



FINANCE AND DEVELOPMENT

SEPTEMBER 2021

Our Last,
Best Chance on
Climate P.6

Economics
Nature's Way P.16

A Path to Zero P.58

No Time to Waste

Contents



The climate crisis is too important to let our goals turn into failed promises.

THE CLIMATE ISSUE

4 No Time to Waste

Kristalina Georgieva

6 Our Last, Best Chance on Climate

The COP26 meeting in Glasgow may usher in a new era of sustainable development

Amar Bhattacharya and Nicholas Stern

10 Five Things to Know about Carbon Pricing

Carbon pricing shows serious promise as a tool in the fight against climate change

Ian Parry

12 Driving Deep Decarbonization

As green energy costs drop, we should shift the emphasis from economy-wide carbon pricing to sectoral policies

James H. Stock

16 Economics Nature's Way

Good economics demands that we manage Nature better

Partha Dasgupta

23 Fighting Climate Change with Innovation

Innovation has brought us to an inflection point; the coming decade will be decisive

Kelly Levin and Andrew Steer

26 Climate Cooperation

Working with its members, the IMF is managing the risks and opportunities of climate change

Eddie Buckley

28 Chimpanzee Politics and Climate Change

The animal kingdom can teach us important lessons about ourselves and increase cooperation to fight climate change

Ruchir Agarwal



ALSO IN THIS ISSUE

20 Clean and Green Finance

A new sustainable financial system can secure a net zero future for the world
Mark Carney

38 Building Back Better

Finland and Dominica pursue innovative ways of coping with climate change
Steven Dorst

41 Walking the Talk

Climate activists share candid advice for top COP officials
Vanessa Nakate, Vladislav Kaim, Ernest Gibson

48 Asia's Climate Emergency

Fiscal policy can help address climate change in Asia, the region hit hardest by global warming
Era Dabla-Norris, James Daniel, and Masahiro Nozaki

53 Climate Change and Monetary Policy

Central banks must do their part in fighting global warming
Isabel Schnabel

56 Investing in a Sustainable Future

Private sector financing can play a pivotal role in amplifying the effects of government climate policies
Valerie Smith

58 A Path to Zero

Reaching net zero emissions is achievable with comprehensive policy action
Christoph Bertram, Ottmar Edenhofer, and Gunnar Luderer

62 Powering Growth

African countries are embracing renewables to accelerate energy access
Benson Ireri and Rebekah Shirley

62



DEPARTMENTS

32 People in Economics**Climate Economist**

Bob Simison profiles Berkeley's **Solomon Hsiang**

36 In the Trenches**No Higher Ground**

For Maldives Environment Minister **Aminath Shauna**, fighting climate change is an existential battle

44 Picture This**Net Zero by 2050**

The IEA outlines a path to decarbonize the energy sector in three decades

46 Back to Basics**What Is Mitigation vs Adaptation?**

The world faces a two-front battle to halt global warming and address the effects of climate change
Adam Behsudi

65 Book Reviews

Monetary Policy in Times of Crisis, Massimo Rostagno and others

Three Days at Camp David, Jeffrey E. Garten
Cogs and Monsters, Diane Coyle

68 Currency Notes**Cleaning Up Crypto**

Bitcoin's carbon footprint is again making headlines
Analisa R. Bala



32



The Climate Issue

IN ERNEST HEMINGWAY'S NOVEL *The Sun Also Rises*, a character is asked how he went bankrupt. "Two ways," he answers. "Gradually, then suddenly."

It's the same with climate change. The damage is becoming less gradual, and unless we take action, the world could suddenly reach an irreversible tipping point.

We now know the problem is much worse than we once thought. It requires not incremental change, but radical overhaul—roughly halving carbon emissions each decade through 2050. Getting there demands a rapid shift to renewables, new electricity networks, greater energy efficiency, and low-carbon transportation. Cheaper renewable energy and technology advances make the move from carbon affordable and feasible.

This special issue on climate, in partnership with the UN Climate Change Conference (COP26), brings together a diverse range of voices from academics, policymakers, the private sector, and youth activists. It focuses on the urgent need for climate action and for different, mutually supportive climate policies. Contributors, including Amar Bhattacharya and Nicholas Stern, identify concrete solutions that can generate massive opportunities for jobs and growth, driven by stepped-up infrastructure investment and technological innovation and supported by a dynamic private sector. The IMF's Kristalina Georgieva recommends credible carbon pricing policies to encourage the use of green energy, while James Stock advocates a shift to sector-specific policies, such as low-carbon aviation fuel.

No transition is easy. It will require compensating the workers and businesses that bear the cost of a green transition. It means breaking down political economy impediments to rapid progress. It depends on collaboration by citizens, governments, corporations, financial institutions, philanthropists, and the scientific community. Perhaps most important, it will require that world leaders expand their ambition and action, including mobilizing finance to help developing economies adapt to climate shocks.

There is a path forward in what can become the inclusive growth story of the 21st century. If we rally to reverse the climate threat, then we may suddenly have a net zero world in reach. **FD**

GITA BHATT, editor-in-chief



ON THE COVER

Our September 2021 cover features "Climate Change Is Real" by young Malaysian artist Nor Tijan Firdaus. Composed of discarded electronic components, Firdaus's work starkly reminds us how human activities are affecting the environment.



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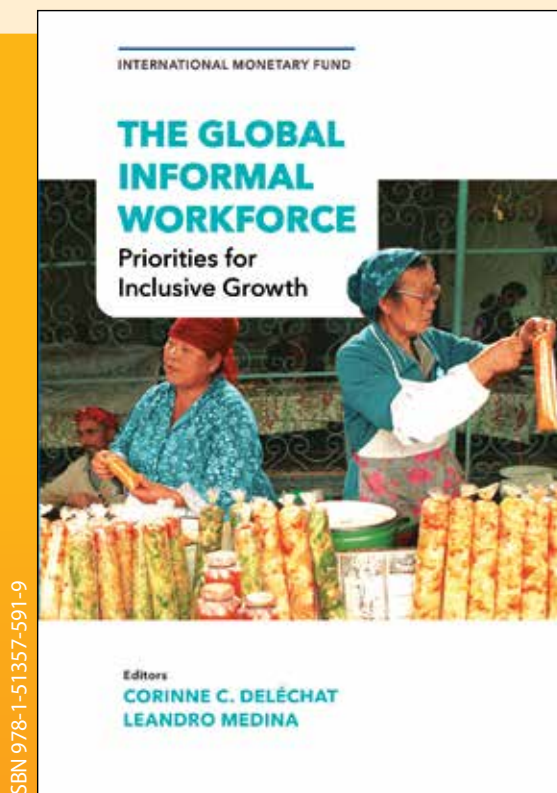
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I N T E R N A T I O N A L M O N E T A R Y F U N D



NO TIME

Kristalina Georgieva

Art can connect us with what we know and it can inspire us to act. This issue's cover by young Malaysian artist Nor Tijan Firdaus starkly depicts the consequences of generations of human profligacy—changing climate, biodiversity loss, and environmental degradation. All threaten the health and well-being of the future our children will inherit.

Recent polls show increasing awareness of climate change, especially among young people. A majority of people consider it a global emergency—well above half in middle-income and least developed countries, and nearly three-quarters among people in small island states and high-income countries. The COVID-19 pandemic has heightened concerns: 43 percent are more worried about climate change now.

Yet, as Leonardo da Vinci said, “Knowing is not enough; we must apply. Being willing is not enough; we must do.”

How do we translate concern into action? Breakthroughs in science and technology yielded COVID-19 vaccines in record time, a hopeful model for the innovation and action needed to develop and commercialize low-carbon technologies. Policy responses to the pandemic demonstrate that governments can also take unprecedented action when needed.

It is critical to act with the same determination to address climate change and speedily put in place policies that can make a difference.

First, we need market signals that work for the new climate economy, not against it. Politically challenging as it may be, the world needs to rid itself of all fossil fuel subsidies—equivalent to more than \$5 trillion annually, yet far more costly to our future. Robust carbon pricing will help redirect private investment and innovation to clean technologies and encourage energy efficiency. Without it, we simply

cannot reach the goals of the Paris Agreement. This price signal must get predictably stronger—reaching an average global carbon price of \$75 per ton by 2030, way up from today's \$3 per ton. Major emitters agreeing on an international carbon price floor would be a good start.

Second, we need to scale up green investments. IMF staff research projects that green supply policies could raise global GDP by about 2 percent this decade and create millions of new jobs. On average, about 30 percent of new investment is expected from public sources, making it vital to mobilize private financing for the remainder.

Third, we must work for a “just transition” to a low-carbon economy—within and across countries.

For instance, revenues from carbon pricing can be used for cash transfers, social safety nets, retraining, and so on to compensate workers and businesses in affected high-emission sectors. Approaches like this are increasingly part of carbon pricing reforms, such as in Germany's national emissions trading system and the EU's planned Just Transition Mechanism.

Across countries, it will require financial support and the transfer of green technologies. The world's poorest countries have contributed the least to climate change, but are most vulnerable to its effects and least able to cover the cost of adaptation. With many of the lowest-cost mitigation opportunities in emerging market and developing economies, it is in the global interest that developed economies fulfill their commitment to provide \$100 billion a year in climate finance for the developing world.

We have no time to waste. As we look ahead to COP26, we must be ready to move decisively—together. We know what must be done; now we must do. **FD**

KRISTALINA GEORGIEVA is managing director of the IMF.



TO WASTE



Our Last, Best Chance on **CLIMATE**

The COP26 meeting in Glasgow may usher in a new era of sustainable development

Amar Bhattacharya and Nicholas Stern

The COVID-19 pandemic showed us that human existence is fragile and perilous. However, if we do not take action now against climate change, the damage could be even greater and more lasting than the effects of the pandemic. Decisions made now are crucial in shaping the future of people and the planet. We must not go back to the old normal; it's imperative to *build back better* through sustainable, inclusive, and resilient growth.

The 2018 Intergovernmental Panel on Climate Change (IPCC) special report *Global Warming of 1.5°C* highlighted the grave risks of global warming beyond 1.5°C, the already evident impact of climate change,

and the limited time to arrest it. Projections show that more rapid and severe climate change will inflict greater harm on the environment, lives, and livelihoods. For example, warming of 2°C instead of 1.5°C would essentially wipe out all coral reefs on the planet, instead of 70 to 90 percent, and expose 37 percent of the population, instead of 14 percent, to extreme heat at least once every five years. Warming that exceeds 2°C significantly increases the risk of larger, likely irreversible environmental changes. The IPCC's 2021 report documents the rapid acceleration of climate change, dramatically narrowing the window for limiting global warming from 2°C to 1.5°C and underscoring the imperative to reach net zero emissions by 2050.

There is a growing realization that the risks and economic costs of climate change have been underestimated. If unchecked, climate change could displace hundreds of millions of people, mostly in the developing world, increasing the potential for conflict. Likewise, carbon-intensive economies depend on jobs that may be eliminated in the future to reduce pollution and avert catastrophic climate change. Jobs and incomes will be lost, driving many into poverty, and the longer decarbonization is delayed, the more disorderly future shocks will be.

Thanks to technological advances, the cost of renewable energy is declining, making it increasingly competitive with fossil fuels. Moreover, there is mounting evidence that decarbonization does not hamper growth, development, and jobs but instead offers a path to more inclusive, resilient, and sustainable growth; indeed it can “unlock the inclusive growth story of the 21st century.”

Investment and innovation

Increased spending on sustainable infrastructure has strong multiplier effects. In the short term, it can help the world economy recover from the effects of the COVID-19 pandemic by creating jobs and investment opportunities. In the medium term, it can spur innovation, create new sources of growth, and reduce poverty and inequality while delivering cleaner air and water. Over the long term, stabilizing climate change is the only path to a viable future.

To enable the shift away from carbon, governments must work with stakeholders to encourage clean energy and transportation systems, smart development, sustainable land use, wise water management, and a circular industrial economy. Major investment is needed to replace aging and polluting

infrastructure, address infrastructure deficits and structural change in emerging market and developing economies, and protect and restore natural capital. In a report prepared for the Group of Seven (G7), we asserted that the world must increase annual investment by 2 percent of pre-pandemic gross domestic product for this decade and beyond.

An even greater boost is needed for emerging market and developing economies (other than China) given their recent sharp declines in investment and need for financing to support growth, development goals, and structural change, including rapid urbanization. The coming two decades will be a crucial period of transition for emerging market and developing economies, requiring greater investment in all forms of capital—physical, human, natural, and social.

In developed and developing economies, investment offers significant potential to accelerate the transition to net zero through lower- and zero-carbon solutions, from sustainable aviation fuels to electric vehicles. The 2020 “Paris Effect” report finds that by 2030, low-carbon solutions could be competitive in sectors accounting for 70 percent of emissions, up from 25 percent today and none five years ago.

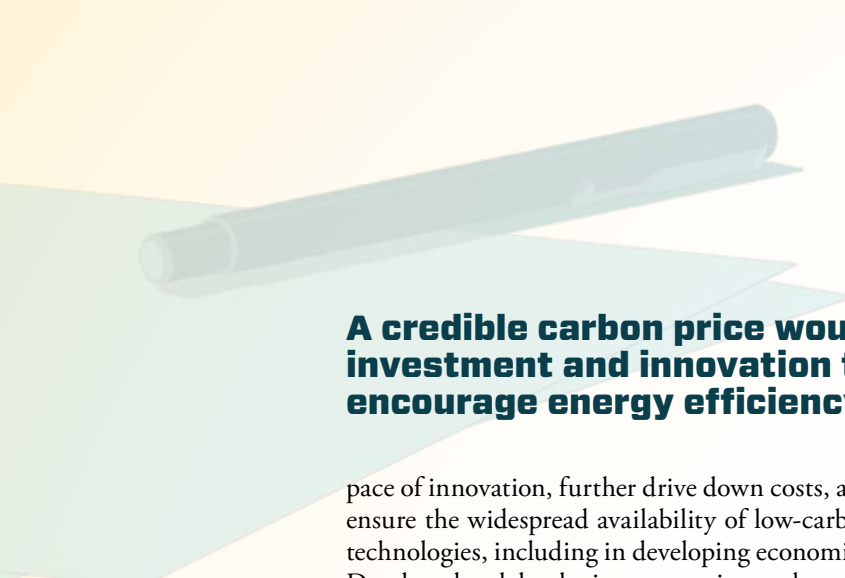
Greater support by governments and stronger international cooperation can help accelerate the

COP26 goals

For nearly three decades the United Nations has been assembling almost every country on earth for global climate summits. Under the UK presidency, this year's summit will take place in Glasgow. The 26th Conference of the Parties on Climate Change (COP26), postponed for a year because of the COVID-19 pandemic, will bring together world leaders, scientists, businesses, public and private finance officials, climate activists, journalists, and other observers.

These are the key objectives for the Glasgow conference:

- Broad-based net zero targets and a credible finance package
- A collective commitment and road map to accelerate the transition to zero-carbon power and zero-carbon transportation, with ambitious action on carbon pricing, sector policies, phaseout of coal, and support for innovation
- Support for adaptation and resilience, especially in poor and vulnerable countries, and for protection and rebuilding of natural capital
- Mobilization of private businesses and finance to support these objectives and channel finance to emerging market and developing economies



A credible carbon price would send a critical signal to direct investment and innovation toward clean technologies and encourage energy efficiency.

pace of innovation, further drive down costs, and ensure the widespread availability of low-carbon technologies, including in developing economies. Developed and developing economies need greater investment and fiscal stimulus now to counter the effects of the pandemic while responsibly managing debt and deficits over the medium term. Fiscal policy, on both the revenue and expenditure sides, can promote the transition to low-carbon, inclusive growth, including through green budgeting.

Policies to accelerate change

Policymakers must set expectations and provide a clear sense of direction on how to achieve the net zero emissions target. To that end, the IMF, the World Bank, and a growing number of academic, public, and private sector voices have called for elimination of fossil fuel subsidies and putting a price on carbon. A credible carbon price would send a critical signal to direct investment and innovation toward clean technologies and encourage energy efficiency. The IMF managing director said that “without it we simply cannot reach the goals of the Paris Agreement” and that “this price signal needs to get predictably stronger—by 2030, we need an average global price of \$75 per ton of CO₂, way up from today’s \$3 per ton,” to be effective.

Along with carbon pricing, the transition to climate-resilient growth will require many different and mutually supportive policies given major market failures, the availability of other powerful and effective policy instruments, and political economy impediments. As outlined in a recent paper, governments and the private sector must

- Reinforce carbon pricing with sector-specific policies—regulations, energy efficiency standards, feebates—and phase out coal.
- Boost public investment in sustainable and resilient infrastructure, including nature-based solutions—restoration of degraded lands and conservation of existing ecosystems—while mitigating the impact on the poor.
- Promote sustainable use of natural resources with policy measures such as payments for ecosystem services, regulations, reform of agricultural and water subsidies, and incentives for a circular

economy to decouple economic growth from use of material resources.

- Deploy industrial and other policies to spur climate-friendly innovation, including in digitalization, new materials, life sciences, and production processes, with a focus on the coordination of policy areas and on long-term policies and policy planning.
- Provide information and promote public discussion on social norms and behavior to reduce energy demand and carbon intensity of consumption and business activity; educate the public about climate change risks and on early warning systems and evacuation plans in case of natural disasters.
- Align finance with climate objectives—manage financial stability risks posed by climate change; align social and private returns with green investment; mobilize resources for investment, including a major boost to international climate finance; and make monetary and supervisory policies consistent with net-zero-emissions objectives.
- Develop insurance instruments and social safety nets to mitigate the immediate impact of climate shocks.
- Foster a just transition with investment in and support for the shift to a low-carbon economy for affected workers, businesses, and regions—rapid change will involve dislocation in both production and consumption.
- Integrate sustainability considerations into public financial management and corporate governance; use better models and look beyond gross domestic product when deciding policy priorities and measuring well-being and sustainability.

By acting together on climate change, countries will benefit from stronger demand expansion and investment recovery, economies of scale, and lower costs for new technologies. The returns to collaboration and innovation are uniquely powerful at present given the high unemployment following the pandemic; the need for global access to COVID-19 vaccines; and the mounting threat of climate change, biodiversity loss, and environmental degradation. Failure to act on any of these threatens human health, economic prosperity, and the very future of the planet.

Mobilizing climate finance

Progress on global climate action will require commensurate ambition on climate finance. There are abundant pools of long-term savings, and interest rates are exceptionally low worldwide, but many emerging markets and most developing economies find it difficult to access long-term financing on the necessary scale, and the cost of capital is a major impediment to sustainable investment.

Developed economies' commitment to provide \$100 billion in climate finance by 2020 is not just symbolic but foundational to climate action. Credible progress on the \$100 billion commitment is a make-or-break issue for the success of the coming conference and for climate action in the developing world.

Rich countries need to build on the G7's commitment by boosting climate finance in 2021–22 and doubling it to \$60 billion by 2025. There is an urgent need to improve the quality of climate finance, by boosting grants from their present low level, immediately doubling finance for adaptation, and ensuring that at least half of concessional climate finance supports adaptation and resilience objectives.

Because of their mandates, instruments, and financial structure, multilateral development banks are the most effective source of support for climate action in developing economies and for the mobilization and leveraging of climate finance. These institutions must use all their powers and instruments at this moment of crisis, agreeing to triple financing by 2025 from 2018 levels. This will require an accelerated replenishment this year of IDA (the World Bank's fund for assistance to the poorest countries), more effective use of development banks' balance sheets, enhanced private sector finance mobilization, accelerated alignment with the Paris Agreement, and proactive capital increases.

Establishing the Resilience and Sustainability Trust within the IMF could also help bolster efforts, and proposals from the United Nations Economic Commission for Africa and the Bezos Earth Fund offer other ways to leverage concessional climate finance. The use of country platforms, which the Group of Twenty (G20) has promoted but has yet to effectively apply, is another option to increase coordination.

Efforts to align the financial system with climate risk and opportunities are underway through the COP26 private finance agenda and in conjunction with initiatives such as the Financial

Stability Board's Task Force on Climate-Related Financial Disclosures, the Network for Greening the Financial System, the Coalition of Finance Ministers for Climate Action, the European Union sustainable finance expert group, and, most recently, the Group of Twenty working group on sustainable finance.

From pledges to action

US Special Presidential Envoy for Climate John Kerry has described the coming conference, scheduled to begin in Glasgow on October 31, as the “last, best opportunity to get real” on the threat of climate change. The UK COP26 presidency, under the leadership of Alok Sharma, has set out priorities for the Glasgow conference: commitment to the net-zero-emissions target, stepping up action on adaptation and resilience, delivering on the \$100 billion climate finance commitment, bolstering and transforming private finance, and increasing collaboration on all these objectives.

There has been encouraging progress already. At its June Carbis Bay meeting, the G7 committed to net zero emissions by 2050, halving collective emissions over 2010–30, increasing and improving climate finance by 2025, and conservation or protection of at least 30 percent of the land and oceans by 2030. And, for the first time, the G20 has signaled the need for action on carbon pricing. In the private sector, a growing number of businesses across all sectors have committed to net zero targets, and major financial institutions have set deadlines to take portfolios to net zero.

This decade will be decisive. What happens at national and international levels will determine whether the post-COVID recovery is strong and inclusive and whether we will embark on a new path of sustainable growth. If we get it right, we can usher in a new era of sustainable development with expanded opportunities for people across the world. Get it wrong and we will not only have a lost decade for development, but the people of the planet will be in great danger in the coming decades. We need to choose now, and we must choose wisely. [FD](#)

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FIVE THINGS TO KNOW ABOUT Carbon Pricing

Carbon pricing shows serious promise as a tool in the fight against climate change

Ian Parry

DETERRING THE USE OF FOSSIL FUELS, such as coal, fuel oil, and gasoline, is crucial to reducing the buildup of heat-trapping greenhouse gases in the atmosphere. Carbon pricing provides across-the-board incentives to reduce energy use and shift to cleaner fuels and is an essential price signal for redirecting new investment to clean technologies. Here are five things to know about carbon pricing.

1 Carbon pricing can be readily implemented. Carbon pricing, implemented through a tax on the carbon content of fossil fuels or on their carbon dioxide (CO₂) emissions, is straightforward to administer as an extension of existing fuel taxes. Carbon taxes can provide certainty about future emissions prices, which makes a difference when it comes to mobilizing clean technology investment. Revenue from carbon taxes can be used to lower burdensome taxes on workers and businesses or to fund investment in climate technology.

Carbon pricing can also be implemented through emissions trading systems—firms must acquire allowances for each ton of greenhouse gases they emit, with the supply of such permits limited by government. Businesses can buy and sell allowances, thus establishing a price for emissions. Emissions trading programs can be designed to mimic the

advantages of taxes through price-stabilizing mechanisms like price floors and revenue-raising measures such as permit auctions.

