve as intermediaries who receive the funds and implement projects, and to work with governments to improve regulations and create a friendlier business environment for low-carbon and resilient investment.

Significant resources

While GCF resources are significant compared with other climate funds, with close to $20 billion already mobilised through its financing and co-financing over the last five years, they still represent a drop in the ocean relative to anticipated need. It is estimated that the world's urban, energy and land-use infrastructure will require investment of $90 trillion to achieve the type of global transformation needed in the face of climate change. This fact is why the GCF needs to provide support in a strategic and catalytic manner, and is central to the Fund's objective of seeking to promote a global paradigm shift toward low-carbon and resilient development.

And the GCF is growing ever more successful in doing so. Despite a somewhat politicised decision-making process, the Fund has proved agile, programming billions of dollars in its first few years of operation.

▲ **Attapeu, southeastern Laos. Families evacuate after their village was destroyed following flash floods and a subsequent dam collapse. The GCF is currently working on a project with Laos to develop ecosystem-based defences against flooding, which depresses the economy by around 3 per cent annually**

In addition, the quality of projects it receives is improving, with bolder ideas and more ambitious impacts. This improvement is due in no small part to the Fund's capacity-building programmes, such as the GCF Readiness Programme, as well as other ad hoc and ongoing support provided to developing countries.

This is not to say it has been all success. For one, the GCF has not yet achieved the mitigation–adaptation parity it strives for. Additionally, some sectors, considered a priority to meet the Paris Agreement's goals, are still under-represented in its portfolio. This is particularly the case for cross-sectoral projects seeking to encourage low-carbon transport (electrification) and a 'mode shift' to lower-carbon forms of transportation. Aware of these issues, the Fund's Board and Secretariat are working to improve on these results.

The Fund's recent replenishment in 2019 further raised some cause for concern. Over the course of the year, contribution promises amounted to $9.8 billion, from 27 countries. Though the bulk of the contributions came from national governments of developed countries, contributions were also made by the governments of Indonesia and Republic of Korea. The total level of pledges fell short of the initial aspiration of doubling the GCF's resources.

This was due in large part to the withdrawal of the United States, which had pledged $3 billion in the GCF's first fundraising round in 2014 and provided $1 billion to the Fund prior to reneging on its remaining $2 billion in commitment in 2017. Another loss to the Fund's balance sheet came from Australia, who provided $200 million in 2015, but declined to contribute in 2019. However, several other countries signalled their confidence in the Fund by doubling their contributions, including Germany, France, the United Kingdom and Norway.

Empowering developing countries' governments and agencies, enhancing those countries' climate policy and regulatory frameworks, building resilience of the most vulnerable communities and catalysing investment shifts from brown to green assets at a regional and global scale; after five years of a taxing learning-by-doing process, the GCF strategic support role is progressively coming into focus.

By seeking science-based, innovative and paradigm-shifting approaches compatible with the Paris Agreement's goals, the GCF is setting the bar higher to allocate its support and is working across the board to move the world towards a low-carbon and resilient future. ●

Reversing atmospheric infection

The Coronavirus crisis has taught us a number of lessons on how we should approach climate change

***Mark Lewis**, Global Head of Sustainability Research, BNP Paribas Asset Management*

The worst pandemic for 100 years has shown that our globalised world is much more fragile than we like to think. The speed with which the disease has spread and the disruption it has caused to health systems, supply chains and financial markets are unprecedented. That it is currently wreaking the greatest havoc in the richest and most medically advanced countries in the world only underlines our vulnerability to new threats all the more.

But human beings have evolved to learn fast in the face of life-threatening dangers and the policies now being adopted globally around social distancing, while alien to our species, match the urgency of the moment. The parallels with climate change are self-evident, and three insights stand out with particular clarity.

First, the heightened frequency and severity of extreme weather events over the last two decades has revealed the fragility of our climate system as the concentration of greenhouse gases (GHGs) in the atmosphere has accelerated. The parts-per-million (ppm) count of GHGs in the atmosphere is the equivalent of the pandemic's infection rate, and with this hitting an all-time high of 415ppm in 2019 at the monitoring station in Mauna Loa[1] we urgently need the equivalent of social distancing in climate policy to halt and reverse it.

Such an equivalent policy already exists and as the collapse in UK coal emissions over the last four years[2] has shown it is a proven palliative: carbon pricing. Ramping the cost of burning fossil fuels globally would reduce the GHG ppm count in the atmosphere just as social distancing is reducing the infection rate of Coronavirus. The limited amount of space left in the atmosphere for storing more GHGs before we burn through the Paris Agreement's carbon budget is the ultimate scarce resource and it needs to be priced accordingly.

Of course, in the same way that social distancing is not enough on its own to eradicate the Coronavirus, so carbon pricing on its own will not stop climate change: it can slow and then reverse the rate of atmospheric infection but if we are to stave off the climate tipping

We do not need to shut the economy down to tackle climate change, but we do need to act decisively now

point then just as governments have implemented confinement as a reinforcement to distancing in fighting the pandemic, so too will we need continuing support for renewables and greatly strengthened incentives for energy storage.

Beyond the mitigation of fragility, we will then need policies on climate adaptation to improve the world's resilience to the warming that is already baked in. Most obviously this means improved infrastructure: enhanced flood defences to deal with rising water levels, better cooling systems for hotter summers, improved irrigation for drought-prone areas, and so on.

Policymakers have met the economic crash caused by the pandemic with massive monetary and fiscal stimulus, and the pay-off from an imaginative long-term financing package for green infrastructure – both for mitigation and adaptation – would be a liveable future for succeeding generations and sustainable and well-paid employment for millions of workers around the world today.

The second insight from the virus is that it has revealed our inter-connectedness and the importance of global institutions such as the World Health Organization. No country, no people, and even no age group has immunity. The way in which the world is coming together to contain, treat and defeat the disease is exactly what we need to see at the next UN climate summit in Glasgow in 2021 if we are to remain within the temperature boundary prescribed by the Paris Agreement. For as with the virus, if we crash through this boundary there will be varying degrees of impact across communities but no immunity anywhere.

And the third key insight from the pandemic is that people are willing to make simple but effective changes to their everyday behaviour when given a clear rationale for doing so. The comparison here is between the handwashing rituals we have quickly become used to as a roadblock to the spread of Coronavirus and the changes we can make to our daily consumption habits as a brake on runaway climate change: saving energy in the home, reducing meat in our diet, buying more locally-sourced produce, flying less, and so forth. Direct and urgent explanation by government to citizens works in a crisis.

Politicians have been willing to shut down the economy in order to save lives. The short-term economic cost will be massive, but everyone agrees it is a price worth paying. We do not need to shut the economy down to tackle climate change, but we do need to act decisively now. Scientists think that climate change will be responsible for 250,000 unnecessary deaths[3] every year within a decade, and at that point there will be no equivalent of social distancing that can save us. And when that point comes, how will we explain that we were willing to go all in to prevent deaths from a virus, but we prevaricated about taking far more modest measures to tackle the climate challenge and save future generations?

In the final analysis, just as we need a vaccine for the Coronavirus in order to prevent future mass infections, so too do we need an inoculation against the increase of GHG concentration levels in the atmosphere to prevent irreversible climate change. That inoculation is a net-zero global energy system by 2050. We all need to start working towards that goal now with the same urgency and dedication as the world's healthcare professionals and leading medical researchers are so selflessly doing on the frontlines of care and in the search for a vaccine. ■

1 *https://www.esrl.noaa.gov/gmd/ccgg/trends/*
2 *https:// www.theguardian.com/environment/ng-interactive/2019/may/25/the-power-switch-tracking-britains-record-coal-free-run*
3 *https://ijmhs.biomedcentral.com/articles/10.1186/s13033-018-0210-6*

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Ocean health

If the global ocean is to continue to support life as we know it while also mopping up much of our greenhouse gas emissions, governments must act now to ensure its long-term health

By **Peter Thomson**, United Nations Secretary-General's Special Envoy for the Ocean

The global ocean and climate are inextricably linked. The ocean serves as a central component of the climate system, vital to global exchange and redistribution of heat, water, gases, particles and momentum. The ocean also plays a fundamental role in mitigating climate change by serving as one of the planet's main heat and carbon sinks.

◀ Fisherman unload their catch on Maio Island, Cape Verde. The island is part of one of the country's several Marine Protected Areas, which are at the core of its sustainable development plans

Anthropogenically created greenhouse gas (GHG) emissions are increasingly altering the ocean's chemistry. We are witness to deoxygenation and acidification of the ocean, warming ocean temperatures, rising sea levels, shifting currents and increasing weather volatility, all with deleterious consequences for nature and humanity's place within it.

If left to cascade forward on its present trajectory, climate change is expected to cause decreased ocean productivity, altering food web dynamics, shifting species distribution, and leading to greater incidence of disease. Thus, as we learn more about the consequences of climate change, the interrelationship between it and the ocean must be acknowledged, understood and incorporated into governmental policies.

Ocean acidification

The ocean is acidifying because it is absorbing more carbon dioxide, which affects the pH of the water. Since the start of the industrial age, carbon dioxide levels in the atmosphere have been steadily increasing, with commensurate increases in the ocean's absorption of this gas.

The effects of ocean acidification are many. For shellfish, crustaceans and coral that rely on carbonate ions to build their shells and skeletons, survival becomes very much more difficult. Since humans and sea creatures alike rely on such lifeforms for their sustenance and in some cases their survival, ocean acidification will have serious consequences for coastal ecosystems and human communities.

Ocean-based climate action can play a major role in reducing the world's carbon footprint

To combat ocean acidification, the reduction of humanity's overall carbon footprint and the urgent reduction of our GHG emissions must be a high priority for all governments if the best interests of their citizens are to be protected.

Adaptation depends on mitigation

The advice of the Intergovernmental Panel on Climate Change (IPCC) is that climate resilience depends on combining mitigation and adaptation. Since mitigation reduces the rate as well as the magnitude of warming, it also increases the time available for adaptation to climate change.

It is important to appreciate that delaying mitigation reduces our options for both mitigation and adaptation in the future. Successful future adaptation is therefore heavily dependent on there being no further delays in our application of effective mitigation measures. We see here once again why the governments of the world, particularly the major emitters, have a responsibility to present nationally determined contributions (NDCs) at COP26 that demonstrate greatly enhanced ambition to lower GHG emissions.

The ocean's mitigation role

Ocean-based climate action can play a major role in reducing the world's carbon footprint. It can deliver up to 21 per cent of the annual GHG emission cuts pledged under the Paris Agreement.

The 2019 report of the UN Secretary-General's Climate Action Summit highlighted the relationship between the ocean and climate change. In this regard, it presented areas of positive opportunity, including ocean-based renewable energy, transportation, carbon storage, aquaculture and dietary shifts, along with carbon storage.

The role of 'blue carbon' in the long-term sequestration and storage of carbon is one of the ocean's vital contributions to mitigation. As much as 7 per cent of carbon dioxide reductions required to keep atmospheric concentrations below 450 parts per million can be achieved by protecting and restoring our natural coastal and marine ecosystems. Let us henceforth place meaningful attention on the true value of salt marshes, mangroves, wetlands, seagrass meadows, kelp forests and seafloors.

Too often the contribution of these ecosystems towards the capture and storage of carbon dioxide is taken for granted. If only for the hugely positive mitigation role they play, and in the face of continuing global degradation of such natural habitats, governments and the international

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◀ Beveridge Reef, Niue in the Pacific. Coral reefs are one of the most important ocean features in terms of supporting life and also one of the most vulnerable to global warming and ocean acidification – see panel opposite

community must give high priority to the conservation and restoration of these natural assets.

With the growing global acknowledgement of the scale of blue carbon's hugely positive mitigation role comes greater realisation of the predicament we face. For even as we realise that blue carbon is among the most efficient of carbon sinks, we find these natural assets are among the fastest-disappearing ecosystems on the planet. At the same time as we are quantifying the crucial services blue carbon provides through food security, water quality, shoreline protection and maritime employment, we are witness to the grand scale of these assets' destruction.

Degradation of these vital ecosystems is caused by unsustainable use of natural resources, poor watershed management, damaging coastal development practices, and woeful sewage and waste management. Their loss is bad news for carbon sequestration, human health, food security and economic development. Thus, as one of the biggest gaps in the effort to mitigate climate change, the approach to COP26 must witness governments around the world rising in defence of blue carbon.

We must invest in the ocean's health

As has often been said, it is not possible to have a healthy planetary ecosystem without a healthy ocean ecosystem, and at present the ocean's health is in decline. Our great challenge is to reverse this cycle of decline and restore good health through good practice. Part of the necessary action must be investment in the restoration and protection of our natural assets of blue carbon.

In the same vein, the deep ocean is often overlooked in consideration of climate change and the necessities of mitigation. It is therefore incumbent upon us to fully research and understand the role of the deep ocean and its seafloor, particularly before any new action is taken to disturb it. The time has come for this responsibility, which may emerge as a vital element in the mitigation of climate change, and therefore be one of universal importance to us all. It must be considered by all governments in the context of COP26 and in ocean–climate actions thereafter.

It is not possible to have a healthy planetary ecosystem without a healthy ocean ecosystem, and at present the ocean's health is in decline. Our great challenge is to reverse this cycle of decline and restore good health

Hope for the Decade of Ocean Science

The IPCC has warned us that unless ambition and action are accelerated worldwide, we are on a trajectory that leads us all towards a potentially disastrous environmental crisis for nature and our species.

The role of the ocean in mitigating such disaster is finally being appreciated. But we need to know much more about the ocean's biome and its contribution to the planetary ecosystem before we start making decisions about it that will affect the future of humankind. It is for this reason that we should all support the UN Decade of Ocean Science for Sustainable Development. The Decade gets underway next year.

2020 is the start of the second ambition cycle of the Paris Agreement. At COP25, the Subsidiary Body for Scientific and Technological Advice (SBSTA) was asked to convene a dialogue on ocean and climate change to consider how to strengthen mitigation and adaptation action. Following on from the 'Blue COP' efforts of COP25, the SBSTA meeting will provide us with a great opportunity to ramp up our understanding of the central role of the ocean–climate nexus.

Our very survival as a species may depend on this understanding being respected and acted upon through the mitigation efforts of governments and the global community as a whole. So once again I say, "All hands on deck!" ●

WHY CORAL MATTERS

By Sara Gill and Rianna Nayee, UNA-UK

UNESCO describes coral reefs as 'rainforests of the sea'. They are vital to the global ecosystem, supporting a quarter of all marine life while covering less than 0.1 per cent of the ocean floor. Due to their key role in our ecosystem, ecologists are deeply concerned by their decline. A 2018 study led by marine biologist Terry Hughes found that approximately half of the Great Barrier Reef died in 2016–18 as a result of global warming, bleaching, coastal pollution and overfishing.

Moreover, the Intergovernmental Panel on Climate Change (IPCC) predicts that coral will decline by a further 70–90 per cent if global temperatures increase by 1.5°C. The situation is even more dire if temperatures rise by 2°C, with the IPCC predicting with "very high confidence" the loss of more than 99 per cent of the world's coral.

The loss of coral has significant feedback effects on ecosystems, impacting marine biodiversity and vital coastal infrastructure. This is something scientists have highlighted for decades: an eight-year study led by Geoffrey P. Jones of James Cook University Brisbane highlights the detrimental effect of coral bleaching in Papua New Guinea, showing that as coral declines so does marine biodiversity. Half of the species surveyed in the study declined to less than 50 per cent of their original numbers.

Aside from the direct impact on marine life, the loss of even 70 per cent of coral – the IPCC's best-case scenario – will have significant implications for the world's diet. According to the United Nations Environment Programme (UNEP), fish are the main source of protein for three billion people worldwide. Coral is vital in sustaining healthy fisheries, and therefore plays a crucial role in maintaining the staple diet of almost half of the world's population. Coral reef fisheries provide 9–12 per cent of the world's catch of edible fish and 20–25 per cent of fish caught in developing countries.

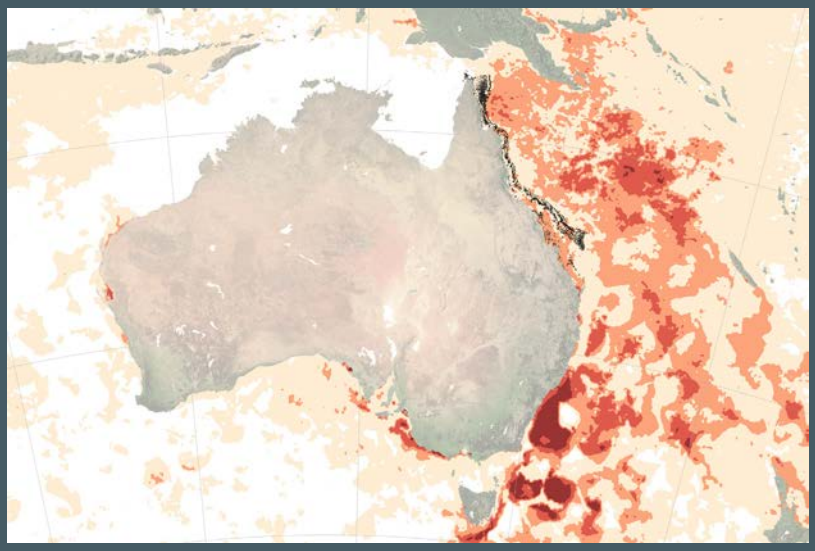
According to a 2003 study by the Food and Agriculture Organization, in Southeast Asian countries coral fisheries account for 70–90 per cent of the edible fish catch. These figures highlight the devastating impact that coral depletion would have on specific regions, and particularly on the poorest and most vulnerable within these regions.

Coral reefs are a natural wonder that have intangible and inherent value that we risk losing. Reefs drive tourism and local economies. According to a 2011 study from the ARC Centre of Excellence for Coral Reef Studies, each year approximately two million people visit the Great Barrier Reef, generating around €4 billion and 54,000 jobs in Australia alone. Around 275 million people (many in small island developing states) depend directly on coral reefs for their livelihoods.

In addition to maintaining economic livelihoods, coral reefs also play an integral role in coastal protection against natural disasters. The UNEP World Conservation Monitoring Centre found that coral protects over 150,000 km of coastline, typically absorbing up to 90 per cent of the impact load of a wave. A study from the Université de Bretagne Occidentale makes it clear that the loss of coastal protection provided by coral would impact a great deal of the world's population: roughly 62 million people live less than 33 feet above sea level and less than two miles from a coral reef.

Coral is not only important due to its cultural value: a 2019 study conducted by the US Geological Survey found that without coral the US alone risks losing $1.8 billion worth of coastal infrastructure. These studies further emphasise the protection that coral reefs provide.

The rise in global temperature scenarios set out by the IPCC means that more pressure is being placed on the world's oceans to absorb CO_2. While the ocean is the greatest carbon sink on Earth, the specific role played by coral within oceanic carbon cycles is not well understood. Contrary to popular belief, it appears coral reefs themselves are not carbon sinks and may even produce very small amounts of carbon. But there is less clarity on the effects of the wider coral ecosystem on carbon absorption. But even if coral reefs are not carbon sinks, their depletion would have catastrophic impacts. The loss of 70 per cent of the world's coral would be a disaster. Losing 99 per cent would be catastrophic.



◀ **Map of Australia and the Great Barrier Reef, showing the levels of heat stress in the ocean during February 2017. Tan indicates the area may have been exposed to heat stress. Orange indicates coral bleaching is possible. Red indicates bleaching is likely, and dark red indicates coral mortality is likely**

A new deal for nature?

The UN Biodiversity Conference is a chance to set the world on a new path to halting catastrophic biodiversity loss. Nations must act on this opportunity before it's too late

By **Rizal Malik**, WWF Leader, Asia-Pacific New Deal for Nature and People Initiative (former CEO of WWF-Indonesia)

When people think of biodiversity, chances are they think of a dense rainforest in the middle of Borneo, or a pristine coral reef in the heart of the Coral Triangle. But the truth is, even our houses in the suburbs are teeming with biodiversity: the spinach we eat, the grass on the lawn, the orange juice we drink, the fungus on our stale bread. Biodiversity is not just the abundance of life on Earth. It is what provides us with air, food and water, and maintains our life and our resilience.

In my part of the world, the Asia-Pacific region, people are highly dependent on the marine, aquatic and terrestrial biodiversity for their survival. The benefits provided by biodiversity thus play a critical role in economic and human development, as well as the cultural and spiritual fulfilment of the population.

Asia-Pacific is one of the most diverse regions in the world, in terms of its social, cultural, biological, climatic and geomorphological make-up. It hosts a high number of endemic species and unique ecosystems of tremendous biological diversity, containing 17 of the 36 global biodiversity hotspots and seven of the 17 megadiverse countries. It has the greatest marine diversity globally, with the longest and most diverse coral reef systems in the world, and more than half of the world's remaining mangrove areas. And, more importantly, 4.5 billion people – more than 60 per cent of world's population – live across this region.

Biodiversity and ecosystem services have contributed to the rapid economic growth of the region. But growth has also come at a hefty environmental cost. A high rate of species and habitat loss, environmental pollution and deforestation have accelerated biodiversity loss, and even led to permanent loss of biodiversity in terrestrial and marine ecosystems.

The impacts are already being felt, especially by indigenous peoples and Asia-Pacific's poorest and most vulnerable communities. They are suffering a continued loss of subsistence and livelihoods from ongoing deforestation and unsustainable fishing practices, as well as impacts on health from pollution and water insecurity.

The impacts are already being felt, especially by indigenous peoples and Asia-Pacific's poorest and most vulnerable communities

The relationship between people and the planet is dangerously unbalanced. We are seeing increasing evidence of this in the impacts on our lives. According to the National Oceanic and Atmospheric Administration, the 20 warmest years on record have all occurred since 1995. The five hottest have all come in the 2010s.

The World Economic Forum (WEF) estimates that the top five most likely risks facing the world over the next decade are all related to the environment: extreme weather, climate action failure, natural disasters, biodiversity loss, and human-made environmental disasters. Biodiversity loss is ranked as the second highest impact risk in the next decade. The *WWF Living Planet Report 2018* shows that, incredibly, the size of vertebrate populations across the Earth declined by 60 per cent on average between 1970 and 2014.

Stark consequences

The science has never been clearer on the impact of human activities on nature and the consequences we will face. Warning after warning in a series of major intergovernmental scientific reports – from the Intergovernmental Panel on Climate Change, the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) and others – have shown a crisis of accelerating nature loss.

