

# Where is the money? Climate finance shortfall threatens global warming goals

Rich nations under pressure to deliver unmet \$100-billion pledge

- \* More ambitious climate plans hinge on international funding
- \* Eyes on U.S. to boost finance at U.N. gathering next week

KUALA LUMPUR/BARCELONA, Sept 16 (Thomson Reuters Foundation) – For a storm-prone developing country like the Philippines, receiving international funding to protect its people from wild weather and adopt clean energy is not only an issue of global justice – the money is essential to deliver on its climate plan.

Without promised support, many vulnerable poorer nations – battered by the economic impacts of COVID-19 and surging climate disasters – say they simply cannot take more aggressive action to cut planet-heating emissions or adapt to a warmer world.

The Philippines, for example, has pledged to reduce its emissions 75% below business-as-usual levels by 2030.

But only about 3 percentage points of that commitment can be delivered with its own resources, its national climate plan says. The rest will require international finance to make sectors like farming, industry, transport and energy greener.

“Environmental groups say our (target) is unambitious because it’s highly conditional. What they don’t see, however, is what we submitted is what is doable for the Philippines,” said Paola Alvarez, a spokesperson at the Department of Finance.

“Our economy is not doing well because of the pandemic and we have back-to-back typhoons every now and then,” which means national resources need to be prioritised for social programmes, she told the Thomson Reuters Foundation.

As leaders prepare to attend the United Nations General Assembly in New York next week, wealthy nations are coming under ever-greater pressure to deliver on an unmet pledge, made in 2009, to channel \$100 billion a year to poor countries to tackle climate change.

With budgets worldwide squeezed by the COVID-19 crisis and U.N. climate talks postponed for a year, the original 2020 deadline to meet the goal was likely missed, analysts have said.

But as November’s COP26 climate summit approaches fast, time is running out to convince developing countries – both big and small emitters – that any efforts at home to raise their climate game will be met with solid financial backing, analysts say.

Alden Meyer, a senior associate in Washington for think-tank E3G, focused on accelerating a low-carbon transition, said the \$100-billion promise is well below what is actually needed by emerging economies to mount an adequate response.

But delivering on it is key to spurring them on, he added.

Right now, they can say, “the developed countries aren’t doing what they said they would do in terms of support, so why should we ramp up ambition (to cut emissions)?” Meyer said.

Government officials in India – the world’s fourth-biggest emitter of planet-heating gases – have said, for example, that any further commitment to reduce its carbon footprint will depend on funding from rich countries.

National pledges to cut emissions so far are inadequate to

keep global temperature rise to “well below” 2 degrees Celsius above preindustrial times, and ideally to 1.5C, as about 195 countries committed to under the 2015 Paris Agreement.

The U.N. climate science panel warned in a report in August that global warming is dangerously close to spiralling out of control and will bring climate disruption globally for decades to come, in wealthy countries as well as poor ones.

#### ‘BARE MINIMUM’

Some big greenhouse gas emitters, including China, Russia and India, have yet to submit more ambitious plans to the United Nations, as they committed to do by 2020 under the Paris pact.

But of the roughly 110 plans delivered by other countries ahead of an adjusted U.N. deadline in July, nearly all hinge on one key condition: money.

According to the World Resources Institute (WRI), a U.S.-based think-tank that tracks national climate pledges, “well over half” of those updated emissions goals include actions that can only happen with the support of international finance.

“This underscores why it’s so critical for developed countries to deliver on their \$100-billion pledge. It’s the bare minimum,” said Taryn Fransen, a climate policy expert at WRI.

In the latest submissions, a growing number of developing nations have stepped up with emissions goals they can implement on their own, she added, including Argentina, Chile and Colombia, which have dropped requests for support entirely.

But honouring the \$100-billion annual commitment – which covers the five years until 2025, when a new yet-to-be-negotiated goal is set to kick in – is key to fostering trust within the global climate talks and facilitating a faster green transition, she stressed.

The latest available figures from the Organisation for Economic Co-operation and Development show that in 2018, a little under \$80 billion was delivered to vulnerable countries.

An analysis by aid charity Oxfam last year put the real figure – when counting only grants and not loans that have to be paid back – much lower, at \$19 billion-\$22.5 billion.

Meanwhile, the 46 least-developed countries between 2014 and 2018 received just \$5.9 billion in total for adaptation, a level that would cover less than 3% of the funds they need this decade, found a July study from the International Institute for Environment and Development.

## **U.S. FALLS SHORT**

Climate and development experts argue industrialised countries built their prosperity by burning fossil fuels, making them responsible for a large part of the losses happening in countries on the frontlines of worsening floods, droughts, storms and rising seas, many of them in the southern hemisphere.

A 2020 study in The Lancet Planetary Health journal estimated that, as of 2015, nations in the Global North were responsible for 92% of carbon emissions beyond safe levels for the planet, while the Global South accounted for just 8%.

Diann Black-Layne from the Caribbean nation of Antigua and Barbuda, which is battling sea level rise and more frequent hurricanes, said climate action for developing countries “has to be conditional, because we can’t get the money”.

Black-Layne, lead climate negotiator for the 39-member Alliance of Small Island States, questioned why wealthy governments continued to fund the fossil fuel industry while failing to meet their \$100-billion-a-year pledge.

“That money is available,” she said. “There is no shortage of money to get us to the 1.5C (temperature goal).”

Ahead of the COP26 summit, which starts on Oct. 31, host nation Britain has tasked Germany and Canada with coming up with a delivery plan for the elusive \$100 billion a year, but observers believe that is unlikely to land until next month.

A major question is whether U.S. President Joe Biden will unveil a bigger U.S. finance commitment at the U.N. General Assembly next week, as concerns grow that the world’s biggest economy is failing to cough up its fair share.

At an April summit he hosted, Biden said the United States would double its climate finance to about \$5.7 billion a year by 2024 – but that level is still seen by many climate finance experts as far below what it owes to developing countries.

A recent analysis from the Overseas Development Institute said the United States should be stumping up more than \$43 billion a year based on cumulative carbon emissions, gross national income and population size.

It called the United States the biggest offender among 23 donor states in terms of falling short of its responsibilities.

On Wednesday, the European Union pledged to boost the \$25 billion per year it provides in climate funding to poorer countries by 4 billion euros (\$4.7 billion) through 2027, and called on the United States to step up too.

Laurence Tubiana, CEO of the European Climate Foundation and a key broker of the Paris Agreement, said this week that “serious pledges” were now needed from Washington given that some European nations had already raised their commitments.

“The U.S. must step up solidarity,” she said, adding she understood Washington was working hard to do so. (\$1 = 0.8462

euros) (Reporting by Beh Lih Yi @behlihyi and Megan Rowling; Editing by Laurie Goering. Please credit the Thomson Reuters Foundation, the charitable arm of Thomson Reuters, that covers the lives of people around the world who struggle to live freely or fairly. Visit [news.trust.org](https://www.news.trust.org))

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# Scoping out corporate carbon neutrality



By Geoffrey Heal/New York

In the run-up to this year's United Nations Climate Change Conference in Glasgow (COP26), a growing number of companies hopped on the sustainability bandwagon, declaring commitments to achieve carbon neutrality – net-zero carbon-dioxide emissions – by mid-century. And among the many ambitious announcements to come out of COP26 is that almost 500 financial-services firms have “agreed to align \$130 trillion – some 40% of the world's financial assets – with the climate

goals set out in the Paris agreement, including limiting global warming to 1.5°C.”