2 Carbon pricing is gaining momentum. More than 60 carbon tax and emissions trading programs have been introduced at the regional, national, and subnational levels. In recent months major pricing initiatives have been launched in China and Germany, the emissions price in the European Union has risen above €50 a ton, and Canada announced its emissions price would rise to CAN\$170 a ton by 2030.

Nonetheless, only about one-fifth of global emissions are covered by pricing programs, and the global average price is only \$3 a ton. That's a far cry from the global carbon price of about \$75 a ton needed to reduce emissions enough to keep global warming below 2°C.

3 Carbon pricing should be part of a comprehensive mitigation strategy. This strategy should contain supporting measures to enhance its effectiveness and acceptability.

The incentives generated by carbon pricing can be reinforced with regulations on emission rates or fees, whose fees and rebates for products (for example,

vehicles, appliances) or firms (for example, power generators, steel producers) depend on the intensity of their emissions. These reinforcing instruments have a narrower impact than carbon pricing—for example, they do not encourage people to drive less—but they may be an easier sell politically because they avoid a significant increase in energy prices.

Using carbon pricing revenues to boost the economy and counteract economic harm caused by higher fuel prices can build support for the strategy. Just transition measures are needed to assist low-income households and vulnerable workers and regions; for example, through stronger social safety nets and retraining. These measures would require only a minor portion of carbon pricing revenues.

Public investment is needed for the clean technology infrastructure networks the private sector may not provide, like electric vehicle charging stations and power grid extensions to accommodate renewable energy sources such as wind and solar.

And carbon pricing must eventually be extended to other sectors, like forestry and agriculture.

4 Carbon pricing must be coordinated internationally through a carbon price floor. Aggressively scaling up carbon pricing remains difficult when countries are acting unilaterally because they fear for their industrial competitiveness and are uncertain about specific policy actions in other countries. The IMF staff has therefore proposed an international carbon price floor to complement and reinforce the Paris Agreement, with two key components.

First, to facilitate negotiation, the price floor should focus on the small number of countries responsible for the majority of global emissions. For example, an arrangement among China, the European Union, India, and the United States would cover 64 percent of future global CO₂ emissions. An agreement among the Group of Twenty (G20) large economies would cover 85 percent of emissions.

Second, the price floor should focus on a minimum carbon price each country must implement, an efficient and easily understood parameter. If major emitting countries were to simultaneously scale up carbon pricing this would be the most effective way to address concerns about competitiveness and uncertainty about policy in other countries. Countries would still have the flexibility to set a higher price than the minimum if this is needed to achieve their mitigation pledges under the Paris Agreement.

The price floor must, however, be based on pragmatic design. Developing economies could have lower price floors and simple mechanisms for financial and technological support. In addition, the price floor could be designed flexibly to accommodate countries where carbon pricing is a political hard sell, so long as other policies achieve the same emissions reductions.

An international carbon price floor can be strikingly effective. A 2030 price floor of \$75 a ton for advanced economies, \$50 for high-income emerging market economies such as China, and \$25 for lower-income emerging markets such as India would keep warming below 2°C with just six participants (Canada, China, European Union, India, United Kingdom, United States) and other G20 countries meeting their Paris pledges.

5 A pragmatically designed price floor is more promising than other regimes. An alternative regime might require all participants to impose the same carbon price. This approach, however, does not allow questions of equity to be addressed through differentiated floors, and it does not accommodate countries where carbon pricing is difficult for domestic political or other reasons.

Another possibility is a regime in which participants agree on annual, and progressively tightening, emissions targets. This approach involves agreement on a larger number of parameters, however. And it is a zero-sum game: if one country pushes for a laxer target, others would need more stringent targets. It also leaves uncertainty about what policy actions each country would take.

Without an international carbon price floor or similar arrangement, countries will likely act on their own to impose tariffs on carbon-intensive imported goods—so-called border carbon adjustments. The European Union announced such a proposal in July 2021, and others are considering this approach. From the perspective of scaling up global mitigation, this regime would be far less effective than an international carbon price floor, however. This is because border carbon adjustments would price only emissions embodied in traded products and not the huge bulk of nontraded emissions (for example, from power generators, manufacturers selling domestically, buildings, and transportation). **FD**

IAN PARRY is the principal environmental fiscal policy expert in the IMF's Fiscal Affairs Department.



DRIVING DEEP DECARBONIZATION

As green energy costs drop, we should shift the emphasis
from economy-wide carbon pricing to sectoral policies

James H. Stock



World leaders have accepted the warnings of scientists that global temperatures must increase by no more than 1.5 or 2 degrees Celsius to avoid severe damage to the Earth's ecosystems and to human health and welfare. According to recent surveys, the general public increasingly agrees on the need for climate action.

As a result, many countries and some subnational entities have set ambitious targets for reducing greenhouse gas emissions. This past spring, the United Kingdom adopted a target of 78 percent emissions reductions by 2035, relative to 1990 levels. In the United States, the Biden administration announced a (nonbinding) goal of reducing net greenhouse gas emissions by 50–52 percent by 2030, relative to 2005. At the subnational level, several US states, including California, Colorado, Massachusetts, and New York, have legislated targets to approach or reach net zero emissions by 2050.

The climate crisis is too important to let these goals turn into failed promises. What policies are needed to turn these ambitious targets into action?

Economists' standard prescription is to implement a robust economy-wide price on carbon. A carbon price that starts at a moderate rate and grows predictably will incentivize individuals to use lower-carbon sources of energy than fossil fuels and will induce firms and power generators to switch away from fossil fuels to low-carbon primary sources of energy. An economy-wide carbon price efficiently obtains emissions reductions from sectors or uses where they are least costly while keeping costs manageable in applications difficult to decarbonize. Moreover, depending on how it is implemented, revenues from a carbon price can be used to reduce distortionary taxes elsewhere or to provide needed public investment.

A frequent response to this prescription is that it ignores the political reality that carbon pricing, especially through a carbon tax, is unpopular. Despite considerable efforts over decades, only a small fraction of worldwide carbon emissions is

covered by a carbon pricing program, and among those programs that do exist, the carbon price is typically low.

Now there is an additional reason to question this focus on economy-wide carbon pricing: it was developed when green energy was expected to remain far more expensive than fossil fuels. In many parts of the world, however, green energy, especially wind- and solar-generated power, is either less expensive than fossil fuel generation or is likely to become so soon. Costs of technologies to use green electricity—electric vehicles, for example—have also fallen dramatically. How does climate policy advice change for a world where it could be cheaper to be green?

Three externalities

Policies for the energy transition confront (at least) three externalities: the greenhouse gas externality; the innovation externality; and, in some cases, network (or chicken-and-egg) externalities. The greenhouse gas externality arises because the cost of damages to others, now and in the future, is not borne by those who burn fossil fuels. The innovation externality arises because the financial gains from innovation generally cannot be fully appropriated by the innovator. This externality justifies public financial support for basic research but also extends to other aspects of innovation, such as non-appropriable learning by doing in production and management. In the context of the energy transition, the network externality typically stems from built infrastructure. An example is electric vehicles (EVs) and charging stations: a lack of charging stations holds back demand for EVs, but a lack of these vehicles holds back the private supply of charging stations. In this case, there can be two stable equilibria: one with few EVs and charging stations and one with many EVs and charging stations.

Environmental economists have historically focused on the greenhouse gas externality, and with good reason: for the past hundred years, it has been significantly cheaper to emit carbon dioxide than not to when producing and using energy. When that is the case, the goal of climate policy is to encourage efficient self-restraint through policies

such as carbon pricing and energy efficiency standards and to encourage changes in behavior, such as flying and driving less.

But two things have changed. First, the cost of *producing* clean electricity by wind and solar power has fallen dramatically, to the point that, in some parts of the United States, building new grid-scale solar and wind systems is less expensive than running existing coal and natural-gas-fired generators. Second, for some applications the cost of *using* clean energy may soon be lower than that of using fossil fuels, although this varies a good deal depending on the sector.

Making it cheaper to be green

The prospect of cheap green energy requires a fundamental shift in how we think about climate policy—from how we can make it more expensive to be dirty to how we can make it cheaper to be green. Whether we actually reach a low-cost green equilibrium is far from certain, however: whether we get there, and how quickly, hinges on policy.

With multiple market failures, efficient policy needs multiple policy instruments. Because all sectors and all countries are different, there is no single elegant one-size-fits-all combination of instruments. Rather, the most efficient suite of policies for one sector is generally not the most efficient suite for other sectors. An efficient mix of climate policy instruments must be crafted to address market failures, technological status, and institutional challenges at a more nuanced level.

Consider, for example, light- and medium-duty vehicles. The price of a new EV is on track to fall below that of comparable conventional internal combustion engine vehicles during this decade. This price decline is driven by the ongoing, remarkable decline in battery prices, manufacturers' increasing experience in producing EVs, and improved battery technologies on the horizon. Moreover, EVs are less expensive to operate and maintain than conventional vehicles.

But the transition to EVs is not a sure thing, and in any event it can be expedited and supported by policy. In particular, the chicken-and-egg externality of charging stations poses some significant challenges. Absent adequate slow (level 2) charging stations, EV owners must provide their own charging capacity—which means a dedicated parking space where they are able to install a charger. Not surprisingly, EV purchases heavily skew toward

higher-income families with their own garages, which in turn affects the types of EVs produced. Policy to support reliable widespread overnight or at-work charger availability could help overcome this chicken-and-egg problem, thereby accelerating the transition and ensuring a larger EV share.

On the other hand, a moderate carbon tax is likely to have little effect on EV purchases, because the cost impact is small (a \$40/ton carbon tax implies \$0.36 for a gallon of gasoline). In fact, there is a substantial literature that investigates whether car buyers properly take into account fuel prices when they purchase a vehicle; that literature tends to find that purchasers only partially account for fuel prices. For light- and medium-duty vehicles, addressing the network externalities and innovation externalities for advanced batteries is more effective and impactful than carbon pricing. Because those policies aim to facilitate the transition from the current low-EV equilibrium to a stable, low-cost high-EV equilibrium, those transitional policies have a limited duration and one-time costs.

In contrast, aviation is a major and growing source of carbon dioxide emissions and appears quite difficult to decarbonize. Currently there is enthusiasm about low-carbon sustainable aviation fuel. Such fuel can be produced through conventional pathways such as conversion of waste vegetable oils and oil crops to renewable jet fuel or through advanced pathways—for example low- or negative-carbon alcohols, such as ethanol from energy grasses, converted to jet fuel.

In its 2021 *Annual Energy Outlook*, however, the US Energy Information Administration projected the price of petroleum jet fuel to be \$2.77/gallon in 2050 (2020 US dollars). The prospect of sustainable aviation fuel competing with petroleum jet fuel at \$2.77/gallon, unaided by an implicit or explicit carbon price, is daunting. A switch to sustainable fuel depends on robust funding to address the innovation externality and, when those fuels become available at scale, a high carbon price (either an explicit price or a clean fuel standard for aviation). Especially if the carbon price is implemented through an aviation fuel standard, this phasing could be critical: implementing a fuel standard too soon runs the risk of preferring first-generation fuels without adequate support for scalable fuels with zero or negative carbon footprints, as has been seen in the failure of the US Renewable Fuel Standard to promote

second-generation low-carbon ethanol. Sustainable aviation fuel works in standard jet engines and uses much the same infrastructure as petroleum jet fuel, so network externalities matter less. For aviation, this suggests policy that strongly supports the development and commercialization of advanced, scalable, and truly low-carbon sustainable aviation fuel now and a credible commitment to a high sectoral carbon price in the future.

In the power sector, all three externalities figure prominently in the transition. In the United States, new wind and solar power generation is less expensive than coal and natural gas in some but not all parts of the country. As a result, US power sector modeling suggests that a national policy that effectively puts a price on carbon—such as a clean electricity standard—is necessary to achieve substantial near-term decarbonization, say 80 percent by 2030. Deeper decarbonization will likely require significant innovation-driven cost reductions in storage technologies. In addition, the infrastructure of the US power sector restricts the ability to transmit green electricity from regions with high renewable resources to demand centers.

The power sector also faces serious institutional challenges, such as the regulatory and physical ability to use time-of-day pricing and load management and the institutional and political problems of siting new transmission capacity. For the power sector, supporting research and development of long-term storage technologies and addressing multiple infrastructure and institutional limitations are essential. The necessary first step, however, is a sectoral policy, such as a clean electricity standard, that has the effect of placing a price on carbon.

This is not to say that an economy-wide carbon tax is undesirable: the decarbonization from a clean electricity standard, and its limited effect on power prices, could be accomplished by an economy-wide carbon tax combined with government subsidies for renewable power, and that tax would yield some decarbonization from other sectors as well. For aviation, an economy-wide carbon price could, two decades from now, support the use of still-expensive low- or zero-carbon alternatives to petroleum jet fuel. But this reasoning suggests that pursuing an economy-wide carbon price is a lower priority today than it was when it was expensive to be green. Economy-wide carbon pricing, while desirable, by itself is neither efficient nor, at politically plausible prices, sufficient to drive deep decarbonization.

How can economists help?

I have focused on the economic case for shifting from economy-wide pricing to sectoral policies. That case is strengthened by the evident aversion of the political system to explicit pricing. But the political benefit of sectoral policies—their less visible costs than economy-wide pricing, in part because nonexperts often do not fully understand them—also exposes them to inefficiencies. Given the scale of the decarbonization challenge, it is critical that such policies be as cost-effective as possible. We cannot afford to spend trillions of dollars on policies that fail to achieve deep decarbonization.

Sectoral climate policy design questions are often nuanced. How can a charging station policy be designed to maximize electric vehicle adoption and use instead of simply providing inframarginal transfers for stations that would be built anyway?

GIVEN THE SCALE OF THE DECARBONIZATION CHALLENGE, IT IS CRITICAL THAT SUCH POLICIES BE AS COST-EFFECTIVE AS POSSIBLE.

Is investing in green industrial policy—for example, subsidizing domestic battery production—a cost-effective way to reduce emissions in the long run? Are subsidies for purchasing electric vehicles likely to be passed through to the consumer and thereby stimulate sales? What policies will most efficiently support the robust development of low-carbon sustainable aviation fuels?

Economists are good at disentangling incentives, anticipating unintended consequences, and assessing the costs and benefits of candidate policies. One practical challenge for economists working on sectoral policies is that those policies can become highly detailed; another is that policy is evolving on a time scale faster than that of academic economists. This is where the world's economic policy institutions, like the IMF, can play a critical role by enhancing and providing nuanced, sectoral expertise to promote the transition to a greener—and in many cases, cheaper—energy future. **FD**

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Vertical Forest (Bosco Verticale) innovative green-clad skyscraper represents a commitment to a sustainable economy, designed by Boeri Studio

Economics Nature's Way

Good economics demands that we manage Nature better

Partha Dasgupta



we have enjoyed relies on the Nature that surrounds us and of which we are a part—from the food we eat, to the air we breathe, to the decomposition of our waste, to opportunities for recreation and spiritual fulfilment. Yet the biosphere has diminished during that same time. Current extinction rates are about 100 to 1,000 times higher than the background rate—the normal process of species loss—over the past several million years. And they are accelerating. The chart shows the Living Planet Index, which tracks the abundance of mammals, birds, fish, reptiles, and amphibians. Between 1970 and 2016, the population of species fell globally by 68 percent on average. A recent report by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services showed that 14 of the 18 global ecosystem services assessed were in decline.

We have been drawing down Nature's assets through extraction of natural resources, depleting the nutrient supply in soils, driving down fish stocks, and so on—and using Nature as a sink for our waste—burning fossil fuels, for example. As a result, the biosphere has been severely degraded; some ecosystems, such as coral reefs, are at the point of collapse.

Certain events can cause us to reflect for a moment. The COVID-19 pandemic has prompted many to question the sustainability of our relationship with Nature, since illegal wildlife trade, land-use change, and habitat loss are key drivers of emerging infectious diseases.

Supply and demand

Earlier this year, *The Economics of Biodiversity: The Dasgupta Review*, commissioned by the UK Treasury, was published. In this study, I sought to show how economics has overlooked Nature. Combining what we know about the biosphere from earth sciences and ecology, the *Review* sets out a framework for including Nature in our economic thinking and provides a guide for change through three broad, interconnected transitions.

The first is to ensure that our demands on Nature do not exceed its supply. What we demand of Nature (what some term our “ecological footprint”) has for some decades far exceeded Nature's ability to meet those demands on a sustainable basis, with the result that the biosphere is being degraded at an alarming rate.

The past 70 years are a success story on many counts. We are healthier, live longer, and enjoy higher income, on average, than our predecessors. The proportion of the world's population in absolute poverty has fallen dramatically. As we benefit from advances in technology, modern science, and food production, we may be excused for thinking that humanity never had it so good. Global GDP has risen enormously since the 1950s (see chart), and world economic output is 15 times higher.

These achievements conceal a simple truth, however, which has profound consequences not only for how we think about and practice economics, but also for the way we live our lives. All the prosperity



Of course, it is not sufficient to account only for natural assets. We need to invest in Nature.

This persistent demand overshoot is endangering the prosperity of current and future generations, fueling significant risk for our economies and well-being. Technological innovations—for example, those geared toward sustainable food production—have an important role to play in ensuring that our demands on Nature do not exceed its supply.

But if we are to avoid exceeding the limits of what Nature can provide while meeting the needs of the human population, consumption and production patterns must be fundamentally restructured as well. Policies that change prices and behavioral norms—for example, by aligning environmental objectives along entire supply chains and enforcing standards for reuse, recycling, and sharing—can accelerate efforts to break the links between damaging forms of consumption and production and the natural environment.

Human population growth has significant implications for our demands on Nature, including for future patterns of global consumption. Support for community-based family planning can shift preferences and behavior and accelerate demographic transition, as can improving women's access to finance, information, and education.

Inclusive wealth

The second transition involves changing our measure of economic success. Reshaping the tools used in economic measurement is a necessary step on that journey. GDP remains a critical measure of economic activity when it comes to short-term macroeconomic analysis. But it is not an appropriate measure of long-term economic performance. This is because it does not tell us how an economy's assets, particularly its natural assets, are being enhanced or diminished by the decisions we make.

We should instead be using a measure that accounts for the value of all capital stocks—produced capital (roads, buildings, ports, machines), human capital (skills, knowledge), and natural capital. We may call that measure “inclusive wealth.”

Comprising all three types of capital, inclusive wealth shows the benefits from investing in natural assets and the trade-offs and interactions between investments in different assets. Only with this more complete picture is it possible to understand whether a country is experiencing economic prosperity. New Zealand's “wellbeing budget” and the use of “gross ecosystem product” in China are examples explored in the *Review* of steps being taken to establish that more complete picture.

To illustrate, the export revenues of natural resources (for example, primary products in the tropics) do not reflect the social costs of their removal from the environment; in other words, the trade of these goods does not account for how the extraction process will affect the ecosystem from which they are drawn or the long-term consequences faced by those communities as a result. There is thus a transfer of wealth from countries that export primary products to importing countries. The implication is more than ironic: it is possible that the expansion of international trade has contributed to a massive transfer of wealth from poor countries to rich countries, without its being recorded in official statistics.

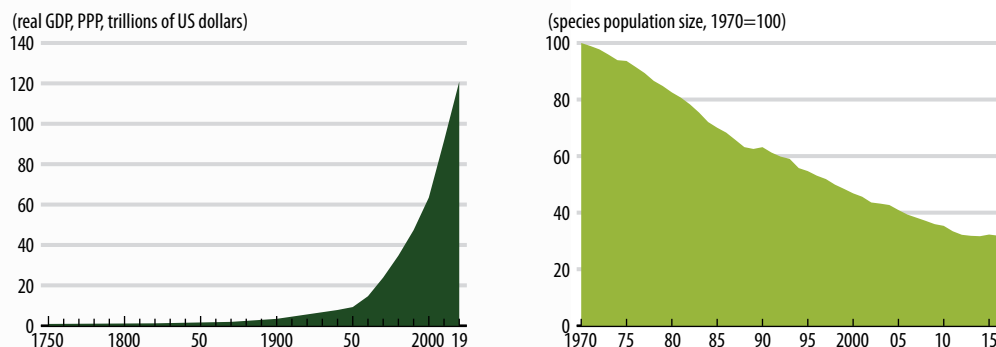
Of course, it is not sufficient to account only for natural assets. We need to invest in Nature. That requires a financial system that channels financial investments—public and private—toward economic activities that enhance our stock of natural assets and encourage sustainable consumption and production. Investment can also mean simply waiting; when left alone, Nature grows and regenerates.

Institutional failure

That brings us to the third transition: transforming our institutions to enable change. At the heart of our unsustainable engagement with Nature lies profound institutional failure. Nature's worth to society—the value of the various goods and services it provides—is not reflected in market prices. The open seas and the atmosphere are open-access resources and have fallen prey to the so-called tragedy of the commons. Such pricing

More prosperous, less biodiverse

Global economic output has increased 15-fold since 1950, but species population sizes have fallen by 68 percent on average since 1970.



Sources: Maddison Project Database 2018; Our World in Data 2020; and World Wildlife Fund Global Living Planet Index 2020.

Note: 2011 prices. PPP = purchasing power parity.

distortions have led us to invest relatively more in other assets, such as produced capital, and underinvest in our natural assets. And since many constituents of Nature are mobile, invisible, or silent, the effects of a number of our actions on ourselves and others—including our descendants—are hard to trace and go unaccounted for, giving rise to widespread externalities.

To exacerbate these distortions, governments almost everywhere pay people more to exploit Nature than to protect it. A conservative estimate of the total global cost of subsidies that damage Nature is about \$4 to \$6 trillion a year.

A thriving natural environment, underpinned by abundant biodiversity, is our ultimate safety net. Just as diversity within a portfolio of financial assets reduces risk and uncertainty, diversity within a portfolio of natural assets—biodiversity—directly and indirectly increases Nature's resilience to shocks, reducing risks to the services on which we rely.

Far more global support is needed to raise financial institutions' understanding and awareness of Nature-related financial risks. Central banks and financial supervisors can do this by assessing the systemic extent of these risks. The IMF, at the center of the global financial safety net, can also play an essential role in both assessing and

managing these Nature-related risks in its surveillance and its financial and technical assistance.

The next steps

With heightened awareness of the place of Nature in our lives, a message brought home to us by the pandemic, this year is critical in reimagining our economics and our economic and financial decision-making. World leaders will gather for two conferences—the UN Convention on Biological Diversity (COP15) and the UN Climate Change Conference (COP26)—to discuss the intrinsically linked issues of climate change and biodiversity loss.