The costs of action are dwarfed by the costs of inaction. The Asia-Pacific region witnessed 50 per cent of the world's 'natural' disasters in 2018 – catastrophes exacerbated by environmental damage. These disasters affected over 50 million people, and cost the region a total of $56.8 billion, according to IPBES's 2019 *Regional Assessment Report on Biodiversity and Ecosystem Services for Asia and the Pacific*.

Unless we urgently change course, there will be catastrophic impacts for life and livelihoods. Nature holds the key to our prosperity, if managed well and sustainably. Each year, around $125 trillion worth of ecosystem services are provided to the global economy through drinkable water, water for industrial processes, food, fresh air, heat absorption, sources of medicines, productive soil, and forests and oceans that soak up carbon (according to the WEF's *Global Risks Report 2020*). Nature loss risks economic development, and some of the fastest-growing economies in the world

▲ **Traditional fishing in Situ Gunung lake, Sukabumi, West Java. The Indonesian island of Java is part of the Sundaland biodiversity hotspot – a biogeographic region with significant levels of biodiversity that is threatened by human habitation**

are particularly vulnerable. Therefore, addressing both climate change and nature loss is a social and economic imperative.

Charting a new course

The next year brings an opportunity for all of us to chart a new course, with the postponed UN Biodiversity Conference taking place here in Asia. Parties to the Convention on Biological Diversity will meet at COP15 in Kunming, China. They must help deliver the transformative change required to safeguard the future for people and all life on Earth. We need a strong and ambitious agreement on the post-2020 global biodiversity framework if we are to halt and start reversing the loss of nature.

This year, we must set a new and sustainable direction for the Earth. Government, business leaders and society at large should all agree to change the way we treat our planet. We must renew our commitments to tackle climate change and improve people's lives. We must have, as WWF advocates, a New Deal for Nature and People. This new deal will have a new narrative that recognises the intrinsic value of nature and the moral imperative for us to coexist with the diversity of life on our planet. It will also position nature and biodiversity at the centre of the sustainable development agenda.

We also need to raise our ambition and scale up our actions. The way we produce food on land, fish the oceans, use forests and river systems, extract minerals, and build infrastructure are today's main drivers of nature loss. The post-2020 global biodiversity framework must now show the will to drive the change that is needed. Transformation of the world's economic and financial systems is critical to reversing nature's depletion and achieving the Sustainable Development Goals.

NASA's *New Horizon*, after its 14-year journey to Pluto and back, has framed visuals of the last planet in our solar system. It didn't capture any living organism in resemblance of a human being. It is clear that we don't have a neighbouring planet to live on. Mother Earth is all we have, and is the only chance of our survival. As many others have said, "there is no planet B". Now is the time to show the will to drive change. It is an immense challenge but – together – we can do this. ●

Eliminating emissions

We must find an equitable pathway to net-zero emissions that curbs temperature rise without creating other problems for our planet

By **Richard Black**, Director, Energy and Climate Intelligence Unit

◀ The 2019 Maria Fire viewed from Santa Paula, California. The wildfire was a consequence of a record dry spell. Although the Trump administration has withdrawn the US from the Paris Agreement, California, the country's most populous and economically powerful state, has committed to a net-zero target

One of the images science communicators often use when explaining climate change is a bath. From open taps, water cascades in, representing greenhouse gases (GHGs). A proportion gurgles away down the plughole, just as a proportion of the warming gases we pump into the atmosphere trickles away naturally into oceans and forests. Whatever is left in the bath warms the world.

The bath analogy is useful but it conceals a crucially important and recently confirmed fact about carbon dioxide, the main GHG: on timescales that matter to people, it doesn't trickle away. If we turned off the GHG taps tomorrow, the global temperature, already elevated by about one degree Celsius, would not magically start to fall. On timescales that matter, the extent of climate change that we will see is proportional to the total amount of carbon dioxide we put into the atmosphere. We can fill up the bath in a flood or a trickle. What matters is how high we allow the water to rise.

If we turned off the GHG taps tomorrow, the global temperature, already elevated by about one degree Celsius, would not magically start to fall

This leads inexorably to a conclusion vitally important for policymaking: if we want to halt climate change, we need to end the net flow of carbon dioxide into the atmosphere. We need to reach net-zero emissions. The sooner we do, the cooler the world we bequeath to our children.

Science cannot be absolutely precise on how soon we need to reach net-zero emissions to hit a given climate target, such as the goal governments agreed at the Paris summit of keeping global warming to 1.5°C. The best shorthand comes from the Intergovernmental Panel on Climate Change (IPCC). Its conclusion: to have an evens chance of hitting that Paris Agreement target, emissions globally need to roughly halve by 2030 and reach net zero by 2050.

The temporary reduction in emissions wrought by COVID-19 cannot hide

Also in this section

the scale of that challenge. With few interruptions, emissions have been rising for centuries, ever since fossil-fuel burning began at scale. We are talking about turning around that supertanker, in which so many have so much invested, in just 30 years. No serious analysis has concluded that it cannot be done, as the technological and economic tools exist. As ever, the big question is whether governments and others will deploy them at the scale and speed required.

Commitments so far

A growing number of governments have bitten the bullet and set out plans to bring their emissions to net zero by 2050 or before. At the time of writing, five countries (Sweden, the UK, France, New Zealand and Denmark) have a net-zero target in national law.

A whole heap more (including the entire European Union) are actively working towards doing so, and altogether more than 120 nations have either set or declared an intention to set a net-zero target. They are joined by states such as California and Catalonia, and cities such as Tokyo and New York.

Analysis by my own organisation, the Energy and Climate Intelligence Unit, shows that without double-counting, net-zero nations, states and cities collectively account for half of global GDP. The number of businesses committing to net zero grows so quickly that the list is permanently out of date.

Definitions of net zero, though, vary. Greta Thunberg is among those to have questioned the idea, opining that we ought to be heading for 'absolute zero' instead. However, it is not clear what that would mean in practice. So long as humanity continues to pursue any activity that releases GHGs, we will need to remove an equal amount of them from the atmosphere – hence 'net zero'.

The virtually unanimous view among analysts is that emissions cannot ever be brought to 'absolute zero', and therefore 'negative emissions' will be required. But the consensus view is also that emissions should be cut as far as possible and that negative emissions are not a silver bullet.

And herein lies the rub. Some of those proposing and enacting net-zero targets – for example, the UK's statutory advisor the Committee on Climate Change (CCC) – are serious about turning the screw on every source of GHGs, using negative emissions only as an unavoidable bolt-on.

However, oil companies, airlines and others are gaily declaring they will move to becoming net-zero companies while continuing with fossil-fuel burning as usual – basically, paying entities in developing countries to plant trees to absorb all the carbon dioxide they produce. The problems with this approach are legion, from potential clashes with local demands for land, to the insecurity of trying to lock up carbon in trees in an era when climate change is increasing wildfires. Such brass-necked adulteration of a scientifically valid concept for commercial ends amply justifies Greta Thunberg's disdain – but does not invalidate the justification for governments pursuing the concept properly.

No serious analysis has concluded that it cannot be done, as the technological and economic tools exist. As ever, the big question is whether governments and others will deploy them at the scale and speed required

Possible scenarios

So what does a proper net-zero transition look like? Fortunately, there is a growing body of scenarios and plans on which we can draw, including from the IPCC, the UK's CCC, and its equivalents in Sweden, France and New Zealand.

First, make all energy use as efficient as possible. Second, make electricity generation entirely zero-carbon. Thirdly, extend the use of electricity into areas where currently we burn fossil fuels directly – principally, heating and transport, but also some industries. Fourth, deploy bespoke solutions for industries in which electrification isn't suitable (hydrogen instead of coking coal in steelmaking, timber instead of cement for buildings, and so on). Fifth, invest in negative emissions approaches to mop up what is unavoidably emitted. These can either be natural – planting new forests, restoring peat bogs – or technological – building machines that in various ways suck carbon dioxide from the atmosphere.

Apart from the fast-growing concern about corporate greenwash, some scientists and campaigners worry that focusing on 'net zero by 2050' allows governments and other entities to avoid taking action now – to avoid focusing on the other key part of the IPCC's analysis, that global emissions should halve over the next decade. This is self-evidently a possibility. But the UK experience so far is the opposite, that having a net-zero target focuses attention on the need for near-term emissions-cutting. Not least because when you are talking about turning over a nation's entire stock of fossil-fuel-powered cars or gas boilers you obviously gain by starting now and doing it progressively, so that new kit does not have to be scrapped before the end of its lifetime.

Because net zero is necessary for stopping climate change, the concept is only going to grow in importance. But the caveats are essential. If negative emissions through willy-nilly tree-planting become a get-out-of-jail-free card for high-emitting corporates – if that is the direction in which things are permitted to go – then climate change will not be stopped.

So for those who, like Greta Thunberg, are not entirely enamoured of net zero, here are at least two ways in which the power of the streets can be brought to bear. One: to insist on action now as a prerequisite for reaching net zero. And two: to disallow the hijacking of the concept by companies that in reality see it as a way to avoid eliminating their carbon emissions. ●

Targeting net zero

Climate ambition needs to be directed by clear, hard targets. The UK has embraced this by enshrining its net-zero emissions target in law

By **Lord Deben**, Chairman, UK Committee on Climate Change

It is sometimes said that setting targets is an easy step for governments. If that's the case, how should we measure the UK Government's decision in June last year to set a 'net zero' target for 2050? With this target, the UK became one of the first major industrialised economies to commit to the effective elimination of greenhouse gas (GHG) emissions.

This was a historic moment, indicating the UK's clear ambition to become a world leader in tackling the climate crisis.

▲ **A 75-metre-long wind turbine blade, manufactured at a local factory, being installed as a sculpture in Hull, UK. The UK has been a pioneer in offshore wind energy and has 8 gigawatts of capacity in operation, with a further 5 gigawatts under construction**

Thanks to the legal duties of the UK's Climate Change Act, the implications of enshrining this target in law are more fundamental than for most government targets. In making net zero law, the United Kingdom, the birthplace of the industrial revolution, has committed to ending its direct contribution to global warming by the middle of the century. It has also indicated that it is ready to make significant changes to how the country's land is managed, homes heated and transport powered.

Climate leadership

To achieve this over three decades will take the UK from the originator of fossil-fuelled industry to the leading green economy. It is a vital step.

I chair the UK Committee on Climate Change, which was set up in law to provide independent advice on emissions targets and UK preparations for the impacts of climate change.

In May 2019, we advised that having a net-zero GHG emissions target by 2050 was necessary to meet the UK's commitments as a signatory to the 2015 Paris Agreement. In our report to the Government, we explained how considerations of 'equity' – the UK's historically high emissions and significant carbon footprint attached to imported products – mean that the UK should aim to reach net-zero emissions ahead of the world as a whole.

The UK is not alone in its ambitions. France, Sweden, Denmark and New Zealand have all enshrined net-zero targets in law, while other nations including Spain and Chile are looking to do so. The next major climate change summit – COP26, to be hosted by the UK in Glasgow in 2021 – will be a true test of the UK's and others' climate leadership. All 'net zero' nations must now grapple with the reality of reducing their emissions to as close to zero as possible.

The challenges of getting to net zero

In the UK, there is already a well-tested and successful framework in place to drive domestic emissions cuts: the Climate Change Act. Importantly, the Act is designed to deliver the long-term target, net zero by 2050, through a series of 'carbon budgets'. These five-yearly budgets put legally binding limits on UK emissions and require the Government to set policies to drive those emissions reductions.

The next budget to be agreed, known as the Sixth Carbon Budget and covering the period 2033–37, will be the first on the pathway to the new net-zero target. It is likely to ratchet up the level of effort required in both the near and longer term.

For some sectors, such as international aviation, agriculture and industry, this will be exceptionally challenging. Reducing emissions from buildings and transport, meanwhile, will require noticeable changes to the way people live their lives. There is no single, one-size-fits-all solution.

Take the way land is used, for example. Planting trees offers a simple method to reduce emissions by absorbing CO_2 from the air. To help deliver net zero, UK tree-planting rates will need to increase significantly to levels not seen since 1989 – requiring around 100 million new trees per year between now and 2050. In practice, that means changing how we use agricultural and other land. Not least, we must recover the ability of farmland to sequestrate carbon and restore the fertility of the soil.

Our assessment shows that a relatively limited reduction in food waste and in the consumption of the most carbon-intensive foods can help release enough land to support such levels of tree planting. Other measures, such as low-carbon farming practices, restoring peatlands and encouraging bioenergy crops are all essential too.

A change of this kind will not be delivered by government policy alone. As stewards of the land, farmers will need wide-ranging support to enhance skills, including training in low-carbon farming practices and the sustainable management of lowland peat.

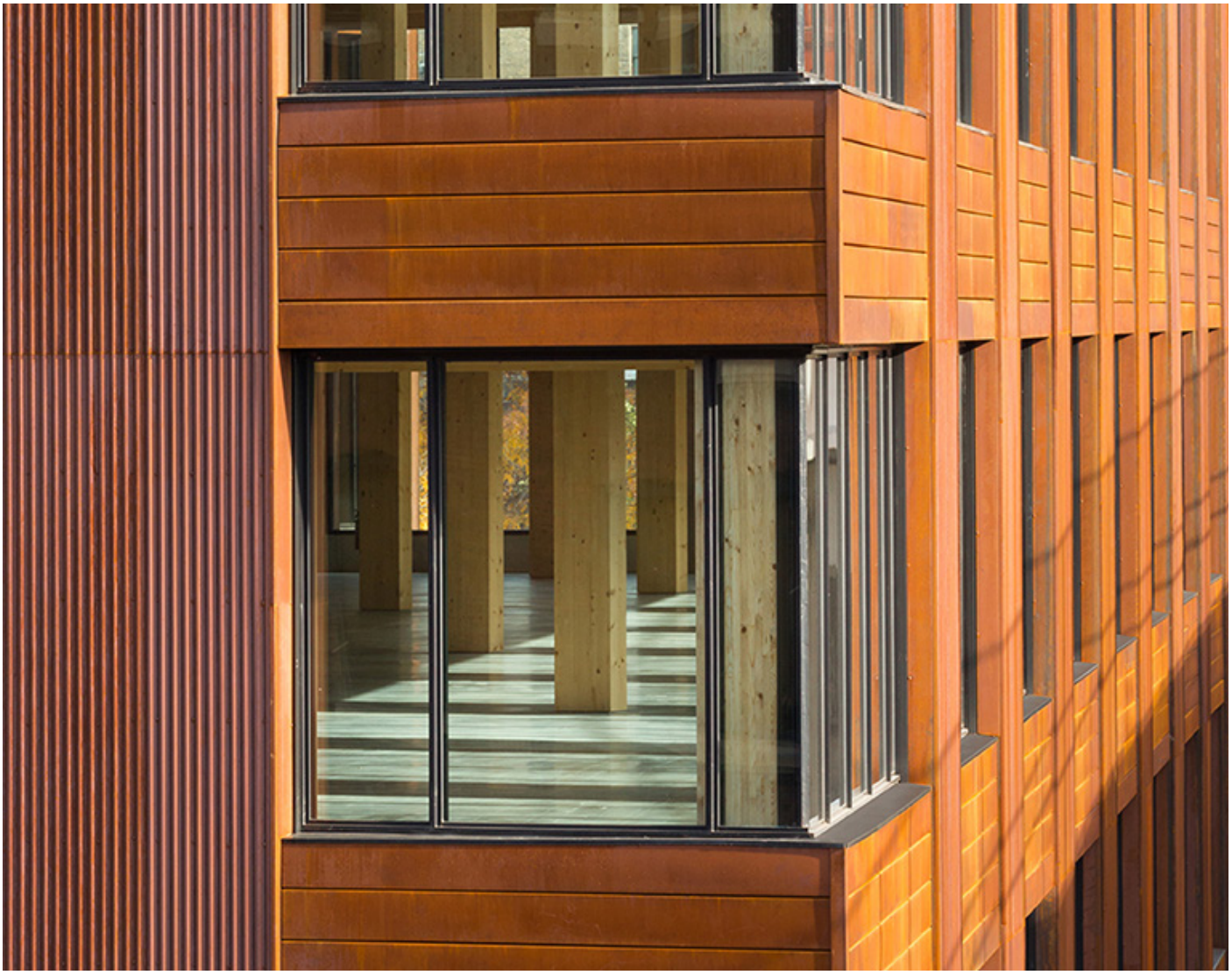
Land use is just one example of the importance of involving citizens in the transition to net-zero emissions. The behavioural and societal changes we will see in the coming years will affect us all. It's therefore vital that the shift is carried out, and seen to be carried out, fairly. Setting a target is just the first aspect of the transition. Concrete action must follow.

In making net zero law, the UK has committed to ending its direct contribution to global warming by the middle of the century. It has also indicated that it is ready to make significant changes to how the country's land is managed, homes heated and transport powered

The global transition to net zero

My Committee's advice was for a net-zero target at a national level. But the UK is only one part of the puzzle, accounting for just 1 per cent of global emissions. Ambition to reduce GHG emissions globally fails to meet the scale of action required under the Paris Agreement and set out in the Intergovernmental Panel on Climate Change's *Special Report on Global Warming of 1.5°C*. Recent extreme weather events in Australia, Brazil and here in the UK act as reminders that time is short to rectify that.

The implications of the global coronavirus pandemic will of course also need careful assessment. The COP26 meeting in Glasgow next year is still one of a limited number of opportunities to ratchet up global ambition to reduce emissions. That starts with targeting net zero. But without concrete, concerted and comprehensive action, all the targets in the world will be worthless. ●



Towards zero-carbon building

Eliminating carbon from the building and construction sector by mid-century will require radical transformation

By **Cristina Gamboa**, CEO, World Green Building Council

In its 2018 landmark report, *Global Warming of 1.5°C*, the UN Intergovernmental Panel on Climate Change warned of a catastrophic climate breakdown if global average temperatures rose by 2°C. Negative consequences for our communities and planet would be long-lasting and, in some cases, irreversible. Recent events in countries like Australia have shown us a glimpse of the future and that the worst, if we do not act now, is yet to come.

Faced with our current state of climate emergency, science and data have already established the role and potential of the building and construction sector in helping to map a pathway to 1.5°C in line with the more progressive ambitions of the Paris Agreement.

▲ **Avoiding carbon-intensive materials: the seven-storey T3 office building in Minneapolis is North America's largest contemporary wooden building. Only the ground floor and the central access core use reinforced concrete, while the top six storeys have been built with wood-frame techniques**

Underpinning those ambitions is a projected transition to net-zero carbon emissions with specific transformations to be met by 2030 and 2050. It is imperative that the sector steps up its climate action, as we know that the path of its decarbonisation is one of the most cost-effective ways to rescue our planet from the worst effects of climate breakdown.

As the world's population increases, the global building stock is expected to double in size by 2060. Without drastic changes to the way our sector operates, this expansion will fuel an expected doubling of the total global consumption of raw materials (according to predictions by the Organisation for Economic Co-operation and Development). This will significantly increase the construction sector's emissions and climate impact.

A wake-up call? Absolutely. That's why at the World Green Building Council (WorldGBC) we see the need to go further and faster to decarbonise. And we want to take the whole sector with us.

Bringing embodied carbon upfront

Carbon emissions are released not only during the operation of buildings but also during the manufacturing and transportation of materials, construction and end-of-life phases of all built assets – buildings and infrastructure alike. Largely overlooked historically, these embodied carbon emissions account for around 11 per cent of all carbon emissions worldwide.

If we drill down further, we see that carbon emissions released before a building or infrastructure enters use (so-called 'upfront' carbon) will account for half of the entire carbon footprint of new construction between now and 2050. This upfront carbon therefore threatens a large chunk of our residual carbon budget, and it's occurring right now.

As steps to reduce operational carbon take effect, embodied carbon will grow in both size and importance as a proportion of total emissions. While we continue to focus on addressing operational carbon, we must now also rapidly increase our efforts to tackle embodied carbon emissions on a global scale.

Our 2019 report *Bringing Embodied Carbon Upfront* describes goal-based steps that stakeholders across our sector can take to meet global climate targets against a staged timeline using a whole-lifecycle approach. The report – both a roadmap and call to action – is especially meaningful, as it is endorsed by some 85 organisations: from financial institutions and policymakers to developers and manufacturers.

These organisations join our global network of Green Building Councils, demonstrating leadership through global initiatives like our Advancing Net Zero programme, which targets full-sector decarbonisation by 2050. Our ambitious vision for the sector sees a highly connected value chain radically reducing both embodied and operational carbon emissions, improving wider lifecycle environmental impacts, and contributing as effectively as possible to the UN's Sustainable Development Goals.

Achieving our vision means taking urgent action to tackle upfront carbon, while planning with whole-life carbon in mind. It means 'designing out' carbon using more robust metrics and methodologies. It means innovating in materials to improve procurement options and maximise circularity. And it means initiating a fresh conversation between investors, policymakers, planners, developers, manufacturers and designers to better manage the supply- and demand-side influences on the built environment.

Designing for better outcomes

Today, increasingly smarter urban planning is maximising opportunities for low-carbon design in buildings and surrounding infrastructure.

When buildings are viewed as, for example, an energy source for electric vehicles, it's clear that interdisciplinary boundaries are being crossed. Building design can therefore be part of a bigger picture that also takes in transport and urban planning.

It is worth reminding ourselves that low-carbon building design also considers future-use and end-of-life scenarios, maximising the potential for maintenance, repair, renovation and adaptation. Smart design for disassembly and deconstruction chooses and uses materials which can be recycled, or which can be extracted and separated easily for processing.

Meanwhile, latest-generation, performance-based metrics are raising the bar for design standards within new builds in a bid to eliminate the carbon emissions associated with operating costs. Here, the focus is on monitoring and measuring outcomes with greater reliability and rigour, and on using integrated design solutions to achieve net-zero emissions today while future-proofing for tomorrow.

Performance-based metrics are raising the bar for design standards within new builds in a bid to eliminate the carbon emissions associated with operating costs

In this context, our Green Building Councils are playing an increasingly active and important role. We recognise the value that rating tools and certification schemes have in different markets in support of performance standards that exceed local regulatory minimums. That's why our Green Building Councils are already developing their own net-zero carbon building certification programmes tailored to local needs.

Such schemes help quantify reduced impacts while encouraging participants to consider enhanced sustainability criteria. Green Building Councils are also rolling out training and education programmes to develop market capacity and support delivery.