But many commentators have been sceptical about such proclamations, suggesting that they amount to greenwashing. Critics point to corporations’ heavy reliance on “offsetting,” which has become an increasingly important – and controversial – issue in the broader climate debate. So great is the confusion about what is real and what is not that the Taskforce on Scaling Voluntary Carbon Markets, led by UN Special Envoy for Climate Action and Finance Mark Carney, has established a new governance committee to review corporate emissions pledges.

The sceptics are right to be concerned about the use of offsets. The world needs to get to net-zero by mid-century, and it cannot do that with offsets. Companies buy offsets precisely so that they can continue emitting greenhouse gases (GHGs) while claiming that their emissions are zero, net of the offsets. The very existence of an offset means that the purchaser’s emissions are not zero.

But not all offsets are alike. The critics focus on offsets in which one company or country pays another to reduce emissions and then claims the reduction as its own. This is the kind of offset that cannot be allowed if the world as a whole is to get to zero emissions. There is a place, however, for offsets generated by removing GHGs from the atmosphere, for example by direct air capture or forest growth. If a company emits 100 tons of CO<sub>2</sub> and then removes the same amount, its net emissions really are zero. If all companies do this, the world as a whole will achieve net-zero emissions.

True, the recourse to forestry requires a cautionary note. Growing trees raises issues of both additionality and permanence – additionality because it is hard to be sure that the forest growth would not have occurred anyway, and permanence because there is a risk that the forest will burn, a problem that has grown more visible and severe in recent years.

Still, offsets can play a positive role. The costs of reducing

GHG emissions, and the willingness and ability to pay for such reductions, vary greatly from country to country, depending on the sources of its emissions and its stage of development. Some countries may not be willing or able to pay for an expensive reduction in emissions at home but could still pay for less costly reductions abroad. When this happens, an offset market can facilitate a reduction in emissions that would not otherwise have occurred, or that would not occur without a policy that penalises CO2 emissions.

In this case, offsets may be useful at least in moving the world closer to net-zero emissions. But to reach the finish line, they will have to be phased out at some point. There ultimately is no place for offsets in a zero-emissions world.

In the meantime, policymakers and business leaders would do well to attend to a related issue that has been neglected: the failure to distinguish between so-called scope-one, scope-two, and scope-three emissions. Scope one refers to emissions that arise from a company's own operations, whereas scope two applies to those associated with the production of electric power purchased by the company, and scope three to those arising from other parts of the supply chain, particularly from the consumption of the product.

Clearly, there is potential for massive double counting here if one adds up all the emissions across companies. If my company purchases electricity from a local utility, the associated emissions are scope two for me and scope one for the utility. If Exxon sells jet fuel to American Airlines for use in Boeing aircraft, the emissions are scope three for Exxon and Boeing, and scope one for American Airlines. These emissions are counted three times, which is anathema to any competent accounting system. Every scope-two or -three emission is someone else's scope-one emission.

Fortunately, such confusion is avoidable. If every company has reduced its scope-one emissions to zero, aggregate corporate emissions will be zero. It therefore makes sense for every company to focus only on this factor. If scope-one emissions are brought to zero, scope-two and scope-three emissions will



take care of themselves.

This should help to simplify the general policy guidance and instructions given to companies: Focus on reducing your scope-one emissions. Plan on phasing out offsets over the long run. And continue to look for opportunities to remove GHGs from the atmosphere, as these reductions can still be counted against your own scope-one emissions. – Project Syndicate

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# What green artificial intelligence needs



Long before the real-world effects of climate change became so abundantly obvious, the data painted a bleak picture – in painful detail – of the scale of the problem. For decades, carefully collected data on weather patterns and sea temperatures were fed into models that analysed, predicted, and explained the effects of human activities on our climate. And now that we know the alarming answer, one of the biggest questions we face in the next few decades is how data-driven approaches can be used to overcome the climate crisis.

Data and technologies like artificial intelligence (AI) are expected to play a very large role. But that will happen only if we make major changes in data management. We will need to

move away from the commercial proprietary models that currently predominate in large developed economies. While the digital world might seem like a climate-friendly world (it is better to Zoom to work than to drive there), digital and Internet activity already accounts for around 3.7% of total greenhouse-gas (GHG) emissions, which is about the same as air travel. In the United States, data centres account for around 2% of total electricity use.

The figures for AI are much worse. According to one estimate, the process of training a machine-learning algorithm emits a staggering 626,000lb (284,000kg) of carbon dioxide – five times the lifetime fuel use of the average car, and 60 times more than a transatlantic flight. With the rapid growth of AI, these emissions are expected to rise sharply. And Blockchain, the technology behind Bitcoin, is perhaps the worst offender of all. On its own, Bitcoin mining (the computing process used to verify transactions) leaves a carbon footprint roughly equivalent to that of New Zealand.

Fortunately, there are also many ways that AI can be used to cut CO2 emissions, with the biggest opportunities in buildings, electricity, transport, and farming. The electricity sector, which accounts for around one-third of GHG emissions, advanced the furthest. The relatively small cohort of big companies that dominate the sector have recognised that AI is particularly useful for optimising electricity grids, which have complex inputs – including the intermittent contribution of renewables like wind power – and complex usage patterns. Similarly, one of Google DeepMind's AI projects aims to improve the prediction of wind patterns and thus the usability of wind power, enabling "optimal hourly delivery commitments to the power grid a full day in advance."

Using similar techniques, AI can also help to anticipate vehicle traffic flows or bring greater precision to agricultural management, such as by predicting weather patterns or pest infestations.

But Big Tech itself has been slow to engage seriously with the climate crisis. For example, Apple, under pressure to keep

delivering new generations of iPhones or iPads, used to be notoriously uninterested in environmental issues, even though it – like other hardware firms – contributes heavily to the problem of e-waste. Facebook, too, was long silent on the issue, before creating an online Climate Science Information Center late last year. And until the launch of the \$10bn Bezos Earth Fund in 2020, Amazon and its leadership also was missing in action. These recent developments are welcome, but what took so long?

Big Tech's belated response reflects the deeper problem with using AI to help the world get to net-zero emissions. There is a wealth of data – the fuel that powers all AI systems – about what is happening in energy grids, buildings, and transportation systems, but it is almost all proprietary and jealously guarded within companies. To make the most of this critical resource – such as by training new generations of AI – these data sets will need to be opened up, standardised, and shared.

Work on this is already underway. The C40 Knowledge Hub offers an interactive dashboard to track global emissions; NGOs like Carbon Tracker use satellite data to map coal emissions; and the Icebreaker One project aims to help investors track the full carbon impact of their decisions. But these initiatives are still small-scale, fragmented, and limited by the data that are available.

Freeing up much more data ultimately will require an act of political will. With local or regional "data commons," AIs could be commissioned to help whole cities or countries cut their emissions. As a widely circulated 2019 paper by David Rolnick of the University of Pennsylvania and 21 other machine-learning experts demonstrates, there is no shortage of ideas for how this technology can be brought to bear.