The only way to combat this biodiversity crisis is through transformative change, which demands sustained commitment from actors at all levels—from citizens all the way to international financial institutions such as the IMF. *The Economics of Biodiversity Review* highlights success stories from around the world, demonstrating that the type of change necessary is possible. We must redeploy the ingenuity that allowed humanity's demands on Nature to grow so large, to bring about the transformation necessary to reimagine our relationship with Nature. We and our descendants deserve nothing less. [FD](#)

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Clean and Green Finance

A new sustainable financial system can secure a net zero future for the world

Mark Carney

PHOTO: COURTESY OF THE BANK OF ENGLAND



THERE WERE MANY innovations from the Paris Agreement, but three were key.

First, setting the clear objective of less than 2 degrees Celsius warming, with the stretch objective of 1.5 degrees.

Second, the innovation of voluntary country plans (NDCs) that were then objectively added up to assess what would happen if countries met their commitments.

Third, the involvement of the private sector and non-state actors, so that solutions to this enormous problem are bottom up as well as top down.

Since Paris, the concepts of Net Zero, Paris Aligned, and a 1.5 degree target have moved from the climate cognoscenti into the mainstream. Net zero is now an organizing principle that is cascading from the global to the country and the company.

But the climate crisis has not abated. The sobering reality is that the problem of climate change grew after Paris. Last year it was estimated that the world's temperature would rise above 3 degrees Celsius by the end of the century.

This would cause catastrophic flooding, pollution, wildfires, drought, extreme weather, and destruction of species. We are already seeing the early warnings of this devastation.

Moreover, the scale of what's required to achieve 1.5 degrees is sinking in: emissions need to fall by 7 percent a year over the course of this decade. Last year, many countries met this high bar, but only because large swaths of the economy were shut down—hardly something to be repeated. This underscores that we must invest and grow to get to net zero.

The UN Climate Change Conference (COP26) will be a watershed for finance. To that end, we are on track to deliver by COP26 the foundations for a system in which every financial decision takes climate change into account.

A financial system for net zero

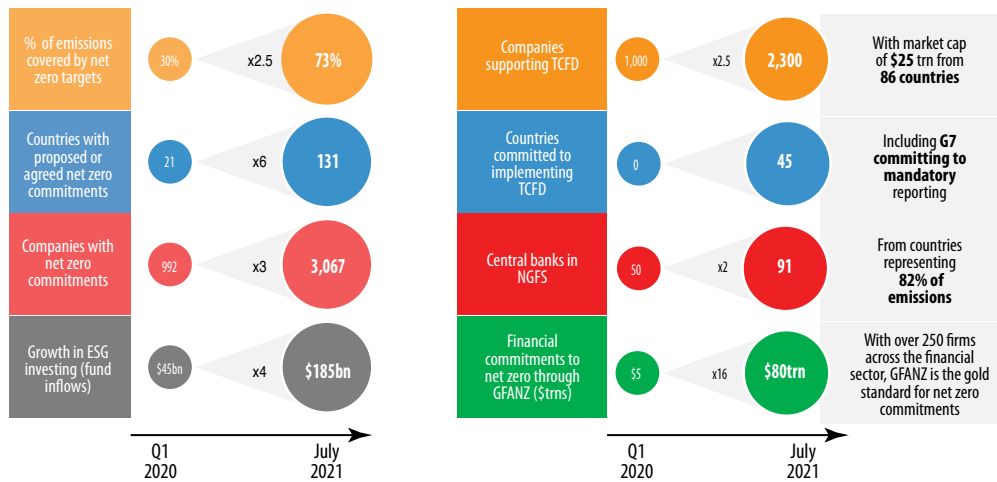
Markets require information to operate effectively. In Paris, the Task Force on Climate-related Financial Disclosures (TCFD), created by the Financial Stability Board, was just a concept. Three years ago in Hamburg, the final TCFD recommendations were delivered to Group of Twenty (G20) leaders. Today, virtually the entire financial sector demands TCFD disclosures, and over 2,000 major companies around the world are responding.

Despite these advances, coverage is still limited, and reporting still incomplete, particularly of critical forward-looking metrics. Now it is time for governments around the world to make TCFD disclosures mandatory and support the International Financial Reporting Standards Foundation's intention to establish a new International Sustainability Standards Board to produce a climate disclosure standard, based on the TCFD. Momentum is building, with strong support at the recent Group of Seven (G7) and G20 meetings.

Better disclosure and a heightened sense of urgency are leading to a transformation of climate risk management. The central banks and supervisors' Network for Greening the Financial System has,

Promising progress

Ahead of COP26, the world has made progress toward net zero.



Source: COP26 Private Finance Hub.

Note: bn = billion; ESG = environmental, social, and governance; GFANZ = The Glasgow Financial Alliance for Net Zero; NGFS = Network for Greening the Financial System; TCFD = Task Force on Climate-Related Financial Disclosures; trn = trillion.

in just a few years, grown from its eight founding members to more than 90 authorities covering over 80 percent of global emissions.

Central banks in countries with 50 percent of global emissions are beginning to conduct climate stress tests of their financial systems. For COP26, our priority is to embed supervisory expectations for climate risk management and ramp up climate stress testing.

Commitment, alignment, engagement

Building on the foundations of reporting and risk management, the financial system can look outward, tackling climate change through commitments, alignment, and engagement.

Commitments begin with net zero objectives of countries. These have advanced from 30 percent of emissions when the UK and Italy assumed the COP presidency to over 70 percent today (see chart).

The Glasgow Financial Alliance for Net Zero (GFANZ) was created to meet enormous investment needs that could total over \$100 trillion over the next three decades. Bringing together over 250 financial institutions responsible for \$80 trillion in assets and anchored in COP's Race to Zero, GFANZ is the gold standard for financial sector commitments to sustainability.

By Glasgow, all major financial firms should decide whether they too will be part of this solution to climate change. GFANZ is a big tent, but it will be the only tent in Glasgow.

GFANZ starts with commitments, but its real purpose is climate action through alignment and engagement.

Alignment means defining best practice net zero plans for companies and financial institutions, leveraging the valuable work already begun. Alignment also means robust assessments of the portfolios of financial institutions relative to net zero pathways.

Central banks, notably the European Central Bank and the Bank of England, are setting the tone as they examine how to revise their monetary policy operations to be more consistent with the legislated climate objectives and policies in their jurisdictions.

In a similar vein, the TCFD has conducted an extensive review of methodologies to assess metrics that measure how aligned portfolios are with the net zero transition.

The combination of forward-looking climate disclosure, net zero plans, and portfolio alignment metrics will pull forward investment, especially if there are credible and predictable climate policies from governments, like carbon pricing.

Developing economies

While estimates vary, most suggest that over a trillion dollars in *additional* investment annually for decades will be needed to build green energy in emerging market and developing economies.

To meet this need, we must turn billions in public capital into trillions in private capital by scaling blended finance, catalyzing stand-alone private capital flows, and building new markets.

Multilateral development banks are uniquely placed to mobilize private finance, but thus far the results have been modest, with only \$11 billion

mobilized in 2018. To orchestrate a step change in financing capacity requires four initiatives:

- **Private commitments:** A GFANZ working group will build on initiatives to secure commitments of significant private financing capacity for projects to advance the net zero transition in emerging market and developing economies.
- **Public facilities:** Multilateral development banks should identify and be prepared to dramatically scale up blended finance vehicles, instruments, and facilities that support significant mobilization of private capital.
- **Country platforms:** The public and private sectors are coming together through initiatives such as Global Investors for Sustainable Development and the Climate Finance Leadership Initiative to build country platforms that will help address specific needs and broader challenges. With private finance focused on achieving net zero, country platforms must integrate Paris-aligned NDCs to attract capital at scale. Projects consistent with long-term country strategies that are certified as Paris-aligned are more likely to

attract private capital and less likely to be subject to project risks, including changes in regulation.

- **High-integrity market for carbon credits:** Carbon credits, which are generated by projects that reduce or remove emissions, such as afforestation, allow buyers to compensate for or neutralize any continuing emissions they have while moving to net zero. The conditions for this market are coming into place. Over 1,600 companies have committed to science-based targets. As they achieve them, companies need an appropriate mix of emissions reductions and credible carbon credits to neutralize and compensate for their ongoing emissions, including nature-based solutions such as reforestation and the switch to greener power in developing economies.

To be clear: companies' primary responsibility is to reduce absolute emissions. But while on the trajectory to net zero they should use high-integrity credits to compensate for their emissions.

At present, the market for carbon credits is small, fragmented, and of uneven quality. This market could grow to over \$150 billion a year and facilitate major cross-border capital flows, as the vast majority of high-emission-reduction projects will be in emerging market and developing economies, with significant potential co-benefits for biodiversity and other UN Sustainable Development Goals.

The private sector Taskforce on Scaling Voluntary Carbon Markets, comprising 250 organizations and led by Bill Winters and Annette Nazareth, recently published its final recommendations on how to develop and rapidly scale a professional, global carbon market with the highest integrity, transparency, and credibility. The taskforce is working alongside other endeavors, like the Voluntary Carbon Markets (VCM) Integrity Initiative, to ensure the VCM finances meaningful, additional climate action.

Moving from blueprint to build is the next step. Two of the world's largest financial centers—London and Singapore—are already stepping up to implement the recommendations and to maximize our very limited carbon budget. On these foundations of a new sustainable financial system, we can align the trillions of dollars of capital needed for companies and projects across all economies to secure a net zero future for the world. [FD](#)

MARK CARNEY is the UN special envoy for climate action and finance.





Fighting Climate Change with INNOVATION

Innovation has brought us to an inflection point; the coming decade will be decisive

Kelly Levin and Andrew Steer

When we gathered in Paris in 2015 to hammer out the historic climate deal, few of us dared hope that by 2021 more than 60 countries—representing over half of global emissions—would have committed to net zero emissions by mid-century. In addition, 4,500 non-state actors, such as companies, cities, regions, and other institutions, have embraced a net zero target. Asset owners and managers are also now stepping up, with over \$40 trillion of assets under management committed to net zero portfolios by 2050.

What has brought us to this inflection point of hope edging out despair?

Innovation—in institutions, understanding, technology, and leadership. The Paris deal itself was hugely innovative. Politics ruled out a legally binding treaty, so a new approach had to be forged. Fiercely criticized by some for its voluntary nature and non-binding targets, it was predicated on the belief that despite a modest first round of commitments, growing scientific evidence, falling technology costs, and rising citizen demands for action would lead to more ambitious targets over time.



Recent evidence appears to support this hypothesis, although it will be essential to continue to ramp up ambition in the years ahead if the Paris Agreement's targets are to be met.

There has also been innovation in the economic understanding of climate change. Not long ago economists, politicians, and business leaders overwhelmingly believed in a trade-off between climate action and economic growth. The cost of action today had to be weighed against the benefits of avoided costs in the distant future, with the discount rate a major focus of debate. This view has been largely replaced by an understanding that smart action against climate change doesn't only stop bad things happening, it leads to increased efficiency, drives new technology, and lowers risk. These benefits in turn stimulate investment, generating jobs, creating healthier economies, and boosting the livelihoods and well-being of citizens, even in the near term.

We've also seen important innovations in leadership. When in 2019 the Intergovernmental Panel on Climate Change (IPCC) concluded that the risks of 2°C average warming were simply too great, and recommended a maximum warming of 1.5°C, it implied a considerably more difficult task ahead. Many expected climate leadership to evaporate in the face of a much steeper hill to climb. However, once the magnitude of the necessary revolution became apparent, enlightened leaders recognized that they had to be all-in to manage risks and seize opportunities. Investors, staff, and customers wanted visionary leaders on the right side of history. To be sure, there are business and political leaders, as well as critical segments of the population, who have vested interests in maintaining the status quo and are resisting change, but the discourse is quite different today than it was only a few years back.

Most dramatically, of course, innovation has driven down costs and introduced new technologies, and this must pick up speed throughout the current decade.

A disruptive decade ahead

Despite this good progress, we are far from an emissions trajectory that avoids even worse effects of climate change. Even if pledges are fully implemented, there remains a wide gulf between our current emissions path and one that achieves the Paris Agreement's goals. Communities around the world are seeing the impact of just 1°C of warming,

from extreme heat to uncontrollable fires to withering food crops to disappearing ice. The future world will be increasingly unrecognizable unless we transform our actions.

Consider the scale of transformation required to limit dangerous warming. The share of renewables in power generation must move from about 25 percent today to almost 100 percent by 2050, and unabated coal will need to be phased out six times faster than it is today. We must renovate our buildings with zero-carbon heating and cooling and improved energy efficiency at a rate of 2.5–3.5 percent by 2030—significantly higher than today's rate of 1–2 percent. While crop yields are expected to rise in the coming decades, according to the UN Food and Agriculture Organization, they must do so even more quickly on existing lands in order to meet a growing population's food needs without encroaching upon forests, doubling recent rates over the next 10 years. This growth must at the same time avoid agricultural expansion and maintain soil health as well as water quantity and quality.

Innovation will be critical to achieving these goals. The International Energy Agency's (IEA's) new net zero roadmap notes that the needed decarbonization by 2030 is largely achievable with readily available technologies, but by mid-century almost half of required emissions reductions will call for technologies that are not yet on the market. Reliance on technologies still under development is even higher for harder-to-abate sectors, such as long-distance transportation and heavy industry.

Three innovation opportunities alone—direct air capture and storage, advanced batteries, and hydrogen electrolyzers—can deliver roughly 15 percent of cumulative emissions reductions between 2030 and 2050. Efforts to spur innovation must focus not only on research and development of these technologies but also on the technologies and infrastructure these solutions depend on, such as integrated grids and battery storage.

Some trends already show incredible promise. Battery pack prices have fallen almost 90 percent over the past decade. We have seen exponential growth in renewables, now the technologies of choice in many places. And electric vehicle (EV) sales have accelerated, with a growing number of governmental phaseouts of internal combustion engines, subsidies to increase EV demand, and car companies' embrace of EV fleet targets.



'Systems change, not climate change'

The famous slogan from climate protesters, “systems change, not climate change,” gets it right. Incremental change that doesn't quickly lock in a different trajectory will not deliver the change we need. Change must be systemic. History has demonstrated that seemingly impossible change can come about, but only when the right combinations of drivers come together.

Addressing the climate crisis will also require innovation in many other arenas, such as finance, institutional design, novel partnerships, philanthropy, and international cooperation, to name a few.

Take technological carbon removal, for example. The IPCC and National Academies of Sciences suggest that, by mid-century, 8–10 gigatons of carbon dioxide (GtCO₂) may need to be removed annually, but we cannot rely on any one approach to achieve that scale. Natural approaches, such as landscape restoration, may remove 5–6 GtCO₂, with significantly renewed efforts, but engineered approaches such as direct air capture and storage will be needed as well if we are to remove and store carbon as much as the latest science suggests is necessary.

Yet many technological approaches remain at the earliest stages of development and require drastic cost reductions. Only a few companies are piloting direct air capture today. Scaling capture and storage will not only rely upon technological innovation to reduce energy inputs and costs, it will also depend on policy support such as tax credits, greater market demand, and public and private investment, among other factors. And in addition to support for the technology itself, another set of drivers must come together to support its enabling infrastructure.

The decarbonization of cement production, one of the world's most energy intensive materials, is another example of the need for innovation. Demand for cement is growing far more quickly than innovation is offering solutions. For a 1.5°C compatible pathway, the energy intensity of cement production must drop 40 percent in the next decade. Emissions-cutting strategies, such as novel cements that require less heat to produce, and the use of carbon capture and storage are not fully mature. In addition to investments in large-scale demonstration projects, scaling will require supportive policies such as low-carbon performance standards and updated industry standards. Public procurement incentives and mandates will also be key to stimulating demand.

Incremental change that doesn't quickly lock in a different trajectory will not deliver the change we need.

Financing needed

The IEA estimates that \$90 billion in public financing is needed as soon as possible to support demonstration projects for the energy transition before 2030, though only \$25 billion is budgeted over the next decade. We must find new ways to leverage private investment while boosting and better aligning government spending. Policy and regulatory frameworks tailored to an innovation agenda and additional reduction of risk are needed to attract more private investment. Developing economies in particular need significant support—in the form of financing, technology transfer, and capacity building—to reap the benefits of innovation and move to a low-carbon future.

With the right support, society's transformation could take off in a way previously unimaginable—providing tremendous opportunities, including new job opportunities and the creation of whole new industries. It could also provide significant health benefits—for example, through air quality improvements. But it must be properly nurtured.

The transformation will no doubt be disruptive. Governments measures must ensure that transitions are just and equitable, especially for workers and industries currently tied to a carbon-intensive future. Our recovery from COVID-19 presents a near-term opportunity to reshape our current systems and advance solutions for the future—instead of further locking in our fossil-fuel-intensive past. **FD**

KELLY LEVIN is chief of Science, Data, and Systems Change at the Bezos Earth Fund, where **ANDREW STEER** is president and chief executive officer.





CLIMATE COOPERATION

Working with its members, the IMF is managing the risks and opportunities of climate change

Eddie Buckley

The IMF took its first major step into the climate change debate in 2008, when a chapter in the *World Economic Outlook* (WEO) identified climate change as “a potentially catastrophic global externality and one of the world’s greatest collective action problems.”

Demands from IMF members for climate-related work have since increased. Countries need effective policy to respond to economic and financial stability threats and to harness opportunities for growth and job creation offered by the green transition.

So the IMF is putting climate change at the heart of its work—across five main areas.



Policy research and analysis

Analyses cover a broad range of climate-related topics.

The October 2020 WEO showed how green investment, combined with a steadily rising carbon price,

could boost global growth in the next 15 years of the recovery by about 0.7 percent of global GDP on average, and create millions of new jobs.

More recently, the first IMF Staff Climate Note highlighted the need for faster and more coordinated action on carbon pricing. Such measures are gaining the spotlight in discussions with IMF members.



Country economic surveillance

Every year or two, IMF staff meet with each of our 190 members to discuss economic developments and ensure that their policies support inclusive

growth and development, an activity known as Article IV surveillance.

Since 2015, the IMF’s coverage of climate change during surveillance has steadily increased. Country authorities facing climate-related transitions and resilience challenges are eager for policy advice. In the past year, for example, climate issues featured in about 30 of our country assessments, including for Canada, Germany, Korea, the United Kingdom, and the United States.

The IMF will cover mitigation policies in the 20 largest greenhouse gas emitters—that

together account for more than 80 percent of all such emissions. In countries especially vulnerable to climate change, our assessments will focus on adaptation policies to build resilience to climate-related disasters.



Financial sector analysis

In 2021, the IMF Executive Board approved proposals for more in-depth climate-related risk assessment and expanded mandatory surveillance from

29 countries to 47. The IMF's Financial Sector Assessment Program (FSAP) will now cover physical climate change risks and potential transition risks as the world moves to a low-carbon economy and the value of high-carbon assets declines.

Previous insurance stress testing assessments focused on risk factors such as droughts, floods, and storms for small island countries, such as Jamaica. For advanced economies, such as Belgium, FSAPs covered natural catastrophe risks through insurance stress testing. Climate risk stress testing in FSAPs can identify financial system pressure points from physical climate shocks and the transition to a low-carbon economy. Recent FSAPs in Norway and the Philippines included climate risk stress testing. Assessments of regulatory and supervisory frameworks can ensure appropriate prudential supervision of all climate risks across a country's entire financial system.



Better data, better decisions

Three building blocks will strengthen the climate information architecture: (1) high-quality, reliable, and comparable data;

(2) a harmonized and consistent set of climate disclosure standards; and (3) a broadly approved global taxonomy. Together, these can unlock trillions of dollars in green finance

and help turn the tables on global warming—so the IMF also supports efforts to improve data, disclosure, and taxonomies so that investors can make informed decisions to effectively price and manage climate risks.

Better data can improve policies and decision-making by country authorities. Recognizing the need for sound climate data, in 2021 the IMF launched an experimental climate data dashboard. The dashboard aims to contribute to statistical cooperation on climate-change-related data and overcome challenges to integrating climate change into the macroeconomic statistics framework.



Capacity development

The IMF's capacity development activities—which give members the tools and expertise for effective fiscal planning and monetary frameworks—

increasingly cover climate-related topics.

On fiscal issues, member support includes mitigation and adaptation policies and measures to build resilience. Technical assistance missions have helped develop carbon pricing programs and related tax policies. And small island states have received help with post-hurricane public financial management reviews and fiscal risk management for natural disasters.

The IMF will likely scale up all aspects of climate-related capacity development. For example, a new diagnostic tool, the Climate Macroeconomic Assessment Program, built in conjunction with the World Bank, will assess the macro-fiscal risks of climate shocks and stresses, the preparedness of climate vulnerable countries, and the implications of climate mitigation policies, such as carbon pricing.

Capacity development is often delivered in collaboration with institutions such as the World Bank, the International Energy Agency, and the Organisation for Economic Co-operation and Development and through organizations such as the Group of Seven and Group of Twenty. [FD](#)

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CHIMPANZEE POLITICS

AND CLIMATE CHANGE

The animal kingdom can teach us important lessons about ourselves and increase cooperation to fight climate change

Ruchir Agarwal

Human beings share 98 percent of their genes with chimpanzees. Yet humans are the dominant species on the planet—founding civilizations, developing languages, learning science, and creating wonderful works of art. American author Jared Diamond argues that the 2 percent difference propels humanity's success, but also its potential for disaster—with civilizations caught up in internal superiority contests that risk destroying their environment and themselves.

Dutch primatologist and ethnologist Frans De Waal coined the term “chimpanzee politics” when he compared the schmoozing and scheming of chimpanzees involved in power struggles with that of human politicians. Have we really evolved enough to escape “chimpanzee politics” and confront the greatest risk our species has faced?

The answer may predict the future of the planet and may have lessons for the global effort to stop

climate change, pandemics, and nuclear threats. In particular, humans have faced significant challenges achieving the degree of cooperation needed to fight climate change—in part because of the public good nature of climate change mitigation. Even if humans have not evolved enough, as seems likely, better economic and financial institutions could help overcome the limits of cooperation and confront climate change and other major challenges.

Correlated payoffs

The design of economic institutions and financial markets should take into account the kind of animal we are, which can help overcome some of the impediments to cooperation. Frans De Waal put it, “Are we a social animal or a selfish animal? Do we respond better when we’re solitary or living in a group? ...You should know as much as you can about the human species if you have a hand in

PHOTO: COURTESY OF AUTHOR

designing human society.” This is particularly relevant to cooperation in the face of climate change.

Cooperative behavior can be favored by natural selection if the survival benefits of actor and receiver are positively correlated. The two main ways in which this *correlation of payoffs* can come about are kinship (when partners share genes by common descent) and *reciprocity* (when current costs account for the expectation of future benefits).

A growing body of evidence shows that cooperation in animal societies most frequently involves kin (such as the case of two cheetah siblings forming hunting bonds, Figure 1a). Nonkin often cooperate when one or both partners seem likely to gain immediate benefits (for example, two chimpanzees grooming each other, Figure 1b, or remoras hitching a ride on sea turtles, Figure 1c).