Material innovation

Materials are the principal source of embodied carbon emissions from buildings

and infrastructure, particularly the upfront carbon being released right now. Winning the support of manufacturers and creating the right conditions for them to take radical action today and tomorrow are crucial.

Materials producers will need finance, and supportive policy frameworks, plus an adequate market demand for their low-carbon products. That is why the coordination of our efforts across the widest possible range of stakeholders is an urgent priority.

Highly carbon-intensive materials such as concrete and steel play a key role in shaping the built environment that we live in. They will continue to do so. Today, our focus must be on identifying and evaluating the best low-carbon solution for a building's needs. That said, the good news is that forward-thinking manufacturers of our most carbon-intensive materials are leading the way in innovating for impact.

HeidelbergCement, the world's fourth largest cement group, is the first company in this sector to design a carbon reduction strategy that is certified to be in line with the Paris Agreement. Dalmia, one of India's top cement manufacturers, has made a commitment to becoming carbon negative by 2040. In steel, ArcelorMittal and SSAB are among manufacturers working to meet the Paris targets by, for example, using cleaner power, by exploiting circular carbon models, and by prioritising carbon capture and storage.

These types of innovations that reduce emissions from materials mean designers have better options. Indeed, the knock-on effect of advances in materials ripples out right across the sector.

Opportunity and challenge

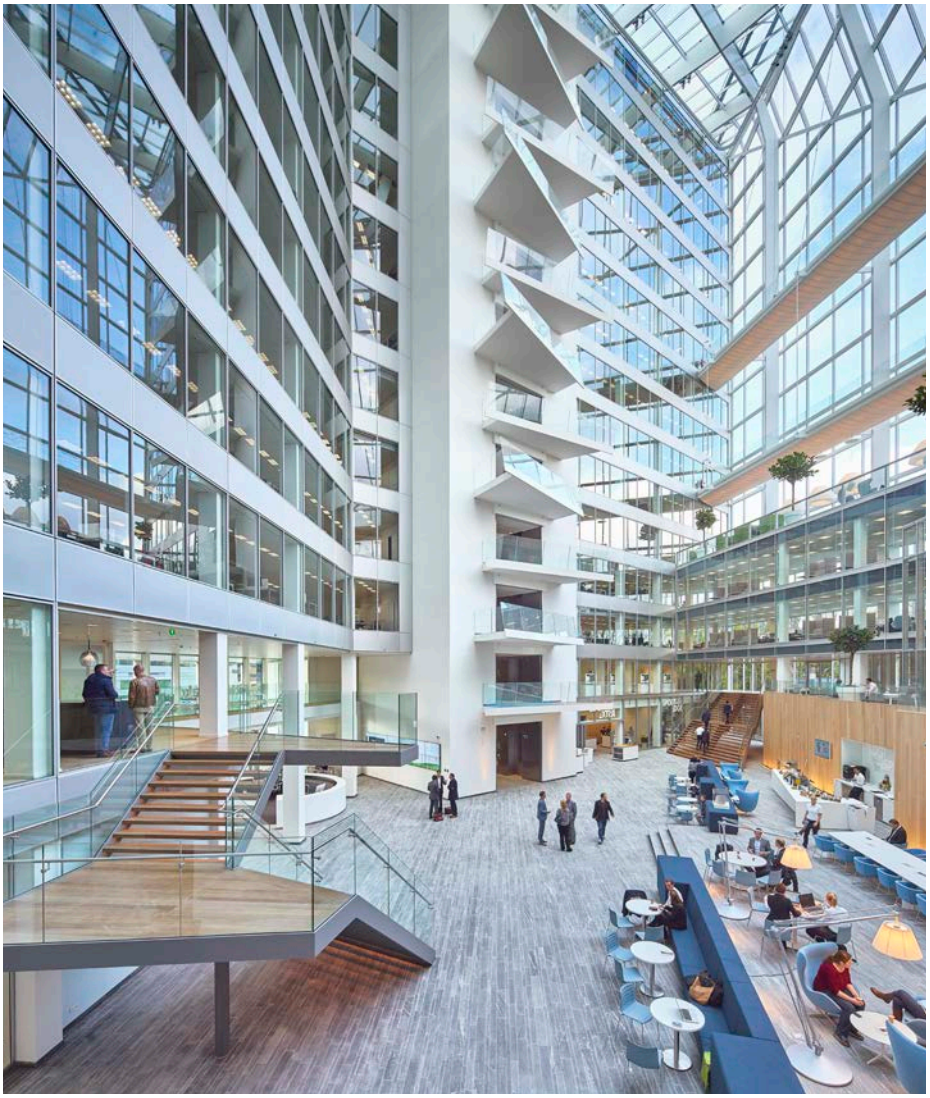
Instilling a better understanding of best practice and the potential for change is key to embedding systemic progress towards our objectives – not just within our sector but across the entire planning and regulatory landscape. When so much of our attention is on the path ahead, it is vital not to underestimate the opportunities associated with our existing building stock – opportunities to upgrade, renovate and retrofit to improve performance across the whole lifecycle.

We can help buildings reach net-zero readiness via efficient on-site electrification – for example, in anticipation of a decarbonised grid. Nature-based solutions and offsets, too, can help shrink residual emissions.

Our vision is one of radical transformation for our sector. To deliver it requires much more market demand as well as a rapid scaling up of solutions by the supply chain. Demand-side actors within the production chain, including investors and developers, must work together with their counterparts on the supply side – the contractors and materials manufacturers.

By stimulating demand, we accelerate investment in actions that lead to increased competitiveness, improve access to innovative solutions, and stimulate action across a broader range of integrated strategies for achieving net-zero carbon – and for securing a safer future for both our generation and those to come.

Net zero is our goal. What does it really mean for us, if not the chance to transform our sector from a major cause of the climate emergency into a major solution to it? ●



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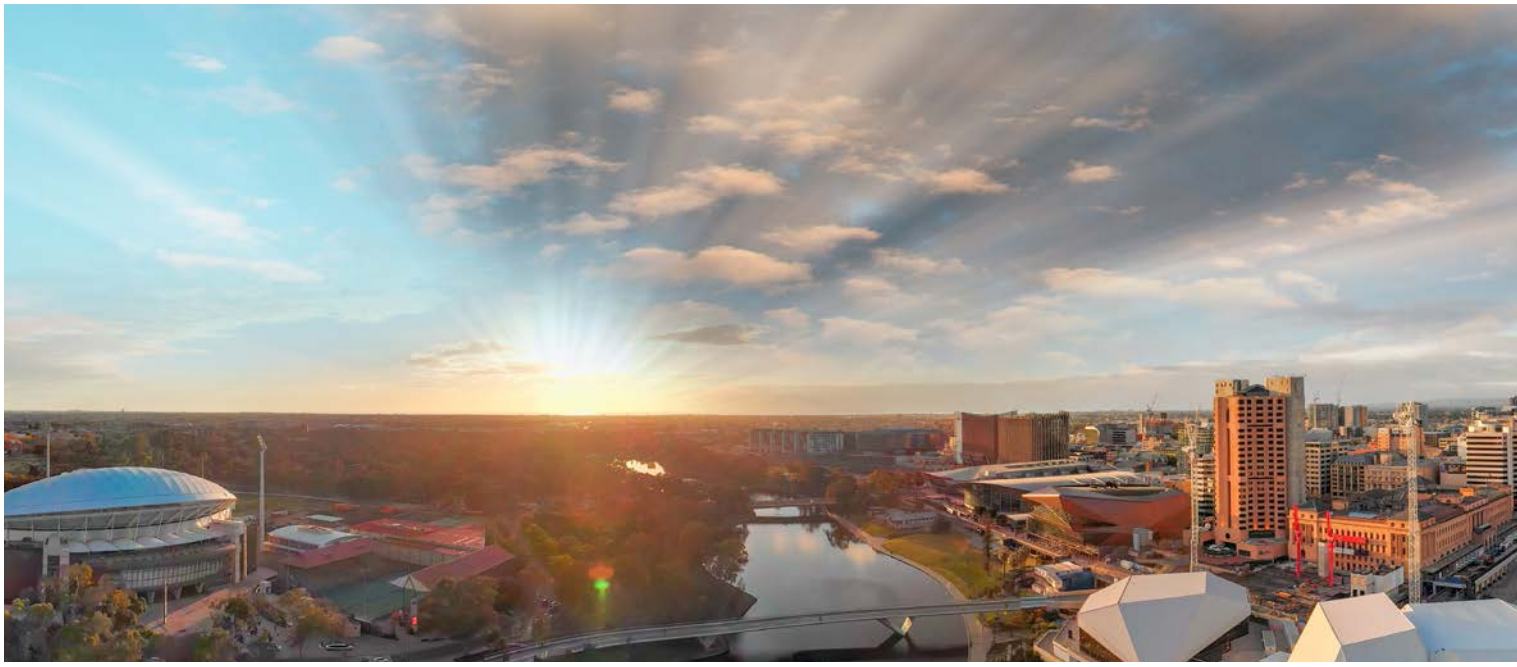
▶ **The Edge in Amsterdam is rated by BREEAM as one of the world's most sustainable office buildings. Among its features, it uses 70 per cent less electricity than comparable buildings, has the largest array of PV panels of any European office building, and uses an aquifer thermal energy storage system for heating and cooling**



Creating a zero-carbon city

South Australia's state capital Adelaide intends to be one of the world's first carbon-neutral cities, an ambition built on several decades of sustainability focus

By **Sandy Verschoor**, Lord Mayor of Adelaide

The City of Adelaide recognises that sub-national government and local municipalities are at the front line of dealing with climate change. We must take decisive actions to both reduce greenhouse gas (GHG) emissions and adapt to a changing climate.

The unprecedented bushfire disasters across Australia in summer 2019–20 are a stark reminder of the reality that governments, businesses and community members must address in a changing climate.

Adelaide's greater metropolitan area is home to 75 per cent of South Australia's population of 1.7 million people. The City of Adelaide Council takes the threats and impacts of climate change on our society seriously. It's a journey that our city and community has been on for the last 25 years. We are responding by making substantial reductions in GHG emissions (mitigation) and helping prepare for and respond to the changing climate (adaptation).

The City of Adelaide began measuring and managing our carbon emissions in 1995 through our participation in the Cities for Climate Protection programme. We set a target to be a carbon-neutral corporation in 2008.

The role of government, at all levels, is to use the policy levers at their disposal to support and effect change within their jurisdiction. Enabling policy has led to significant private investment in renewable energy. In South Australia, policy at the state-government level in 2002, paired with the federal government's renewable energy target, has led to significant ongoing investment in large wind-energy projects, and more recently solar and energy storage.

In 2018, 53 per cent of South Australia's electricity came from renewable sources. Our state government has reaffirmed its goal of net 100 per cent renewable energy by 2030. As of October 2019, AUD 21.5 billion of new large-scale renewable energy projects are in the pipeline in South Australia. At the end of November 2019, the City of Adelaide had 10.63 MW of solar installed from 1,376 small-scale residential and business systems.

The city council is leading by example and investing in its own operations becoming carbon neutral. We recently signed a long-term electricity supply contract for all our operations to be supplied with 100 per cent renewable electricity. This contract will eliminate 11,000 tonnes of emissions each year, which equates to taking roughly 3,500 cars off the road. In addition, the contract will deliver a 20 per cent reduction in electricity costs to our budget – freeing up funds to be spent on other services for our residents and ratepayers.

An argument used for decades in order to avoid taking climate action has been to highlight perceived negative impacts on the economy. However, South Australia and

◀ Adelaide, the capital of the state of South Australia, has set itself the ambitious net-zero target date of 2025

Adelaide are a beacon to the world that it is possible to decouple emissions from growth, while benefiting from the growth of the low-carbon economy.

Strong track record

Our track record on sustainability has led to the council fostering an internationally regarded working relationship with the state government. The Carbon Neutral Adelaide Action Plan is a community-owned vision for Adelaide to become one of the world's first carbon-neutral cities. The state government has a goal for South Australia to generate net-zero emissions by 2050. The action plan identifies and tracks numerous initiatives to achieve carbon neutrality as a city.

Between 2007 and 2018, our residential population grew by 33 per cent, gross regional product increased by 33 per cent, and city users increased by 43 per cent. Despite this growth, the community's total carbon emissions were reduced by 15 per cent. Electricity emissions fell by 44 per cent, due to the growth of renewable energy sources in the region.

While electricity emissions are dropping across South Australia, within the city of Adelaide, transport emissions grew 27 per cent, natural gas by 20 per cent and waste by 6 per cent. These areas must become a renewed focus of government action, particularly from the state and federal levels, which hold the main policy levers for these sectors.

Nonetheless, the City of Adelaide is a firm believer in the philosophy that cities must measure what they manage. In 2019, Adelaide scored a top 'A grade' from CDP for the climate adaptation and mitigation work that our city is implementing. At the time of writing, 10 cities in south east Asia and Oceania and 105 cities globally have achieved this score.

Since 2008, the City of Adelaide has allocated at least 1 per cent of its rates revenue to climate change action – with more than AUD 2 million allocated in the 2019–20 budget. While this may not be considered an overwhelming figure, the city's approach is to leverage public spending to grow private investment. We also have a long-held commitment to reducing GHG emissions.

We are supporting businesses and residents to reduce their emissions through several programmes and incentives. Our Sustainability Incentives Scheme provides a range of rebates that build on the City of Adelaide's reputation of national firsts in supporting community investment in sustainable technologies. The scheme positions Adelaide at the forefront of technology and trends for low-carbon living. More than AUD 1 million of incentive funds have leveraged more than AUD 8.4 million in economic output for over 500 projects. The scheme has returned a ratio of AUD 8.15 for each dollar that the city has invested.

Australia's CitySwitch Green Office programme provides a network of support and practical resources to help businesses successfully implement sustainability initiatives. In South Australia, the programme is offered to commercial office tenants from local government areas. In December 2019, there were 61 signatories in Adelaide representing 242,627 square metres of office tenancy.

Our Solar Savers Adelaide programme has delivered the installation of solar photovoltaic (PV) energy systems on eligible low-income and residential rental properties in the city. In late 2017/early 2018, around 2 kW of PV was installed on each of the 40 properties in the scheme. The Council is recovering the costs of the system from participating property owners through a separate council rate charge paid over 10 years.

The City of Adelaide is also leading the way for electric vehicles (EVs). In partnership with the state government, Adelaide has installed a city-wide network of 42 publicly available EV on-street and off-street charging stations.

As part of setting the carbon-neutral goal, we established the Carbon Neutral Adelaide Partners network with an initial 40 members. Over the past two years, it has grown to more than 175 members representing businesses, not-for-profits and research institutions, all committed to reducing emissions.

While we are well along the journey towards climate action, we also recognise that this is a shared responsibility. From residents, visitors and businesses all the way to state and national government, shared commitment and actions are required to reach net-zero emissions as a community, especially with respect to low emissions transport, energy and waste management. ●

Jeep® Renegade 4xe, plug-in hybrid

Charging our future

Fiat Chrysler Automobiles is rising to the challenge that climate change presents to mobility

Mobility reform is one of the toughest challenges facing the automotive industry today. Mobility is essential for people and businesses. Car and commercial vehicle manufacturers must be able to meet ever-growing demand and evolving customer needs – while also developing solutions that protect the health of our planet.

Fiat Chrysler Automobiles (FCA) has accepted this challenge by responding with its approach to electrification.

Over the last few years, FCA has developed a suite of electrification technologies. These include hybrid, plug-in hybrid and full-battery electric vehicles (EVs) that offer improvements in fuel economy and lower CO_2 emissions.

We have already introduced EV technologies on FCA models in several countries, such as:

- the fully electric Fiat 500e, launched in 2013 in North America;
- the Chrysler Pacifica plug-in hybrid, marketed in 2017 in North America and launched in China in 2018;
- mild-hybrid technology, marketed as 'eTorque', launched in the all-new 2018 Jeep® Wrangler and all-new 2019 Ram 1500 in North America;
- the all-new 2019 Jeep® Commander plug-in hybrid in China.

> At CES 2020 in Las Vegas, FCA showcased its newest electrification technologies: the Jeep® Wrangler 4xe, the Jeep® Compass 4xe and the Jeep® Renegade 4xe

In 2020, FCA's electrification rollout will see a rapid development with several models marketed in Europe. In particular, the production of the Jeep® Compass and Jeep® Renegade plug-in hybrid versions, the Fiat 500 BEV, the hybrid version of the Fiat 500 and Panda, as well as the Lancia Ypsilon will all be produced in Italy. Further plans include production of the Fiat Professional Ducato Electric.

All new Maserati models will be 100 per cent developed, engineered and built in Italy, and will adopt hybrid and battery electric propulsion systems delivering all the innovation and outstanding performance typical of the brand's DNA. Moving forward, to meet the growing demand for EVs, we have confirmed plans to invest more than €9 billion in developing vehicle electrification, plus

New Fiat 500, all electric

additional investments in manufacturing plants in North America and Italy.

Powerful partnerships

FCA's strategy is not limited to electrifying vehicles, but also to creating a new mobility system, ensuring customers can drive an EV in a sustainable way. With this in mind, FCA has signed new partnerships with Enel X and ENGIE – global leaders in the energy sector – to offer private and public e-charging solutions and services across all major markets in Europe. The initiative also includes research and testing of new technologies that will reduce the cost of EVs to vehicle owners.

To support the flexibility and safety of the electricity grid, FCA has also signed a Memorandum of Understanding with Terna, a major electricity grid operator. The two companies have agreed to set up an innovative technology lab in Turin (Italy) to test the potential of connecting FCA's EVs to the electricity grid. The aim of the pilot project is to supply ancillary services to the grid and, potentially, to let FCA customers exchange power from their vehicles to the grid and vice versa, maximising value from the vehicle batteries when they are not in use.

Jeep® Renegade and Compass 4xe 'First Edition': discovering the new plug-in hybrid models of the Jeep® brand

As EVs become increasingly connected, FCA will also be able to provide customers with dedicated mobile services. Our collaboration with Transatel, Europe's leading mobile virtual network enabler, will offer drivers and array of online in-vehicle services, from rate-per-kilometre options, long-term car rental and peer-to-peer car-sharing solutions.

In addition, our partnerships with insurance company Generali and data and analytics experts LexisNexis Risk Solutions will develop tailor-made insurance services and products for EVs in Italy and in the main European markets.

Accelerating the drive to electrification

FCA is adding another element to its e-mobility strategy – a new Battery Hub. This hi-tech battery assembly centre, based in Turin, will employ advanced technology in modular and flexible processes, including collaborative robots working hand in hand with human operators.

The Battery Hub is expected to be an advanced technology centre for innovation, prototyping and testing, as well as for training. It will enable FCA to respond quickly to the continually evolving electrification sector.

As our EV portfolio grows, we will continue to develop electric and hybrid technologies, focusing on solutions that are both competitive and beneficial to society as a whole. ■

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Fiat Chrysler Automobiles (FCA) is a global automaker that designs, engineers, manufactures and sells vehicles in a portfolio of exciting brands, including Abarth, Alfa Romeo, Chrysler, Dodge, Fiat, Fiat Professional, Jeep®, Lancia, Ram and Maserati. It also sells parts and services under the Mopar name and operates in the components and production systems sectors under the Comau and Teksid brands. FCA employs nearly 192,000 people around the globe. For more information about FCA, please visit www.fcagroup.com

FCA

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UNA-UK thanks Fiat Chrysler Automobiles for its generous support for this publication

Science-based targets for business

Science-based targets take companies beyond good intentions and towards concrete commitments to operate within a 2°C pathway. With early adopters showing the clear benefits for both business and planet, we must encourage rapid widespread take-up to reduce GHGs

By **Alberto Carrillo Pineda**, Director of Science Based Targets at CDP and Steering Committee member of the Science Based Targets initiative

According to the World Economic Forum's *Global Risks Report 2020*, severe threats to the climate account for the top five long-term risks to humanity. Science tells us that global emissions must peak in 2020 to avoid catastrophic impacts from extreme weather, rising sea levels, massive crop loss and more.

Five years after the landmark Paris Agreement, governments are scheduled to meet in Glasgow in 2021 to put more ambitious national climate action plans on the table. The UK and France recently passed legislation to reduce greenhouse gas (GHG) emissions to net zero by 2050. Sweden and Norway have enshrined net zero by 2050 into national law. Yet this is only part of the solution. To curb global temperature rise, we need serious action from the private sector.

That's where science-based targets come in. Science-based targets use the latest climate scenarios and pathways to specify how much and how quickly companies need to reduce their GHG emissions to keep global warming to well below 2°C and 1.5°C. Businesses that adopt science-based targets are key partners in the fight against climate change.

Setting science-based targets for success

Investors are waking up to the fact that the businesses that act now will be best placed to thrive in the future. More are asking the companies they invest in to do a better job of disclosing their climate risks and impacts. As Larry Fink, CEO of asset management company BlackRock, wrote in his 2020 letter to CEOs, climate change has become a defining factor in companies' long-term prospects.

◀ The Wipro campus in Bangalore, India. The IT company, which employs more than 160,000 people worldwide, has committed to reducing its scope 1 (direct) and 2 (indirect) GHG emissions by 48 per cent by 2030, and scope 3 (supply chain) by 30 per cent, from a 2017 base year

Science-based targets boost investor confidence because they are the most credible way of demonstrating that a company's ambition is aligned with the long-term global climate goals.

Another benefit is brand reputation. Companies need to be leaders on the climate issue to have a social licence to operate in many markets where they sell their products. Grassroots movements worldwide, such as the youth climate movement led by Greta Thunberg, are bringing more attention to the climate issue. Customers and employees are becoming more vocal about wanting the companies they buy from and work for to act responsibly.

Setting science-based targets also helps companies unlock innovation, giving them a competitive edge and leading to the creation of new products and solutions to increase efficiency. For example, in response to their targets, German building materials company HeidelbergCement is improving energy efficiency, increasing the use of alternative fuels and alternative raw materials, and investing heavily in research and development into new products and technologies for capturing carbon.

One of the most promising such technologies they are investigating is recarbonation, the process of capturing carbon from the production of new cement and binding it into recycled concrete from demolished buildings. For this option to work at scale, certain barriers need to be overcome. These include the lack of a clear recycling system for concrete from demolished buildings and lack of regulations around recarbonation of recycled concrete.

The rise of science-based targets

Five years ago, in the run-up to the landmark Paris climate conference, the Science Based Targets initiative (SBTi) was launched. The initiative, a collaboration between CDP, the United Nations Global Compact, World Resources Institute (WRI) and WWF, mobilises companies to set science-based targets and boost their competitive advantage in the transition to the low-carbon economy. It defines and promotes best practice in science-based target-setting, independently assesses companies' targets, and provides companies with resources and support.