But that brings us to a second major challenge: Who will own or govern these data and algorithms? Right now, no one has a good, complete answer. Over the next decade, we will need to devise new and different kinds of data trusts to curate and share data in a variety of contexts.

For example, in sectors like transport and energy, public-private partnerships (for example, to gather “smart-meter” data) are probably the best approach, whereas in areas like research, purely public bodies will be more appropriate. The lack of such institutions is one reason why so many “smart-city” projects fail. Whether it is Google’s Sidewalk Labs in Toronto or Replica in Portland, they are unable to persuade the public that they are trustworthy.

We will also need new rules of the road. One option is to make data sharing a default condition for securing an operating license. Private entities that provide electricity, oversee 5G networks, use city streets (such as ride-hailing companies), or seek local planning permission would be required to provide relevant data in a suitably standardised, anonymised, and machine-readable form.

These are just a few of the structural changes that are needed to get the tech sector on the right side of the fight against climate change. The failure to mobilise the power of AI reflects both the dominance of data-harvesting business models and a deep imbalance in our public institutional structures. The European Union, for example, has major financial agencies like the European Investment Bank but no comparable institutions that specialise in orchestrating the flow of data and knowledge. We have the International Monetary Fund and the World Bank, but no equivalent World Data Fund.

This problem is not insoluble. But first, it must be acknowledged and taken seriously. Perhaps then a tiny fraction of the massive financing being channelled into green investments will be directed toward funding the basic data and knowledge plumbing that we so urgently need. – Project Syndicate

- *Geoff Mulgan, a former chief executive of NESTA, is Professor of Collective Intelligence, Public Policy and Social Innovation at University College London and the author of Big Mind: How Collective Intelligence Can Change Our World.*

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# Clean Energy Has Won the Economic Race



For decades, spectacularly inaccurate forecasts have underestimated the potential of clean energy, buying time for the fossil-fuel industry. But as two new analyses from authoritative institutions show, renewables have already convinced the market and are now poised for exponential growth.

DENVER – For decades, we at the Rocky Mountain Institute (now RMI) have argued that the transition to clean energy will cost less and proceed faster than governments, firms, and many analysts expect. In recent years, this outlook has been fully vindicated: costs of renewables have consistently fallen faster than expected, while deployment has proceeded more rapidly than predicted, thereby reducing costs even further.

Thanks to this virtuous cycle, renewables have broken through. And now, new analyses from two authoritative research institutions have added to the mountain of data showing that a

rapid clean-energy transition is the least expensive path forward.

Policymakers, business leaders, and financial institutions urgently need to consider the promising implications of this development. With the United Nations Climate Change Conference (COP26) in Glasgow fast approaching, it is imperative that world leaders recognize that achieving the Paris climate agreement's 1.5° Celsius warming target is not about making sacrifices; it is about seizing opportunities. The negotiation process must be reframed so that it is less about burden-sharing and more about a lucrative race to deploy cleaner, cheaper energy technologies.

With the world already suffering from climate-driven extreme weather events, a rapid clean-energy transition also has the virtue of being the safest route ahead. If we fail at this historic task, we risk not only wasting trillions of dollars but also pushing civilization further down a dangerous and potentially catastrophic path of climate change.

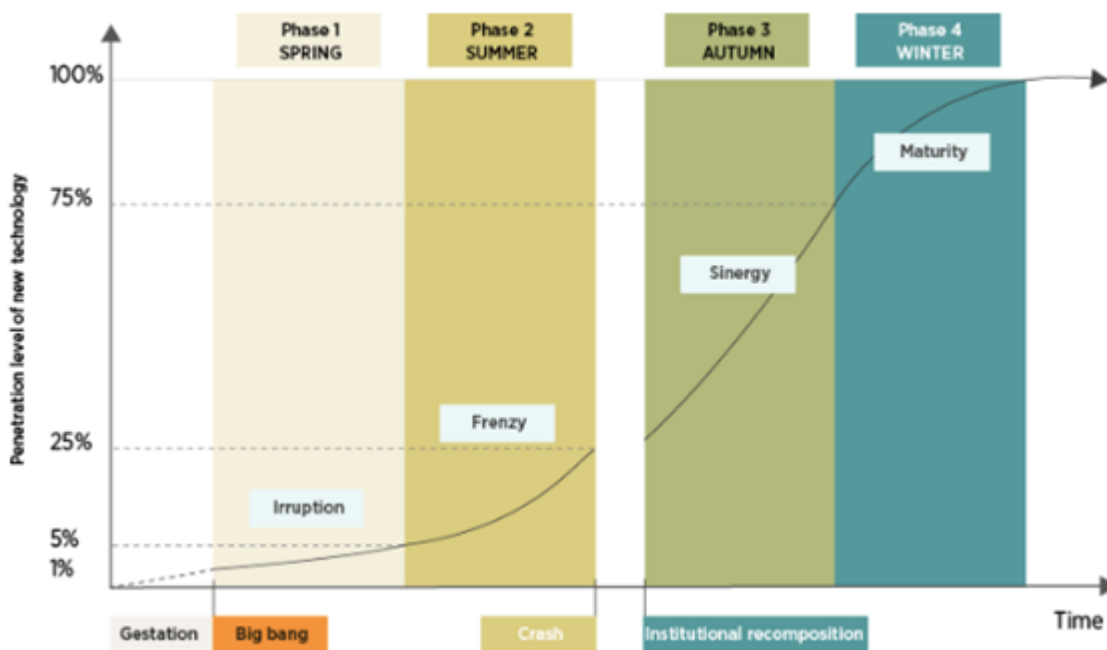
One can only guess why forecasters have, for decades, underestimated the falling costs and accelerating pace of deployment for renewables. But the results are clear: bad predictions have underwritten trillions of dollars of investment in energy infrastructure that is not only more expensive but also more damaging to human society and all life on the planet.

We now face what may be our last chance to correct for decades of missed opportunities. Either we will continue to waste trillions more on a system that is killing us, or we will move rapidly to the cheaper, cleaner, more advanced energy solutions of the future.

New studies have shed light on how a rapid clean-energy transition would work. In the International Renewable Energy Agency (IRENA) report *The Renewable Spring*, lead

author Kingsmill Bond shows that renewables are following the same exponential growth curve as past technology revolutions, hewing to predictable and well-understood patterns.

Accordingly, Bond notes that the energy transition will continue to attract capital and build its own momentum. But this process can and should be supported to ensure that it proceeds as quickly as possible. Policymakers who want to drive change must create an enabling environment for the optimal flow of capital. Bond clearly lays out the sequence of steps that this process entails.



Examining past energy revolutions reveals several important insights. First, capital is attracted to technological disruptions, and tends to flow to the areas of growth and opportunity associated with the start of these revolutions. As a result, once a new set of technologies passes its gestation period, capital becomes widely available. Second, financial markets draw forward change. As capital moves, it speeds up the process of change by allocating new capital to growth industries, and by withdrawing it from those in decline.

The current signals from financial markets show that we are in the first phase of a predictable energy transition, with spectacular outperformance by new energy sectors and the de-

rating of the fossil-fuel sector. This is the point where wise policymakers can step in to establish the necessary institutional framework to accelerate the energy transition and realize the economic benefits of building local clean-energy supply chains. As we can see from market trends highlighted in the IRENA report, the shift is already well underway.