In some cases, cooperation between animals can even appear altruistic. Although choosing not to help is typically in an individual’s greatest short-term self-interest, it could mean failure to receive reciprocal help from others in the future. This motivates altruistic behavior when individuals interact repeatedly (a troop of baboons, Figure 1d).

Cognitive constraints limit the ability of many nonhuman species to implement and maintain reciprocally altruistic strategies. Our brains, by contrast, have evolved sufficiently to overcome such cognitive constraints and enter into complex economic and financial trades and elaborate cooperative outcomes. Reciprocal exchanges of resources between nonkin are widespread among humans and often involve considerable time delays between assistance given and received, and extensive opportunities for cheating. In economics, we simply call that “intertemporal trade” (not “altruism”).

When it comes to the global fight against climate change, however, at least four factors hinder cooperation by our species. Since fighting climate change requires cooperation on a truly global scale (between countries at opposite poles of the planet and between current and future generations), the *presence of multiple nonkin* actors is a significant hurdle. The *long time lags between cooperative acts* also make it hard for individuals to imagine the potential for reciprocity. *Geographic inequality* lowers mutual benefits from cooperation. And finally, there are *evolutionary limits to our imagination*, such as our inability to understand the diversity of belief systems or comprehend the extent of the climate threat.

Overcoming chimpanzee politics

Good economic institutions and well-designed markets may help break free from the constraints that prevent human cooperation—including by identifying and maximizing correlated payoffs. In this view, the role of economic and financial institutions can be to imagine and design novel ways humans can enter into mutual obligations to cooperate and promote the greater good. Seven insights from evolutionary biology could inform the design of economic institutions and financial markets. The first four pertain to mitigation, the next two to adaptation, and the last to monitoring of key climate risks.

Good economic institutions and well-designed markets may help break free from the constraints that prevent human cooperation.

- **Greater global integration of economic and financial markets will lead to greater cooperative action on climate change.** Among wild chimpanzees, social bonds are a key predictor of cooperative resource sharing. A chimpanzee is much more likely to share food with a long-standing grooming partner than with others. Similarly, among humans, economic interdependence between two countries reduces the risk of warfare. As Montesquieu said in 1748, “The natural effect of commerce is to bring peace. Two nations that negotiate between themselves become reciprocally dependent.” This is because trading alliances create financial incentives not only to keep peace with trading partners, but also to protect them from being attacked so as not to disrupt trade. From this perspective, greater global integration in trade could help avoid conflict and foster cooperation—including on climate change.
- **Smaller actors need to be held accountable and act on climate change.** As we learn from the animal kingdom, incentives to cheat are strong when the system of punishment for non-cooperative behavior is weak. In the fight against climate change, there are few tools available to the international community to ensure countries stick to their international climate pledges. Work must continue to strengthen the international rule of law, but a parallel solution could be



FIGURE 1a



FIGURE 1b

Cooperation in animals: Cheetah brothers after a hunt in Maasai Mara, Kenya (Fig. 1a); Non-kin chimpanzees grooming in Kibale Forest, Uganda (Fig. 1b).

decentralization of the problem by encouraging subnational governments and corporations to make climate and environmental pledges too. Decentralization leverages the system of accountability inherent in smaller communities of stakeholders. Many private companies, for instance, have promised to go carbon-neutral in response to pressure from customers, shareholders, and other stakeholders, even when the countries where they operate have not.

- **Give weight to future generations in every cost-benefit exercise.** Nonhuman animals discount future rewards much more than human beings do. But humans who lack understanding of issues also tend to heavily discount the future. In particular, the long lag between a climate mitigation decision and the impacts of that decision may hinder optimal investment in climate

change mitigation: it makes the impacts less salient. One way to offset this lack of understanding is to place weight explicitly on the utility for future generations in every cost-benefit analysis underpinning government, corporate, or private actions. Several countries, such as Bhutan, do this already as part of their policy frameworks. This approach could be adopted for a broader set of issues—including by encouraging greater representation of younger people in political life and by building policy institutions that focus on long-term issues, such as intergenerational inequality (that lasts beyond the electoral cycle).

- **Innovation cooperation may be easier to achieve than cooperation on other climate-related issues.** The experience of COVID-19 demonstrates that global innovation can be scaled up significantly when needed—including through unprecedented collaboration across multiple actors from around the world. Before COVID-19, the fastest vaccine development took four years (for mumps). Yet by the end of 2020 several COVID-19 vaccines had proved highly effective, reflecting massive research and development. However, it is taking far longer for the world to cooperate to produce and distribute vaccines equitably. And although the case for higher carbon taxes to fight climate change is persuasive, it has proved politically difficult to implement in many countries. At the same time, the recent shift toward renewable energy is largely because of rapid technological advances that have driven down the cost of renewable energy. If our species' ability to cooperate and tackle climate change has evolved slower than our capacity to harm the planet, then we may need to make it easier for self-regarding humans to make climate-friendly choices by accelerating clean energy innovation. This would increase the private benefit of switching to cleaner energy absent strong public action.
- **A centralized global market to hedge climate risks is needed to maximize risk sharing and promote cross-country cooperation.** Despite our best efforts to mitigate climate change, it is very likely there will be residual risk requiring adaptation measures. One way to adapt is to share risk to limit the harm to individual actors. Food sharing between chimpanzees works well when there is idiosyncratic risk (there may be enough food for the whole group regardless of

which chimpanzee has been successful in the hunt on any given day). Similarly, insurance markets among humans work well in hedging idiosyncratic risks such as car accidents, health shocks, and mortality. However, when a risk is correlated among actors (such as property in danger from natural disasters), it can appear to be “aggregate risk” and can be insured only by a global market. From this perspective, a successful market to share climate risks would benefit from a single global platform, which maximizes coincidence of needs. It is important for the centralized global platform to bring together entities from different parts of the world that will experience the impact of climate change differently or at different times (in a less correlated way).

- **Action on climate risk sharing is needed now—before the uncertainty about cross-country distribution of climate change impact is resolved.** Vampire bats need to feed often to survive; if one misses a feeding three nights in a row, it could starve to death. To cope with this risk, they have developed a system of trade, with well-fed bats regurgitating blood directly into the mouths of hungry and unrelated peers. Moreover, the bats keep track of who has helped them in the past and share primarily with those bats. It is the uncertainty about whether a bat may go hungry tomorrow that incentivizes it to share with other bats today. Similarly, for markets to play a greater role in hedging the biggest climate change risks, they must act before uncertainty about the cross-country impact of climate change is resolved. After the risk has materialized, the problem becomes burden sharing not risk sharing. That is, if it becomes clearer that relatively poor countries (for example, those in the tropics) will suffer most from climate change in the future there may be few incentives for richer countries to enter into risk-sharing agreements with them.
- **Invest in information and imagination.** Markets are not likely to take action to share risks if people have limited information about what the risks are. In India, for example, a large proportion of the population lives in areas where average annual pollution levels as measured by PM2.5—particles smaller than approximately 2.5 microns—are several times higher than the level considered safe by the World Health Organization. Yet most of these people are not aware of these risks, as India



FIGURE 1c



FIGURE 1d

has too few continuous air monitoring stations. Similarly, if socioeconomic feedback loops are better understood (for instance, the potential impact of climate refugees coming to high-income countries), the problem of climate change leading to flooding of low-lying areas in the tropics may be seen as more of a global problem. Therefore, greater environmental disclosures in better information and imagination to study feedback loops that may occur far in the future can help make the problem of global climate change more compelling to key actors and spur action today. After all, it might be our ability to imagine and our urge to connect with others that truly separates us from other species. **FD**

Two remoras hitching a ride on a sea turtle, Honduras (Fig. 1c); Baboon sharing stolen maize in Kakamega Forest (Fig. 1d).

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Climate Economist

*Bob Simison profiles Berkeley's **Solomon Hsiang**, who uses big data to inform climate change policies*

PHOTO: NOAH BERGER PHOTOGRAPHY

Solomon Hsiang is a smart man. He listens to his wife.

Over breakfast a day or two after the California pandemic lockdown in March 2020, Google researcher Brenda Chen asked a question. Couldn't her husband's Global Policy Laboratory at the University of California, Berkeley, shed some light on the world's fight against COVID-19?

"A lab called 'the Global Policy Lab' should be able to tackle this question," she recalls saying.

He raised it with his team on a conference call that morning. The lab uses sophisticated statistical analysis of economic data—econometrics—and advanced computing power to address questions related to climate change, development, violence, migration, and disasters. When the group reconvened after a day of research, "we realized that nobody knew if all these lockdown policies would really work," says Hsiang, a 37-year-old economist and climate physicist.

Over the next 10 days, Hsiang and 14 researchers worked around the clock gathering vast amounts of data on dozens of pandemic policies such as business and school closings, travel bans, social distancing mandates, and quarantines from China, France, Iran, Italy, South Korea, and the United States. Applying econometric tools, they found that the anti-contagion policies significantly slowed the spread of disease, averting 495 million infections. The paper they cranked out appeared June 8, 2020, in the journal *Nature*. It has been accessed 309,000 times and cited by 361 news outlets, according to *Nature*.

Transforming economics

The episode shows how Hsiang (pronounced "Shung") is helping to transform the way economists conduct research. He's leading a new generation in leveraging newly available giant databases, massive modern computing power, and large, interdisciplinary teams to address thorny global issues such as climate change and the pandemic. Previous work on the economics of climate change relied largely on sweeping assumptions rather than hard data and was carried out mostly by solo researchers or a few collaborators.

Within just a decade of earning his doctorate from Columbia, Hsiang has published a raft of startling and sometimes controversial findings. He and various research partners showed that rising temperatures increase civil conflict and slow

economic growth; that as tropical storms grow more intense, the economic effects are more severe and last longer; and that trying to fight climate change by mimicking volcanic eruptions to dim the sun would reduce global crop yields. Now he's leading researchers in a years-long effort to calculate the true cost worldwide of greenhouse gas carbon emissions.

"Sol is one of the preeminent figures in interdisciplinary research on the impacts of climate change," says the University of Maryland's Maureen Cropper, a leading climate change economist who was a co-chair of the 2017 National Academies report on the social cost of carbon. "His work is having a huge impact—directly and indirectly—on climate policy."

Organizations citing Hsiang's work include the Federal Reserve, the Congressional Budget Office, the Environmental Protection Agency, the United Nations, the Bank of England, and the IMF. After the COVID-19 study appeared in June 2020, the US Centers for Disease Control and Prevention tapped Hsiang's group to analyze a massive database on every disease-control policy worldwide.

"Economics is at the dawn of a new era of taking advantage of computers and data to fully understand the impact of climate change," says the University of Chicago's Michael Greenstone, a frequent collaborator of Hsiang's. "And Sol is at the forefront of it."

Hsiang came to economics through his love for biology and physics. His father is a math professor and his mother a computer science professor at Syracuse University in New York. At home growing up, it was all science all the time, he says.

As an undergrad at the Massachusetts Institute of Technology, he studied earth, atmospheric, and planetary science. "I started to understand that the problems in the atmosphere are results of policies and economics," he says. His senior year he loaded up on economics courses and "fell in love with it," he says. For graduate school, he landed at Columbia, known for its premier interdisciplinary program in sustainable development.

High school prom date Chen joined him there for her doctorate in biomedical engineering. Before their first date 19 years ago, the couple would hang out in the art room after high school. "Sol is a great oil painter," Chen says. They've since taken up snowboarding, surfing, rock climbing, birding, and pottery. Last spring, they welcomed a daughter. Hsiang has a strong romantic streak, Chen says.

Hsiang sees climate change as the fundamental 21st century challenge for economics.

“For date night once, he sent an email that had some computer code attached,” Chen says. “When I ran the code, it drew nautical flags on the screen. Decoding the flags revealed an ISBN number. I found the book with that number deep in the stacks of the Columbia library. Behind it was a book for me, a card with paw prints from our cats, and tickets to a Broadway show.”

During Hsiang’s first year at Columbia, the British Treasury published a 712-page report, *The Economics of Climate Change: The Stern Review*. The authors argued that the world could lower greenhouse gas emissions at a significant but manageable cost and recommended regulations, carbon taxes, and carbon trading.

“Everyone was talking about it,” Hsiang says. “The problem is that the review had almost no data. There were lots of grand assumptions. My question was, Why not go out and look at the real data?”

That’s what Hsiang did. For his master’s thesis, he crunched weather and economic data for 28 countries in Central America and the Caribbean from 1970 through 2006. He showed that each 1°C increase in surface temperature was associated with a 2.5 percent reduction in economic output. The paper appeared in the *Proceedings of the National Academy of Sciences* in August 2010.

“When I showed the data to the chairman of my graduate committee, he said it couldn’t be right,” Hsiang says. “I had similar reactions to other findings, such as the effect of higher temperatures on increasing violence.”

Following postdoctoral work at Princeton and the National Bureau of Economic Research, Hsiang took an assistant professorship at Berkeley. He won tenure within two years and promotion to full professor in five, at the age of 34.

21st century challenge

Hsiang sees climate change as the fundamental 21st century challenge for economics, much as slavery was the dominant issue of the 19th century and whether humans should organize collectively to share things—socialism—was for the 20th century.

“Climate change is the question of who owns the rights to this multitrillion-dollar asset, the atmosphere,” he says. “If we assign those rights, there

are huge implications. And if we don’t, there are huge implications.”

Many people have long been skeptical of climate change “for reasonable reasons,” Hsiang acknowledges. It’s hard to grasp, he says, that the world economy could be so energy-intensive as to raise the temperature of the very air and oceans around us. But now the data prove it.

It’s important to consider the matter in economic terms and not just scientific or philosophical terms, Hsiang argues. That’s because climate change grows out of economic activity, and managing it will involve economic trade-offs. In 2019, he testified before Congress that the direct thermal effects of warming over the next 80 years could reduce American incomes by \$4.7 trillion to \$10.4 trillion. The combined effects of climate change on agriculture, energy, labor, health, crime, and coastal communities could cost the United States 1.2 percent of gross domestic product for each 1°C increase in temperature, he said, while overall death rates, suicides, sexual assaults, murders, and birth-related harm would all rise significantly.

At the same time, the economist rejects the urge of some environmental advocates to throw everything possible at the problem. Some critics fault his research for generating cost and benefit estimates that don’t seem catastrophic enough, he says.

“We can’t pretend that climate change is our only economic problem,” Hsiang says. The stakes in mitigating and adapting to climate change are so high that “if we make a mistake, the amount of misallocation of resources could be astronomical,” he says. “We shouldn’t overspend on climate change.”

Consequently, Hsiang and collaborators have focused on calculating the social cost of carbon, or the comprehensive future impact on the world of each additional ton of carbon dioxide emitted into the atmosphere. Carbon dioxide is the main greenhouse gas responsible for climate change, and much of it comes from the burning of fossil fuels. The world spews more than 30 billion tons of it into the atmosphere every year, according to the International Energy Agency. And the CO₂ will stay there for 1,000 years.

“The social cost of carbon is one of the most important economic numbers we don’t know,”

Hsiang says. “It will play a huge role in making decisions. If we knew what it was, we could put a value on our atmosphere as an asset” and decide on policies for addressing climate change. The Biden administration has made it a priority to update the US government’s estimate. In 2010, the Obama administration put it at \$51 a ton. The Trump administration cut that to \$7. The case can be made that the figure should be at least \$125, according to the University of California Santa Barbara’s Tamma Carleton, one of Hsiang’s former students, and the University of Chicago’s Greenstone.

In the 2015 book *Economic Risks of Climate Change: An American Prospectus*, Hsiang and 11 co-authors made the first comprehensive assessment of the economic risks of climate change for the United States. Out of that effort grew the Climate Impact Lab, a six-year-old research consortium led by Hsiang, Greenstone, Rutgers climate scientist Robert Kopp, and Trevor Houser, a partner in the research organization Rhodium Group.

The lab deploys more than 30 researchers at Berkeley, the University of Chicago, and Rutgers, many of them graduate students, and relies on Rhodium Group’s computing power. The team includes economists, climate change scientists, data engineers, and risk analysts.

“It’s a recognition of the scale of the problem that you need a lot of human resources,” Hsiang says. The Climate Impact Lab uses climate and economic data on a local level to document how climate change affects society, from droughts in California to mortality in India to labor productivity in China. Even though the Trump administration downplayed the issue at the federal level, the lab’s granular data helped American states and cities decide where factories could be safely built and how to plan for hurricanes, according to Carleton, who was the lab’s first graduate student employee.

Hsiang projects that the Climate Impact Lab will publish the initial version of its calculation of the global cost of carbon within a year. But that won’t be the end of the work, he says.

“We need more economists working on this problem,” Hsiang says. At the request of the editors of several academic journals, Hsiang and collaborators produced a four-part tutorial on climate change for economists. “We’re trying to document our new methods for others,” he says.

“We’re all supposed to produce science,” says Maximilian Auffhammer, an environmental economist

at Berkeley. “The great ones also produce other scientists, and Sol has already trained a bunch of really impressive students.”

Of course, Hsiang has detractors. The University of Sussex’s Richard Tol, the creator of the widely used FUND model for estimating climate change’s economic effects, has been a frequent critic.

“My main issue is that he uses weather shocks to study climate change,” Tol says. “Weather shocks are unexpected. Climate change is slow and predictable. As a result, he overstates the impacts.”

Data and policymaking

Hsiang rejects that, saying, “we have been doing a lot of innovation to study how populations adapt,” and argues that his use of data and econometrics produces quite different findings from the FUND model.

Others say it’s a waste of time to calculate the cost of carbon because there will always be too much missing data to get it right. “We don’t need a full optimization model to make certain decisions,” write Nobel laureate economist Joseph Stiglitz and Britain’s Nicholas Stern in a February 2021 paper. Policies should be built around the goals set in the 2015 Paris Agreement, they say.

Hsiang maintains that policymakers need to rely on data-based findings. “Almost everyone’s intuition for the role of the climate in the economy is not right,” he says.

“The advent of large-scale data collection, high-powered computing, and the application of science to policy means that we can now build transparent and evidence-based systems to guide our thinking,” he says. “The future of managing all planetary resources fairly and sustainably, even beyond climate change, will rely on these tools.”

As for the alarming effects of climate change and the world’s tardy, confused, and incoherent response, Hsiang takes a long view, harking back to the days when leaders consulted oracles to divine the future.

“We are at the state of scientific sophistication where we can understand future pathways and make thoughtful decisions in advance,” he says. “This is the first time in human history where we saw something this big coming and have the opportunity to do something about it.” **FD**

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No Higher Ground

*For Maldives Environment Minister
Aminath Shauna, fighting climate change
is an existential battle*

MALDIVES IS A COUNTRY that lives and dies by the ocean that surrounds its 1,200 islands. The nation has built an economy on drawing tourists to its crystal blue waters. But the same waters, rising because of climate change, also continually threaten its population.

Aminath Shauna, the nation's minister of environment, climate change and technology, is working on a holistic approach to help island communities adapt to the ravages of climate change while trying to show that even small island states can contribute to the reduction of greenhouse gases.

In this interview with F&D's Adam Behsudi, Shauna discusses how a country on the front lines of climate change is adapting and surviving.

F&D: What is at stake for Maldives when it comes to climate change?

AS: The right question is what is *not* at stake. The Maldives is one of the most low-lying nations in the world, and for us climate change is an existential threat. There's no higher ground we can run to. It's really just us, the islands, and the sea. Eighty percent of our islands are less than a meter above sea level. Over 90 percent of the islands report flooding annually. Ninety-seven percent are reporting shoreline erosion, and 64 percent of the islands experience severe erosion. Fifty percent of all our housing structures are within just 100 meters of the coastline. So most really cannot withstand tidal floods, let alone tsunamis. Really, everything is at stake.

F&D: What measures has the government taken to fight the effects of climate change?

AS: Almost all 187 inhabited islands in the Maldives have infrastructure that protects them from tidal swells and beach erosion—hard engineering solutions that have been developed over a span of 20–25 years. All the islands have a harbor, shoreline protection—and most of them have erosion prevention measures. The first barrier of protection is obviously the coral reefs. Building the resilience and protecting the health of coral reefs has really been at the forefront of government policies.

However, the approach that our government has taken is a holistic one. We believe that building resilience of the entire community is necessary. Changing how we manage our waste and generate power are critical in terms of adaptation. We have introduced a net zero policy to shift our economy from running on diesel to basically running on sunshine, which we have in abundance. We have also introduced a single-use-plastic phaseout by 2023, which is already being implemented. We can clean up our act and stop the open burning of garbage on the islands. We are currently working on two major waste management projects with the Asian Development Bank and other development partners and another with the World Bank to build world-class waste management centers. Our government has a target of protecting 20 percent of our ocean resources by 2030—so we can better protect our reefs, our mangroves, and other biologically important areas. So we're thinking of it as a very holistic approach rather than just hard engineering solutions.

F&D: What role can a small island state like Maldives play in the global effort to decrease emissions and prevent global warming from increasing?

Aerial view of Malé, Maldives' capital.



PHOTO: ISTOCK / NARVIKK

AS: Just yesterday we celebrated the Maldives reaching a target of phasing out its chlorofluorocarbons 10 years before the deadline in the Montreal Protocol. Yes, we are a very small country and our greenhouse gases are negligible, as is our contribution to climate change. But we want to show that if the Maldives can do it, why can't the rest of the world? We are not here to tell a story that we're just victims. We are also willing to lead by example.

F&D: When it comes to financing adaptation measures, how has the pandemic hindered efforts?

AS: Twenty-eight percent of our GDP is directly related to the tourism industry. Sixty percent of our foreign exchange receipts come from tourism. The pandemic really stopped the source of income for over 30,000 people who are directly employed in the tourism sector and many others who indirectly benefit from the tourism industry. Fishing is the second largest economic activity, and during the pandemic, we had no way of exporting. We really had no money. At the same time, we had to spend so much on health care.

What we had allocated in any other year for things like providing water to islands during the dry period, urgent erosion, and some adaptation measures—all of this money was allocated for health care and urgent economic relief and stimulus. Restrictions on movement and lockdowns generated a whole lot of waste as well. In a country already struggling with lack of proper waste management resources, this exacerbated an

environmental problem at a national level. A lot of the funds from multilateral organizations and our development partners that were allocated to us to address climate change and environmental issues were immediately redirected for the provision of urgent medical care supplies. Although we all want to build back better, it has been quite a challenge because of this reallocation of resources.

F&D: What is the best way to help smaller countries finance climate change measures?

AS: It's important for countries on the front line to have easier access to financial instruments and funds. We have very few projects that are under global climate funds because it is difficult to access these funds owing to the bureaucracy in the development of projects that qualify.