Today, more than 840 companies spanning 46 countries and 45 sectors, ranging from chemicals to construction and textiles to telecom, have committed to set science-based targets. Together, their operational emissions total more than one billion tonnes of CO_2e, comparable to the annual emissions of Brazil. Their combined market capitalisation is over $10 trillion. Over 345 of these companies have already had their targets approved, putting them on track to reduce emissions by more than 265 million tonnes of CO_2e, similar to shutting down 68 coal-fired power plants.

These companies are driving systemic change throughout the global economy. They are demonstrating that operating within the scientific thresholds for a climate-safe world goes hand in hand with running a successful business.

As the initiative has snowballed into a global movement, science-based targets have become standard practice in some sectors and geographies. More than 20 per cent of high-impact companies (in terms of emissions and market capitalisation) in the following sectors are setting science-based targets: apparel, biotechnology, food and beverage, healthcare, hospitality, information technology, pharmaceuticals and telecommunications.

First movers from high-emitting industries like cement, steel, chemicals and automobiles are also now having their science-based targets approved, sending a clear signal that industry-wide transformation is underway. Companies in heavy industrial sectors contribute significantly to global GHG emissions, and are therefore, more than others, challenged in lowering carbon production without new technology or innovation.

Governments therefore can significantly reduce emissions by creating the right conditions, policies and incentives to support them.

Accelerating the 'ambition loop'

Despite the rapid adoption of science-based targets, there is a long way to go. While at least 20 per cent of high-impact companies headquartered in Finland, France, Denmark and Japan have set science-based targets, only a few in emerging markets have done so. There is an urgent need to pick up the pace in these economies, which are expected to drive global growth in the future.

This requires business and government leaders to work together to kick off what we call an 'ambition loop', a cycle in which ambitious government policy and private-sector leadership reinforce each other and take climate action to the next level. Ambitious corporate action helps to send strong market signals and should give governments confidence to urgently ramp up their national climate plans. This will in turn give business the clarity and confidence to invest decisively in the zero-carbon economies of the future.

Japan, a leader in companies setting science-based targets, is demonstrating how government action can spur private-sector ambition. Japan is the first country to provide explicit government help for companies to set science-based targets, creating a support programme worth approximately 150 million yen ($1.4 million) in fiscal year 2019.

The programme has been effective at growing the number of Japanese companies with approved science-based targets, now at more than 60. By stepping up with leading mitigation targets, Japanese companies are providing a foundation for the government to set more ambitious policies and regulations. These efforts can be straightforwardly replicated in other countries seeking to kickstart the transition towards ambitious long-term climate goals.

In 2020, countries can accelerate the ambition loop by putting forward more ambitious national climate commitments under the Paris Agreement. Bolder pledges and supporting policies will give businesses greater clarity and confidence to invest in climate solutions – driving growth, creating jobs and ensuring a brighter future for us all. ●

Game-changing technologies

Much of the technology to help cut GHG emissions already exists or is in research and development. How can we speed up its deployment?

By **Jiang Kejun**, Director, Energy Research Institute, China's National Development and Reform Commission

Limiting global average temperature rise to 1.5°C or 2°C above pre-industrial levels, as agreed by world leaders at Paris in 2015, requires deep cuts in CO_2 emissions. For a 2°C pathway, emissions must fall by 50 per cent by 2050 compared with 2010 levels. To limit the rise to 1.5°C, we must achieve nearly net-zero carbon emissions by mid-century. The Intergovernmental Panel on Climate Change's *Special Report on Global Warming of 1.5°C* identifies that technological progress will play a crucial role in achieving these deep cuts in emissions.

To reduce emissions to around net zero, four areas will be key. First, we must achieve zero emissions in power generation by 2050. Second, end-use sectors must get more of their power from clean electricity and less from burning fossil fuels. Third, we must see big gains in energy efficiency. And fourth, we must increase the carbon sink from land use, land use change and forestry.

To do all of these, we will need to make advances in a wide range of technologies, including: low-cost renewable energy power generation; nuclear power generation; bio-energy with carbon capture and storage; electric vehicles (EVs); fuel cells, including hydrogen fuel cells for aircraft; hydrogen production (for example, from electrolysis or thermochemical processes); using hydrogen instead of coke to reduce emissions in steel-making; IT and artificial intelligence applications in energy use; and demand-side management.

Encouragingly, in the last decade, we have seen significant progress in some of these technologies. For example, the cost of solar photovoltaic (PV) power generation has fallen by more than 90 per cent, making it one of the cheapest forms of power in some parts of the world. In 2019, around 20 GW of new solar PV installed in China did not require any government subsidy.

What's more, the price of electricity generated by some of these new solar PV power plants is lower than that of existing coal-fired plants.

There are similarly encouraging signs about the economic viability of EV development, including hydrogen fuel cell vehicles. And, last year, steel maker Thyssenkrupp launched a series of tests into using hydrogen in a working blast furnace – a world first.

In China, a project using a similar process, with the capacity to manufacture 600,000 tons of steel a year, will start operation in 2020. These new, green technologies are now beginning to bloom in many areas, offering confidence that we can indeed make the deep emissions cuts needed to meet the Paris targets.

Picking up the pace

Unfortunately, however, the pace of technological change to help achieve the required cuts is still too slow. If we want to realise the goals set in Paris, and preserve our planet, CO_2 emissions must peak now and start to fall. We are at a critical moment, and we need to push further and faster on technological development.

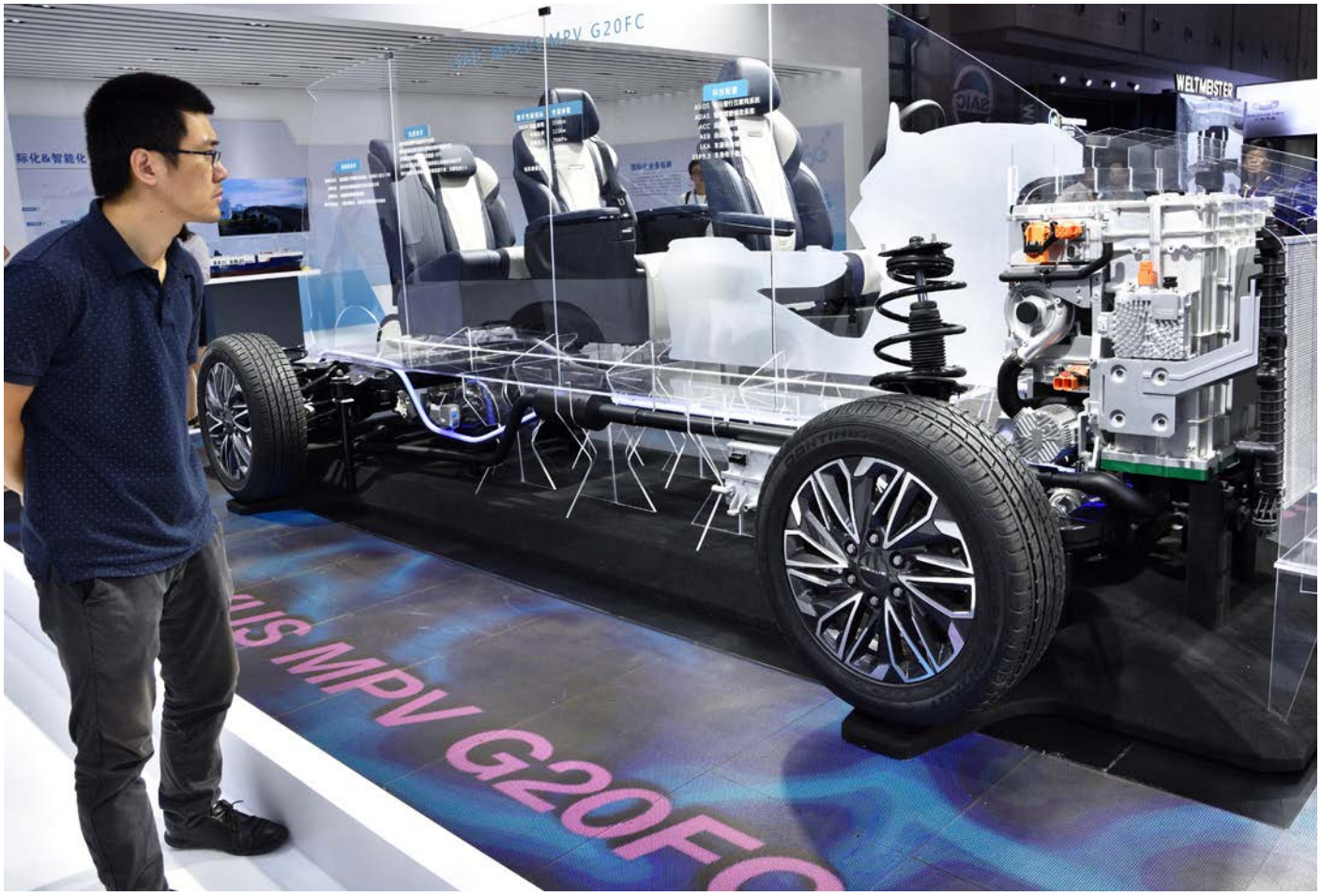
Both government and the private sector have critical roles to play. Governments must set a clear strategic objective for reducing emissions. This is crucial for guiding the future direction of technological research and development (R&D).

The EU, for example, is taking a lead on strategic direction, releasing a roadmap towards greenhouse gas (GHG) neutrality by 2050. The EU's strategy and roadmap present clear signals for the pathways that industry should follow.

Countries that lead on technology must have a clear strategy to help developing nations to use new technologies – and ensure these technologies meet the same high emission standards as in developed countries

The private sector, meanwhile, is best placed to make the tangible technological breakthroughs, investing in R&D and implementation that aligns with the strategic direction set by government.

There are already several success stories that can act as models for future development. Germany and the EU's policy on solar PV and wind power generation has totally changed the path of renewable energy development. Policy in China from 2015 on EVs has changed the pattern of car development, speeding up EV technology and manufacturing around the world.



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▲ Hydrogen fuel cell vehicle on display at the China International Industry Fair in Shanghai. Governments must give clear, strategic direction to stimulate the private sector to deliver the technological advances needed, as China successfully did with EV technology

International collaboration is important for both technological R&D and implementation. The major emitting countries and regions with the potential for deep cuts in CO_2 emissions – including the EU, US, Japan, China, Korea and Australia – could work together much more closely in technological development. For example, the R&D required for nuclear fusion power generation is on such a large scale that it necessitates collaboration by many countries.

For all its impressive work, ITER, an international nuclear fusion research and engineering project, is moving slowly, and it is essential that we speed it up. Perhaps we need to see more collaboration outside ITER – for example, with more technology choices and laboratory testing. But we have little time, so we must work together to make new technologies like this move faster.

Meanwhile, developing countries need technologies to implement cuts in GHGs. Countries that lead on technology must have a clear strategy to help developing nations to use new technologies – and ensure that the technologies they help to develop meet the same high emission standards as in developed countries.

Driving future growth

Time is of the essence. For many countries outside the EU, clear emission-reduction targets and strategies are essential to guide technological investment now.

If we can work together, we have a realistic chance of meeting the Paris targets. However, governments must ensure that action on climate change is a central pillar of national social and economic development.

For those countries in the driving seat of technological innovation, action on climate change could bring positive economic impacts, as the EU's 2050 climate roadmap shows. The potential profits of GHG mitigation are bigger than the costs, and opportunities abound to align action on climate change with economic development.

New technology offers one of the most important ways to boost economic activity through higher efficiency – achieving more with less. The good news is that industries across the board are now beginning to seize on the opportunities that green tech offers, as they see how it can drive future growth. The next 10 years will be critical in making a significant transition to these game-changing technologies. ●

Communicating the science

As the responses to COVID-19 have demonstrated, we must be evidence based and precise in communicating the science around the risks of climate change

By **Enyseh Teimory**,
Communications Officer, UNA-UK

In October 2019, US Senator Bernie Sanders was fact-checked after he referred to climate change as an "existential threat" during a Democratic debate. FactCheck.org stated: "Scientists agree that climate change does pose a threat to humans and ecosystems, but they do not envision climate change will obliterate all people on the planet."

Sanders has not been alone in referring to the threat of climate change in these terms. In 2018, UN Secretary-General António Guterres warned: "Climate change is the defining issue of our time – and we are at a defining moment. We face a direct existential threat." Researchers at the Australian National Centre for Climate Restoration implored policymakers – in their 2018 report *What Lies Beneath* – to reframe their climate action around the principle that "human-induced climate change represents an immediate and existential threat to humanity".

The fact checkers were, to an extent, correct in their assessment. Present climate projections and modelling underpinning our understanding and assessment of climate change to the end of this century do not include, for now, our veritable extinction. However, we need to consider what constitutes an 'existential' threat. These projections envision catastrophic risks that could lead to the complete destruction of vulnerable communities, entire natural species and ecosystems, and threaten the nature of human civilisation.

At present the global community is gripped by a global health emergency. The COVID-19 pandemic shows us the

◀ New Zealand's Prime Minister Jacinda Ardern delivering a COVID-19 briefing. She has won wide praise for the clarity and effectiveness of her communication, and has succeeded in her strategy to suppress the outbreak in the country

devastating impacts of a threat that may not be existential, yet demands urgent mitigation to save lives and protect our communities.

The science

The accepted international authority on climate change is the Intergovernmental Panel on Climate Change. The IPCC is a body of the UN tasked with providing comprehensive and objective scientific information on the risks of climate change. The Panel brings together hundreds of experts and stakeholders from across the world.

Since 1990, the IPCC has produced five assessment reports, each one a major review of the latest climate science, and six special reports. Its most recent *Fifth Assessment Report*, published in 2014, adopted four 'Representative Concentration Pathways' (RCPs) – greenhouse gas concentration trajectories for the 21st century – to form the basis of climate modelling and research. Of these pathways, RCP 8.5 projects an increase in global warming to approximately 4°C by 2100. This projection has formed the foundation of the climate change debate as the 'worst case' apocalyptic scenario. This is opposed to the 'best case' scenario of the 2016 Paris Agreement of warming of 1.5°C – the target to preserve civilisation as we know it.

The worst-case scenarios

A future of 4°C of global warming is a terrifying one. It would see 1.2 to 2.2 million people displaced from the Caribbean, Indian and Pacific oceans, a prospect that the Foreign Minister of the Marshall Islands stated to be "equivalent in our minds to genocide". Whole ecosystems would be lost, and there would be eight million cases of dengue fever annually in Latin America alone. The global economy would be 30 per cent smaller and would likely have to take a very different form. Civilisation as we know it would be unrecognisable: humans would be forced to migrate as regions became uninhabitable or unfarmable due to droughts, floods or deadly temperatures.

The modelling for this future scenario depends on global consumption of fossil fuels increasing sixfold. This projection seems unlikely, given developments in recent years such as the fall in renewable energy pricing and the decline in coal combustion in the developing world.

Instead, in the *World Energy Outlook* published at the end of 2019, the International Energy Agency (IEA) projects that if we continue on a likely path of 'business as usual', global temperatures will increase by between 2.9°C and 3.4°C. This would still be catastrophic.

According to a report by Carbon Brief, a projection of global warming at this range would see Southern Europe in permanent drought, areas burned by wildfires would increase in the USA sixfold, and damages from river flooding would increase by 30 times in Bangladesh and 60 times in the UK. Life would continue, but not as we know it.

Climate projections are imperfect and necessarily flexible, and the worst-case scenarios may yet be worse than possibly thought. However, what remains evident is that with higher global temperatures, the risk of further warming also increases. Scientists warned in 2018 that this could trigger a 'hothouse Earth' – a domino effect of warming with tragic consequences not yet imagined, if the global community does not take action.

The most likely scenario?

With each passing year the Paris Agreement target of 1.5°C of warming becomes increasingly difficult, perhaps even unrealistic according to the United Nations Environment Programme (UNEP) *Emissions Gap Report 2019*. The recent IEA report instead projects that if countries deliver on their obligations under the Paris Agreement, warming could be limited to 2.7°C to 3°C.

This likely scenario of warming above 2°C may be a world away from the consequences of 4°C of warming, but it is still dramatically worse than the prospects posed by a future of 1.5°C of warming. The IPCC's 2018 *Special Report on Global Warming of 1.5°C*, demonstrated that warming of 2°C compared to 1.5°C would:

- increase the number of people both exposed to climate-related risks and susceptible to poverty by up to several hundred million by 2050;
- result in around 420 million more people being frequently exposed to extreme heat waves;
- see 26–34 million more people exposed to increased flooding in 2050.

Climate projections are imperfect and necessarily flexible, and the worst-case scenarios may be worse than possibly thought. What remains evident is that with higher global temperatures, the risk of further warming also increases

Warming considerably above 2°C would likely lead to a scenario somewhere between these outcomes and the worst-case outcomes above.

All these projections demonstrate that we are undeniably set for a future where global warming transforms the way we live and our quality of life, and threatens the existence of vulnerable communities and entire ecosystems.

However, the science also shows that these prospects are hugely variable. Changes as seemingly small as 0.5°C can be the difference between a bearable future and one that causes considerable suffering for hundreds of millions of people.

The communication challenge

The focus of messaging on climate change

must highlight the capacity that exists for our meaningful and transformational impact on this trajectory, while continuing to stress the urgent need for immediate action.

The current COVID-19 pandemic holds important lessons. It is a threat much like climate change in its impacts but is moving rapidly enough to be more comprehensible to those living through it. It has led to a devastating loss of life, a threat to the global economy, and the suspension of ordinary existence for many. It is a reality that experts warned would come, and is indicative of what the future holds.

It has also served as another stark reminder that although the risks associated with the climate crisis threaten us collectively, the impacts will not affect us equally. The most vulnerable in our communities, the lowest paid and underprivileged already experience the harshest impacts of our changing environment. For these groups of our global community, the climate crisis is not an existential threat of the future, but of today.

COVID-19 also shows us how a threat that is not existential – in the sense that it has no power to wipe out the human race entirely, or even in considerable proportion – can still be absolutely devastating, can change our recognition of the nature of our society, and dramatically make life on Earth worse. The threat does not have to be of extinction to be one which should require us to make Herculean efforts to mitigate it – even if that means dramatic changes to our way of life.

In an editorial for *UN News* in April 2020, the head of UNEP, Inger Andersen, cautioned against misleading rhetoric that certain visible, positive environmental impacts of the pandemic are a 'silver lining'. Instead, Andersen urged that the vital and urgent takeaway from this catastrophe must be a collective effort to change and propagate the transition to greener, more sustainable habits of production and consumption. We have the power to mitigate and alter the path towards the worst possible future scenarios for our planet.

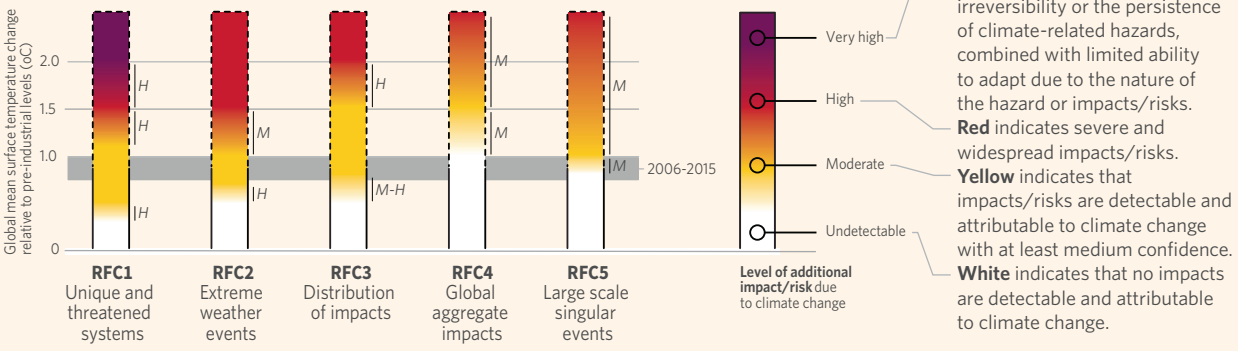
As we work to inform and transform policy and perspectives on climate change, the core messaging must be that changes to our way of life are inevitable, but we can and must act to avoid the most devastating global future.

Climate science shows we still have a role to play in determining just how extreme the changes in our future world will be. We can and must act to save hundreds of millions of human lives, prevent entire natural species from being wiped from the face of the planet, and to preserve the best characteristics of the civilisation we know today. ●

How the level of global warming affects impacts and/or risks associated with the Reasons for Concern (RFCs) and selected natural, managed and human systems

Five Reasons For Concern (RFCs) illustrate the impacts and risks of different levels of global warming for people, economies and ecosystems across sectors and regions.

Impacts and risks associated with the Reasons for Concern (RFCs)



Purple indicates very high risks of severe impacts/risks and the presence of significant irreversibility or the persistence of climate-related hazards, combined with limited ability to adapt due to the nature of the hazard or impacts/risks.
Red indicates severe and widespread impacts/risks.
Yellow indicates that impacts/risks are detectable and attributable to climate change with at least medium confidence.
White indicates that no impacts are detectable and attributable to climate change.

RFC1 Examples include coral reefs, the Arctic and its indigenous people, mountain glaciers, and biodiversity hotspots.
RFC2 Heatwaves, heavy rain, drought and associated wildfires, and coastal flooding.
RFC3 Risks/impacts that disproportionately affect particular groups due to uneven distribution of physical climate change hazards, exposure or vulnerability.
RFC4 Experienced on a global scale: monetary damage, environmental degradation and loss of ecosystems and biodiversity.
RFC5 Abrupt and sometimes irreversible changes in systems that are caused by global warming. Examples include disintegration of the Greenland and Antarctic ice sheets.