**Figure 7:** Performance of clean energy and fossil energy stocks in 2020



Source: Carbon Tracker based on Carlota Perez

Reinforcing the findings from the IRENA report, a recent analysis from the Institute for New Economic Thinking (INET) at the Oxford Martin School shows that a rapid transition to clean energy solutions will save trillions of dollars, in addition to keeping the world aligned with the Paris agreement's 1.5°C goal. A slower deployment path would be financially costlier than a faster one and would incur significantly higher climate costs from avoidable disasters and deteriorating living conditions.

Owing to the power of exponential growth, an accelerated path for renewables is eminently achievable. The INET Oxford report finds that if the deployment of solar, wind, batteries, and hydrogen electrolyzers continues to follow exponential growth



trends for another decade, the world will be on track to achieve net-zero-emissions energy generation within 25 years.

In its own coverage of the report, *Bloomberg News* suggests as a “conservative estimate” that a rapid clean-energy transition would save \$26 trillion compared with continuing with today’s energy system. After all, the more solar and wind power we build, the greater the price reductions for those technologies.

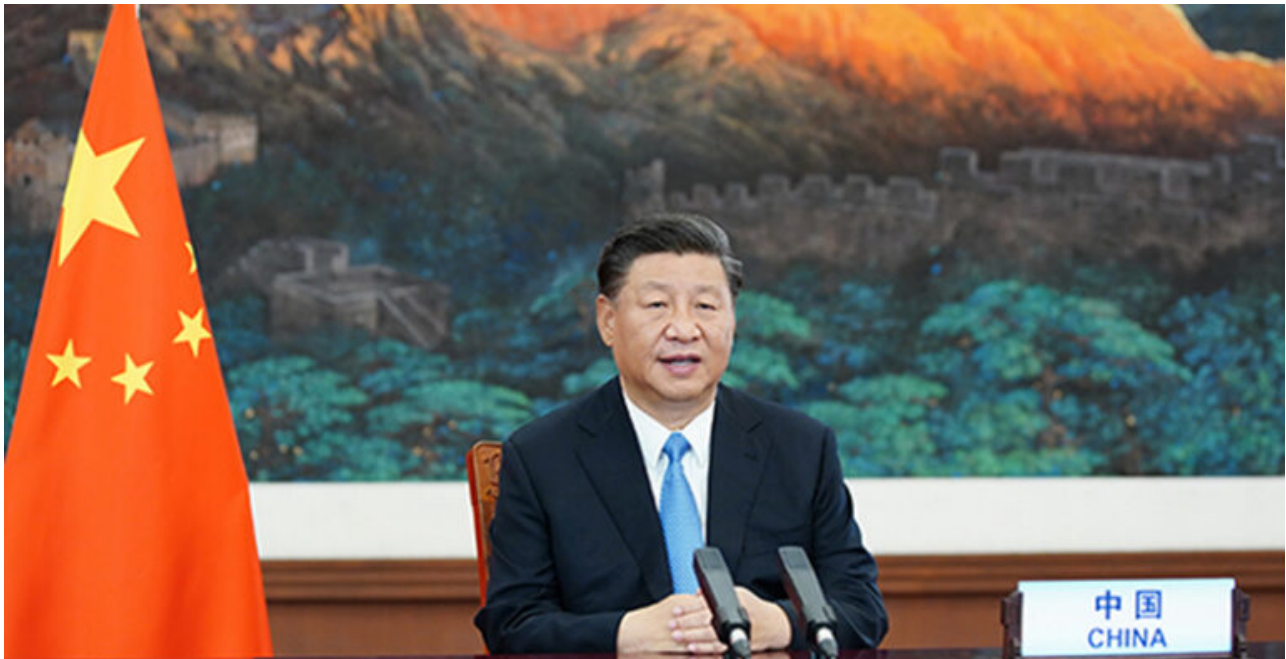
Moreover, in his own response to the INET Oxford study, Bill McKibben of 350.org points out that the cost of fossil fuels will not fall, and that any technological learning curve advantage for oil and gas will be offset by the fact that the world’s easy-access reserves have already been exploited. Hence, he warns that precisely because solar and wind will save consumers money, the fossil-fuel industry will continue to try to slow down the transition in order to mitigate its own losses.

We must not allow any further delay. As we approach COP26, it is essential that world leaders understand that we already have cleaner, cheaper energy solutions ready to deploy now. Hitting our 1.5°C target is not about making sacrifices; it is about seizing opportunities. If we get to work now, we can save trillions of dollars and avert the climate devastation that otherwise will be visited upon our children and grandchildren.

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## **How China Plans to Become**

# Carbon-Neutral by 2060



China's industrialization has occurred at a breathtaking pace, lifting hundreds of millions out of poverty and transforming the country into the world's factory floor. That's also made it the biggest emitter of carbon dioxide, the main greenhouse gas driving climate change. The most-populous nation has set itself the ambitious goal of becoming carbon-neutral by 2060, a challenging target given it hasn't even reached its emissions peak. To get there, President Xi Jinping wants to transition away from an economy reliant on coal and other fossil fuels by switching to renewable energy and developing new technology to capture emissions.

## 1. What is carbon neutral?

It means cutting as much of your carbon dioxide emissions as possible and then offsetting what you can't eliminate. For a country, this could mean switching to renewable energy such as solar power instead of coal and investing in projects that absorb carbon dioxide, such as reforestation. Carbon neutral has become a goal of companies and countries alike to address public concerns about the impact emissions have on the climate.

## **2. What is China's goal?**

Even though China is the world's second-largest economy, it's still classified as a developing nation and hasn't reached its emissions peak. That's forecast to come by 2030, with Xi committing to carbon neutrality by 2060, 10 years after the U.S. deadline set by President Joe Biden. If China pulls it off, it would be the fastest decline from peak emissions among major economies, speedier than Europe's goal of 70 years and the US target of 40 years. China's plan, which the country's climate envoy said includes all greenhouse gases and not just carbon dioxide, would boost global efforts to limit the rise in temperatures and potentially give it greater sway in global matters.

## **3. What needs to be done?**

China has to find replacements for the fossil fuels that have powered its economy and rapid urbanization. A key early step was taken in July when China opened the world's largest carbon trading market, creating a framework for how emissions are priced and regulated in the country. It's already pushing the expansion of electric vehicles and automation while investing in nuclear power, which doesn't emit greenhouse gases. There is more spending on research into technologies such as storage batteries and using hydrogen as a fuel to complement low-emissions energy sources. The government will have develop more wind and solar power projects so that coal-fired plants play a smaller role in generating electricity. Local authorities have been told to develop regional plans to lower emissions and some have already taken measures to curb what they perceive as wasteful uses of electricity, such as Bitcoin mining.

The ruling Communist Party of China has an overarching goal of creating a "great modern socialist country" to ensure a prosperous life for its citizens. That's a mantra that has required continuous economic growth and led to increased

pollution. Breaking the link between growth and emissions will require policies that take aim at fossil fuels and encourage development of renewable energy. Monetary policy will need to be adjusted if the transition causes inflationary pressure. Beijing will also need to support vulnerable sectors and regional economies during the decarbonization process. For example, the coal industry in Shanxi contributes 20% of the province's revenue, according to PingAn Securities chief economist Zhong Zhengsheng.