When I was previously in government, we were working to justify to one of the multilateral organizations that a harbor on an island was absolutely needed to prevent erosion, prevent coastal flooding, and protect the island from tidal swells. We were asked whether the harbor was economic infrastructure and how could we prove that erosion was caused by climate change. In countries like the Maldives, we don't have research-based organizations with data that go back 20 or 30 years to show that this particular island is eroding because of climate change.

We don't have time to wait until a project goes through different phases and different board approvals. If we did, there would be no island left! More direct access to global climate funds would really help us address urgent issues.

F&D: What inspires you on a daily basis to shape policies that will help your country?

AS: Because the Maldives is such a small country, change is really possible. This is what keeps me going. Seeing our island communities live so peacefully with nature, with their beaches, with their coral reefs. We depend so heavily on fisheries and tourism; we have no option but to protect and preserve the beauty of this country.

When I lived in the United States, I visited quite a few national parks. I could see what conservation and protection can do for a country in terms of tourism. What the United States has been able to do for its national parks, we could do here in the Maldives as well. **FD**

This interview has been edited for length and clarity.

Building Back Better

Finland and Dominica pursue innovative ways of coping with climate change

Steven Dorst

The devastating scenes of destruction that have played out in recent weeks—from record-breaking floods in China to raging fires in Greece—offer a glimpse into what a warmer world looks like. Climate chaos is not inevitable, however. Climate solutions exist, and they are being delivered in countries with the will and leadership to do so.

The countries highlighted here have different goals. In Finland, it's mitigation. The country has set an ambitious target of becoming carbon neutral by 2035, in part by shifting from plastic, concrete, and steel to wood and bio-based materials through careful forest management.

In Dominica, a Caribbean island on the front lines of the war on climate change, adaptation is the priority. Storms regularly batter the island and climate change will inevitably increase both the frequency and intensity of those storms. The country is determined to become the first climate-resilient nation by 2030 and is investing heavily to “disaster-proof” its buildings and infrastructure.

In terms of economic size, structure, and output, Finland and Dominica couldn't be more different. But when it comes to climate change, they both know how much is at stake. They've set ambitious

targets and are using the cards they've been dealt to simultaneously forestall and prepare for the future.

Finland's wood innovations

With fires, landslides, and floods raging around the world, the climate crisis demands a sea change in how we live and consume.

One country, Finland, is answering the call in an unexpected way—replacing fossil-based chemicals, key emitters of greenhouse gases, with renewable raw materials such as wood to produce goods, services, and energy.

With 65 percent of its land covered by forests, Finland has wood in abundance. That share is expected to grow, thanks to the country's Forest Act, which mandates that four trees be planted for every tree harvested.

Environmental benefits abound. Cutting-edge Finnish companies are coming up with new ways to use wood, from the production of clothing to multistory buildings, from packaging to sustainable fuels and even battery production. Products are easy to recycle, biodegradable, and hypoallergenic, and CO₂ can remain stored in cut wood for decades and even centuries.



The Helsinki Central Library Oodi in Helsinki, Finland.

“Replacing fossil fuels and materials such as plastic or concrete and steel used for building with wood and bio-based materials limits the carbon emissions to the atmosphere,” says Lotta Heikkonen, chief specialist with Finland’s Ministry of Agriculture and Forestry.

The economic incentives of this growing market for wood-based products further motivate smart tree management. And many of the wood-based products are made from production by-products and residues or from materials recovered after product use.

“In a circular bioeconomy, products are bio-based,” says Timo Heikka, vice president of stakeholder relations at Stora Enso Oyj, a manufacturer of pulp and paper products based in Helsinki. “They are also being shared, reused, remanufactured, and recycled. Finally, they biodegrade or are used for renewable energy. Trees grow back, absorbing CO₂, and so the cycle continues.”

While biomass alone can’t replace all the materials produced from fossil and mineral sources, “there will be further opportunities to replace fossil-based raw material components with renewable wood-based ones,” says Chief Technology Officer Jyrki Ovaska with Finnish company UPM, which makes a host of wood-based products ranging from biofuels to biomedical products. “This is where molecular wood-based biochemicals play a key role.”

Finland isn’t new to climate action. The first country to introduce a carbon tax, in 1990, it has since cut greenhouse gas emissions by about a fifth. But its ambitions don’t end there: Finland has set a goal of becoming carbon-neutral by 2035. It plans to do this by deploying electric vehicles, phasing out fossil fuel heating, and creating carbon sinks to absorb and neutralize CO₂ emissions.

Although carbon emissions in Finland are already subject to significant pricing, additional measures are needed to achieve the 2035 emissions neutrality goal. The IMF is working with Finland on additional energy pricing and sectoral measures to help bridge the gap.

While Finland’s wood-based approach to climate change may not work for all countries—given climate differences and the trade-offs between agriculture and tree growth—it offers a timely reminder to rethink how we can harness nature to address the global challenge of climate change.

Dominica develops resilience

The island nation of Dominica, home to some of the Caribbean’s most breathtaking natural beauty, lies smack in the middle of Hurricane Alley.

Because of its rugged topography, with dense mountain rain forests and nine active volcanoes, most of the country’s 72,000 denizens live along the coast—vulnerable to strong winds, high seas, and landslides.

The situation has become increasingly volatile with the growing frequency and severity of extreme climate events.

In 2017, Category 5 Hurricane Maria ripped a catastrophic path of destruction through the island. Whole communities, government buildings, roads and bridges, and power and water services were damaged or destroyed, resulting in the loss of lives and \$1.2 billion in damage in just a few hours.

With growing climate threats looming, Dominica knew it had to adapt. The fallout from the storms “convinced everybody that it was not optional to

Rebuilding climate-resilient housing and a clinic in Dominica.



become a disaster-resilient nation. It was a matter of survival for all Dominicans,” says Alejandro Guerson, IMF mission chief for Dominica.

The enormity of the crisis led to a pivotal shift. After Hurricane Maria, “the task of building back better and becoming a more resilient nation in all aspects became the mantra for the government,” says Denise Edwards, Dominica’s financial secretary.

The question was how. Rebuilding to climate-resilient standards would cost 25 percent more than traditional methods. Even more daunting, the country had just suffered damages totaling 226 percent of GDP. Moreover, benefits materialize only over time, making financing choices difficult.

But the business case was already on display. The airport, inoperable after 2015 Tropical Storm Erika, was up and running a few days after Hurricane Maria, thanks to measures taken to build back better. Likewise, communities rebuilt to new resilience standards were still intact.

“This was proof you could see that we can build infrastructure that can stand up even to the might of a Category 5 hurricane,” says Francine Baron, CEO of the Climate Resilience Execution Agency for Dominica.

The IMF began working with Dominica to understand the probability and intensity of natural disasters, as well as the costs and benefits of building to new standards. Armed with a new framework and strategy, the government launched on a path to become the world’s first nation resilient to hurricanes, earthquakes, and other natural disasters.



Efforts are focused on upgrading and expanding the road network, including making bridges higher to allow for water and debris overflow, building resilience into the housing sector, and upgrading hospitals and health centers. Investments also support resilient agriculture for food security, education, reforestation, and community preparedness training, among other things.

As a small island state that did not cause global warming, Dominica is suffering the consequences—and the cost of adapting—disproportionately.

“If we want to make a meaningful contribution to helping small states adapt to climate change, then the international community needs to step up,” says Baron.

Indeed, Dominica serves as a beacon for other countries, making smart, tough decisions to protect its people in a world that is changing fast. **FD**

STEVEN DORST is a documentary film producer.



A young woman holds a megaphone during a climate protest by the Cornwall Climate Youth Alliance in Cornwall, United Kingdom in June 2021.

WALKING THE TALK

Climate activists share candid advice for top COP officials

Young people are calling for action on the climate crisis, and the world is taking notice. Thanks to the internet, youth protestors are organizing across continents like no generation before them. As leaders prepare to meet in Glasgow, F&D asked a few prominent youth climate activists the single most important message they have for policymakers at the COP26 summit. Here's what they said.

Vanessa Nakate, Uganda

IF THERE IS ONE THING we learned from the pandemic, it's that nature is in charge. Yet we continue to destroy our fragile ecosystems and our climate at a horrific rate. COVID-19 should serve as a warning to the world.

The climate crisis is speeding up. The evidence is everywhere—from massive floods this summer in Nigeria, Uganda, China, and Western Europe, to the raging wildfires and fierce heat waves in North America and Turkey.

Above all, though, the climate crisis is having the greatest impact on those places that have contributed the least to global emissions. Madagascar's 28 million people produce less carbon than a Western city the size of Cincinnati, yet they face a historic drought and famine, resulting in large part from the emissions of the world's biggest polluters.



Financing new fossil fuels is inexcusable; we need massive investment in global solutions

Here in Africa, electricity demand is likely to double by 2030. We need to meet these demands with clean energy. At the same time, we also need to bear the costs of adapting to the impact of climate change with limited resources.

PHOTOS: TOM NICHOLSON/REUTERS/NEWSCOM; COURTESY OF VANESSA NAKATE; ANTOVA

We can talk about small fixes and incremental solutions. But, as has been made clear many times before, we need to immediately stop digging and burning fossil fuels to meet the climate thresholds for a stable world. Even the International Energy Agency says this now. Most of the fossil fuels currently sitting in reserves need to remain unburned for us to have a chance of keeping below even 2°C. In case you need a reminder, 2°C of warming would be a death sentence for countries like mine.

Massively scaled solutions are required across all aspects of society for this change. Subsidies, development finance and private finance must stop funding fossil fuel infrastructure now. Anything less is inexcusable. Huge public and private investment must instead go into scaling renewable energy around the world. On top of this, all sorts of solutions need to be used and funded, and they don't always involve technology. For example, Project Drawdown lists educating girls and family planning as the fifth most impactful global climate solution to keep temperatures under 1.5°C of warming.

Let us not sleepwalk into another global crisis. We can either cling to our reliance on fossil fuels, or we can take this opportunity to save ourselves from an uninhabitable future. We cannot eat coal, drink oil, or breathe so-called “natural” gas.

VANESSA NAKATE is a climate activist from Uganda.

Vladislav Kaim, Moldova

AS A YOUNG PERSON from Moldova, arguably Europe's most vulnerable country to climate change, I am waiting for COP26 to deliver a comprehensive and sustainable solution when it comes to financing green transitions in places least equipped to do so.

Since 2009, the climate finance target of \$100 billion a year stands as a reminder of the broken promises, lack of visionary leadership, and absence of political will, which has direct costs in lost natural, human, financial, and other forms of capital in the least privileged countries. As a young economist, I urge all leaders to take into account the fact that, in this battle where the future of the green economy and livelihoods are at stake, a positive result on climate finance should build on other important milestones coming up. Here my special attention goes to the annual meetings of the IMF and the World Bank, as well as to the Group of Twenty (G20) finance ministers meeting in Rome right before the start of the COP26 Leaders' Summit.

The road to an effective solution for climate financing at COP26 lies through comprehensive efforts to address not just the roadblocks accumulated through years of futile negotiations but also the immediate fiscal challenges brought by COVID-19. Many vulnerable countries risk defaulting on their Nationally Determined Contributions, current or enhanced. The road to walking the talk on the Paris target on finance starts with making sure these countries are the primary beneficiaries of any new issuance of Special Drawing Rights (SDRs) and that they secure a significant share of those proceeds for climate action.

A second stepping stone is a comprehensive, all-hands-on-deck debt restructuring for the most affected countries to help them advance green solutions to their problems, through such instruments

Leaders must deliver a comprehensive, sustainable solution to climate finance



PHOTO: COURTESY OF VLADISLAV KAIM

as debt-for-nature and debt-for-climate swaps and more. The G20's Debt Service Suspension Initiative, despite its extension, represents merely a duct tape solution to a monumental problem. Last but not least, we need ironclad road maps from multilateral development banks to go fully green and 50 percent adaptation-focused by 2024.

If parties to the United Nations Framework Convention on Climate Change rise to the challenge, then the climate finance agenda at COP26 stands a chance to win. Otherwise, another big-ticket item that previous generations were too lazy and careless to pay for will end up on the tab of my own.

VLADISLAV KAIM is an economist committed to ensuring green and decent jobs for youth and a member of the UN Secretary-General's Youth Advisory Group on Climate Change.



PHOTO: COURTESY OF ERNEST GIBSON

Ernest Gibson, Fiji

I JOINED THE CLIMATE movement out of necessity. As a Pacific Islander from a large ocean state, I know all too well the impact of more severe weather events, rising and warming seas, and longer seasons on island nations like my own.

We need to move away from looking at the climate crisis as an environmental issue—it is an ethical issue, a human rights issue, an economic issue. It is about peace and security. Whether we like it or not, all these things are connected. And the solutions lie in our ability to take charge of this capitalist, greed-driven system and fundamentally change the world we inhabit.

If we do not vehemently oppose this current system, we give currency to it. By allowing it to continue, we are giving it our tacit support.

There are, as is often the case, many ways to challenge this current system. But I would like to reflect on two key points: the value of communities and grassroots activities in combating the climate crisis and the importance of social movements in speaking truth to power.

In the development process, we often run the dangerous risk of treating communities as problems to be solved and not as agents of change and contributors to the solution. If we would like to achieve our genuine climate ambitions, we need to change this. Communities possess a wealth of

Local communities know how to sustain a healthy relationship with the environment—we should take our cue from them

experience in fostering and sustaining a healthy relationship with the environment, and it is on this richness that we should draw. We should take our cue from them.

This also implies that we need to adjust the way that we measure the success of our actions to ensure that we are accountable to grassroots communities and the people on the frontlines of the climate crisis—as well as the people whose futures are affected by the choices we make today. We have to make certain that our processes are informed by community needs.

We know that young people face a unique set of barriers and challenges when engaging in the various policy and change-driving spaces. Consequently, to ensure that we encourage the fullest participation possible, we need to put in place mechanisms that protect young people so they can challenge the “powers that be” without fear of retaliation. **FD**

ERNEST GIBSON is a climate activist in Fiji and a member of the UN Secretary-General's Youth Advisory Group on Climate Change.

NET ZERO BY 2050

The IEA outlines a path to decarbonize the energy sector in three decades

FOLLOWING A RAFT of net zero target announcements in 2020 and 2021, scrutiny is mounting about the plans to get there. Some countries have detailed outlines of how they will reduce their emissions to net zero, but many still do not. Thanks to countries with detailed plans we have an idea of the task at hand to decarbonize at the country level, but it is hard to imagine what it will take on a global basis. This is especially true given that the current global pledges won't get us to net zero in time to limit the temperature rise to 1.5°C.

To address this problem, the International Energy Agency (IEA) released its "Net Zero by 2050" report. The study's detailed road map outlines the policies, technologies, and behavioral changes needed to achieve a net zero energy system in just three decades. The energy sector holds the key to decarbonizing the global economy: energy-related emissions account for about three-quarters of total CO₂ emissions.

A daunting picture emerges from the report: the energy sector needs a complete overhaul. To succeed, governments must act immediately and decisively to end fossil fuel consumption and craft a resilient

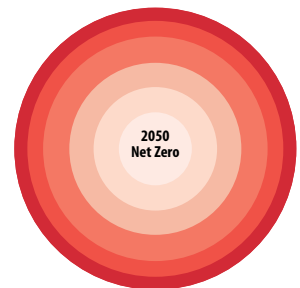
energy economy dominated by renewables such as solar and wind power. The pathway to success is narrow, but the IEA report makes it clear that it is achievable. Decisive climate action now will put the global economy on a stronger and more sustainable footing over the long run. **FD**

ANDREW STANLEY is on the staff of *Finance & Development*.

Emissions Target

As the major source of global emissions, the energy sector holds the key to the world's climate challenge.

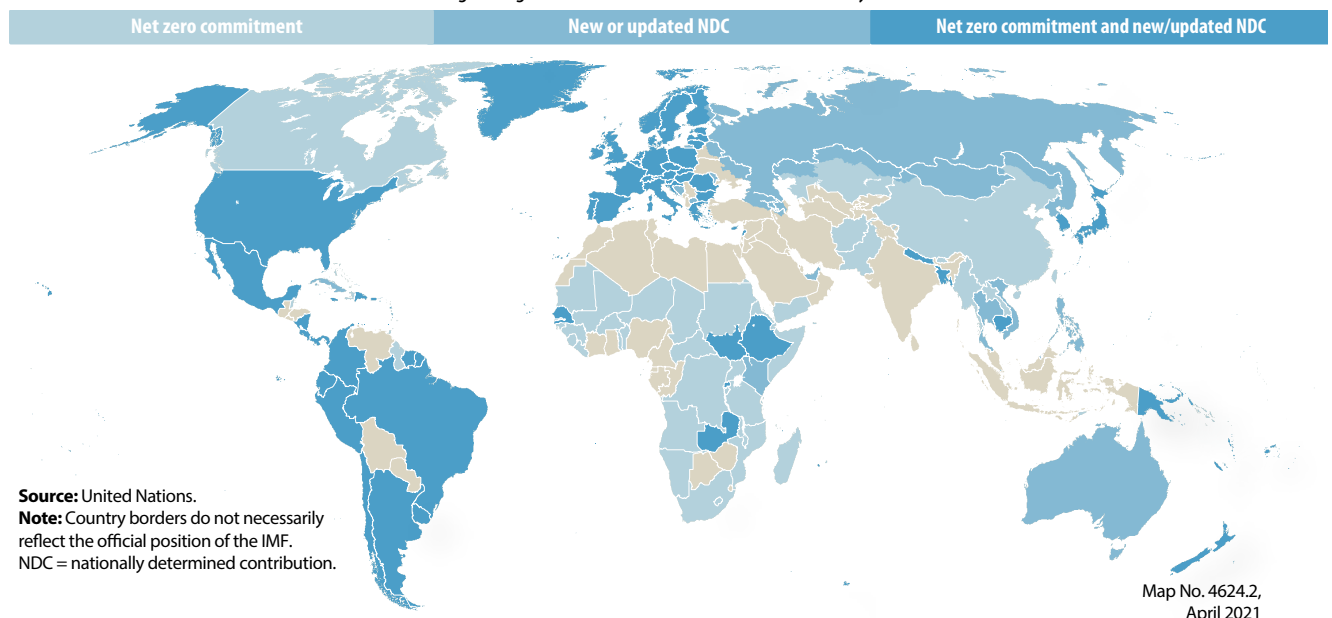
GtCO ₂	
33.9	2020
30.2	2025
21.1	2030
12.8	2035
6.3	2040
2.5	2045
0.0	2050



Source: International Energy Agency, "Net Zero by 2050."
Note: GtCO₂ = gigatons of carbon dioxide.

Growing Commitments

The number of countries with net zero commitments is growing but still falls short and must be backed by credible action.



Buildings

No new sales of fossil fuel boilers by 2025; all new buildings zero carbon ready by 2030; 50% of existing buildings retrofitted to zero-carbon-ready levels by 2040; 50% of heating demand met by heat pumps by 2045; more than 85% of buildings zero carbon ready by 2050.



Transportation

60% of global car sales electric by 2030; 50% of heavy truck sales electric and no new internal combustion engine car sales by 2035; 50% of aviation fuel low emission by 2040.



Industry

Most new clean technologies in heavy industry demonstrated at scale by 2030; all industrial electric motor sales best in class by 2035; 90% of existing capacity in heavy industries at the end of their investment cycle by 2040; more than 90% of heavy industrial production low emission by 2050.



Electricity and heat

No new unabated coal plants by the end of 2021; 1,020 gigawatts of annual solar and wind added by 2030; unabated coal plants phased out in advanced economies by 2030; net zero emission electricity in advanced economies by 2035; net zero emission globally, including global phaseout of all unabated coal and oil power plants by 2040; almost 70% of electricity generation globally from solar photovoltaic technology and wind by 2050.

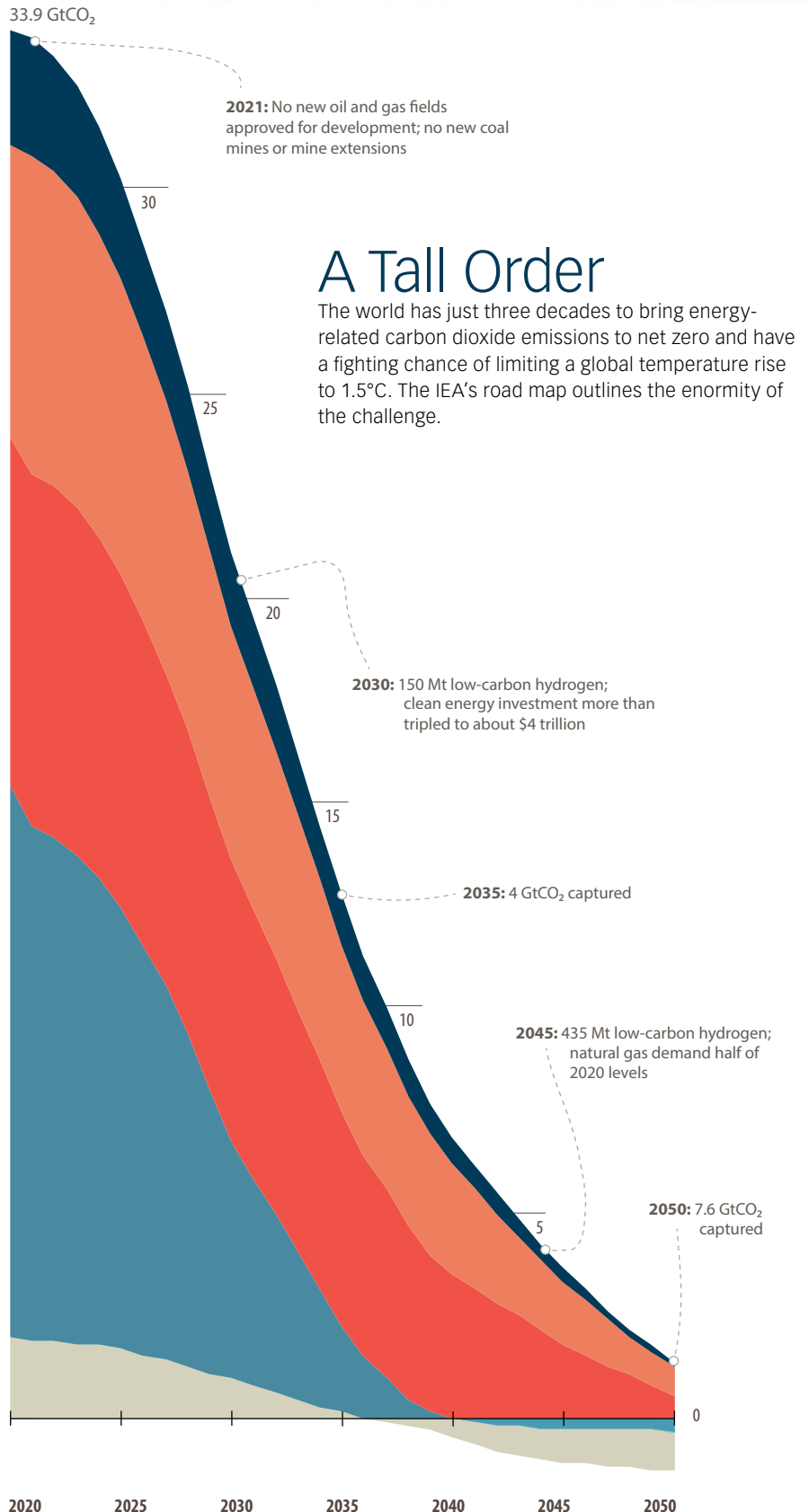


Other



Source: International Energy Agency (IEA). 2021. "Net Zero by 2050." Paris.