Source: IPCC Special Report on Global Warming of 1.5°C

SUSTAINABLE DEVELOPMENT SOLUTIONS NETWORK
A GLOBAL INITIATIVE FOR THE UNITED NATIONS

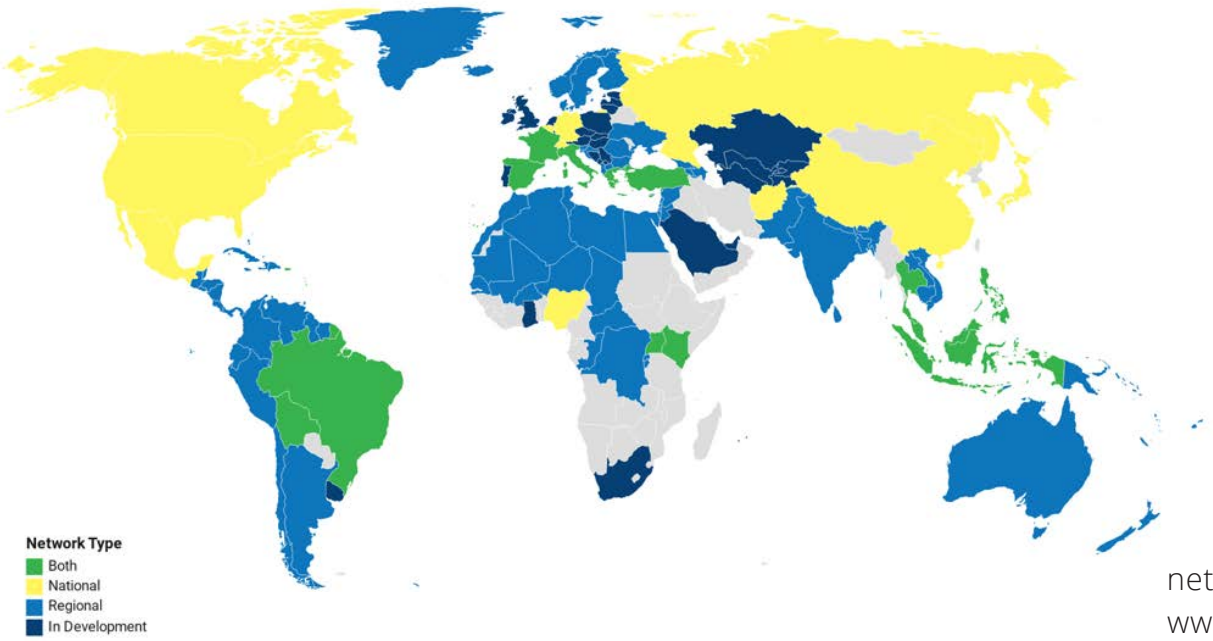
The UN Sustainable Development Solutions Network (SDSN) has been operating since 2012 under the auspices of the UN Secretary-General. We support the implementation of the Sustainable Development Goals (SDGs) and the Paris Climate Agreement by accelerating joint learning and promoting integrated approaches.

SDSN's Regional and National Networks

Spanning 6 continents, the SDSN network is comprised of over 1,200 member institutions, consisting of universities, research centers, civil society organizations, businesses and other knowledge centers coordinated by 38 chapters. These networks focus on distinct projects and priorities in line with their local contexts and challenges.

SDSN Networks (April 2020)

For more information on SDSN's National and Regional Networks, visit www.unsdsn.org/networks-overview



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A green post-COVID-19 recovery

Thinking must start now about the kind of sustainable economic recovery needed after the pandemic

By **Edward B. Barbier**, University Distinguished Professor, Department of Economics, Colorado State University

The economic response to the COVID-19 pandemic involves both short-term priorities and longer term planning of the eventual recovery.

The immediate need is to continue mobilising public health resources and actions to contain, suppress and ultimately eradicate the virus. With a third of the global population currently in lockdown and economy activity restricted, these actions have resulted in a severe supply-side shock to the world economy. Emergency stimulus measures are urgent for mitigating this shock and protecting vulnerable populations and businesses. According to the IMF, almost all countries are enacting sizable packages, and some, such as the US, are spending around 10 per cent of GDP ($2.2 trillion in the case of the US).

But we must also start thinking now about how best to rebuild our economies after the pandemic wanes. Simply reviving the existing 'brown' economy will exacerbate irreversible climate change, biodiversity loss and other environmental risks. Instead, we must foster green structural transformation of the world economy.

A good place to start is learning what worked and what did not from previous efforts to green the economic recovery during the 2008-9 Great Recession.

There are three key lessons. First, policies for a sustained economic recovery amount to much more than just short-term fiscal stimuli. Green structural transformation will require long-term commitments (5 to 10 years) of public spending and pricing reforms.

Second, the package of reforms will be different for major economies, such as the G20, as opposed to low and middle-income economies.

Third, as the UN Secretary-General's report *Shared Responsibility, Global Solidarity* has emphasised, the lack of collective international action in support of the Paris Climate Change Agreement and in ensuring progress towards the 17 Sustainable Development Goals (SDGs) has made the world more vulnerable to the pandemic than it should have been. Bolstering these international commitments and others, such as the renegotiation of the Convention on

◀ Bringing in the daily catch in south-eastern Viet Nam. The seafood industry is a prime candidate for investment, standing to yield an extra $53 billion annually from investing $5–10 billion each year in a global agreement on biodiversity

Biological Diversity, is essential for making the world economy healthier and more inclusive.

Green transition

For G20 economies, investing in a workable and affordable Green New Deal is essential. The aim must be to transition from fossil fuels to a low-carbon economy, through public spending to support private-sector green innovation and infrastructure, development of smart grids, transport systems, charging station networks, and sustainable cities. Pricing carbon and pollution, and removing fossil-fuel subsidies, can accelerate the transition, raise revenues for the necessary public investments, and lower the overall cost of the green transition.

To understand why it is important to combine long-term public spending commitments with pricing reforms, we should learn from the experience of South Korea, which did attempt to launch its own national Green New Deal in 2008-9.

Initially, South Korea responded to the Great Recession by promoting "low carbon, green growth" as the new long-term development vision of the country. The government proposed allocating $60 billion, or 5 per cent of Korea's GDP, for its Green New Deal. In the end, however, South Korea may have spent only $26 billion on low-carbon energy. It also failed to adopt pricing reforms and other incentives to foster renewables, such as phasing out fossil fuel subsidies, carbon targets and stringent regulatory frameworks. This has slowed the pace of reducing energy intensity and de-carbonisation. Although the goal was to lower energy intensity by 2.5 per cent per year up to 2030, it declined by less than 1 per cent annually from 2006 to 2016. The result is that South Korea's CO_2 emissions have continued to increase in recent years.

Strategies for developing economies

For developing economies, the focus must be on finding sustainable ways to alleviate poverty, which is increasingly rural, and reducing land-use change. Promising strategies include reallocating irrigation subsidies to expand basic water and sanitation services, fostering adoption of renewable energy and improved energy efficiency technologies in rural areas, market-based incentives to reduce forest loss and degradation, and allocating fossil-fuel taxes to fund natural climate solutions.

For many of these initiatives, poorer economies will need international financial and technical assistance. But increasingly, low and middle-income economies are finding innovative ways to design, implement and fund their own efforts.

A good example is the 'tropical carbon tax'. This is a levy on fossil fuels that is invested in natural climate solutions aimed at conservation, restoration and improving land management to protect biodiversity and ecosystem services. This reduces land-use change – a major source of greenhouse gas emissions in many tropical developing countries.

Costa Rica and Colombia have already adopted such a strategy. If 12 other 'megadiverse' countries roll out a tropical carbon tax similar to Colombia's, they could raise $1.8 billion each year between them to invest in natural habitats that benefit the climate. A more ambitious policy of taxation and revenue allocation could yield nearly $13 billion each year for natural climate solutions.

Moreover such a policy can be 'pro-poor'. Ecosystem services such as drinking-water supply, food provision and cultural services are estimated to contribute between 50 and 90 per cent of income and subsistence among the rural poor and those who live in forests. Such services can make an important contribution to ending extreme poverty (SDG 1), achieving zero hunger (SDG 2), improving health (SDG 3) and meeting many of the other 14 SDGs.

Global agreements

Post-COVID-19, we should also rethink our approach to international environmental agreements. For decades, governments and international organisations have fallen short of the funds required to reverse the global

Also in this section

decline in species and habitats on land and in oceans.

If there is a new global agreement on biodiversity, corporations in industries that benefit directly from nature should formally join the accord and contribute financially to it. As parties to the agreement, governments would set over-arching conservation goals and pledge specific national targets, policies and timelines. In addition, wealthier countries should assist conservation in poorer nations.

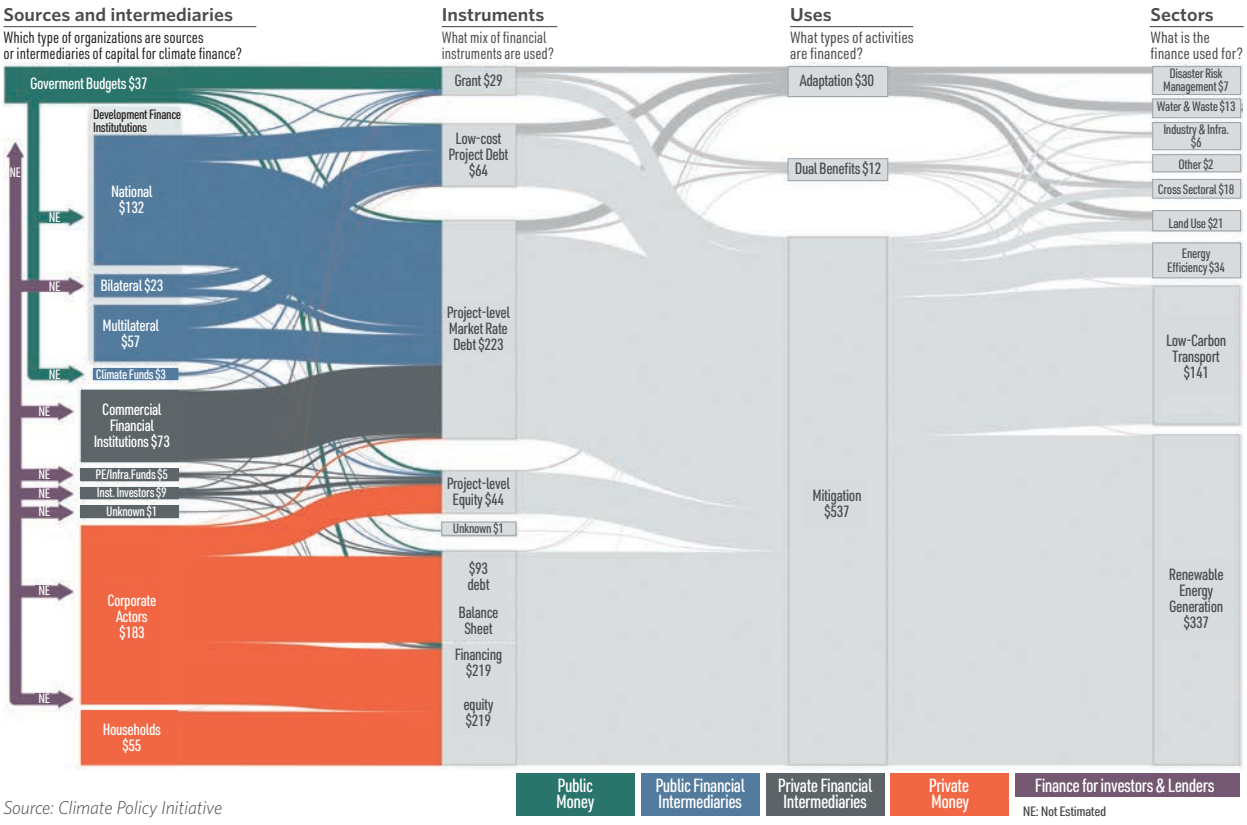
However, major companies in key sectors such as seafood, forestry, agriculture and insurance also have a financial stake in averting the global biodiversity crisis. These sectors should agree on targets for increasing marine stocks, protecting forests, preserving habitats of wild pollinators and conserving coastal wetlands. Individual companies should pledge to meet these goals as well as provide financial and technological assistance for conservation in developing countries.

The resulting increase in industry revenues and profits could provide $25-50 billion annually for global conservation. For example, the seafood industry stands to gain $53 billion annually from a $5-10 billion investment each year in a global agreement on biodiversity, while the insurance industry could see an additional $52 billion with a similar investment. By spending $15-30 billion annually, the forest products industry would attain its sustainable forest management goals. Agriculture also has an incentive to protect habitats of wild pollinators, who along with managed populations enhance global crop production by $235 billion to $577 billion annually.

Such a novel accord would represent a 'new wave' of international agreements that would engage government and industry, and hopefully other non-state actors, in a manner unparalleled in the history of global environmental conservation. This has been proposed for the Paris Agreement, which could add a mechanism to allow corporations, cities, and other non-state actors to formally join the accord. Already some corporations, local governments and other non-state entities have announced voluntary pledges and low-carbon strategies to comply with the Paris Agreement, but the private sector is not a formal participant, nor do corporations contribute to the accord's climate financing.

The COVID-19 pandemic is one of the greatest threats to humankind, and is requiring unprecedented collective action to combat and control. The next phase is to define and guide the global recovery for a more sustainable economy and planet in the post-COVID era. ●

Landscape of climate finance in 2017/2018



Source: Climate Policy Initiative

Targeting finance

With limited resources to fund the seismic changes needed to curb temperature rise, and time running out, focusing climate finance where it can have greatest impact is essential

By **Mafalda Duarte**, CEO, Climate Investment Funds

There is no denying that we have made headway in beating the climate crisis. Recent polls show record levels of support for climate solutions. Climate movements are gaining ground and inspiring new generations of change-makers. Plus, renewable sources of energy like wind and solar are more affordable than ever before, expanding to ever-farther reaches of the world.

Progress is being made, but we are still a long way off from limiting global warming to the 1.5°C target enshrined in the Paris Agreement. Global greenhouse gas emissions are not waning but rising, reaching levels unseen in recorded history. Coal, oil, natural gas and other high-emitting fossil fuels still supply a staggering 81 per cent of the world's electricity, and additional coal, oil and gas plants are on the way. If these facilities come online as planned, forecasters say total carbon emissions will exceed Paris Agreement targets by 120 per cent. This is not acceptable. Straying from a 1.5°C pathway will yield significant environmental, economic and human impacts – many of which could be irreversible.

To right these trends, experts agree that we need to reduce emissions by 45 per cent by 2030 from 2010 levels, and also achieve carbon neutrality by 2050. This is an ambitious target that will require

▲ **Reforestation in Berekum, Ghana: a project that incorporates agroforestry with shade-grown cocoa to sustain the local economy**

more than lip service to make a reality. The path forward will be sweeping in scope and unprecedented in scale. The Intergovernmental Panel on Climate Change has urged nothing less than "rapid and far-reaching transitions in energy, land, urban and infrastructure, and industrial systems".

Transition underway

A low-carbon world therefore depends on our ability to enact bolder climate policies, reach new heights in technological innovation, and drive behaviour change across whole societies and economies. Needless to say, this is no small task. The good news is that we already have the tools to bring these changes to fruition. What's more, there are signals that these transitions are already underway.

At the Climate Investment Funds (CIF), one of the largest and most experienced multilateral climate financing bodies, we have seen first-hand the power of sound partnerships and concessional finance to accelerate green and climate-resilient growth, policy reform and behaviour change. For more than 10 years, developing countries have partnered with CIF to make urgently needed investments in clean energy, climate resilience and sustainable forestry.

In Zambia, for example, concessional investments paved the way for the first national climate change authority, helping put climate change at the heart of national development strategies. Today, provinces and districts across the nation are all required to plan for climate change impacts and work to reduce climate change risks. This is a remarkable step in a country on the frontline of the climate crisis.

India's clean energy pathway is also getting a boost from concessional finance. In only three years, a $625 million injection helped the country's burgeoning rooftop solar panel industry unlock over 430 megawatts of new capacity. This would later usher in an additional $4 billion in financing and 5,000 megawatts of added capacity, marking a potential tipping point in the rooftop solar market and accelerating progress towards India's target of 40 gigawatts of rooftop solar capacity by 2022.

Ghana, meanwhile, is deploying concessional resources to help reverse an alarming deforestation rate, going from a deforestation rate of 1.5 per cent to a reforestation rate of 1.2 per cent in target areas. This is being achieved in part by resolving longstanding tree tenure challenges and establishing 28,000 hectares of climate-resilient, shade-grown cocoa. In addition to helping reforest target areas, this effort will promote sustainable agriculture practices and bolster livelihoods.

Concessional finance can accelerate socio-economic development and drive innovation. Equipped with the right resources, government and business leaders can transcend new frontiers in low-carbon technology, such as concentrated solar power, or CSP. This uses sun-tracking mirrors to harness the sun's energy and then molten salts to store it. CSP is becoming more accessible globally amid growing confidence in the technology, falling costs, and an easing learning curve across the private and public sectors, thanks in large part to CIF investments. CIF is supporting around 15 per cent of total installed capacity worldwide, including the world's largest CSP facility in Ouarzazate, Morocco, which supplies energy to two million people.

A low-carbon world depends on our ability to enact bolder climate policies, reach new heights in technological innovation, and drive behaviour change across whole societies and economies

Essential ingredients

These are significant changes, made possible with significant levels of concessional finance. But in the world of climate finance, more critical than the 'how much' is the 'how'. Public finance for climate action is not unlimited, so it must be used as wisely and strategically as possible. Success is not strictly funding a climate-resilient bridge here or a solar power plant there. One-off investments working in isolation will not ignite the changes we need to mount a serious defence against climate change. From our experience at CIF, we know there are essential ingredients to delivering finance that moves the needle on climate.

First, climate investments must be demand-driven and support broader development goals in developing countries. Second, multilateral development banks have deep-seated know-how and in-country expertise, and so must be involved as strategic implementing partners. Third, concessional finance programmes must have sufficient scale, allow for adequate risk-sharing, and be as flexible as possible, ensuring responsiveness in a dynamic operational environment. Fourth, and by no means least important, vulnerable populations such as women, indigenous groups and local communities can and must have a seat at the table throughout the lifecycle of an investment programme, including identification, development and implementation.

We bring this ethos to everything we do. Looking ahead, we are planning to ramp up support for cutting-edge innovations and approaches that could be what gets fledgling low-carbon and climate-resilient sectors off the ground in developing countries. We are also exploring new mechanisms for mobilising private and institutional capital in support of large-scale climate action in developing countries.

I am not naïve about what lies ahead. A climate-smarter world will not be easily won, and there is no avoiding setbacks or false starts. But right here, right now, the signs of change are everywhere. We still have time to employ the tools we already have – with grit, clarity of purpose and courage – to empower nations and peoples with the resources they need to deliver the climate-smarter future we all deserve. ●

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Financing for adaptation

Despite financial pledges and rhetoric on the importance of climate adaptation for vulnerable nations, the lack of tangible finance flows tells a different story. If the most at-risk communities are to adapt before it's too late, we must unblock adaptation finance now

By **Mizan R Khan**, Deputy Director, International Centre for Climate Change and Development (ICCCAD), Dhaka, and **Saleemul Huq**, Director, ICCCAD

We already live in a climate-changed world. The recent Intergovernmental Panel on Climate Change (IPCC) special reports warn us of the increasing frequency and magnitude of climate hazards. Extreme weather events are now the 'new normal'. The IPCC's *Special Report on 1.5°C* presents a stark picture of the much higher risks for natural and human systems of global warming of 1.5°C compared with current global temperatures. At 2°C, the risks to those systems are yet higher.

The IPCC argues that these risks depend on the magnitude and rate of warming,

▲ **Globally Important Agricultural Heritage Systems (GIAHS) in Peru. Andean agriculture is one of the best examples of the adaptation and knowledge of farmers to their environment over the last 5,000 years or more. This indigenous knowledge can provide a rich source of inspiration for climate adaptation**

geographic location, levels of development and vulnerability, and on the choices and implementation of adaptation and mitigation options. However, the impending emissions pathway points to a global temperature rise far above that pledged at Paris in 2015. Even if all the collective commitments under the 170 submitted nationally determined contributions (NDCs) are fully complied with, the world will witness warming of 3°C.

Climate impacts have temporal and spatial dimensions. Because of the ratchet effect caused by previously emitted greenhouse gases, the future impacts will be much more severe. Developing countries will overwhelmingly bear these impacts. The foremost victims are the small island developing states (SIDS) and the least developed countries (LDCs).

Many of these countries can be regarded as 'nano emitters' with the least capacity to adapt. Oxfam's 2019 report, *Who takes the heat? Untold stories of climate crisis in the Horn of Africa and Mozambique*, shows that while climate impacts are likely to cause an average reduction of about 0.4 per cent of developed countries' GDPs, the reduction for low-income countries (LICs) will be almost 2 per cent. Climate impacts are likely to push an additional 100 million people into poverty by 2030. LICs' geographic location and their low level of development combine to increase their vulnerability.

Here is the rationale of support for climate adaptation for these countries. The basic provisions of the United Nations Framework Convention on Climate Change (UNFCCC), such as Articles 3, 4.3 and 4.4, and Articles 9.1, 9.5 and 9.7 of the Paris Agreement, impose obligations on developed countries to provide climate finance transparently to developing countries.

Preferential treatment should be given to the SIDS and LDCs. Articles 4.3 and 4.4 provide for assistance with "new and additional… adequate and predictable" finance, particularly for meeting the costs of adaptation. These provisions implicitly refer to the 'polluter pays' principle.

As a response, developed countries pledged $30 billion as 'fast-start' finance during 2010–12 and $100 billion a year by 2020, subsequently shifted back to 2025. But the availability of support is orders of magnitude smaller than the needs estimated by various agencies, which range from $86 billion to more than half a trillion dollars a year.

Reports from the Organisation for Economic Co-operation and Development show the availability of around $60 to $70 billion a year from both public and private sources. But research from Oxfam shows that countries in need have received less than $10 billion during the last decade from UNFCCC funds including the Green Climate Fund (GCF). Oxfam's calculations also show that LDCs are receiving just $2.4 to $3.4 billion a year in adaptation finance – or the equivalent of less than one cent per person per day. A Himalayan gulf between the claimed delivery and actual receipts continue to damage mutual trust.

The International Institute for Environment and Development shows that only 10 per cent of adaptation finance reaches the local level – or just 2 per cent of the global total of climate finance flows from developed to developing countries.

Despite the repeated pledges of balanced allocation between mitigation and adaptation, including the GCF's commitment to an equal share, more than 80 per cent of climate finance goes towards mitigation. And when it comes to the adaptation finance that is provided, the picture is even bleaker for the SIDS and LDCs, with less than 20 per cent of adaptation finance going to them (in contrast with the GCF's commitment that at least 50 per cent of adaptation finance should go to vulnerable countries).

More disquieting is the fact that grants account for only a third of bilateral climate finance, and a paltry 10 per cent of multilateral funding.