## **5. What will be the economic impact?**

Services and high-technology will have to boost their contribution to the economy, a move that could unleash investment demand of as much as 300 trillion yuan (\$46.3 trillion), according to the People's Bank of China. The central bank has said a big chunk of the funds will come from market investors but a policy framework encouraging private investment will be important. That is in addition to cleaner air, improved road safety and prevention of potential climate damage that the World Bank said could be worth 3.5% of gross domestic product by 2030. Such benefits have to be weighed against the impact on ordinary Chinese people of an economic restructuring that phases out jobs in carbon-emitting sectors, with the coal mining and processing industry employing 3.5 million workers alone.

## **6. Who are the biggest losers?**

China's 2,200 electricity utilities powered by fossil fuels, a group that accounts for almost half of the carbon China spews into the atmosphere and 14% of the world's total, are among the first to feel the impact through the country's carbon market. Power is one of the eight industries that account for nearly 90% of its carbon emissions, a group that also includes steel, construction materials and transport, according to a report by China International Capital Corp. Eliminating their dependence on fossil fuels will require a move to cleaner

sources such as wind and solar and spending on mitigation measures or carbon offsets. Regional Chinese economies that rely heavily on fossil fuel production, such as Shanxi and Inner Mongolia provinces, will also be affected.

## **7. Who stands to benefit?**

Electric-vehicle makers are one of the high-profile beneficiaries of China's plan thanks to government subsidies. Beijing has set a target of having new-energy vehicles account for 20% of sales by 2025 compared with 6% in 2020. Utilities that make the shift to renewable sources will also benefit, along with providers of services such as emission measurement and carbon trading, according to Nannan Kou, head of China research for BloombergNEF. Other winners could include makers of photovoltaic systems, recycling firms and producers of new materials and non-ferrous metals for electric vehicle assembly.

## **8. What role will the central bank play?**

China's goal of carbon neutrality is shared across China's key institutions and is a top priority for the PBOC. The central bank removed so-called clean-coal projects from its definitions of green bonds while pledging to revamp tools so it can offer cheap funds for banks to encourage more environmentally focused loans. Regulators also plan to adjust the rules on capital adequacy and how it counts green assets. At the end of March, China's outstanding green loans stood at 14 trillion yuan, an amount set to expand at a rapid pace.

## **9. Will private banks play a role?**

Banks will need to change who they lend to and balance how their loans mesh with Beijing's climate ambitions. The high capital cost of building power plants, steel mills and factories mean companies in those sectors often carry significant financing needs and any rapid change could affect their ability to manage credit risks, according to Zhou

Xuedong, executive vice president at National Development Bank and a former senior PBOC official. He said a climate-change stress test for financial institutions will be necessary.

*This story has been published from a wire agency feed without modifications to the text.*

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## The promise of 'green' hydrogen



By Thomas Koch Blank/ Stockholm

While we already have mature technologies that can replace fossil fuels in many parts of our economy, there are areas where eliminating carbon pollution will be much more difficult. Steel, shipping, aviation, and trucking, for example, account for a combined 40% of our global carbon footprint and are on track to consume two times the remaining carbon budget for staying below 1.5C of warming.

Fortunately, “green” hydrogen – H<sub>2</sub> produced through electrolysis using renewable energy – holds enormous promise for these sectors. Through various applications, this tiny molecule can provide the heat, reduction properties, fuel, and other services needed to replace fossil fuels. In fact, given the technical challenge of getting these “hard-to-abate” sectors to a state of carbon neutrality, hitting 2050 net-zero targets without it would be virtually impossible.

H<sub>2</sub> uptake can serve other objectives beyond decarbonisation. For example, hydrogen’s ability to substitute for natural gas in many applications allows for a degree of energy independence and reduced reliance on liquefied natural gas or pipeline imports from Russia. And while renewables like solar and wind are limited by the extent of electrical grids, hydrogen can be transported by pipeline or potentially by ship. That means it could become an exportable renewable-energy source, eventually replacing petroleum as the main global energy commodity.

H<sub>2</sub> uptake is starting from vastly differing points, depending on the market. In Europe and Southeast Asia, political and market incentives are already fully aligned for the deployment of H<sub>2</sub> infrastructure. But in large oil- and gas-exporting economies, the incentives are often conflicting. Notably, there is significant misalignment in the United States, where natural gas fulfils all the political priorities that hydrogen can provide for other markets.

As a crucial element in achieving 2050 net-zero targets, hydrogen production, storage, and transport represents a multi-trillion-dollar opportunity, not only for energy incumbents but also for investors. While hydrogen is currently more expensive (per unit of energy delivered) than competing options such as fossil fuels, the scaling up of electrolyser production is driving down costs. Within the next decade, we can expect H<sub>2</sub> to reach break-even points with fossil fuels across different applications, after which hydrogen uptake will bring cost savings.

Green hydrogen is particularly attractive for developing

economies. There is a strong geographical overlap between countries and regions with the lowest production cost for renewable energy and those with lower per capita GDP. These countries thus could secure a global competitive advantage by becoming hydrogen producers and exporters. Doing so would also help them attract zero-carbon heavy industry, such as fertiliser manufacturing or hydrogen-based direct reduction steelmaking. And, of course, the development of these sectors would lead to significant job creation.

H<sub>2</sub> is also attractive for wealthy industrialised countries, which currently lead the world in the manufacture of hydrogen electrolyzers. However, if the recent history of the photovoltaic (solar panel) industry is any guide, wealthy countries may need stronger industrial policies to ensure that production does not migrate to China and other regions.

There is more work to do before hydrogen can realise its full decarbonisation potential. As matters stand, green hydrogen represents a very small portion of existing hydrogen production. Instead, most hydrogen is “gray,” because it is made using fossil fuels through a steam methane reforming (SMR) process. Though there is potential to capture and store some of the associated carbon dioxide emissions to make a slightly cleaner fossil-based “blue” hydrogen, this option would not be emissions-free. H<sub>2</sub> therefore has a complex CO<sub>2</sub> footprint, for now.

Furthermore, for hydrogen to deliver on its promise, the decarbonisation of electric grids must happen in parallel. But as with electric vehicles (EVs), we cannot wait for a 100% clean grid to begin deploying electrolyzers; we must start now.

This is not as financially risky as it sounds. There will undeniably be a threshold where green hydrogen becomes the lowest-cost source of hydrogen generally. Notably, the US Department of Energy’s recently announced goal of reducing the cost of “clean hydrogen” to \$1 per kilogram is nearly impossible to achieve with hydrogen produced through the SMR process at sustainable price levels for natural gas. That



means US policy is already aligned behind green hydrogen. Nonetheless, using green hydrogen to decarbonise heavy industry will demand a truly awesome amount of electricity. Producing the necessary volume of hydrogen would almost double total current global electricity generation. The only way to meet this demand is to build renewable energy even faster. That, in turn, will lead to critical infrastructure-design questions, such as whether to prioritise H2 pipelines or power lines. And the growth of this sector will have many regulatory implications. To ensure a rapid build-out of hydrogen infrastructure, it will be important to enable monetisation, create rate structures to encourage capital-expenditure deferral, and provide system-wide planning across infrastructure types.