Note: Hollow circles represent negative emissions. GtCO₂ = gigatons of carbon dioxide; Mt = metric tons.



What Is Mitigation vs Adaptation?

The world faces a two-front battle to halt global warming and address the effects of climate change

Adam Behsudi



IMAGINE YOUR BOAT has sprung a leak.

To keep from sinking you must address the source of the problem. That means plugging the holes. But what about all the water already rushing in? To stay dry, you grab a bucket and start bailing. To stay afloat and prevent damage to your boat, you need to address both issues simultaneously.

In the face of climate change, humanity must similarly act on two fronts at the same time.

Mitigation efforts require measures to address the underlying problem by slowing or stopping the rise in fossil fuel emissions, which could irreversibly and catastrophically raise the Earth's temperature. Adaptation is needed to help people and governments withstand and minimize the ravages of climate change that are already here.

Mitigation

Scientists and economists mostly agree on what must happen in the next 30 years to mitigate climate change. The challenge for policymakers, however, is how to incentivize and spread the use of clean technologies to power vehicles and produce electricity

and, ultimately, make it less economically advantageous to use fossil fuels.

Enter carbon pricing.

Reducing carbon emissions from burning fossil fuels like coal, oil, and gas won't happen without some prodding. Just as you might pick the cheaper of two similar items when shopping, people are less likely to choose fossil fuels with an added environmental cost if cleaner alternatives are cheaper.

Pricing carbon is essentially calculating the cost of releasing another ton of carbon dioxide (CO₂) into the air. The use of fossil fuels may create jobs and commerce right now, but they enjoy an implicit subsidy: users don't have to pay for environmental damages. In economic terms this is known as a "market failure" in which the price of a good or service doesn't fully reflect all the costs.

When a power company is deciding between investing in a new wind farm or a coal-fired power plant, the decision should take into account the cost of pollution on top of the costs of both technologies.

To correct this failure, policymakers have started to rely on two major ways to price carbon:

Carbon tax: This sets a direct tax on coal, oil products, natural gas, and other fossil fuels in proportion to their carbon content. The tax is passed from suppliers to consumers in the form of higher prices for electricity, gasoline, heating oil, and other products and services that rely on fossil fuels.

Cap-and-trade system: This sets allowances on the total amount of carbon emissions released each year, creating a market-based system in which the allowances can be traded from less-carbon-intensive to more-carbon-intensive sectors.

The best form of carbon pricing depends on a country's individual circumstances, but a carbon tax has been identified as the most effective way to change behavior. Carbon taxes are appealing because they can be added to existing taxes on gasoline and other fuels and can help countries meet pledges to reduce emissions under the 2015 Paris Agreement. They can also provide an additional revenue stream

for governments, allowing them to cut burdensome taxes or fund development.

Beyond direct carbon pricing, regulatory measures can minimize carbon emissions. Governments can set what's called a renewable portfolio standard, which mandates production of a certain amount of energy from renewable sources like wind and solar, among others.

Carbon pricing, however, has an advantage over regulatory approaches because it forces a more rapid and broader behavioral shift in both the type and amount of energy used. To save money, electricity providers, manufacturers, and consumers will seek cleaner, lower-cost energy sources; adopt more efficient technologies; and reduce their demand for energy.

The ultimate goal is to reduce emissions enough to limit global warming to 1.5°C–2°C above pre-industrial levels—the point of likely irreversible changes in sea level rise, extreme weather, availability of water, and other significant shifts.

An international carbon price floor is increasingly viewed as the way to get the world's largest CO₂ emitters to reduce emissions enough to keep global warming below the 2°C target. Concerted action can allay concerns that one country's energy-intensive or trade-exposed sectors will be less competitive or that companies will flee to countries where there are lower or no carbon prices.

The IMF has found that it will take a \$75 a ton price on CO₂ worldwide by 2030 to limit warming to 2°C. The world has far to go. Four-fifths of global emissions are not priced, and the global average emissions price is only \$3 a ton.

There's a reason for slow action: such measures have costs both in real terms and in political decision-making. At \$75 a ton, over 10 years electricity prices would rise, on average, by 45 percent and gasoline prices by 15 percent.

Pursuing a just transition is vital. The revenue raised through carbon taxes will be necessary to compensate low-income households that struggle to afford higher energy costs and to support people who currently rely on coal, petroleum, and other fossil fuels for their livelihoods.

Adaptation

Yet the world is already facing increasingly severe weather. This is taking a toll on government budgets

worldwide but especially in poorer countries that already struggle to provide basic services.

Adapting to climate change with more resilient infrastructure, securing water resources, improving crop production for dryland farming, protecting coastlines, and other measures can pay a triple dividend. Countries will suffer less from future climate shocks, enjoy greater productivity and growth, and reap social and environmental benefits.

Adaptation can take many forms beyond direct government financing of infrastructure. It involves encouraging the private sector to adapt, social protection after disasters, and a holistic strategy for budgeting and planning that factors in climate change.

Adaptation is smart. Every \$1 invested in adaptation could yield up to \$10 in net economic benefits, depending on the activity, according to a report from the Global Commission on Adaptation.

The benefits of adaptation measures are obvious and save money in the long run, but they require up-front costs that are a struggle for many developing economies.

Some are caught in a vicious circle: limited fiscal space hinders their ability to adapt to climate change, and worsening climate shocks raise their risk premiums, increasing the cost of borrowing in global financial markets. When debt costs are higher, adaptation measures are less feasible.

Helping countries sustainably finance these investments is critical for adaptation and will help public finances in long run. Reducing climate vulnerability by investing in resilience can put a lid on climate risk premiums.

But there's still too little climate financing available to prevent this destructive cycle. Financing for adaptation totaled \$30 billion on average annually in 2017 and 2018. Annual adaptation costs in developing economies alone are currently estimated at close to \$70 billion and are expected to rise to \$140–\$300 billion by 2030.

The world can meet its climate targets, but there's more work to be done on both mitigation and adaptation. Unlike our metaphorical boat, there is only one Earth: our efforts to keep it afloat are a task of existential proportions. **FD**

ADAM BEHSUDI is on the staff of *Finance & Development*.

A stylized illustration of a city skyline in shades of white and light blue against a dark blue background. The skyline includes recognizable structures like the Oriental Pearl Tower on the left and the Petronas Towers in the center. The buildings are reflected in a dark blue, wavy shape at the bottom, suggesting water or a cityscape reflection.

Asia's Climate EMERG



ENCY

Fiscal policy can help address climate change in Asia, the region hit hardest by global warming

Era Dabla-Norris, James Daniel, and Masahiro Nozaki

Climate change is the defining challenge of our time, and the stakes are particularly high for the Asia-Pacific region. Temperatures are rising two times faster in Asia than the global average, which is associated with the increased frequency and severity of weather-related natural disasters. In 2019 alone, India was buffeted by a severe heat wave that led to water scarcity in parts of the country. Torrential rains in South Asia caused large-scale population displacement, while water levels in the Mekong Delta fell to unprecedented lows due to intense dry weather. Australia faced historic bushfires fueled by a particularly harsh dry season. And more than 25 tropical cyclones wreaked damage on the Pacific and Indian Ocean coasts. Such climate hazards are projected to intensify in the period ahead.

Rising sea levels from global warming are eroding arable land in low-elevation coastal zones, posing a severe risk for rural incomes, food security, and commodity exports. By mid-century, rising waters will impact nearly a billion people in the Asia-Pacific region. Megacities such as Mumbai, Dhaka, Bangkok, Ho Chi Minh City, Jakarta, and Shanghai run the risk of being submerged. Indonesia is already planning to move its heavily populated capital, Jakarta, to the island of Borneo to protect its residents from dangerous flooding. For small Pacific island countries such as Kiribati,

the Marshall Islands, and Tuvalu, rising sea levels pose an existential threat.

But while Asia-Pacific suffers keenly from the effects of climate change, the region is also a key source of the problem. The region produces about half of the world's carbon dioxide (CO₂) emissions and contains five of the largest greenhouse-gas-emitting countries. In view of Asia's substantial share of current emissions as well as its expected future emissions growth, China, India, and other large CO₂-emitting countries' policies to curb emissions will be a critical element of the global effort.

In addition to contributing to global warming, greenhouse gas emissions from Asia's coal-based power generation and carbon-intensive manufacturing (such as steel and cement, motor vehicles, agriculture, and domestic cooking and heating) have resulted in dangerously high levels of particulate matter in the air (McKinsey Global Institute 2020). Delhi, Dhaka, Ulaanbaatar, Kathmandu, Beijing, and Jakarta are among today's 10 most polluted cities. The use of fossil fuels must be contained to make a serious dent in air pollution, a major contributor to mortality and respiratory diseases in developing Asia.

Climate change threatens growth, livelihoods, productivity, and well-being across all countries in the region. But fiscal policy can play a role in responding to the problem. In our recent paper, we discuss how policymakers in the Asia-Pacific region can accelerate mitigation and adaptation efforts, using fiscal policy to manage policy trade-offs and ease the transition to a low-carbon economy (Alonso and others 2021).

Preventing further buildup of risks

Much of Asia is already responding to the mitigation challenges of climate change. Virtually all countries have made or updated commitments under the 2015 Paris Agreement, the landmark global agreement on emissions reduction. China recently stated its goal of carbon neutrality (achieving net zero CO₂ emissions) before 2060. Japan and Korea have pledged the same goal by 2050. However, more needs to be done to scale up and accelerate the transition to a low-carbon economy. Achieving this ambitious goal calls for changes in production and consumption patterns and the transformation of energy, transportation, and land use.

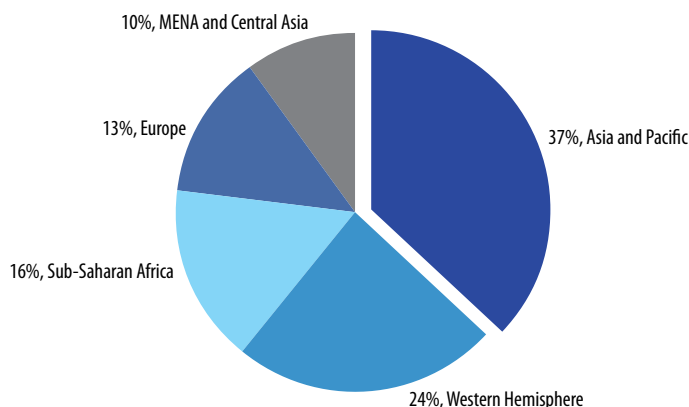
A carbon tax, where the government taxes carbon emissions, can be an effective tool to reduce CO₂ emissions (IMF 2019). Take the case of Vietnam,

Chart 1

Prone to disaster

The Asia-Pacific region sees a greater number of weather-related disasters than other regions, with increased frequency and severity.

(occurrence, all weather-related disasters, 2000–19)



Source: EM-DAT 2020.

Note: MENA = Middle East and North Africa.

which has relied heavily on fossil fuels for its rapid industrialization and is also among one of the most hazard-prone countries in the world. Gradually introducing a carbon tax of \$25 a ton over the next decade would help the country meet its Paris mitigation targets. Raising the price of carbon would create incentives for firms and households to use energy more efficiently and encourage a shift from coal-powered energy to renewables. Carbon revenues of about 1 percent of GDP could then be used to finance the country's adaptation and mitigation plans or to meet other social development needs.

Fiscal policy can also help solve the region's air pollution problem. In China, India, and Mongolia, about 68–80 percent of emissions come from coal. A specific tax on coal produced or consumed at an equivalent carbon tax rate could be considered in these countries. India's coal tax, introduced in 2010 and doubled in 2020, could be further strengthened. Implementing a coal tax equivalent to \$25 a ton could save about three million lives by 2030 in China alone.

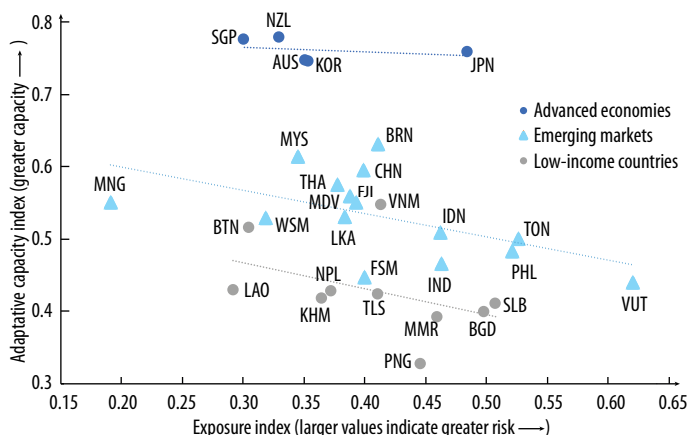
A critical part of enabling the transition to a low-carbon economy will be managing potential side-effects, such as rising energy costs for households and firms, labor displacement, and an unequal impact across the regions. But the effects of policies will vary across countries. For example, a carbon tax, if implemented, would be moderately regressive (disproportionately borne by poor) in China and Mongolia, but moderately progressive (disproportionately borne by rich) in India. Countries with a regressive carbon tax must support people—such as coal miners—whose livelihoods depend on energy sector jobs. These workers tend to be relatively poor and may have difficulty transitioning to growing sectors (including renewable plants).

To make up for the negative fallout from the transition, governments will have to find ways to compensate households and firms. In India, for instance, using the revenue from a carbon tax to finance a universal lump sum transfer (possibly using Aadhaar unique identification numbers) would leave 80 percent of households better-off and reduce inequality. In China, both a universal lump-sum transfer per person and a subsidy to rural households would reduce inequality. Displaced workers employed in affected sectors could be supported by extended unemployment benefits, training, and reemployment services. And higher public spending—for instance, on clean public infrastructure—could create new jobs in low-carbon

Chart 2

Ability to adapt

Poorer and more exposed countries have less capacity to adapt to the effects of climate change.



Source: IMF staff calculations based on 2015–18 data from the European Commission, the United Nations University Institute for Environment and Human Security, the University of Notre Dame, and the IMF World Economic Outlook database.

Note: Data labels in the figure use International Organization for Standardization (ISO) country codes.

sectors. Governments could also consider putting in place market-based incentives that promote access to green finance to ease financial constraints for firms.

Governments in the region have also adopted a range of other instruments to address climate mitigation including emission trading systems, in which governments set limits on emissions and let the market determine the price. Currently, emissions trading is limited to power generators and large industries and typically covers only about half of national emissions in most countries in the region—China and Korea, for example. Extending coverage of these systems to small-scale users would help. So would complementary measures such as feebates, which impose a sliding scale of fees or rebates for particular products and activities above or below certain emission rates. Finally, stricter regulations on air quality, fuel quality, and vehicle emission standards would help support decarbonization efforts. Investments in clean public transportation, smart electricity grids to incorporate renewables into power generation, and retrofitting buildings to make them more energy efficient would complement these efforts (IMF 2020).

Accelerating adaptation

Improving the adaptive capacity to offset the damages from more severe climate hazards, more frequent climate-related disasters, or both will be essential for all countries. This will mean developing early warning systems, building resilient

infrastructure, reducing exposure, and ensuring that appropriate financing mechanisms are in place. Gaps in adaptive capacity, however, remains large for Pacific island countries, such as Vanuatu and Tonga, as well as for developing economies such as Bangladesh, Indonesia, and the Philippines. Adaptation is also likely to entail tough choices about what to protect and what to relocate, as well as how to safeguard the most vulnerable populations.

Adaptation is likely to entail tough choices about what to protect and what to relocate.

Despite the challenges, many countries in the region have been at the forefront of adaptation efforts. Japan, Singapore, and Thailand are among the best performers in the world in adopting and implementing frameworks for identifying, assessing, and reducing natural disaster risks. Restoring mangroves, protecting coral reefs, and adopting national and local adaptation plans are among the measures these countries are putting in place. Yet, even in these countries, governments could do more to fully cost and prioritize adaptation plans and factor rising climate risks into infrastructure decisions.

Building adaptive capacity calls for substantial investment, but there are opportunities as well. Developing economies such as Vietnam and Indonesia have large infrastructure needs and growing urban areas. This means they can ensure that what goes up is more resilient and better able to withstand the heightened risks of climate change. New roads could incorporate drainage to withstand heavier rainfall or be built on higher ground to reduce flood risk, a relatively inexpensive solution.

For other countries, bolstering resilience will require retrofitting existing climate-exposed assets or developing coastal protection infrastructure, which can be significantly more costly. Public investment needs for climate-proofing infrastructure are estimated to average 3.3 percent of GDP annually for the region. But the cost of developing coastal protection infrastructure is disproportionately high in many Pacific island countries. In Tonga, for example, climate-related investment needs (of which adaptation investment accounts for a major part) are estimated at 14 percent of GDP annually for 10 years (IMF 2020b). Public investment needs are also

sizeable in Indonesia, Laos, and the Philippines, because of their large existing stock of exposed assets. These high costs highlight the urgency of starting to build better to avoid further accumulation of vulnerable assets.

Investing in adaptive infrastructure can yield high returns. It can unlock private capital, including through reducing risk and damage from disasters; limit disaster recovery spending and debt distress; and ensure a quicker rebound in economic activity. But financing adaptation measures is particularly important, given the sheer scale of infrastructure needs for many countries. Revenue mobilization and spending prioritization and efficiency will have to play a role in easing growth-debt trade-offs. For the most vulnerable low-income and Pacific island countries with limited fiscal space, meeting adaptation needs will require concessional financing.

Exploiting synergies

The climate challenge is significant and urgent for the Asia-Pacific region, so governments must seize every opportunity to accelerate adaptation and mitigation work already taking place.

Fiscal packages to jump-start the recovery from COVID-19 should exploit synergies between infrastructure needs and opportunities for emissions reduction and adaptation. Innovation in climate-smart infrastructure and technologies (for example, carbon capture and storage) can help reduce the cost of mitigation. The region is well positioned, as countries such as China and Japan are already at the forefront of innovation—from electric vehicles to renewables. More active promotion of green finance will also help ensure that more money will flow into low-carbon, climate-resilient investments. [FD](#)

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Climate Change and Monetary Policy

Central banks must do their part in fighting global warming

Isabel Schnabel

The devastating effects of climate change are becoming increasingly evident. Temperature records are being shattered again this year—in Canada, the United States, arctic Russia, and central Asia. Globally, the past six years have been the hottest six on record, and temperatures in 2020 exceeded the 1850–1900 average by 1.25°C (2.25°F).

Exactly how climate change will affect the economy and the financial system is uncertain. The European Central Bank (ECB) is currently trying to quantify the consequences of climate change on companies and banks through an economy-wide stress test. The exercise, the results of which will be published soon, draws on a range of climate scenarios developed by the Network for Greening the Financial System (NGFS), a global association of central banks and supervisory authorities advocating a more sustainable financial system. These scenarios are used to assess the potential impact of climate change on roughly 4 million companies worldwide and nearly 2,000 banks in the euro area.

Preliminary results show that without further mitigation policies, physical risks from climate change—heat waves, windstorms, floods, droughts, and the like—will probably increase substantially (Alogoskoufis and others 2021). The average default probability of the credit portfolios of the 10 percent of euro area banks most vulnerable to climate risks could rise substantially—up 30 percent by 2050. Firms across Europe are exposed to physical risks from climate change, although risks are distributed unevenly (see chart).

Compared with these risks, the costs of transitioning to a carbon-neutral economy appear relatively contained (de Guindos 2021). There are clear benefits to acting early. The transition may be costly in the short run, but up-front investment will likely be more than offset over the long run as firms avoid the aggravation of physical risk and reap the economic rewards of mitigation. Based on a range of different models, recent IMF research echoes these findings (IMF 2020). The resulting message is simple: now is the time to undertake ambitious and broad-based action to ensure an orderly transition and mitigate the effects of climate change.

The existential threat posed by climate change implies that all policymakers must contemplate

how to contribute to the fight against global warming. While governments are the primary actors, a consensus is building that central banks cannot stand on the sidelines. The NGFS, established with eight members in 2017, now has 95 members and 15 observers, including all major central banks. In 2019, the IMF joined as an observer.

The main reason central banks should increase their attention to climate change is the likelihood it will affect their ability to achieve their mandates. The ECB's primary mandate is price stability, an objective shared by most central banks. Evidence suggests that climate change has crucial implications for price stability and also affects other areas of central bank competence, such as financial stability and banking supervision.

Climate change affects price stability through at least three channels.

First, the consequences of climate change might *impair the transmission of central banks' monetary policy measures* to the financing conditions faced by households and firms, and hence to consumption and investment. Losses from materializing physical risks or stranded assets (such as oil reserves that will not be tapped as the world moves away from fossil fuels) could weigh on financial institutions' balance sheets, reducing the flow of credit to the real economy. In addition, the longer climate change is insufficiently addressed, the greater the risks to policy transmission from a sharp and abrupt rise in credit risk premiums. Central banks themselves are exposed to potential losses—from securities acquired in asset purchase programs and on the collateral provided by counterparties in monetary policy operations.

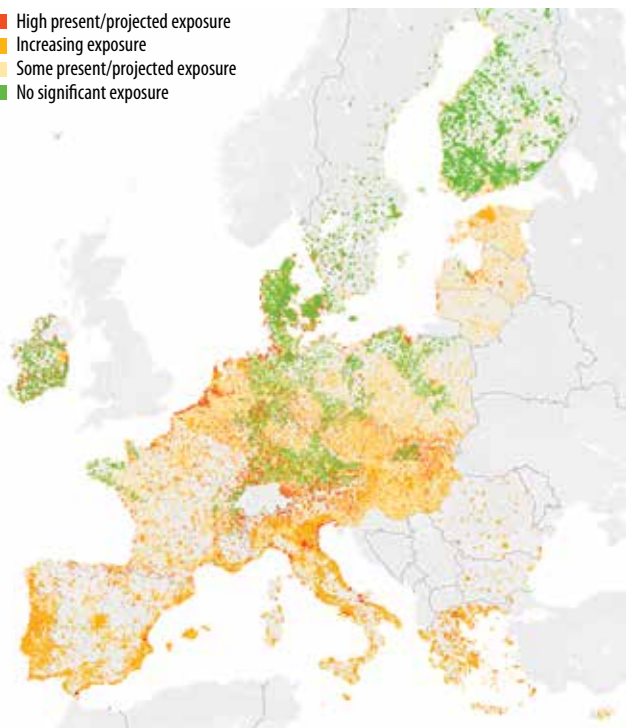
Second, climate change could *further diminish the space for conventional monetary policy by lowering the equilibrium real rate of interest*, which balances savings and investment. For example, higher temperatures might impair labor productivity or increase rates of morbidity and mortality. Productive resources might be reallocated to support adaptation measures, while climate-related uncertainty may increase precautionary savings and reduce incentives to invest. Collectively, these factors can reduce the real equilibrium interest rate and therefore increase the likelihood that a central bank's policy rate will be constrained. But this is far from certain; equilibrium rates might instead rise because of green innovation and investment and chart a path out of the current low-inflation, low-interest-rate environment.