The delivery of adaptation finance is also extremely fragmented: the number of public and private financing channels range from 99 to over 500, including more than 20 multilateral funds. There are too many overlaps, necessitating huge transaction costs and generating frustration both at the delivery and receiving ends. All this compromises the effectiveness of adaptation finance support.

A further frustration is that the long-agreed principles of climate finance under the UNFCCC, such as that financing should be "new and additional" have been totally diluted, with no signs of their resuscitation. Climate finance has been an extremely rancorous issue in UNFCCC negotiations since the $100 billion pledge of 2010. But the absence of an agreed understanding of what climate finance is, accompanied by persistent opposition by many developed countries, gives those countries the wiggle room for creative accounting.

> ***"The powerful never voluntarily give up their power and their wealth. And so it has to be extracted like teeth in a dentist's chair." (Saleemul Huq, in a Guardian podcast)***

The decision rule adopted at COP24 on reporting of climate finance under Article 9.7 is relatively permissive, allowing countries to report the full value of loans, rather than the 'grant equivalent' share as climate finance. So the double – or triple – counting of the same money, or the repackaging of development assistance as climate finance, continues.

Looking through the lens of justice and equity, we can firmly conclude that adaptation finance is failing us totally.

As power manufactures consent from the weak, developing countries have had to forego any option of claiming compensation. Climate governance, rooted in neoliberal values, presents distinct challenges.

Within the post-Paris context, we are witnessing the further neglect of

distributive justice as a guiding principle. This allows the naked pursuit of short-term self-interest, the de-emphasising of public responsibility in favour of the market and private sector, a focus on transparency without robust systems of accountability, and exclusive decision-making processes in which core decisions are increasingly made bilaterally between powerful states outside the consensus-based UNFCCC process. This has resulted in harping on voluntary action, and a growing emphasis on leveraging private finance and market-based strategies.

Finally, we have some suggestions for COP26 on how to scale adaptation finance and improve its effectiveness:

- To agree to a scheme that when a country fails to reduce emissions as pledged in the NDCs, the 'failed' amount should be valued financially. This should then be transferred towards adaptation support (to one or more of the existing UNFCCC funds).
- The evolving consensus on carbon pricing globally should be translated into a decision by COP26 under the UK's leadership, and the money delivered as support for adaptation.
- As the private sector appears less interested in adaptation because of the inefficacy of market mechanisms (with the exception of profit-based insurance), a specified share of their profits should be dedicated as adaptation finance as their corporate climate responsibility, both at national and global levels.
- No more bureaucratic dilly-dallying by the GCF to direct access to adaptation finance. It should focus on ensuring a robust accountability mechanism at the receiving end.
- The extreme fragmentation of adaptation support warrants a 'thinning out' of the weedy tendrils of agency bureaucracies, which often slow or prevent finance reaching the target communities.
- We need an agreement between development partners and developing countries that a majority share of adaptation finance must go directly to the most vulnerable communities, including women.
- We need increased investment of adaptation finance to enhance the adaptive capacity of local communities, facilitated by local governments, with a focus on youth and women.
- Finally, we need to reach an understanding of what climate finance and adaptation finance is, both for public and private sources. ●

▼ **Road-building near Mombasa, Kenya, showing mangroves planted in the foreground to protect against water surges. Ecosystem approaches are becoming the mainstay of climate adaptation**

Investor influence

As the economic case for climate action crystallises, investors will assume an ever more vital role in pushing companies to reduce their greenhouse gas emissions

By **Rory Sullivan**, CEO, Chronos Sustainability and Chief Technical Advisor, Transition Pathway Initiative (TPI) and **Adam Matthews**, Co-Chair, TPI and Director of Ethics & Engagement, Church of England Pensions Board

It is clear why investors should be deeply concerned about climate change. The direct impacts are being seen in agriculture and food supply, infrastructure, flooding and water supply. Furthermore, the actions being taken by governments in response have major implications for investors. As an illustration, the structure of the mining, energy and transport sectors will change dramatically as governments encourage reductions in fossil-fuel use and incentivise renewable energy, energy efficiency and energy saving.

Investors have a critical role to play if we are to successfully transition to the low-carbon economy and adapt effectively to the physical impacts of climate change. Investors will provide much of the capital required for mitigation and adaptation. They can challenge the companies they invest in to reduce their own greenhouse gas emissions and those of their suppliers. They can encourage companies to respond effectively to the unavoidable physical impacts of climate change. They can be an important voice in policy discussions around how i) the transition to a low-carbon economy and ii) effective adaptation to the physical impacts of climate change, might be achieved.

In fact, one of the most striking features of climate policy discussions over the past year or two has been that investors have started to take much more of a leadership role. Investors were one of the key voices at COP25. They played a central role in the

▲ **WindFloat Atlantic, featuring the world's largest offshore wind turbine on a floating platform, off the Portuguese coast of Viana do Castelo. Repsol, part of the consortium behind the project, is a fossil-fuel energy company that has responded constructively to investor pressure to eliminate GHG emissions**

European Commission's High-Level Expert Group (HLEG) on Sustainable Finance in 2018 and in the subsequent discussions around the policies and regulations needed to implement the HLEG's recommendations.

Growing influence

There are four reasons why we think investors will play an even more influential role in the coming years.

First, the urgent need to act is clear. Insurance company Munich Re has estimated that hurricanes, wildfires and floods will have cost the world $150 billion in 2019. The devastating forest fires in Australia confirm that, as a society, we need to be prepared for and able to respond to more extreme weather events.

We are very likely – as suggested in the UN-supported Principles for Responsible Investment's (PRI's) analysis of what it calls the Inevitable Policy Response – to see strong, economically significant and disruptive climate-related policies in the coming years. To take just one example, thermal coal is likely to be rapidly phased out in many countries.

Second, investors have now developed a scalable, replicable model of collective action that can drive ambitious change in company practice and performance, most notably through initiatives such as Climate Action 100+ (CA100+). As a consequence of investor engagement, high-impact companies such as Repsol and Maersk have committed to net-zero carbon targets by 2050.

Others such as Shell have agreed a joint position with investors to establish an engagement framework that supports the transition of its business to substantially reduce its carbon intensity. In addition, again as a result of investor engagement, Repsol, Shell and other companies have started to challenge the lobbying by industry associations against measures to curb carbon emissions.

Third, we have evidence that it is economically feasible for companies to be aligned with the goals of keeping global temperature rise within 2°C (or even 1.5°C) above pre-industrial levels. The TPI's research on 57 of the world's largest transport companies indicates that approximately one fifth (19 per cent) of these companies are already on course for a 2°C future. TPI's analysis of the global electricity sector provides a similar finding, showing that 31 of the 109 assessed companies (or 28 per cent of them) are in line with a pathway to stay below 2°C. Many of these companies are in Europe, where public policy has provided the necessary support for them to align with a 2°C scenario. These companies prove that it can be done. But there is a long way to go. TPI's recent review of the energy sector found that 22 per cent of the companies analysed did not even have a policy on climate action or recognise climate change as a relevant risk.

> ***Ultimately, responding to climate change requires a new form of partnership***

Fourth, investors are making strong commitments to action. At the UN Climate Summit in September 2019, the PRI and United Nations Environment Programme Finance Initiative launched the UN-convened Net-Zero Asset Owner Alliance. The Alliance, which currently represents nearly $4 trillion in assets under management, is capturing commitments by asset owners to align portfolios with a 1.5°C scenario.

In parallel, the Institutional Investors Group on Climate Change's Paris Aligned Investment Initiative is developing a practical and useable framework for investors to understand what it would mean for a pension fund to align with the goals of the Paris Agreement. The initiative is jointly chaired by APG of the Netherlands and the Church of England Pensions Board, and is supported by over 60 major institutional investors with over €13 trillion in assets under management.

The likely consequence of these two initiatives is that more asset owners will make similar commitments. This will reinforce the engagement asks being made by CA100+ and drive demand for tools, metrics and indices that enable investors to assess and report on their performance.

Despite these positive changes, we are acutely aware that we need to do more. The most immediate challenge is that we must move away from looking at companies and sectors in silos. We know that supply and demand of energy, products and services are effectively two sides of the same coin.

Take the case of aviation. Reducing emissions from the sector is not just about making planes more efficient or buying carbon offsets. These actions are important, but only as part of a much wider agenda for change. If we are to reduce emissions from the sector, we need major airlines, energy providers, engine and plane manufacturers, and experts in transport systems and infrastructure (among others) to identify the pathway and the technological and regulatory challenges that need navigating.

We also need the financial incentives that could be brought into play to accelerate achieving the goal. Investors must be part of these discussions – whether that is as shareholders or bondholders applying pressure for action, or as experts in the development of incentives and instruments (for example, low-carbon transition bonds) that can drive and accelerate the changes needed. As part of these efforts, we need to empower and enable regulators to act. Without effective policies and incentives, progress is unlikely to be as quick, sustained or ambitious as it needs to be.

In 2020 we – in a project led by the Church of England Pensions Board, Swedish pension fund AP7 and BNP Paribas Asset Management – will be developing a new standard on positive climate lobbying. This will bring together leading companies already addressing lobbying misalignment in their industry associations with progressive investors. It will set a new standard that works across the value chain to support net-zero-carbon pathways.

Ultimately, responding to climate change requires a new form of partnership. It requires investors, companies, regulators, civil society and other actors to work together to develop and then deliver the systemic, economy-wide changes needed for us to successfully transition to a low-carbon economy and to adapt effectively to the physical impacts of climate change. ●

Who to trust?

How can asset owners and investors evaluate the climate-friendly credentials claimed by investment firms?

By **Jérôme Tagger**, CEO, Preventable Surprises

Assets managed under environmental, social and governance (ESG) principles (as reported by market participants) have grown to around $30 trillion. What was once a marginal effort borne by activists is now close to standard practice in investment management. If anything, it's proof that it's possible to wish something into existence.

But what that something *is* precisely remains up for debate. It's also a source of confusion and obfuscation.

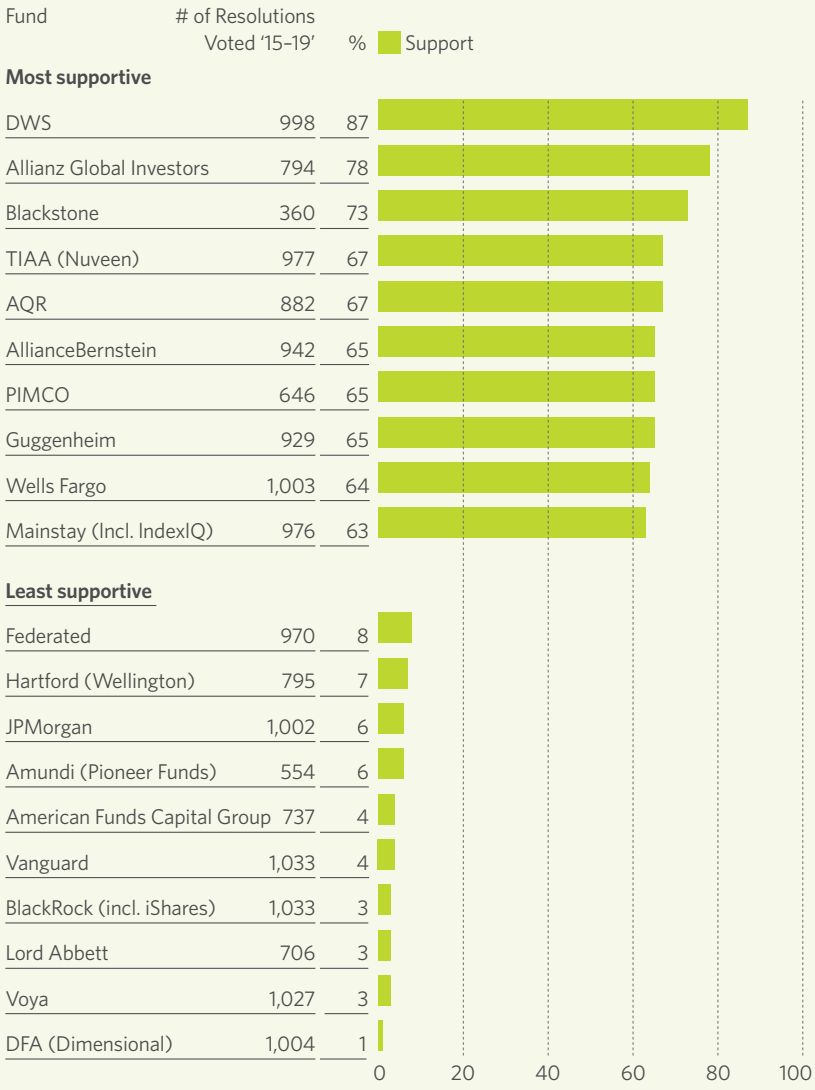
Investors, whether families or institutions, must consider two questions when considering ESG funds. First, what will the fund do for them in terms of financial performance? And, second, what will it do to make the economy more sustainable?

The financial performance bit leads to varied claims – of extra performance, of risk mitigation, of neutrality – based on whether and how ESG considerations affect stock selection. All of the claims are plausible. It is up to fund managers to build a demonstrable track record of their practices.

But listening to the marketing claims of ESG funds, it often sounds like integrating ESG in financial decision-making leads to better sustainable outcomes for the planet. There is, however, no evidence that what makes a decision better for an investor will spontaneously mitigate global warming, save species from extinction or turn the curve of income inequalities.

There is a feel-good dimension to thinking that it's possible to have sustainable outcomes with some superficial rearranging. But unfortunately, these big environmental and social systemic challenges require much more decisive intervention. In fact, many observers recognise that – quite the opposite – it is the

The 10 most and least supportive fund groups over five years



Source: Morningstar's Proxy Data. Data as of 11/07/19. Based on all environmental and social resolutions, voted 1 July 2014 to 30 June 2019. Votes have been aggregated over five years. Support is calculated as a percentage of all votes cast 'for', 'against' and 'abstain'.

big systemic issues that have an impact on global economic performance and therefore on investment performance. But only few have recognised the scale of the challenge, or are doing something about it.

Put simply, clients might be disappointed to learn that buying into 'sustainable funds' may have no sustainable real-world impact.

Doing your homework

So how to recognise fact from fiction? As with most decisions in life, relying on other people's assessments is often insufficient and doing a bit of homework is good. Here's a rule of thumb: if it's confusing and full of jargon, then it's probably not that good. Good plans are clear about managers' intentions, and what they will do to achieve them. Let's focus on public equities for simplicity.

To start with the obvious: memberships prove little. When an asset manager touts its membership of the Principles for Responsible Investment (PRI), the Task Force on Climate-related Financial Disclosures or Climate Action 100+, it means very little taken alone. I was a year-long, card-carrying member of the Friends of the Louvres Museum association – and set foot in the museum exactly once during that time, but the 'cool' factor was really high. And, more relevant, I was the COO of PRI for four and a half years.

Second, 'ESG integration' taken alone means nothing. What it does mean is that an asset manager has set up the pipes so that ESG data flows through its organisation. We're all proud of the fancy spices in our kitchen cabinets, but that doesn't mean we ever use them. The cool factor is equally high. And making money from inequality or climate change – the technical goal of 'integration' – isn't the same as doing something about the problem.

Third, assessment tools which are basically about self-marking – such as the PRI's assessment framework – were good 15 years ago, but have become part of the problem now. For example, BlackRock got an A+ from the PRI, but only got a D mark from ShareAction's very worthwhile recent analysis of the world's 75 leading asset managers. Why? The main difference between the two is that ShareAction took an explicit focus on outcomes and impacts and the concrete actions that managers can take towards achieving them. Just as companies have learnt how to game ESG rating agencies, so big fund managers especially have learnt how to game these self-assessment tools.

Customers should look at what sustainability goals investors explicitly pursue and how they are willing to wield their influence on the companies they invest in to support those goals, particularly on the more significant issues of our time. And very big investors should have big very impacts in the real world. Here's a handy tip: if an investor is open about actual impact, warts and all, there is a good chance they are less likely to be engaging in greenwash.

How have managers used their votes at companies' annual general meetings? There are stark disparities in the field when looking at resolutions addressing climate change or other ESG issues, as a February 2020 Morningstar report titled: *How Fund Families Support ESG-Related Shareholder Proposals* illustrates. The laggards' voting record is often widely out of line with their public commitments to climate risk.

Are the managers asking for data or for real change? Investors have tended to require disclosures from managers, whether on climate risk, gender diversity or other issues. Much better is to require action: for example, in the form of transformation plans for industries that are parties to the decarbonisation process – as Legal & General Investment Management does with its climate pledge.

Are they willing to stick their necks out? For example, hedge fund TCI has said it will vote against directors at companies that fail to disclose carbon and greenhouse gas (GHG) emissions, and against auditors when company reports do not account for climate risk. Goldman Sachs will now vote against the re-election of boards where no women are present. One can argue that the bar is low, but at least the message is clear.

Do they recognise the urgency of issues? A real climate plan should be focused on the decisive next five to ten years (some say three to five), not a vague long-term commitment. Acknowledging the climate emergency is the first step to acting on this urgency.

Do the investment managers focus on the more strategic and important companies in a given sector and the more strategic sectors? For example, BlackRock's recent thermal coal exclusion policy – something that campaigners have been pushing – does not cover the most influential players: diversified miners that include Anglo American, BHP and Glencore. Do investors who claim to be climate aware focus on influential financial sector firms – for example, the mega banks, insurance companies and media companies – or do they take the easy route and say these firms have a small direct GHG footprint?

The answers to these and related questions offer an honest and discerning perspective on the authenticity of fund managers' ESG claims. They're also a good indicator of motivation. When it's only external and responding to client demand, then fund managers will treat ESG as a marketing and compliance exercise. But when the motivation is also internal, then fund managers will take more strategic approaches. They may not be able to claim responsibility for changes in corporate practice – here, there are other voices at play including the companies themselves – but that doesn't mean they shouldn't know and express what they want.

The practical challenge is that making such an assessment is not easy. There is today no comprehensive one-stop assessment. The best one in our opinion is ShareAction's, but it only covers the largest managers at the exclusion of smaller and often more committed firms. The assumption here is also that action on climate-related systemic risk is a proxy for wider sustainability issues and this needs to be tested. There is an urgent need for clients and their investment consultant agents to come together to develop such a tool.

When the dust settles, after all, the only question on sustainability that matters is: what good have you done? ●

How clean is biomass?

Championed as a carbon-neutral source of renewable energy, biomass enjoys regulatory and subsidy support in several countries. But are assumptions about its green credentials correct?

By **Duncan Brack**, independent environmental policy analyst and Associate Fellow, Royal Institute of International Affairs (Chatham House)

The use of wood for electricity generation and heat in modern (non-traditional) technologies has grown rapidly in recent years, particularly in EU member states, in pursuit of renewable energy and climate policy goals. In 2016, energy from solid biomass (mainly wood) accounted for about 7.5 per cent of EU

◀ Timber being rafted to a sawmill in Idaho, US. In 2016 the EU used biomass (mainly wood) for 44 per cent of its renewable energy consumption, relying heavily on imports from the US, Canada and Russia

gross final energy consumption and about 44 per cent of total renewable energy consumption.

Although the EU is the world's largest producer of wood for energy in modern technologies, consumption is higher. So the EU is also a major importer, mainly from the US, Canada and Russia. In 2016, the UK alone was responsible for consuming a quarter of global production of wood pellets.

For its supporters, the use of wood for energy offers a flexible way of supplying renewable energy, with additional benefits to the global climate and to forests. To its critics, it can release more greenhouse gas emissions into the atmosphere than the fossil fuels it replaces, and it also threatens the maintenance of natural forests and the biodiversity that depends on them. Just like the debate around transport biofuels in recent years, this has become a highly contested subject with very few areas of consensus.

The biomass industry has grown rapidly in recent years on the back of financial and regulatory support from governments in many countries. The justification for this approach is the claim that biomass is a carbon-neutral energy source. Yet if biomass is burnt in the presence of oxygen, it produces carbon dioxide – and, in general (depending on the type of 'feedstock' (fuel) and efficiency of the power plant), at a higher rate per unit of electricity generated than coal, and much higher than gas.

The claim of carbon neutrality tends to derive from the assumption that the emissions from burning the biomass are part of a natural cycle in which, over time, tree or plant growth balances the carbon emitted on combustion (as long as the trees or crops are regrown after harvesting). Hence calculations of the impact of biomass use on the climate ignore entirely emissions from combustion, and measure only emissions from the supply chain (from harvesting, processing the wood and transporting it). This is a very widely held assumption. It underlies, for example, all the climate mitigation scenarios involving biomass reviewed by the Intergovernmental Panel for Climate Change in its *Fifth Assessment Report* in 2014.

But, left to themselves, trees continue to grow and sequester carbon. If trees are harvested specifically for energy, not only is the stored biomass converted into carbon dioxide immediately, but the future carbon sequestration potential of the tree – i.e. the carbon that would have been absorbed during the remainder of its lifetime – is lost. This foregone future sequestration can be replaced if replanting occurs after harvesting, but the initial rate of absorption will be slower. This is because although young trees grow faster than mature specimens, their much lower leaf cover means they absorb much less carbon from the atmosphere. The carbon payback period – the time before which carbon emissions return to the level they would have been at if fossil fuels had been used – can be decades or even centuries.

Complicated calculations

While there is a difference between the carbon sequestration rates of individual trees and entire forests – older forests tend to contain fewer trees, as an increasing number succumb to pests or disease – studies suggest that in forests between 15 and 800 years of age, net ecosystem productivity (the net carbon balance of the forest, including soils) is usually positive.

It is also possible to manage forests for conservation, for example by removing dead trees to reduce the risk of wildfires. This, coupled with forest ecosystem restoration – letting forests regenerate naturally – is a much better approach to maximising the uptake of carbon from forests than planting trees for timber production. Tree plantations are much poorer at storing carbon than are natural forests, and their regular harvesting and clearing releases stored carbon dioxide back into the atmosphere every 10 to 20 years. In practice, plantations hold little more carbon, on average, than the land cleared to plant them. By contrast, natural forests continue to sequester carbon for decades or centuries.

Also in this section

These calculations relate to the use of whole trees harvested specifically for energy. In practice, however, at present the main feedstocks used by the biomass industry – though not the only ones – tend to be wastes or residues from other forestry operations, including sawmill wastes and forest residues (material such as branches, tops or stumps left after harvesting for wood products). In this case the impacts on forest or soil carbon stocks are much lower, since these do not involve harvesting specifically for energy, and consequent loss of future sequestration.