Equally, a move to H2 will accelerate the obsolescence of many fossil fuel-based assets. For these large volumes of stranded assets not to produce negative side effects, they will need to be repurposed or helped into early retirement with various financial incentives.

One high-potential area for repurposing infrastructure is in natural-gas pipeline networks, which, in some cases, can be retrofitted to allow for hydrogen transport. Some thermal power plants can also potentially be repurposed; but, here, the end-to-end efficiency of power-to-hydrogen-to-power is low, so the profitable use cases are limited. For the steel industry, the picture is grimmer, as existing blast furnace capacity may need to be replaced with direct reduction. Similarly, gasoline and diesel fuelling infrastructure will need to be replaced. But the future of such infrastructure is already in doubt, owing to the growing market for battery EVs. Hydrogen brings enormous opportunities but also a daunting scaling challenge. Globally, the industry currently has the capacity to produce only around one gigawatt of hydrogen electrolysers each year, whereas, according to the International Energy Agency's analysis on what a 1.5C pathway requires, green hydrogen production will need to grow 1,000-fold from today to 2030.

There are actions that can and must be taken to meet this challenge. First, we need policies to ensure stable demand at scale, so that electrolysis makers can leap-frog into industrialised manufacturing. Second, governments must provide subsidies to cover the initial “green premium” until learning-curve effects take over. And, finally, we must address the tension between current asset locations and the places with the lowest-cost clean-sheet footprint for decarbonised industries.

Backed by direct and indirect political priorities, hydrogen markets have already gained momentum and crossed the point of no return. As such, they are quickly bringing cleaner industry and a decarbonised economy within striking distance. – Project Syndicate

- Thomas Koch Blank is Senior Principal of Breakthrough Technologies at RMI.

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## **Why an Electric Car Battery Is So Expensive, For Now**



At Tesla Inc.'s ballyhooed Battery Day event last year, CEO Elon Musk set himself an ambitious target: to produce a \$25,000 electric vehicle by 2023. Hitting that sticker price – about \$15,000 cheaper than the company's least expensive model today – is seen as critical to deliver a true, mass-market product. Getting there means finding new savings on technology – most critically the batteries that can make up a third of an EV's cost – without compromising safety. Alongside Musk, traditional automaking giants including Toyota Motor Co. and Volkswagen AG are pouring tens of billions of dollars into the race.

## **1. Why are EV batteries so expensive?**

Largely because of what goes in them. An EV uses the same rechargeable lithium-ion batteries that are in your laptop or mobile phone, they're just much bigger – cells grouped in packs resembling big suitcases – to enable them to deliver far more energy. The priciest component in each battery cell is the cathode, one of the two electrodes that store and release electricity. The materials needed in cathodes to pack in more energy are often expensive: metals like cobalt, nickel,

lithium and manganese. They need to be mined, processed and converted into high-purity chemical compounds.

## **2. How much are we talking?**

At current rates and pack sizes, the average battery cost for a typical EV works out to about \$6,300. Battery pack prices have come down a lot – 89% over the past decade, according to BloombergNEF. But the industry average price of \$137 per kilowatt hour (from about \$1,191 in 2010) is still above the \$100 threshold at which the cost should match a car with an internal-combustion engine. Costs aren't expected to keep falling as quickly, and rising raw materials prices haven't helped. Still, lithium-ion packs are on track to drop to \$92 per kWh by 2024, according to BNEF forecasts, and \$58 per kWh by 2030.

## **Greedy for Gigawatts**

EVs are going to be the driving force for lithium-ion battery demand

Source: BloombergNEF Long-Term Electric Vehicle Outlook, June 2021

## **3. How will the batteries get cheaper?**

A major focus for manufacturers is on the priciest commodities, and particularly cobalt. One option is to substitute the metal with nickel, which is cheaper and holds more energy. Doing so requires safety adjustments, however, as cobalt's advantage is that it doesn't overheat or catch fire easily. Another move has been to use alternatives that don't contain cobalt at all, like low-cost lithium iron phosphate cells, once derided for poorer performance but winning a revival as design changes deliver improvements. Simplifying

battery pack design, and using a standard product for a range of vehicles – rather than a pack tailored to each model – will deliver additional savings.

## **4. What about fire risks?**

Lithium-ion batteries, whether used in grid-sized storage facilities, cars or devices like smartphones, can catch fire if they've been manufactured poorly, damaged in an accident, or the software that runs them hasn't been designed properly. Incidents remain rare, but garner huge scrutiny in what remains a developing sector. A decision in August by General Motors Co. to carry out a \$1.8 billion recall of more than 100,000 Chevrolet Bolt models as a result of battery defects underscored the seriousness. Blazes or overheating incidents this year also impacted major energy storage projects in Australia and California. And the fires aren't easy to extinguish; it took firefighters four hours and took more than 30,000 gallons (113,560 liters) of water to douse a Tesla Model S after a fatal crash in Texas. Tesla insists that incidents involving electric models garner undue attention. According to its 2020 Impact Report, cars with internal-combustion engines (ICE) catch fire at a "vastly" higher rate. From 2012 to 2020 there was about one Tesla fire for every 205 million miles (330 million kilometers) traveled, compared to a fire every 19 million miles for ICE vehicles, the EV pioneer said.

## **5. Who are the biggest manufacturers?**

Asia dominates manufacturing of lithium-ion cells, accounting for more than 80% of existing capacity. The Chinese company Contemporary Amperex Technology Co. Ltd. (CATL) shipped the highest volume in 2020, capturing almost a quarter of the market. By September this year it had extended its lead to 30%, followed by South Korea-based LG Energy Solution and Japan's Panasonic Corp. Tesla and Panasonic's joint venture is

the biggest battery producer in the U.S. Emerging producers include Northvolt AB in Sweden, founded by former Tesla executives, and Gotion High-tech Co. in China.

## **6. Are the batteries all the same?**

They have the same basic components: two electrodes – a cathode and an anode – and an electrolyte that helps shuttle the charge between them. But there are differences in the materials used, and that's key to the amount of energy they hold. Grid-storage systems or vehicles traveling short distances can use cheaper and less powerful cathode chemistry that combines lithium, iron and phosphate. For higher-performance vehicles, automakers favor more energy-dense materials, such as lithium-nickel-manganese-cobalt oxide or lithium-nickel-cobalt-aluminum oxide. Further refinements are seeking to improve range – how far a vehicle can travel before recharging – as well as charging speed.

## **7. So China's in pole position?**

Yes, in almost every aspect. China is responsible for about 80% of the chemical refining that converts lithium, cobalt and other raw materials into battery ingredients, though the metals themselves are largely mined in Australia, the Democratic Republic of Congo and Chile. China also dominates processing capacity across four key battery components (cathodes, anodes, electrolyte solutions and separators), with more than half of the world's commissioned capacity for each, BNEF data shows. The nation faces a challenge when it comes to advanced semiconductor design and software, components that are increasingly important as cars become more intelligent. Less than 5% of automotive chips are made in China, according to the China Association of Automobile Manufacturers.