Third, both climate change and policies to mitigate its effects can *have a direct impact on inflation dynamics*. Recent history confirms that a greater incidence of physical risk can cause short-term fluctuations in output and inflation that amplify longer-term macroeconomic volatility. Unless mitigation policies are more forceful, the risk of even larger climate shocks grows, with more persistent consequences for prices and wages. In addition, even mitigation policies, such as carbon pricing programs, can affect price stability, potentially precipitating large and long-lasting trends in relative prices and driving a wedge between headline and core measures of inflation.

At risk

Firms across Europe are subject to physical risks from climate change, which can pose a threat to financial stability.

- High present/projected exposure
- Increasing exposure
- Some present/projected exposure
- No significant exposure



Source: Alogoskoufis and others (2021).

Note: Gray indicates that no information is available.

As a result of these factors, central banks are starting to integrate climate-related risks into their monetary policy operations.

Toward carbon neutrality

Climate change considerations formed an integral part of the ECB's monetary policy strategy review that concluded in July 2021. We published an ambitious action plan and a detailed road map confirming our strong commitment to further incorporating climate change considerations into our monetary policy framework. Our comprehensive strategy review demonstrated that there are many areas in which central banks can contribute to the fight against global warming, and further areas may open up in the future.

By thoroughly analyzing potential actions and developing ways to make them operational, for example regarding the classification of more or less “green” activities, the ECB and other central banks can act as catalysts for a more sustainable financial system. Moreover, by preannouncing changes to our operational framework, we can encourage market participants to speed up the transition to carbon neutrality.

As part of its action plan, the ECB will embed climate change considerations into its monitoring of the economy—for example, by bolstering analytical capacity in climate-related macroeconomic modeling and forecasting.

As part of its statistical function, the ECB will develop new climate-related statistical indicators, for example regarding the classification of green instruments, the carbon footprint of financial institutions' portfolios and their exposures to climate-related physical risks.

In addition, the ECB is advocating climate disclosures that are internationally consistent and auditable. The ECB will introduce disclosure requirements for private sector assets, either as a new eligibility criterion or as the basis for differentiated treatment for collateral purposes and asset purchases, which could help speed up disclosure in the corporate sector. The ECB will start disclosing climate-related information on its non-monetary policy portfolios, and its corporate sector purchase program (CSPP) by the first quarter of 2023.

Starting in 2022, the ECB will conduct climate stress tests of the Eurosystem balance sheet, using the methodology of its ongoing economy-wide

climate stress test. The ECB will further perform a review to gauge the extent to which credit ratings and asset valuations under our collateral framework reflect climate-related risk exposures.

The ECB will also incorporate climate-related criteria into its corporate bond purchases. In the past, allocations of private sector bonds have generally been guided by the principle of market neutrality—in which purchases reflect the composition of the overall market—to avoid relative price distortions.

However, emission-intensive sectors tend to have large fixed long-term capital investment needs and generally issue bonds more frequently. As a result, CSPP-eligible debt and the ECB's portfolio exhibit high emission intensity. (Papoutsis, Piazzesi, and Schneider 2021). In other words, adherence to the market neutrality principle is likely to perpetuate preexisting market failures or even exacerbate market inefficiencies that give rise to a suboptimal allocation of resources.

It seems appropriate, then, to replace the market neutrality principle with one of market efficiency that more fully incorporates the risks and societal costs associated with climate change (Schnabel 2021), taking into account the alignment of issuers with EU legislation implementing the Paris Agreement.

With its new strategy and action plan, the ECB acknowledges that climate change is a global challenge that requires an urgent policy response, including from central banks. Within our mandate, we are determined to contribute to accelerating the transition to a carbon-neutral economy. **FD**

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Investing in a Sustainable Future

Private sector financing can play a pivotal role in amplifying the effects of government climate policies

Valerie Smith



PHOTO: COURTESY OF CITI

WE ARE FACING a global climate emergency that demands immediate action and long-term solutions, with financial institutions uniquely positioned to help support a net zero carbon future and a more sustainable world.

The urgency has never been greater: polar ice is melting and sea levels are rising, as are global temperatures. The National Aeronautics and Space Administration reports that last year tied with 2016 as the warmest on record since recordkeeping began in 1880, and that 19 of the warmest years have occurred since 2000.

Given the stakes, it's no surprise that investors are keenly focused on the climate change crisis. A 2019 *Harvard Business Review* study found that sustainability and environmental, social, and governance issues are now a top priority for leading investment firms and public pension funds. As the study points out, the world's largest asset owners have trillions invested in the global economy and multigenerational obligations that call for a long-term view of systemic risks; they can no longer afford to let the planet fail.

The next few years will be pivotal and consequential. Last year, with the world's attention understandably centered on the global pandemic,

the UN Climate Change Conference, scheduled for November 2020, was postponed until this fall. Sustainable finance will feature prominently on the agenda, specifically mobilizing public and private funds to mitigate the causes of climate change.

Private sector's role

We know that public financing alone will not be sufficient to the task: the United Nations estimates that by 2030, costs may range from \$140 billion to \$300 billion a year, rising to \$280 billion to \$500 billion annually by 2050, well above the \$100 billion a year commitment expected from developed economies.

As financiers of the global economy, banks will play a key role in supplementing public financing targeted at climate change. Banks also can help by aligning their lending with the Paris Agreement's goal of limiting global warming and directing capital to where it will have the most positive impact—for instance, by linking financing to environmental and social performance. Carbon pricing is another area where banks' involvement could prove critical. According to a new IMF staff paper, establishing a price on carbon emissions offers the most effective way to halt global warming. Lack of an international agreement on carbon pricing remains an impediment, however, and underscores the need for cross-border collaboration.

Large-scale international collaboration is underway in the financial sector. The Network for Greening the Financial System, launched in 2017, is approaching 100 members, composed of central banks and banking supervisors working to strengthen the global response on climate. The Net Zero Banking Alliance, an industry-led organization convened by the United Nations this spring, brings together more than 50 banks from two dozen countries, with a commitment to net zero greenhouse gas emissions by 2050.

As a founding signatory of the alliance, Citi announced a commitment to net zero greenhouse gas emissions by 2050, including emissions associated

with our financing, and for our own operations by 2030. We expect to issue an initial plan within the coming year on how we'll achieve this ambitious goal, including interim 2030 targets for our energy and power portfolios. There isn't a straight line to the goalpost as our clients include oil and gas companies and other carbon-intensive industries. Citi's Environmental and Social Risk Management Policy guides us internally and provides a framework to advise clients on climate change risks and transitioning to a net zero economy. We're also partnering with the UN Framework Convention on Climate Change to accelerate the goals of the Paris Agreement through building capacity, connectivity, and awareness. No one institution can address the climate crisis alone—so we must all work together and take concrete steps to achieve net zero.

Commitments and challenges

Of course, announcements without action or accountability are mere words. So what must we do, and how will we know if we are succeeding? Following the money is one way. Citi has committed to providing \$1 trillion in sustainable financing by 2030. This commitment includes extending our environmental finance target to \$500 billion by 2030, plus an additional \$500 billion in areas such as affordable housing, economic inclusion, and gender equity. Along with funding clean energy, green buildings, and sustainable transportation, we are directing funding and advisory services away from those that don't have a strategy to phase out reliance on coal. Internally, we're incorporating sustainable finance and climate strategy into the scorecards for our CEO and other senior executives.

Like others, we're continuing to integrate climate change risks into overall strategy, corporate governance, and risk management practices. The problem? Risk assessment requires robust climate, company, and asset-level data, so data quality and consistency must be improved as we assess the impact of businesses on global climate change and the impact of global climate change on businesses.

Recognizing the need for better data and transparent reporting, the Financial Stability Board's Task Force on Climate-related Financial Disclosures issued recommendations in 2017 for voluntary, consistent climate-related financial disclosures, but concluded in 2020 that disclosure of the financial impact from climate change remains low. As a result, lenders, investors, and insurers can't gauge which

companies will struggle or flourish amid changes in the environment, the regulatory environment, technology, and customer behavior. Moreover, the task force adds, absent better data, financial markets "may potentially face a rocky transition to a low-carbon economy."

With regard to transparency, I'm proud that Citi has reported its greenhouse gas emissions for nearly two decades and, in 2018, was the first major US bank to release its initial climate disclosure report, following the task force's recommendations. Others are doing the same; by late 2020, more than 1,500 organizations had expressed their support for the task force framework.

Banks will help fill the information gap. Citi and scores of others are working through the Partnership for Carbon Accounting Financials to develop global standards to measure and disclose the greenhouse emissions associated with bank loans and investments. In a similar vein, Citi and other banks have been experimenting with the Paris Agreement Capital Transition Assessment tool, open-source software to align bank loan portfolios with climate benchmarks.

Given the stakes, it's no surprise that investors are keenly focused on the climate change crisis.

As with other crises, we know that climate change will disproportionately affect communities of color and the poorest members of society. Federal Reserve Board Governor Lael Brainard highlighted this disparity in a recent speech, noting that lower-income communities often are in areas that are particularly vulnerable to climate-related risks, including health risks and weather disasters. Steps toward a more sustainable future must include conversations about environmental racism and inequality; these issues are inextricably connected, and to neglect that when undertaking sustainability initiatives would be shortsighted and unwise.

Citi's 2020 ESG report expressed our support for action to create a just, sustainable future, including through carbon pricing and disclosure of climate risks, and we'll continue to report on our progress across our many initiatives. **FD**

VALERIE SMITH is the chief sustainability officer at Citi.



A PATH TO ZERO

Reaching net zero emissions and limiting global warming to 1.5°C
are achievable with comprehensive and rapid policy action

Christoph Bertram, Ottmar Edenhofer, and Gunnar Luderer

Breathtaking progress in crucial green technologies has brightened prospects for achieving the unprecedented emissions reductions needed to limit global warming to 1.5°C, as envisioned by the Paris climate agreement. But it will take a full restructuring of global energy and land-use systems, with the right mix of policy incentives. Decision-makers can rely on an increasing body of knowledge and experience to encourage the deployment of existing green technologies and speed the development of newer technologies.

Attaining a path toward 1.5°C would not only greatly reduce risks associated with climate change, it would also carry a number of important co-benefits, ranging from improved air quality to

the modernization of infrastructure and economies to increased energy sector employment and jobs with better long-term prospects.

Electricity decarbonization

Given that carbon dioxide (CO₂) emissions remain in the atmosphere for hundreds of years, cumulative emissions of this greenhouse gas largely determine the resultant warming. That means the extent of near-term emissions reductions is more important than the exact year by which we reach zero. Achieving the 1.5°C target with medium likelihood requires emissions to decline immediately. The cheapest way to reach the 1.5°C target entails cutting emissions roughly in half by 2030 compared with 2020 levels.

The first key to these pathways is the electricity sector, which currently contributes roughly a third of total CO₂ emissions (see chart). While electricity generation is still dominated by coal and gas, the addition of new capacity from wind and solar power increasingly outweighs fossil-fuel-based capacity gains.

The pandemic has shown that electricity systems tend to become cleaner with reduced demand, as higher-cost coal and gas power plants get switched off first, while solar, wind, nuclear, and hydro continue to generate as much electricity as can be taken up by the markets (Bertram and others 2021). Clearly, more efficient use of electricity can contribute significantly to swifter emission declines without sacrificing system capacity. This will be especially valuable in the next decade, when a large share of electricity generation will still come from carbon-intensive fossil fuels.

Increased efficiency in liquid, solid, and gaseous fuel consumption by industry, transportation, and buildings is even more crucial, because gains in efficiency lead to immediate emission reductions.

Limited availability of clean power technology is no longer an impediment to the decarbonization of electricity—solutions for integration are also improving—but the slow phaseout of fossil-fuel-based capacities is. Regulation of greenhouse gas emissions, ideally via some form of carbon pricing, is necessary to shift new investments to green power technology and create incentives for phasing out power plants. If the global community is successful in seizing the opportunity offered by rapid power system decarbonization, the power sector can slash its emissions by more than two-thirds by 2030, as shown in the Net Zero 2050 scenario in the chart.

What about land use and achieving net zero emissions? The land sector currently includes both CO₂ sinks (uses that take carbon out of the atmosphere, such as establishing new forests) and CO₂ sources, most notably deforestation but also other land-use processes. Changes in land-use practices could even achieve CO₂ neutrality in that sector by 2030 (though land use—chiefly agriculture—will inevitably continue to contribute to warming through methane and nitrous oxide emissions).

This leaves energy demand from industry, buildings, and transportation as the primary contributors of fossil-fuel-based CO₂ emissions in 2030 and beyond in scenarios in line with the

1.5°C target. In these scenarios, the combined emissions of these sectors would need to be more than halved by 2040 and to reach about a quarter of today's levels by 2050 in order to achieve carbon neutrality around that date.

Compensating for even this comparatively low level of residual emissions requires a very fast and challenging expansion of CO₂ removal options, such as planting new forests, direct air capture—capturing CO₂ from the atmosphere and then storing it geologically—and bioenergy with carbon capture and storage, or BECCS, technologies that produce clean energy from biomass while also capturing and permanently storing CO₂.

Many of the technologies required to decarbonize the demand sectors involve direct or indirect electrification via hydrogen-based fuels, such as fuel cell technology and synthetic fuels (Ueckerdt and

There are options for realizing a net zero global energy system in which all carbon added to the atmosphere is offset by carbon removed.

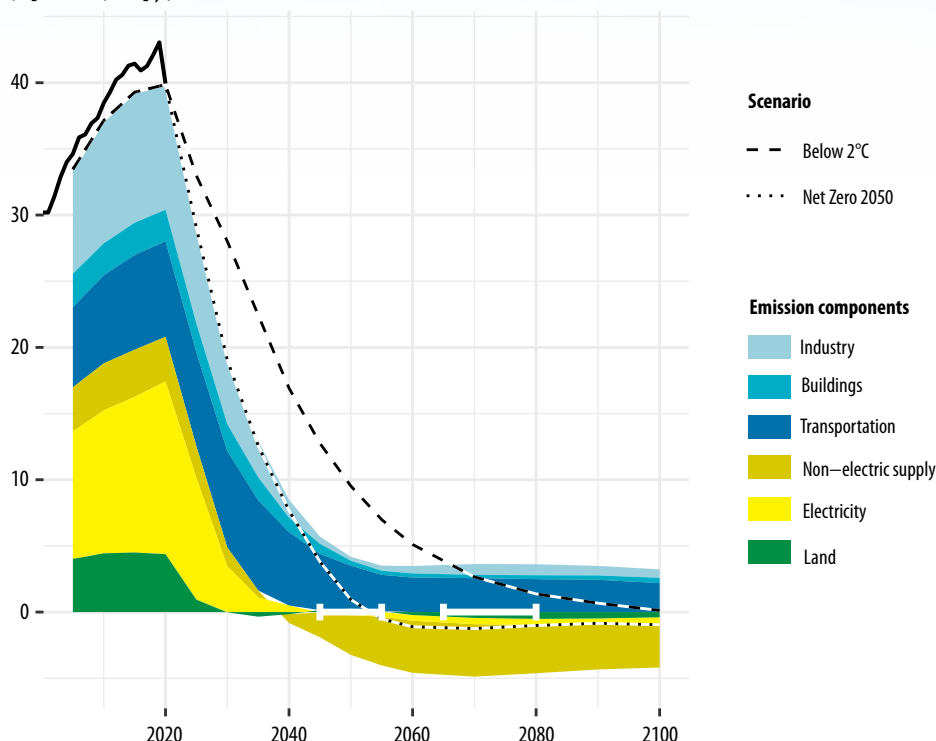
others 2021). Moreover, these technologies are not yet deployed at scale in markets and will likely face institutional and environmental challenges. Their future performance and costs are thus considerably more uncertain than those of technologies deployed today (for example, renewable energy and battery-electric vehicles).

This uncertainty implies that there are various options for realizing a net zero global energy system, one in which all carbon added to the atmosphere is offset by carbon removed. If all these options develop more favorably than expected, it may also be possible (and worthwhile) to achieve stronger net negative emissions (removing more carbon than is added), thus lowering global mean temperature after its peak. If some technology options develop faster than expected, while others lag behind, the balance of options may be different than projected, but the overall net zero goal is still achievable. Only if all options develop more slowly than expected—or if unforeseen hurdles or bottlenecks cannot be overcome (for example, bioenergy-related sustainability issues)—would

Getting to zero

Various sectors must contribute to bringing CO₂ emissions to zero by 2050, in line with a limit on global warming to 1.5°C, and a few decades later to 2°C by 2100.

(CO₂ emissions, GtCO₂/yr)



Source: Author estimates, based on scenario data from the Network for Greening the Financial System and historical data from the Global Carbon Project.

Note: Non-electric supply includes emissions from the production of fuels, mostly from refineries. White lines show the required carbon neutrality dates according to the Intergovernmental Panel on Climate Change SR1.5 (2018). GtCO₂/yr = gigatons of carbon dioxide a year.

achievement of net zero energy systems be much more difficult than currently projected.

Orderly transition

The transformation required to limit global warming to 1.5°C with acceptable likelihood must be comprehensive and rapid to succeed. Nevertheless, with the right mix of policy incentives it can be a relatively orderly process. In fact, an inclusive and just transition that leaves no one behind is a political prerequisite for continued policy support. Policymakers should therefore carefully implement a mix of policies that rely on the right tools.

A central tool for this transition can be a carbon price, implemented either as a permit market like

the European Union's Emissions Trading System or a carbon levy that rises over time. The Network for Greening the Financial System's "Net Zero 2050" scenarios (NGFS 2021) estimate carbon prices of between \$100 and \$200 a ton of CO₂ in 2030, rising sharply until 2050. However, carbon prices in the long term can be kept lower if auxiliary policies absorb some of the decarbonization burden, as can be seen, for example, in the International Energy Agency's "Net Zero by 2050" scenario (IEA 2021) in which regulatory policies play a much more prominent role and carbon prices do not exceed \$250 until 2050. (The NGFS scenario set, developed in partnership with an academic consortium led by the Potsdam Institute for Climate Impact

A promising option to foster cooperation between countries is the establishment of climate clubs with differentiated minimum carbon prices.

Research, includes additional high-risk scenarios, but the net zero 2050 scenarios are comparable with IEA's in most aspects.)

The chief advantage of carbon pricing is that it can fulfill the role of coordination of effort across sectors (and across countries in the future) to ensure efforts are balanced. Furthermore, it fosters vital regulatory certainty, incentivizes adequate long-term investment, and raises resources that enable governments to implement additional policies that require public funding.

One important component of this tool should be some form of revenue recycling to citizens that makes sure no one is left behind by the transition. Although uniform carbon pricing acts regressively in many countries, responsible revenue redistribution renders it a progressive policy that can foster social cohesion and political support. An additional use for revenue is the support of future-oriented infrastructure projects such as charging stations for electric vehicles. Such projects are a crucial way to foster fledgling markets for technology entrants that fail as a result of lock-in of obsolete infrastructure and technology spillovers.

Vital international cooperation

Some countries are making progress in implementing the agenda for a domestic net zero emissions trajectory by mid-century, but the global picture is still daunting. To overcome the underlying obstacles to collective action—such as distribution problems—international cooperation must undergo a sea change to ensure that all countries can recover from the pandemic on a similar path.

The global South and North have different responsibilities toward this end. A key conclusion from our analysis of 1.5°C scenarios (NGFS 2021) is that this target does not allow for decarbonization on widely varying timetables (Bauer and others 2020). All major countries in transition must realize peak emissions very soon and decline thereafter, and recent power sector developments make that possible from a technology perspective. High-income countries in turn should acknowledge

that they owe other countries more support during this transition, not least because of their historical responsibility for climate change. Easier access to technology and financing could help, as would increased direct investment.