Calculating the overall carbon impact is particularly complicated, however, due to the varying consequences of counterfactual uses. Sawmill residues can be used for engineered wood products, locking the carbon in the built environment, as well as for energy. If forest residues that would otherwise have been left to rot and fertilise soils in situ are removed, this may have significant negative impacts in terms of soil degradation and associated declines in levels of soil carbon and rates of tree growth.

▼ **A biomass gasifier power plant being operated on Gosaba island, 62 miles south of Kolkata, India. The 500kw plant provides electricity to about 1,200 households**

© Jayanta Shaw/Reuters

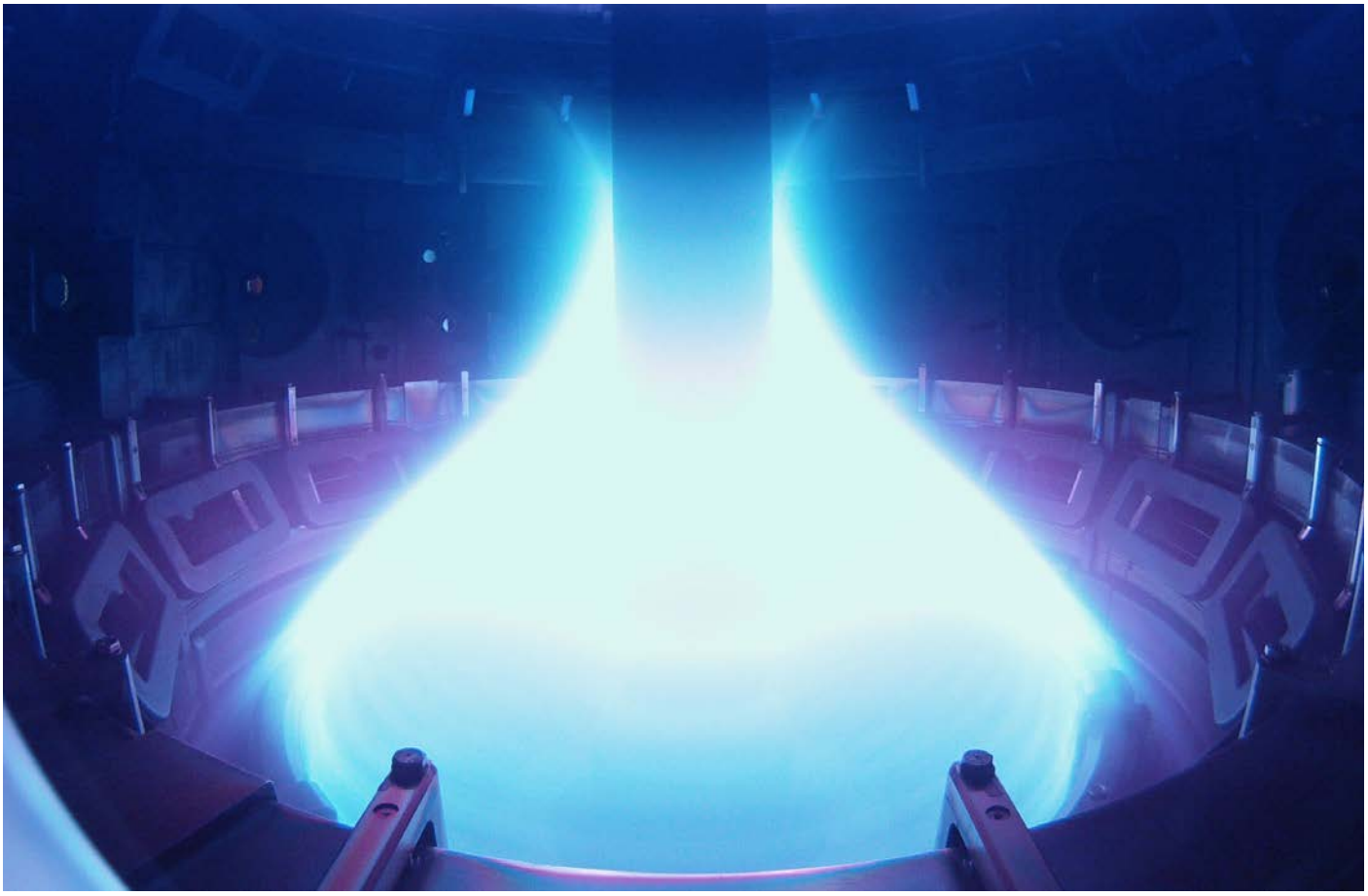
The overall impact of the use of wood for energy accordingly needs to take into account a wide range of factors that affect the balance between carbon in biomass and in the atmosphere. These include: the impacts of any initial land clearance to grow trees (in the case of plantations); any indirect land-use effects; any losses of soil carbon during harvesting; supply-chain emissions from the energy consumed in harvesting, processing and transporting biomass; and the time delay until replacement trees are large enough to absorb carbon at the same rate as the harvested trees.

This is why many observers argue for ending financial and regulatory support for biomass, an argument strengthened within the energy sector by the rapid falls in the cost of competing sources of renewable power – mainly solar and wind – in recent years. But non-fossil-fuel alternatives to biomass for producing heat directly are much less well commercialised. There may also be scope for the process known as 'biomass energy with carbon capture and storage' (BECCS), through which the emissions from combustion are captured and stored underground.

Whether these uses of biomass are really carbon neutral or (in the case of BECCS) carbon negative will depend critically on the feedstocks used. Fast-growing energy crops, for example, are likely to be much better than wood. The case for carefully regulating the feedstocks that can be subsidised – restricting them, for example, to those that are most likely to reduce net carbon emissions – is a very strong one.

Sadly, although an increasing number of scientists and others are now calling for just such restrictions, the recent level of support for biomass has led to the development of an industry that now lobbies fiercely against the removal of its subsidies. Whether policymakers have the courage to grasp this nettle – as they are beginning to, for example, with the similar case of subsidies for transport biofuels – will be one of the great challenges of the next few years. ●

For Chatham House's work on biomass, see https://www.chathamhouse.org/about/structure/eer-department/environmental-impact-use-biomass-power-and-heat-project



A second pathway for the future of nuclear energy

Will nuclear energy, in the form of fusion, be the answer to the world's demand for abundant, clean energy?

By **Michael E. Mauel**, Professor of Applied Physics, Columbia University, New York

Nuclear power is a contentious topic in climate action circles. When the world woke up to the need to act on climate change and held its first COP in 1995, nuclear power was already well established, but it was no longer a leading choice for low-carbon energy. The Chernobyl disaster less than a decade before and the subsequent Fukushima disaster in 2011 made nuclear power politically unappealing. Furthermore, the economics of nuclear power had changed. Nuclear power plants require costly safety systems, lengthy licensing times, and permanent long-term solutions for handling radioactive waste and by-products.

Today, there is a reluctance to build new plants and a movement to close established facilities. Although China is building new nuclear power plants, many European nations, including Italy, Germany, Spain, and Switzerland, are phasing out nuclear power.

▲ **Shaped plasma inside the Mega Ampere Spherical Tokamak (MAST). MAST was a precursor to ITER, designed to improve understanding of tokamaks – devices that use magnetic fields to hold plasma in a torus (doughnut) shape**

These objections to nuclear power are significant. However, society struggles to identify an alternative when planning for net-zero carbon emission and accounting for global energy demand growth. In the Intergovernmental Panel on Climate Change's *Special Report on Global Warming of 1.5°C*, most decarbonisation pathways call for an increase for nuclear in the energy mix.

But, the future of nuclear power has two pathways. In addition to improving the prospects for nuclear fission, scientists around the world are working to develop fusion power as a nearly unlimited source of carbon-free energy. The first tests of fusion energy production are within our reach. If all goes well and if the technical hurdles are mastered, this second nuclear pathway will address fears about accidents and radioactive waste. Continued scientific and technical success will bring greater clarity on what commercial fusion power entails and costs, and advocates of climate action may come to embrace fusion as a sustainable zero-carbon energy source.

Realising fusion

Heavy hydrogen, known as deuterium, is found everywhere in water. If it were used to fuel nuclear fusion power plants, then the entire world's energy needs could be supplied with a small stream of water equivalent to rain falling across one square kilometre. Fusion would give us abundant, clean energy, with no fuel costs and no greenhouse gases. This enormous potential has motivated three generations of scientists to develop the knowledge needed to realise fusion power. Today, after decades of research progress, there is growing optimism that the obstacles facing practical fusion power may finally be surmountable.

Commercialisation of fusion energy would transform energy production and dramatically reduce carbon emissions. Governments have supported fusion research for decades, and fusion research represents one of the largest energy development efforts the world has ever seen. But, even after decades of effort, many challenges remain. Fusion already exists: it is the power of the sun and the stars. But, delivering fusion energy for humanity is far from easy. It requires combining the scientific knowledge of astrophysics with the technical know-how of nuclear power engineering.

Today, there is good cause for optimism that a path towards practical fusion power is in hand. Using several large and sophisticated experiments, scientists have tested and understood how very strong magnetic force fields confine ionised hydrogen gas at temperatures 10 times hotter than the heart of the sun.

So far, the largest fusion science experiments have produced a fusion power equivalent of 1,000 homes. But the power from these experiments was released in pulses lasting only a few seconds and only while scientists injected heat to keep the heavy hydrogen hot.

Fusion would give us abundant, clean energy, with no fuel costs and no greenhouse gases. This enormous potential has motivated three generations of scientists to develop the knowledge needed to realise fusion power

A game-changing experiment

ITER, set to be world's largest science experiment, offers a step change in the evolution of fusion technology. Begun in 2010 and now more than halfway to operation, ITER is designed to release fusion power at the scale of a power plant – and be the first experiment to release more fusion power than injected. The project will also demonstrate many (though not all) of the technologies needed for delivering electricity from fusion.

ITER was designed to be the smallest possible device to produce 10 times as much power as needed to reach high fusion temperatures, while also sustaining fusion power for long pulses. To achieve this, ITER is being built with the world's largest system of superconducting magnets. The strongest of these magnets are made from a specially prepared superconducting metallic mixture of niobium and tin, discovered in 1954. To confine the burning plasma, ITER's gigantic magnets generate a peak pressure of 500 atmospheres and must be supported within a massive cage of stainless steel. Superconductors are also used in the Large Hadron Collider (LHC) particle accelerator at CERN. ITER's superconducting magnets, however, will be five times larger than the LHC magnets.

In the 1980s, the International Energy Agency (IEA) sponsored the first tests of niobium tin magnets for fusion at a test facility at the Oak Ridge National Laboratory in Tennessee. At the same time, fusion scientists from around the world learned how the magnetic force field confined hot fusion fuel. An entire new field of plasma physics, including the physics basis for the ITER design, was created. Today, scientists use supercomputers to predict the flow of energy and particles within the fusion device and, importantly, make predictions on how to maximise energy production.

As ITER construction continues, scientists are further testing and refining their predictions for fusion power production. Worldwide confidence that ITER will achieve its scientific mission has improved. The demonstration of fusion power production in ITER will be an immense technical achievement. It will also remove any doubt of the scientific and technical potential for fusion power.

Research beyond ITER

In addition to ITER, we need more research to improve and fully enable fusion electricity. Materials that surround the energy-producing burning plasma must survive in an environment comparable to that near the surface of the sun. These material systems must be maintained reliably, extract heat efficiently and generate

electricity. Finally, a commercial fusion power system that generates electricity for years must safely breed the heaviest form of hydrogen – tritium – from lithium and must continuously recirculate unburnt fusion fuels back into the reactor.

The expectations of research programmes around the world are to meet these technical challenges with innovative engineering and research led by nuclear power experts. Governments can accelerate progress and bring fusion energy online sooner. They can support the testing of fusion energy technologies as part of a cost-conscious, goal-oriented effort to integrate innovative engineering systems with magnetic fusion confinement science.

The best way to speed the pace of fusion energy development is to reduce the size and capital cost of fusion power plants. Instead of large research facilities like ITER, whose high costs are shared by many nations, next-step fusion power plants that generate electricity will utilise manufacturing and materials innovations that can make them smaller and less costly than ITER.

The 1986 discovery and subsequent commercialisation of cuprate superconductors more powerful than the niobium tin magnets used in ITER makes plausible smaller and lower-cost fusion devices. Today, a dozen companies produce commercial lengths of rare-earth barium copper oxide (REBCO) tape that can be wound into advanced superconducting magnets. Last year, the European EcoSwing consortium demonstrated a full-scale 3.6 MW wind turbine with REBCO magnets at Thyborøn, Denmark. The US National High Magnetic Field Laboratory built a REBCO magnet and achieved a record high magnetic field, eight times higher than in the ITER.

The combination of improved confidence that ITER will produce fusion power at the scale of a power plant and new high-field superconductors that will make fusion devices smaller has attracted the participation of private industry in a race to establish leadership in fusion energy technologies.

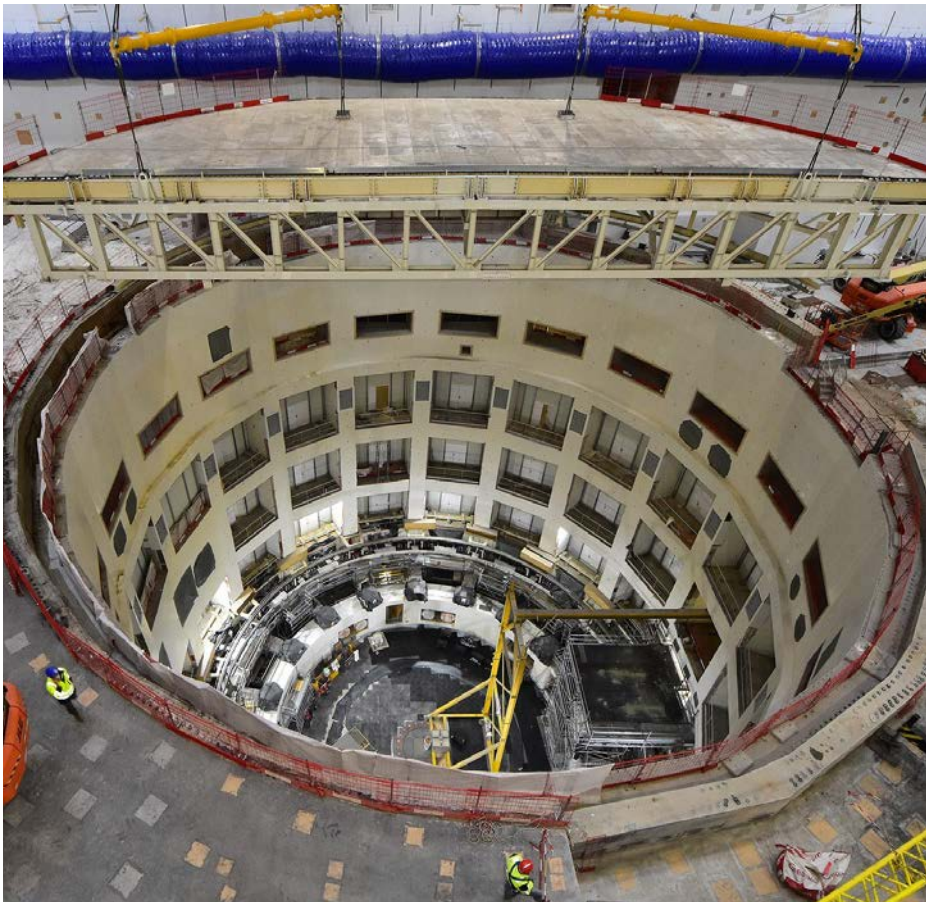
Almost 40 years ago, the IEA and government agencies funded the first large tests of niobium tin magnets that are used in ITER. By contrast, today, private companies, including Commonwealth Fusion Systems (based in Cambridge, Massachusetts) and Tokamak Energy (based in Oxfordshire), aim to conduct the first tests of large high-field REBCO magnets for fusion. If these magnets can reach twice the strength of the magnetic force field used in ITER, then the size of the fusion containment device can be made twice as small (with an eight-fold reduction in volume) while also achieving a fusion power density at least 10 times higher.

The long road to commercialisation

Even with strong international support from governments and the growing participation of private industries, the race to commercial fusion energy is a marathon, not a sprint.

The new science of magnetic fusion confinement and the new technologies that will make fusion economically attractive still require decades of research and development. Near-term climate change concerns will need to be addressed by other energy technologies. However, with history as our guide, humanity's needs for energy will grow beyond the near term. The goal of fusion scientists and engineers is to meet humanity's long-term needs with fusion-generated electricity.

The fuel for fusion energy is everywhere and practically limitless. The potential to tap into this energy source, the progress in fusion as demonstrated in the construction of ITER, and the discoveries in superconducting magnet and manufacturing technologies combine to inspire confidence that fusion energy will become the global choice for clean energy in the long term. ●



© ITER

▶ **Construction of the Tokamak Pit, the heart of ITER. Construction workers in the foreground show the massive scale of this device**

Storing renewables

What kind of energy storage do we need to fight climate change with renewables?

By **Jessika E. Trancik**, Associate Professor, Data, Systems, and Society, Massachusetts Institute of Technology

To allow solar and wind energy to meet a large share of the demand for electricity, we need augmenting technologies that can help match the fluctuating supply to the demand for electricity and other energy services.

◀ The Hornsdale Power Reserve, the world's largest lithium-ion battery, co-located with a windfarm in South Australia. The battery provides stability to the grid and can supply 100 MW to prevent blackouts when supply dips from intermittent renewable sources

One such important augmenting technology is energy storage. A key focus of engineers, companies and policymakers interested in mitigating climate change is to develop ultra-cheap storage. Current technologies and batteries can get us part of the way. But our models tell us that to lean heavily on renewable energy, we will need much cheaper energy storage that can hold large quantities of energy over long periods of time. We shouldn't put all of our eggs in one basket, so it is a good idea to pursue a diversity of technological approaches.

At the same time, in the real world where we always have limited time and financial resources, and where climate change risks are continuing to grow rapidly and threatening human and planetary wellbeing, an all-of-the-above strategy is not workable. Our technology development portfolios should be balanced between diversifying across many options and concentrating on promising ones to accelerate improvement.

We shouldn't put all of our eggs in one basket, so it is a good idea to pursue a diversity of technological approaches

Models can help us find the right strategy by estimating technology performance targets. Recently we developed a new model with this goal in mind. We investigated current and future hypothetical storage technologies and their ability to help renewable energy reliably meet demand. We learned several important lessons for the development of batteries and other energy storage technologies. We also learned about the desirable features of technologies other than energy storage that can play a 'storage-like' role, including demand-side management to shift electricity demand in time.

Estimating targets for energy storage

Battery technologies are improving, but how much is enough? What storage technology features would enable solar and wind energy to meet electricity demand at costs that compete with coal, natural gas and nuclear energy?

We addressed these questions in our study by examining solar and wind energy resource fluctuations in four locations (Texas, Iowa, Massachusetts and Arizona) over 20 years. We optimised renewable energy and storage installations to reliably meet electricity demand profiles while minimising electricity costs. We then estimated storage cost targets that would allow renewable resources to compete with conventional technologies.

This approach was new. Where other studies have assessed current technologies against the need for storage, sometimes allowing for incremental improvement, here we instead modelled an extremely wide range of current and future hypothetical technologies. This allowed us to develop a picture of what the target solution could look like, and in this way inform technology innovation efforts.

We found that when relying fully on renewables through optimal combinations of wind and solar electricity and storage in each region:

- Energy storage technologies with an energy capacity cost (the cost of storing quantities of energy) below $20/kWh could enable cost-competitive power in some locations. Reducing energy capacity costs was found to be more important than reducing storage power capacity costs (the cost per unit power of converting the stored energy to electricity).
- Reaching this target would require a roughly 90 per cent decline in the costs of today's battery technologies, such as lithium-ion battery technologies.
- The $20/kWh target is closer to estimated costs of pumped hydro storage. But hydro technology is more limited in terms of where it can be installed than batteries, since current designs require the right land features to pump water uphill and hold it in a sizable reservoir.
- Some new battery technologies have been proposed, including flow batteries, to reach these targets, but they are still in development. 'Second-life' batteries

might offer another piece of the puzzle, if they can be successfully collected in large quantities and repurposed as grid-scale storage. However, further research is needed to develop and assess the potential of these options.

In contrast, when relying on renewables and storage but also other supplemental technologies in a 'renewables-storage-plus' scenario we found that:

- Meeting electricity demand with supplemental energy sources other than solar and wind energy during just 5 per cent of hours over 20 years can halve electricity costs, and raise the energy storage capacity cost target to $150/kWh.
- The results are explained by a small number of large resource shortage events that occur only a handful of times over 20 years. These require a reliable, renewables-only system to have significantly greater storage capacity than this system, which uses something else for a small amount of time.
- These supplemental sources might include low-carbon fuels such as hydrogen produced from the large amounts of excess solar and wind electricity seen in our modelled, cost-minimised scenarios. In this case, the low-carbon fuels could possibly also be used to provide energy services in other sectors such as industry and transportation.
- Shifting demand in time with demand-side management technologies is another option. But this requires innovation to be able to provide a large demand response all at once and extending across several days or a week. More research is needed to understand this potential.
- Supplemental electricity generation sources such as nuclear energy or electricity from natural gas plants with carbon capture and storage are another option. However, any infrastructure used for a small amount of time will usually be more costly, and we should work to better understand those costs.
- Yet another approach is to expand transmission infrastructure to mitigate the fluctuations in solar and wind energy. But the infrastructure would need to extend over large enough distances to balance out the large fluctuations seen.

Following this renewables-storage-plus scenario would have very different implications for the energy storage required. Battery costs would not need to fall as much but other developments would still be needed.

These results do not argue for a particular set of technologies or supply mix, but instead reveal features of potential solutions for policies to target. It is too early to pick winners. But the cost targets and the two scenarios (renewables-storage and renewables-storage-plus) can guide efforts by engineers and policymakers. They can help battery developers select suitably low-cost materials and designs, and can inform the development of demand-side management technologies and low-carbon fuels.

Actions needed

The two scenarios described here for using renewables to achieve dramatic decarbonisation – renewables-storage and renewables-storage-plus – serve as bounds for a set of scenarios that fall in between the two. In one (renewables-storage) we would achieve ultra-low-cost energy storage. In the other (renewables-storage-plus) we would find new ways to manage demand and produce low-carbon fuels, and integrate other low-carbon supplemental energy generation, even if this infrastructure is used to meet only a small portion of electricity demand. Policymakers and technology developers should be working towards both strategies.