## **8. Is cost the only hurdle?**

There's still an issue with driving range. While the most-expensive EVs can travel 400 miles or more before a top up, consumers considering mainstream models remain anxious about how often they'll need to recharge. Automakers and governments have become directly involved in the roll-out of public recharging infrastructure for drivers on the road. However, most recharging is expected to take place at home, and that means another cost for consumers. While the average price of a home-charging kit has fallen 18% since 2017 to about \$650, some top-of-the-line bi-directional chargers (which let you send energy from the vehicle to the home or grid), cost more than \$6,000. Installation costs in the U.S. can run from as little as \$400 to more than \$3,300.

## **9. What's around the corner?**

Most keenly anticipated is the arrival of solid-state batteries, which promise a huge performance upgrade by replacing the flammable liquids that enable charging and discharging with ceramic, glass or polymers. QuantumScape Corp. says it has innovations in that field to increase a car's range by as much as 50% and the technology could be deployed in vehicles at dealerships as soon as 2026. Another industry focus is modifying anodes – typically made using graphite – to add more silicon, or by using lithium metal. That would likely make it viable to power smaller aircraft. Storing renewable power with utility-scale batteries for days or weeks, rather than hours at present, is also a key challenge. Form Energy Inc. is developing iron-air batteries that it says could enable entirely carbon-free grids. CATL and others are also working on plans to substitute lithium, or combine it with, far cheaper sodium-ion technology for some niche applications.

## The Reference Shelf

- Electric vehicle sales should increase sharply in the next few years and account for 16% of regular car sales by 2025, BNEF forecasts.
- These are the Nobel Prize winning scientists who pioneered the lithium-ion battery.
- Bloomberg News examines how the U.S. is falling behind as the EV battery soars.
- More QuickTakes on the road to driverless cars, the broader trend toward electrification, greener hydrogen and electric airplanes.
- Bloomberg Opinion's Anjani Trivedi explains how new power packs will require new supply chains.
- Bill Gates discusses the electrification of transportation in this blog post.
- A TOPLive Q&A with Carnegie Mellon University professor Venkat Viswanathan on the future of batteries.

– *With assistance by Chunying Zhang*

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**Environmental threats are the  
'greatest challenge to human  
rights': UN**





## United Nations

The UN rights chief has said the “triple planetary crises” of climate change, pollution, and nature loss represented the biggest threat to human rights globally, at the opening yesterday of a month-long session set to prioritise environmental issues.

“The interlinked crises of pollution, climate change and biodiversity act as threat multipliers, amplifying conflicts, tensions and structural inequalities, and forcing people into increasingly vulnerable situations,” Michelle Bachelet told the opening of the 48th session of the UN Human Rights Council in Geneva.

“As these environmental threats intensify, they will constitute the single greatest challenge to human rights of our era,” she added.

The former Chilean president said the threats were already “directly and severely impacting a broad range of rights, including the rights to adequate food, water, education, housing, health, development, and even life itself”.

She said environmental damage usually hurt the poorest people and nations the most, as they often have the least capacity to respond.

Bachelet referred to recent “extreme and murderous” climate events such as floods in Germany and California’s wildfires.

She also said drought was potentially forcing millions of people into misery, hunger and displacement.

Bachelet said that addressing the environmental crisis was “a humanitarian imperative, a human rights imperative, a peace-building imperative and a development imperative. It is also doable”.

She said spending to revive economies in the wake of the coronavirus (Covid-19) pandemic could be focused on environmentally-friendly projects, but “this is a shift that unfortunately is not being consistently and robustly undertaken”.

She also said that countries had “consistently failed to fund and implement” commitments made under the Paris climate accords.

“We must set the bar higher – indeed, our common future depends on it,” she added.

Her remarks come at the opening session of the September 13 to October 8 session of the Human Rights Council, where climate change themes were expected to be central, alongside debates on alleged rights violations in Afghanistan, Myanmar, and Tigray, Ethiopia.

In the same speech, she voiced alarm at attacks on indigenous people in Brazil by illegal miners in the Amazon.

Geneva-based diplomats told Reuters that two new resolutions on the environment were expected, including one that would create a new Special Rapporteur on Climate Change and another that would create a new right to a safe, clean, healthy and sustainable environment.

Yesterday Germany’s Foreign Minister Heiko Maas voiced support for the first idea, which has not yet been formally submitted in draft form.

“Climate change affects virtually all human rights,” he said.

Marc Limon of the Universal Rights Group think-tank said the Council’s recognition of the right to a healthy environment would be “good news”.

“It would empower individuals to protect the environment and fight climate change,” he said.

During her address, Bachelet said that at the 12-day COP26 climate talks in Glasgow, set to begin on October 31, her office would push for more ambitious, rights-based commitments.

She added that in many regions, environmental human rights defenders were threatened, harassed and killed, often with complete impunity.

She said economic shifts triggered by the Covid-19 pandemic had apparently prompted increased exploitation of mineral resources, forests and land, with indigenous peoples particularly at risk.

“In Brazil, I am alarmed by recent attacks against members of the Yanomami and Munduruku peoples by illegal miners in the Amazon,” she said.

In her opening global update, Bachelet touched on the human rights situations in several countries, including Chad, the Central African Republic, Haiti, India, Mali and Tunisia.

On China, she said no progress had been made in her years-long efforts to seek “meaningful access” to Xinjiang.

“In the meantime, my office is finalising its assessment of the available information on allegations of serious human rights violations in that region, with a view to making it public,” she said.

Rights groups believe at least 1mn Uyghurs and other mostly Muslim minorities have been incarcerated in camps in the northwestern region, where China is also accused of forcibly sterilising women and imposing forced labour.

Beijing has strongly denied the allegations and says training programmes, work schemes and better education have helped stamp out extremism in the region.

Decisions made by the Council’s 47 members are not legally binding but carry political weight.

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# The Reality of Climate Financial Risk



Those who argue that climate change has little to do with macroprudential risk management are offering a counsel of despair. If the 2008 global financial crisis revealed anything, it is that regulation matters, even if it isn't always politically popular or easily optimized.

LAUSANNE, SWITZERLAND – In a recent commentary, John H. Cochrane, a senior fellow at the Hoover Institution, argues that “climate financial risk” is a fallacy. His eye-catching premise is that climate change doesn't pose a threat to the global financial system, because it – and the phase-out of fossil fuels that is needed to address it – are developments that everyone already knows are underway. He sees climate-related financial regulation as a Trojan horse for an otherwise unpopular political agenda.

We disagree. For starters, one should acknowledge the context in which regulation emerges. With respect to climate policy, the Intergovernmental Panel on Climate Change has set the stage with its sixth assessment report, which concludes with a high degree of certainty that the Earth's climate is changing,

and that human activities are the cause. Ecologist William Ripple, the co-author of another recent study of planetary “vital signs,” goes further: “There is growing evidence we are getting close to or have already gone beyond tipping points associated with important parts of the Earth system.”

Unlike the 2008 global financial crisis – when banks that took excessive risks were bailed out, and global financial regulation was overhauled in light of our new understanding about interdependent financial markets – unmitigated climate change will lead to a crisis with irreversible outcomes.

The question, as Cochrane puts it, is whether climate-related financial regulation can do anything to help us avoid such outcomes. Although the answer is complex and currently incomplete, we would argue that it can. Financial regulation to mitigate climate risk is indeed worth pursuing, because the stakes are too high to let the perfect become the enemy of the good.