We should focus policies and technology development efforts on ultra-cheap and scalable energy storage, trading off low-energy capacity cost for higher-power capacity cost if needed. Creativity-driven research is important here, but so is having a numerical target to guide the development of storage technologies for which there are so many different options. These include storage of different forms of energy (chemical, mechanical, gravitational, nuclear) and different materials and device designs for implementation.

Alongside these efforts, technology development should focus on finding ways to produce, store and use low-carbon fuels from excess solar and wind energy. New kinds of demand-side management should also be developed. We should consider energy services beyond electricity, such as transportation and heating, when developing these technologies. Low-carbon fuels could potentially be used for transportation and industrial energy services as well as for electricity. Demand-side management services could perhaps be provided by some industries and could be included in these industries' decarbonisation plans. For example, manufacturers might design plants to ramp up during periods of excess renewable energy and shut down for several days during renewable energy resource shortages.

Policy instruments such as environmental pricing and development funding for technology have led to impressive low-carbon technological innovation

We can take inspiration from past policy successes in driving drastic improvements in beneficial technologies. Policy instruments such as environmental pricing and development funding for technology have led to impressive low-carbon technological innovation.

Perhaps the most notable example is that of the evolution of solar energy technology, where the costs of solar (photovoltaic) panels dropped by 99 per cent over four decades, stimulated by government policies around the world that funded research and jump-started technological development in private firms. This example is one that we should be working hard to replicate for energy storage and other 'storage-like' technologies. ●

What role for carbon capture?

How can we reconcile the potential for carbon capture identified by the Intergovernmental Panel on Climate Change and the opposition to the technology from environmental groups?

By **Larry Baxter**, Professor, Chemical Engineering, Brigham Young University, Provo, Utah and Cofounder/Technical Director, Sustainable Energy Solutions, Orem, UT

We know that carbon dioxide (CO_2) from burning fossil fuels primarily drives climate change, posing real threats to our planet's people, economies and ecosystems. We also know that ambient CO_2 concentrations continue to rise, albeit with seasonal variation, despite major efforts to reduce emissions.

A candid view of recent and future energy projections indicates that the hope for a future energy infrastructure free of CO_2 is naïve, especially in the short term. Instead, we can expect that much-needed continued economic development will drive substantial increases in energy demand, with developing economies dominating new sources of CO_2. The climate issue is clearly too urgent to wait for a transition from fossil fuels. Therefore, the hope of mitigating climate change through decreasing global CO_2 emissions depends critically on carbon-capture technologies. This is recognised by the IPCC, the International Energy Agency and others.

Yet carbon capture often encounters rejection – or a begrudging or hostile reception – in climate change circles. Certainly, it is among the more controversial of climate change mitigations. Detractors argue that it extends the life of fossil fuels, which are the root cause of climate change. But they too simplistically and hastily conclude that a transition to renewables and carbon capture are mutually exclusive.

While the data undoubtedly support a need for immediate action, carbon capture offers a potentially market-driven complement to renewables – with much greater potential to mitigate climate change than any scenario that does not involve it.

Many broad-based and respected analyses conclude that climate change mitigation costs less, requires less time, and involves less technical risk when carbon capture plays a substantial role. Some carbon-capture technologies, notably cryogenic carbon capture™, benefit renewable energies (through energy storage) as much as fossil energy (through carbon capture), and provide especially effective climate change mitigation pathways.

Carbon options

The large and growing literature on carbon-capture technologies frequently cites 90 per cent capture from power plants and industrial facilities as a figure of merit, but with no justification of this number. Given that climate change mitigation requires reducing CO_2 emissions by more than the

▲ **An engineer inspects a biomass furnace at Drax Power Station in the UK. A project at Drax has been capturing CO_2 at a rate of a tonne per day. The goal is to generate negative emissions within the decade**

total of all such large, stationary sources, the 90 per cent target seems low. Capturing carbon from these large fixed sources requires much less energy and capital, and is logistically simpler, than capturing CO_2 from the ambient air, from small distributed sources (such as residential and commercial buildings), or from mobile sources (vehicles of all kinds).

Therefore, leaving 10 per cent of the CO_2 in large stationary source emissions increases the amount that the more costly, inefficient and difficult systems must capture. A capture rate of more than 99 per cent for large, stationary, continuous sources represents a more appropriate target.

Similarly, a great deal of literature suggests converting CO_2 to useful products. This should be pursued whenever it makes economic sense, but the expectations should be weighed against the market and energy barriers associated with such conversion. For example, atmospheric CO_2 emissions exceed by a factor of 30 the sum of all carbon used in manufactured products today.

So while there remain some realistic carbon markets, most CO_2 will require sequestering if captured in sufficient quantities to influence global climate change. Similarly, thermodynamic barriers dictate that converting CO_2 to products will consume much more energy than using other feedstocks. This process can only make sense when the energy used to drive it involves little or no CO_2 emissions and, even then, that CO_2-free energy is often more effective at reducing CO_2 emissions by displacing fossil energy than by making products.

What does 'good' capture look like?

Carbon capture technology development currently resides in a classical "technology push stage": there is no well-defined and long-term market that defines the characteristics of the process, establishes prices, is of sufficient scale, or financially motivates investment. There are a number of regional and national short-term incentives that play important roles in developing technology. However, there are several process characteristics that are most likely to lead to successful carbon capture adaption and market penetration for continuous point sources such as power plants and industrial facilities:

- low cost per unit of CO_2 avoided;
- low energy demand per unit of CO_2 avoided;
- very high reliability or low probability of causing an unscheduled shutdown;
- retrofittable to existing systems with minimal upstream modification;
- capable of following load (adjusting output based on demand fluctuations);
- capable of high CO_2 capture rates (more than 99 per cent);
- robust to other pollutants without creating new ones;
- compatible with (and preferably complementary to) high renewable penetration and smart grid dispatch.

Several of these characteristics couple with each other. For example, systems that retrofit existing infrastructure with little or no required modification have much more value than those that need major or complete upstream changes. The capital and operating costs of carbon-capture systems on power plants far exceed those of any traditional water or 'criteria' air pollutant (particulate matter, ground-level ozone, lead, carbon monoxide, nitrogen dioxide and sulfur dioxide).

However, these costs are still small compared to the power plant itself. If the plant must be replaced to enable the capture technology, the effective cost of carbon capture increases many-fold compared with the cost of the capture equipment. The ability to retrofit existing systems couples strongly with cost and will play a major role in commercialisation, especially in the developed world. Similarly, power generation systems have among the highest reliability of any major industrial process. Any capture system that materially increases the chance of an unscheduled shutdown of such systems increases its effective cost many-fold.

State of development

The world's first utility-scale example of carbon-capture technology deployed and fully integrated at a commercial coal-fired power plant was at SaskPower's Boundary Dam facility in Saskatchewan, Canada. Operational in 2014, by the autumn of 2019 the system had captured three million tonnes of CO_2. Boundary Dam has both demonstrated that carbon-capture technology works, and has provided valuable knowledge to inform the next generation of carbon-capture systems.

Economic viability is critical to achieving widespread adaption of carbon capture as a mitigation tool. Of the several technologies in use and in various stages of development, amine adsorption (see table) has become the de facto standard, and is the most commercially advanced.

Most of the remaining technologies have successfully demonstrated carbon capture at laboratory up to pre-pilot scale. Several of these technologies require major up-stream modification (such as metal–organic frameworks and membranes) or replacement (as with oxyfuel and chemical looping). Essentially, all of them require flue gas cleaning well above current standards, most cannot easily follow fluctuations, and most cannot achieve very high capture rates at reasonable cost. Uniquely, cryogenic carbon capture™ meets all of these goals.

Economics

While amine technology sets the standard for energy use and cost, estimates of both vary considerably, depending on the precise nature of the technology (primarily the types of amines used).

Models indicate that the amount of energy that amine-based systems require per tonne of CO_2 captured range from 1.05 gigajoules (National Energy Technology Laboratory) to 1.52 gigajoules (TNO) and that the power plants typically experience between 20 per cent and 30 per cent decrease in efficiency. The reduction in efficiency, also known as parasitic load, at the fully operational Boundary Dam facility has been 30 per cent.

The combination of parasitic load and the costs of the carbon-capture system itself have a pronounced impact on the cost of producing power – the 'levelised cost of electricity' (LCOE). Detailed models indicate the LCOE increases by between 46 per cent and 80 per cent, resulting in costs ranging from $62/MWh to $143/MWh, with a median score of $115/MWh. Retrofit carbon capture technologies decrease this

cost by half and carbon capture on natural gas systems is also much cheaper.

Retrofit carbon capture technologies compete with current and future renewable costs. The International Renewable Energy Agency (IRENA) projects that the global average LCOE for onshore wind in 2025 will be $50/MWh (it was already $70/MWh in 2015). Solar photovoltaic is projected to be $60/MWh and offshore wind $120/MWh. However, the fossil plants provide essential grid reliability much more easily compared with the intermittent nature of many renewables.

Not just coal power

The application for carbon capture will include cleaning the emissions of existing coal power stations, particularly in developing countries where it might not be economically viable to prematurely decommission a well-functioning power station. But although most of the research has been carried out on coal-powered power plants, this is not the sole application for this technology.

Natural-gas-derived power has increased dramatically in both developed and developing countries with access to it; carbon capture should be retrofitted here. Aside from power generation, there are several applications for which there are limited alternatives. Cement manufacture, which accounts for approximately 8 per cent of global carbon emissions, will be able to retrofit carbon capture.

Likewise, the steel industry, responsible for a similar share of emissions, is a viable candidate. Carbon capture is central to low-carbon initiatives in both industries. Notable examples include ULCOS (Ultra-Low CO_2 Steelmaking), a pioneering partnership of 48 companies and organisations from 15 European countries, and LEILAC project (Low Emissions Intensity Lime and Cement), which is already trialing carbon capture at HeidelbergCement's Lixhe plant in Belgium.

As stated above, the IPCC has noted carbon capture as an essential tool in all potential pathways to limit warming to 1.5°C. In addition to its role in eliminating emissions in situations where no other mitigation methods have been identified, it also has a role in generating negative emissions. When carbon capture is applied to truly carbon-neutral biomass (see page 66), there will be net-negative emissions, a scenario described as bioenergy with carbon capture and storage (BECCS).

The Drax power plant in the UK is already running a BECCS project, which is removing CO_2 at a rate of one tonne per day. By 2030, Drax intends to be carbon negative, removing 16 million tonnes of CO_2 per year. An application that may also make a contribution, but is still very much in its infancy, is direct air capture (DAC). Current levels of performance have a huge gulf to bridge before they are a contender. The Climeworks facility in Switzerland can capture 900 tonnes per year but the costs are prohibitive at $600 per tonne.

The Paris Agreement requires carbon-capture technology to be mainstream within the next decade. Research to date has proven its capability and there must now be a push to accelerate its application across a range of industries. It is time to banish its reputation as a smokescreen for fossil fuels and accept its appropriate use as an indispensable technology in the fight against climate change. ●

Larry Baxter is part of the team developing cryogenic carbon capture™

Types of carbon capture processes

The literature classifies carbon capture processes several ways. This table highlights some of the characteristics of many of the current and developing technologies, with details in several recent reviews

CAPTURE METHOD	EXAMPLES	APPLICATIONS	TECHNOLOGY NOTES
Selective absorption–adsorption (gases are passed through a chemical solution to remove the CO_2)	Amines, metal-organic frameworks (MOFs)	Post-combustion waste gases, direct air capture in the case of MOFs	Amines systems are the de facto standard
Oxygen isolation (burning happens in an environment of pure oxygen so that the waste gas takes the form of pure CO_2 which can be easily captured)	Oxyfuel, chemical looping	Post-combustion	Requires new power plants
Preferential diffusion (gases are passed through a mechanism to filter them into their respective components)	Membranes	Post-combustion or oxygen separation (process could be used to remove CO_2 from waste gases or to create pure oxygen environment for oxygen isolation)	Could synergistically combine with other technologies; large footprint with poor flexibility
Condensation (cooling is used to separate gases)	Cryogenic carbon capture™	Pre and post-combustion	Good potential demonstrated at 1 tonne/day scale

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A burning issue

Is incinerating waste to generate energy compatible with efforts to limit global temperature rise?

By **Janek Vähk**, Climate, Energy and Air Pollution Programme Coordinator, Zero Waste Europe

Across the European Union, waste-to-energy (WTE) incineration is increasingly promoted as an alternative to landfilling for treating residual waste. According to Eurostat, in the 10 years to 2016, the amount of waste incinerated in the EU increased by 30 per cent. Yet, the data also reveals that, since 2010, CO_2 emissions from incinerators have increased

◀ Rubbish being brought to the waste-fuelled Hundertwasser Power Plant at Spittelau, Vienna, Austria

by around 50 per cent. This suggests that carbon dioxide emissions from incineration are intensifying.

Eurostat statistics show that most of the increase in incinerated waste consists of residual municipal solid waste (MSW) – solid items thrown away by members of the public. In fact, Eurostat's latest available data shows that approximately 70 million tonnes of MSW was incinerated in 2017. This is more than double the amount incinerated in 1995.

Burning MSW produces significant amounts of carbon dioxide. Incinerating just one tonne of MSW releases about 0.7 to 1.7 tonnes of CO_2. This includes emissions of both fossil and biogenic CO_2. The former is carbon that has previously been locked out of the atmosphere for tens of thousands of years. The latter represents more rapidly cycling forms of carbon such as those from plant decomposition – although the biogenic carbon cycle can have turnover times of up to 500 years. Although biogenic CO_2 is directly released into the atmosphere, making a significant contribution to climate change, only the carbon emissions from fossil sources are considered for the purposes of a global analysis of greenhouse gas emissions. This is an important loophole in accountability. For this reason, the allocation of carbon as fossil or biogenic has a crucial influence on the calculated amounts of climate-relevant CO_2 emissions from incineration.

Incinerators are designed to last for about 30 to 40 years... continued use of them is simply delaying a much-needed and urgent transition to less carbon-intensive power generation infrastructure

The level of fossil carbon dioxide emitted by burning one tonne of MSW depends on the composition of the material that is burned. Plastics – derived mostly from fossil sources – make up a significant proportion of the material burned at WTE incinerators. It is therefore estimated that burning a tonne of waste releases approximately 0.458 tonnes of CO_2 from fossils.

In 2017, over 40 million tonnes of CO_2 was released by WTE incinerators in the (then) EU 28 countries. This represents 22 per cent of total emissions from the entire waste sector (177 million tonnes with WTE incineration). Moreover, the emissions of carbon dioxide from WTE of municipal waste have increased by 288 per cent since 1999, making them a significant emission source when striving to maintain global temperatures below 1.5°C. Several reports also reveal the high proportion of recyclables in residual waste that could be either recycled or composted.

The carbon intensity of WTE

In the power sector, decarbonisation is gaining pace. In 2018, 32 per cent of all electricity produced in the EU came from renewables. Similarly, the average carbon intensity of EU electricity has been continually falling due to the increasing uptake of renewables. In 2018, it stood at 296g CO_2eq/kWh.

However, the carbon intensity of electricity produced through WTE incineration is about double that amount, at 540g CO_2eq/kWh. WTE incineration is also far more carbon intensive than energy generated from fossil fuels such as gas (370g CO_2eq/kWh). Due to the progressive decarbonisation of the electricity sector, power generated by incinerators is therefore increasingly out of step with the sector's approach to limiting climate change impacts in the future.

Incinerators are designed to last for about 30 to 40 years. The data shows that continued use of them is simply delaying a much-needed and urgent transition to less carbon-intensive power generation infrastructure, such as wind and solar renewable energy.

It is therefore environmentally irresponsible to continue to promote WTE incineration infrastructures that are already largely outperformed by the EU average and, even worse, by conventional fossil-fuel energy generation such as gas. Promoting WTE electricity from incineration would make it impossible to facilitate the ambitious emissions reductions in the energy sector that would align with the Paris Agreement. If we genuinely seek to limit global average temperature increase to below 1.5°C, we must end WTE incineration as soon as possible. ●

Not all forests are equal

While tree planting can be good medicine for our sick planet, sheer numbers will not provide the cure. We need a carefully managed restoration effort that helps complex ecosystems to recover

By **Robin L. Chazdon**, Professor Emerita, Ecology and Evolutionary Biology Department, University of Connecticut and Senior Fellow, World Resources Institute Global Restoration Initiative

It is hard not to love trees. They provide myriad benefits for people and wildlife. They protect soil, water quality and the atmosphere. Trees are beautiful and inspiring. Human civilisation was literally built and fed using trees for fuel, fibre and food. Our species is adept at cutting trees down, but gets poor marks for replacing them in kind. Of the estimated six trillion trees that could potentially grow on Earth, only three trillion remain.

These numbers mask the dramatic alteration of the geographic distribution and species composition of tree cover on the planet. Net gains in tree cover over the past 30 years are heavily concentrated in the temperate zones, while net losses prevail in the tropics. The potential for removing carbon from the atmosphere through reforestation is greatest in deforested tropical regions with year-round conditions that favour tree growth.

The cumulative loss of trees through land clearance, fires or drought over the past few centuries contributed heavily to the twin global crises of climate change and biodiversity loss that challenge us today. It seems reasonable to conclude that repopulating the planet with a trillion (or more) newly planted tree seedlings would be an appropriate solution to compensate for these cumulative losses. But this simple-minded equation holds hidden fallacies.

Natural climate solutions including reforestation, avoided deforestation, and improved forest management can contribute significantly to mitigating climate change and biodiversity loss. But a solitary focus on repopulating trees all over the world is not going to return what has been lost or come close to compensating for ever-growing greenhouse gas (GHG) emissions. Conversion of forest to farmland emits about a quarter of global GHG pollution every year. Successful tree planting in all potential areas of the planet would still leave more than 70 per cent of the climate problem unresolved.

Natural climate solutions must avoid adding fuel to the fire, literally. An enormous wildfire in Alberta, Canada in 2016 was a direct outcome of draining and converting peat bogs to plantations of black spruce trees whose rapid growth reduced groundwater supplies, dehydrated the ecosystem, and turned the plantations into a tinder box.

Truly effective solutions to reverse environmental degradation require addressing the reasons why we so spectacularly failed to take care of the world's forests, shrublands, grasslands, rivers, wetlands and oceans, and the estimated 8.7 million species that depend on them (including us). We failed to safeguard the life-support systems of our planet by viewing natural ecosystems as expendable and converting the land that they previously occupied to simplified production systems. Our civilisation has become overly reliant on combustion of fossil fuels and on lucrative global trade based on products sourced from former tropical forests, driving continued deforestation and species loss.

I expose five fallacies of massive tree-planting schemes that claim to ameliorate the global climate crisis. These misconceptions stem from viewing trees as autonomous carbon-sucking machines that can be deployed to function predictably in space or time. Trees interact with other organisms to create forest ecosystems. Indigenous cultures long recognised the unique properties and products of different tree species and used this knowledge to sustainably manage tree cover over many millennia. Aiding the recovery of trees and forests requires similar attention to how different species and assemblages function, and applying this information to manage recovering systems for desired social and ecological outcomes.

Fallacy 1: The number of trees or hectares planted is an effective goal or target. Loss of trees and forests are symptoms of a larger systemic pathology. It requires long-term, targeted and effective treatment to bring about the restoration of ecosystems and landscapes along with reduced emissions of carbon dioxide and other GHGs. Treatment is not the goal. It is the means towards achieving recovery and better functioning. The socio-ecological outcomes of tree planting should be targeted and recognised. Tree-planting contests are publicity stunts.

Fallacy 2: Tree planting compensates for lost forests. Planted trees do not replace the species or ecosystems that were originally present. A species-rich tropical forest, for example, cannot be restored with a plantation composed of one or a few species. Protecting and enhancing remaining forests is the best way to maintain carbon stocks and protect forest-dependent species.

Forests naturally regrow under suitable conditions, particularly in areas adjacent to existing forests where land was lightly used. This means that new forests can regenerate in many areas, reducing the need for tree planting. But recovery of forests takes many decades and is not a quick fix.

▲ Wildfires near Fort McMurray, Alberta, Canada in 2016. The fires were a direct consequence of draining peat bogs and replacing them with black spruce plantations

Fallacy 3: Trees should be planted in all places where they once grew. Where forests once prospered, land cover now consists of agricultural fields, pastures, cities, roads, dams and barren lands. Many of these areas provide unfavourable conditions for newly planted trees or offer far greater socio-economic returns to be viable opportunities for reforestation. Assessments of priority areas for tree planting need to consider multiple benefits and feasibility factors.

Fallacy 4: The more trees, the merrier. What matters is how trees function to support the recovery of ecosystems and landscapes. It is important that trees selected for planting grow and survive well beyond their first year, support native wildlife, replenish soil fertility and organic matter, and support the livelihoods and wellbeing of local people who are the stewards of the land. Local communities should be actively involved in selecting the tree species and locations for planting, as they will live with these trees for many decades.

Planted trees should be an asset to the landscape, not a threat to native species and ecosystems, as some exotic species turn out to be. Not all trees are equal in terms of their ecological performance and functions. Fast-growing trees, which are often selected for quick tree-planting outcomes, can reduce local water supplies. Moreover, fast-growing trees are not built to last. Their low-density wood stores less carbon and for less long.

Fallacy 5: Reforestation equals restoration. Planting trees is not always a restorative measure, particularly if the location was not formerly a forest ecosystem. Tree planting when implemented in the context of aiding recovery of an ecosystem or improving landscape functions is a vital restorative action that requires participation and support of local people to provide long-term social and ecological benefits.

We are soon to embark on the United Nations Decade of Ecosystem Restoration, but our ship is not yet seaworthy. Actions need to be strategic, informed by science, and based on values and principles in opposition to those that intensify the climate and biodiversity crises. Effective actions are strengthened by alignment with hard-won international conventions and agreements, such as the United Nations Framework Convention on Climate Change, the United Nations Convention on Biological Diversity, and the United Nations Convention to Combat Desertification.

We must think and act differently. Tree planting should be viewed as a means to reach many goals, including promoting the global drawdown of atmospheric carbon. Tree-planting activities need to be part of an intelligently planned restoration effort with strong engagement and support of local stakeholders. All of these actions will help achieve the UN's Sustainable Development Goals. Intelligent tree planting can achieve a wide set of objectives that ensure that trees and forests are working for people as well as the environment. ●

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Climate 2020: sustainability

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