Consider some of the arguments about systemic financial risk and extreme climate events. First, we are told that the risk of “stranded assets” – particularly fossil-fuel assets – will become a fact of life, to be borne only by investors. Here, Cochrane points out, correctly, that fossil-fuel investments have always been risky. But can we reasonably say that the prevalence of this energy source should be left to market players alone, or that only investors will bear the costs?

Though per capita fossil-fuel consumption in countries such as the United States and the United Kingdom has declined since 1990, total consumption has grown dramatically elsewhere, rising by 50% globally over the last 40 years. In 2020, China and India were the planet’s two largest coal-energy producers, relying on coal for 61% and 71% of their electricity, respectively. Their economies, and those of many other developing countries, simply would not sustain a precipitous reduction in fossil-fuel energy.

Cochrane also suggests that there is no scientifically validated possibility that extreme climate events will cause systemic financial crises over the next decade, and that regulators are therefore stymied from assessing the risks on financial institutions' balance sheets over a five- or ten-year horizon. But the sheer scale of the challenge should make us reconsider the temporal dimensions of regulation.

If temperature increases are to be kept within 2° Celsius of pre-industrial levels this century, about 80% of all coal, one-third of all oil, and half of all gas reserves must be left unburned. All of the Arctic's oil and the remainder of Canada's oil sands – the world's largest deposit of crude oil – must be left in the ground, starting almost immediately.

Finally, it is said that the technocratic regulation of climate investments cannot protect us against un-modeled tipping points. But this view simply ignores the extensive literature in climate economics. In this field, the work of Nobel laureate economist William Nordhaus is widely referenced. His Dynamic Integrated Climate-Economy (DICE) model has influenced many scientists' and economists' own modeling of tipping points, and the US government already relies on these "integrated assessment models" to formulate policy and calculate the "social cost of carbon."

This interdependency between economics, policy, politics, public opinion, and regulation should be familiar from the crash of 2008. The dangerous over-leveraging that generated that crisis was an open secret; but those in a position, politically and culturally, to do something about it were willing to deny the systemic risk it posed. One can find the same denialism in the climate debate. According to the Center for American Progress, 139 members of the current US Congress (109 representatives and 30 senators; a majority of the Republican caucus) "have made recent statements casting doubt on the clear, established scientific consensus that the world is warming – and that human activity is to blame."

Cochrane makes an eloquent case for why policymakers should focus on creating coherent, scientifically valid policy responses to climate change and financial systemic risk separately, rather than pursuing climate financial regulation. But this isn't an either/or choice. We need both kinds of policies, and we need coordination between the two domains.

We therefore should welcome the approach being taken by US Secretary of the Treasury Janet Yellen's Financial Stability Oversight Council, which has brought together leading regulators and tasked them with preventing a repeat of the 2008 Wall Street meltdown. Yellen has said she will use this multi-regulator body as her principal tool to assess climate risks and develop the disclosure policies needed to shift to a low-carbon economy.

Counterintuitive though it may be, climate-related financial regulation could usher in a new form of political accountability, by putting governments and individuals (elected and unelected) on the hook for their decisions. Such accountability was notably absent before and during the 2008 crisis. With political will, serious thinking about regulating climate financial risk could open up a fruitful debate for similar action on all neglected policy fronts.

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**Surging wind industry faces  
its own green dilemma:  
landfills**



### **Siemens launches first recyclable wind turbine blade**

- **Anti-wind groups use dumping of blades as rallying issue**
- **Industry calls for EU landfill ban**

Wind turbines have become a vital source of global green energy but their makers increasingly face an environmental conundrum of their own: how to recycle them.

The European Union's share of electricity from wind power has grown from less than 1% in 2000, when the continent began to curb planet-heating fossil fuels, to more than 16% today.

As the first wave of windmills reach the end of their lives, tens of thousands of blades are being stacked and buried in landfill sites where they will take centuries to decompose.

Spanish turbine maker Siemens Gamesa this week launched what it called a "game changer" – the first recyclable blades, which use a technology that allows their carbon and glass fibres to be reused in products like screen monitors or car parts.

"We have reached a major milestone in a society that puts care for the environment at its heart," said Andreas Nauen, chief executive of Siemens Gamesa, which expects the blades to become the industry standard.

Europe is the world's second largest producer of wind-



generated electricity, making up about 30% of the global capacity, compared to China's 39%, according to the Global Wind Energy Council, an industry trade association.

Wind Europe, a Brussels-based trade association which promotes the use of wind power in Europe, expects 52,000 blades a year to need disposal by 2030, up from about 1,000 today.

"The public want to be reassured that wind energy is fully sustainable and fully circular," said WindEurope's chief executive, Giles Dickson, describing Siemens Gamesa's new recyclable blade as a "significant breakthrough".

While wind turbine blades are not especially toxic, the resulting landfill, if improperly handled, may contribute to dangerous environmental impacts, including the pollution of land and waterways.

All forms of energy have some environmental cost but renewables, almost by definition, cause less damage to the planet, said Martin Gerhardt, Siemens Gamesa's offshore wind chief.

"If you look at oil wells and the spills or if you consider methane leaks, compared to the fossil industries, wind is the lesser problem," he said.

Wind power is one of the cleanest forms of energy, with a carbon footprint 99% lower than coal and 75% less than solar, according to a study by Bernstein Research, a US-based research and brokerage firm.

Its emissions come mainly from the production of iron and steel used in turbines and concrete for windmill foundations.

If these were mitigated by techniques such as carbon capture and storage – where carbon dioxide is buried underground – "you'd be able to cut out the carbon footprint completely," said Deepa Venkateswaran, the study's author.

The growing mountains of waste created by old blades has become a rallying point for groups opposed to wind turbines, which they also say are noisy and spoil the countryside.

But landfill is likely to remain the preferred disposal option because it is the cheapest, said Eric Waeyenbergh, advocacy manager at Geocycle, a sustainable waste management firm.

“If you just throw it in the landfill, this is the cheapest price you can have when you’re dismantling the windmill. And that’s a problem because there’s no mandatory recycling or recovery obligation,” he said.

Geocycle and WindEurope are lobbying for landfills to be banned across Europe where only four countries – Austria, Germany, the Netherlands and Finland – have outlawed the landfilling of composite materials, such as wind turbine blades.

Geocycle co-runs a cement kiln in Germany, with building industry giant Lafarge, which is partly fuelled by burning thousands of tonnes of old wind turbines, which create less carbon dioxide than fossil fuels.

Recyclable blades can also be ground up for use in products such as rearview car mirrors and insulation panels, or heat-treated to create materials for roof light panels and gutters. However, industry groups say these techniques are not currently available at commercial scale or at a price that would make them viable alternatives to landfill.

David Romero Vindel, co-founder of Reciclalia, which cuts and shreds turbine blades for recycling as carbon fibre yarn and fabric, said a landfill ban would help his firm.

“We need the EU to push the sector in this direction of recycling,” he said.

Vivian Loonela, a spokeswoman for the European Commission said it will review its landfill policies in 2024.

“The recycling of (windmill) composite fraction remains a challenge due to the low value of the recycled product and the relatively small amount of waste (produced), which does not stimulate the recycling markets,” she said.

– Thomson Reuters Foundation