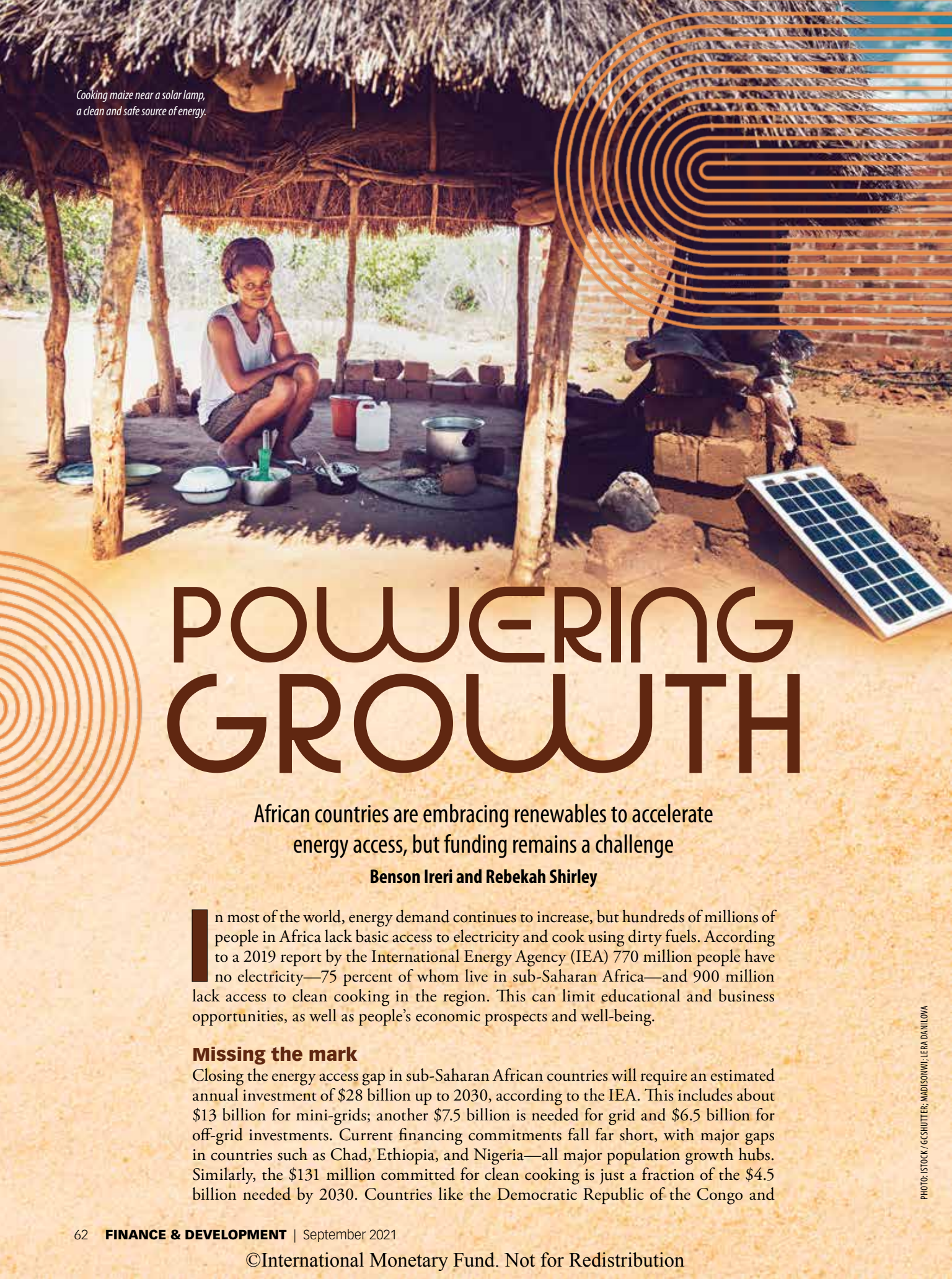
A promising option to foster cooperation between countries is the establishment of climate clubs with differentiated minimum carbon prices. Low- and medium-income countries would start with lower floor prices and benefit from some of the revenue generated by higher pricing in high-income countries. Richer countries would, in turn, benefit from the assurance that manufacturing, trade, and emissions would not simply shift to unregulated markets at their expense. This would ensure both the mitigation efficacy of their actions and fair trading conditions. Although implementing such a program is clearly a challenging task for political systems in both groups of countries, the rewards—thriving, modernized economies and healthier, resilient societies—are well worth it. **FD**

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Stephen Bi, Jérôme Hilaire, and Elmar Kriegler also contributed to the research behind this article.

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A woman is sitting on the ground under a thatched roof, cooking maize. A solar lamp is visible, and a solar panel is on the ground. The scene is set in a rural area with a brick wall in the background.

Cooking maize near a solar lamp,
a clean and safe source of energy.

POWERING GROWTH

African countries are embracing renewables to accelerate
energy access, but funding remains a challenge

Benson Ireri and Rebekah Shirley

In most of the world, energy demand continues to increase, but hundreds of millions of people in Africa lack basic access to electricity and cook using dirty fuels. According to a 2019 report by the International Energy Agency (IEA) 770 million people have no electricity—75 percent of whom live in sub-Saharan Africa—and 900 million lack access to clean cooking in the region. This can limit educational and business opportunities, as well as people's economic prospects and well-being.

Missing the mark

Closing the energy access gap in sub-Saharan African countries will require an estimated annual investment of \$28 billion up to 2030, according to the IEA. This includes about \$13 billion for mini-grids; another \$7.5 billion is needed for grid and \$6.5 billion for off-grid investments. Current financing commitments fall far short, with major gaps in countries such as Chad, Ethiopia, and Nigeria—all major population growth hubs. Similarly, the \$131 million committed for clean cooking is just a fraction of the \$4.5 billion needed by 2030. Countries like the Democratic Republic of the Congo and

Ethiopia, where 95 percent of the population lacks access to clean cooking, receive less than 1 percent of the annual investment.

Significant financial commitments are needed to close this gap. However, challenges persist, including political instability, macroeconomic uncertainty (because of inflation and exchange rates), policy and regulatory issues, institutional weaknesses, and lack of transparency. All these make for a less favorable investment climate, alongside market failures and lack of aid to channel financing where it is needed most (see chart).

Several developed economies have already failed to deliver on their pledge of \$100 billion annually in climate finance and are cutting foreign aid, at a time when investment needs to be doubled. The UN Climate Change Conference (COP26) and the Energy Transition Council should play a central role in driving urgent mobilization of capital for clean energy investment in the region.

Despite these challenges, there are successful initiatives that, if replicated, could help mobilize needed capital. For example, the Sustainable Use of Natural Resources and Energy Finance initiative—a French Development Agency facility—catalyzes commercial lending to the clean energy sector and has helped finance more than 60 projects in both commercial and industrial sectors, as well as on-grid projects across Kenya, Tanzania, and Uganda. It offers an integrated approach that provides banks and their clients with structured financing. It also offers technical assistance and support for companies in structuring their investments. The facility shares—through guarantee mechanisms—some credit risks borne by banks seeking to develop finance portfolios in renewable energy.

The Sustainable Energy Fund for Africa—a multi-donor fund established in 2011 and managed by the African Development Bank (AfDB)—has provided finance to unlock private sector investments in renewable energy and energy efficiency. Its technical assistance, as well as concessional and catalytic financing instruments, aim to de-risk investments in the sector and is targeted at green baseload power, green mini-grids, and energy efficiency. The fund facilitated the AfDB's first two scale-up programs in Burkina Faso and the Democratic Republic of the Congo and played a key role in the development of energy blended finance initiatives. These initiatives include the Africa Renewable Energy Fund, which has

catalyzed private sector funding through investments—for example, in Frontier Energy. Frontier Energy has invested over \$1.8 billion in more than 45 renewable energy projects in sub-Saharan Africa, with a total capacity of more than 750 megawatts.

In 2020, the AfDB, through the Sustainable Energy Fund for Africa, committed \$5 million to investment firms Enabling Capital and Spark+ to raise equity for clean cooking companies in the region. This funding, together with €10 million from the European Union through its blending facility, has attracted many investors, helping to mobilize capital for investment in clean cooking.

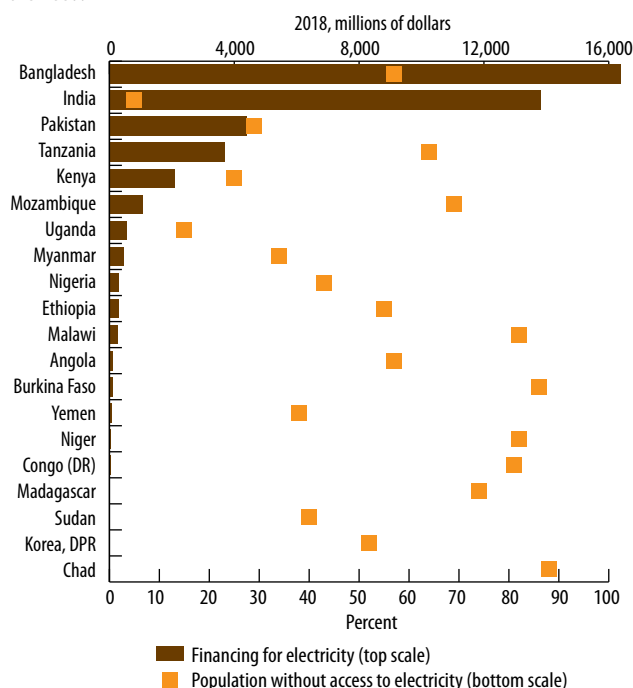
Unlocking financing

These initiatives represent just a few of the interventions that are helping unlock capital for clean energy investment in the region. But the pace and scale of funding must pick up. Here are five areas where COP26 commitments could help minimize barriers and meet needs.

- **De-risking investment in sub-Saharan Africa's clean energy sector:** Private investors are essential to financing renewable energy, but high costs and uncertain energy policies and regulations increase investors' risk perception. There are various de-risking instruments, but studies show that most are fragmented. They do not offer a complete set of tools for reducing uncertainty and fail to cover all stages of a renewable energy project life cycle. Innovative instruments such as renewAfrica, which aims to provide end-to-end de-risking, will make a big difference. RenewAfrica uses a one-stop-shop model to deliver end-to-end support, including technical assistance and financial support, as well as policy help and advocacy. Products like the Green 4 Access first-loss debt facility and policy and regulatory reforms to address investor risks will also help.
- **Financing projects that stimulate demand for clean energy:** Investments in the energy sector have been directed mostly to electricity supply. But there is little focus on generating demand, making electricity in rural areas largely unaffordable. For example, financing to farms for solar-powered irrigation would help increase productivity, enhance food security, and reduce the sector's vulnerability to climate change. Similarly, support for investment in reliable and affordable energy for production industries along the agricultural value chain can mean more rural

Funding shortfall

The financing available for electricity in sub-Saharan Africa pales in comparison to the need.



Source: Sustainable Energy for All and Climate Policy Initiative. 2020. "Energizing Finance: Understanding the Landscape." Vienna.

jobs, higher income for farmers, and less food waste. Affordable financing coupled with technical assistance—particularly in the estimation of sectors' energy demand—will help promote the uptake of clean energy. Mapping out such opportunities, complete with data on energy requirements, will help investors identify areas for financing. This requires a shift in planning methods. Policymakers and development partners must take an integrated approach to planning, which will help break down silos between sectors. Commercial banks should develop financing packages that target such opportunities.

- Modernizing Africa's power infrastructure to support reliability, flexibility, and sustainability:** A reliable and strong power system with the flexibility to integrate variable renewable energy is key to attracting much-needed investment in Africa's clean energy transition. Modernizing the electricity grid to improve its efficiency and flexibility is essential, along with enhanced sustainability and power system readiness. As such, the role of power utilities in the transformation is key. Helping power companies overcome the numerous challenges that keep them from attracting investment is therefore critical. Interventions that assist utilities with development and implementation of new

business models for integrated energy service and identify viable opportunities for commercial partnerships with other energy service stakeholders will address market-related bottlenecks. Lower-cost access and solutions to traditional utility challenges of efficiency, revenue recovery, and losses will be the outgrowth of such efforts. Addressing governance challenges that continue to face utilities can restore the confidence of potential investors. Commitments by national governments and development partners to deliver energy access to all is an opportunity for collaboration in this endeavor.

- Shifting investments away from fossil fuels and large hydroelectric power projects:** Most funding for new capacity in sub-Saharan Africa goes to large hydroelectric power projects, as well as fossil fuels, including natural gas and coal. The region's greenhouse gas emissions remain on average relatively low but achieving the goals of the Paris Agreement will require pursuing clean energy sources. And reduction of overreliance on hydropower, which is vulnerable to climate change, is essential to long-term energy security for the region. Bilateral partners, such as China, which is financing most of the hydropower and coal projects in the region, must shift away from these sources to non-hydroelectric renewable energy.
- Unlocking clean cooking solutions:** Financing for the clean cooking sector has increased, according to Sustainable Energy for All's 2020 report and the Clean Cooking Alliance 2021 industry snapshot. However, it is considerably less than what is needed to close the gap. Providing innovative mechanisms such as concessional and blended finance by development finance institutions will help catalyze private sector participation. Policy and regulatory reforms such as tax exemptions and reductions and de-risking investments will promote increased uptake of clean cooking technologies.

Reliable, abundant, and clean energy is key to a prosperous, sustainable, and inclusive economy. With a significant gap in access to energy and plenty of renewable energy resources, Africa is the last frontier for transformative investment in clean energy and climate action. [FD](#)

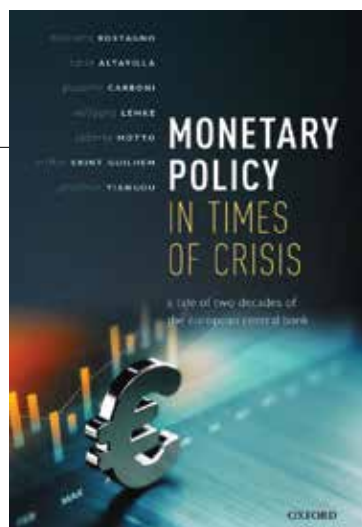
BENSON IRERI is the Africa lead for energy access at the World Resources Institute (WRI). **REBEKAH SHIRLEY** is WRI Africa's director of research, data, and innovation.

The Science and Art of Monetary Policy

THE EUROPEAN CENTRAL BANK (ECB) has its share of detractors and skeptics who say the institution doesn't do enough or is too frequently "behind the curve," in market parlance. *Monetary Policy in Times of Crisis* is more than a strong defense. Written by a team at the ECB, it is a unique exposition, laid out more transparently than by any other advanced economy central bank, of the analysis that draws from theory and models to inform the deliberations of its governing council's monetary policy decisions. Readers will be impressed with what is under the hood—the science and art that go into monetary policymaking.

The authors provide a masterful analysis of the monetary policy challenges this young institution faced in its first two, unusually eventful and crisis-prone, decades and how it grappled with a monetary union still in the making. Most are familiar with President Mario Draghi's 2012 "whatever it takes" dictum, which addressed the existential threat to the euro, but few will be aware of the ECB's behind-the-scenes effort in pushing early for the creation of the European Stability Mechanism, which made its (never used) Outright Monetary Transaction instrument effective in resolving the euro area crisis. The ECB also takes credit for the creation of a unified banking supervision system that reduced fragmentation and made its monetary policy more effective across the monetary union.

The array of instruments the ECB uses—negative interest rates, asset purchases, subsidized loans to banks for onlending, and forward guidance on policy rates—typically begs the question of why its strategy is more complex than that of other central banks. This book provides strong empirical evidence on the complementarity between these instruments in delivering an accommodative monetary stance, and especially how these instruments together contain pressure on longer-term



Massimo Rostagno, Carlo Altavilla, Giacomo Carboni, Wolfgang Lemke, Roberto Motto, Arthur Saint Guilhem, and Jonathan Yiangou

Monetary Policy in Times of Crisis: A Tale of Two Decades of the European Central Bank

Oxford University Press

Oxford, UK, 2021, 448 pp., \$115

borrowing costs. Detractors will, of course, point to other central banks that achieve similar outcomes with a smaller arsenal. That may, however, miss the important nuance that the ECB is operating in a currency union with very diverse financial imbalances among sovereigns and banks across the euro area. Low interest rates would not be evenly transmitted to the entire euro area if the ECB did not subsidize lending to weaker banks.

The ECB's continued difficulty meeting its price stability objective remains a concern and argues for continuing its accommodative stance. But here, too, the analysis is persuasive in showing that using this array of instruments has stemmed the decline in longer-term inflation expectations. In other words, the counterfactual would have been worse.

Though the analysis in this book covers the period to the end of 2018, the authors make a convincing case that the policy tools developed over the past decade have been instrumental in enabling the ECB to respond quickly and forcefully to the COVID-19 pandemic. The wealth of analysis here will appeal to a much wider audience than just the experts. **FD**

MAHMOOD PRADHAN, deputy director, IMF European Department

Behind Closed Doors

HISTORY IS A CONFLUENCE of underlying forces and specific triggering events. Think of the start of World War I: economic, imperial, and nationalistic tensions that had simmered for years exploded into open conflict when Archduke Franz Ferdinand's motorcade took a wrong turn, putting him in the path of an assassin's bullet. Less dramatic—but for international economists and officials at the time, no less momentous—was the collapse of the Bretton Woods system of fixed exchange rates in the early 1970s. While much has been written about the

deplete its gold stock. With US monetary gold falling to \$10 billion (against \$40 billion in liabilities), the situation became dire—prompting Nixon to summon his leading financial officials to a meeting at Camp David, the presidential retreat, over the weekend of August 13–15, 1971.

We meet key players—Nixon, Arthur Burns, John Connolly, Paul Volcker, George Shultz, and others—whose backgrounds, personalities, and preoccupations greatly influenced the outcomes at Camp David. Burns and Volcker worried about how foreign officials would react to closing the gold window. Connolly argued that doing so would help bludgeon the surplus countries into revaluing their currencies. Shultz, a student of Milton Friedman, favored floating exchange rates, which would make the whole issue moot, while Nixon cared less about foreign central bankers and worried only about the reaction of the American public.

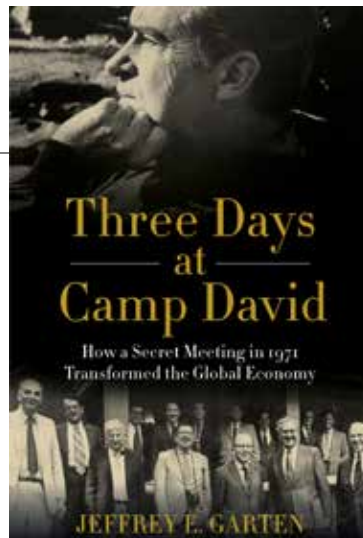
Garten gives a detailed account of the discussions, chronicling how politician Nixon transformed the dominant narrative about shuttering the gold window: from a mea culpa that acknowledged the United States' lax policies and abrogation of its international responsibilities, to one that proclaimed a triumphant fresh start for its place in the world, which went down well with his domestic audience.

Garten describes the aftermath, the short-lived Smithsonian Agreement, and relays an anecdote illustrating how sensitive officials were to any change in parities. When Connolly pressed the Japanese finance minister to revalue the yen by 17 percent, he refused, on the grounds that a 17 percent revaluation during the interwar period had resulted in the then-finance minister's assassination. Connolly, who was in the car during President John F. Kennedy's assassination (and had himself been shot), accepted a 16.9 percent revaluation. (In fact, the Japanese prime minister had pre-authorized up to a 20 percent revaluation.)

It would be trite to say that Garten's book belongs on every international economist's bookshelf. It doesn't. It belongs on their bedside tables as light, but thoroughly enjoyable, reading and a useful reminder that, whatever economic forces might be at play, it is people, personalities, and politics that make history. **FD**

ATISH REX GHOSH, IMF historian

Jeffrey E. Garten
**Three Days at Camp David:
 How a Secret Meeting in
 1971 Transformed the
 Global Economy**
 HarperCollins,
 New York, NY, 2021, 448 pp., \$23.99



flaws of that system and the forces that made its demise inevitable, far less is known about the event that triggered that demise—President Richard Nixon's decision to close the “gold window” on August 15, 1971. Jeffrey E. Garten's superb account in *Three Days at Camp David* fills this gap.

When Bretton Woods was established, the United States promised to provide gold, on demand, in exchange for dollars accruing in foreign central banks. As the country ran balance of payments deficits during the 1960s, however, it began to

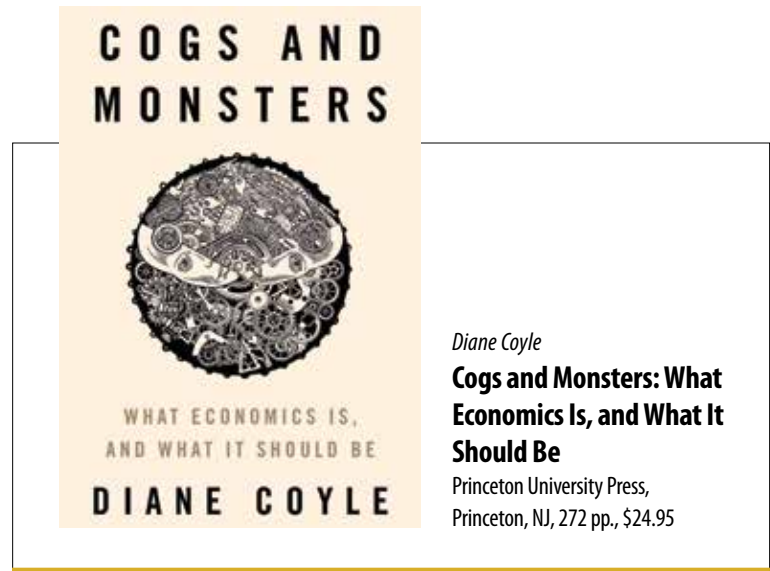
Course Correction

THE PAST TWO DECADES have been a doozy for economics. In the early 2000s, sophisticated financial markets and deepening global economic integration were touted as achievements of modern economic and financial systems, until the global financial crisis prompted questions about why economists had not foreseen the buildup of tensions and vulnerabilities in financial markets and their consequences. Just over a decade later, COVID-19 called into question the wisdom of tightly integrated and globally distributed production chains. These crises cast doubt on earlier beliefs and fueled existing skepticism about capitalism and economics more broadly.

In *Cogs and Monsters: What Economics Is, and What It Should Be*, Cambridge economist Diane Coyle examines some of these themes. “Cogs” represent what is (presumably) wrong with economics—the artificial and unrealistic assumption in standard economic models of fully rational agents able to optimize complex objective functions. Analogous to the strange creatures on medieval maps that indicated unknown regions, “monsters” allude to the many changes in the global economy, creating new, uncharted territories that current economics is ill-equipped to navigate.

Coyle presents a long list of cogs. Central among them is the stylized nature of economic models. Economists will be eager to point out that any model, to be useful, must abstract from reality. As Coyle herself notes, a map of the London Underground might be a terrible depiction of what London looks like but is extremely useful for its intended purpose: navigating the Tube. But she does not let economists off the hook so easily, pointing to the excessive “mathiness” of economics, often obscuring underlying assumptions. While this is a valid criticism, her solution of embracing “theoretical ad-hoc-ery” is unlikely to improve the credibility of economic models.

In general, however, Coyle manages to separate genuine criticisms of economics from straw men often built by critics. This is not without building some straw men of her own. For example, she laments the Pareto criterion—that a policy is desirable only if no individual is made worse



Diane Coyle

Cogs and Monsters: What Economics Is, and What It Should Be

Princeton University Press,
Princeton, NJ, 272 pp., \$24.95

off—as not useful for policymaking. But most economists do not see it this way. Take trade policy: most would support trade liberalization as a policy creating more gains than losses. The problem here is not that the Pareto criterion is violated, but that policymakers rarely make good on their promise to compensate the losers.

The author also describes what plagues the profession itself, including entrenched networks preventing fresh ideas, an aggressive debating culture, and a lack of gender and racial diversity. It is a long list, and this means less attention can be devoted to other topics. Coyle convincingly outlines the difficulties the digital economy poses for the measurement of GDP and economic modeling. Missing, however, are some of today’s most pressing issues: What role can and should economic policy play in addressing climate change? How can we make economic growth more inclusive? And what does increasing automation imply for the future of work? Nonetheless, Coyle has persuasively highlighted several important issues the economics profession—in both academia and policy circles—should take to heart. [FD](#)

MARTIN SCHINDLER, deputy division chief, IMF Institute for Capacity Development

Cleaning Up Crypto

Bitcoin's carbon footprint is again making headlines, but there's a way to make cryptocurrencies cleaner

Analisa R. Bala

TESLA CEO ELON MUSK reignited a long-simmering debate in June over Bitcoin's energy consumption. Tesla will accept the cryptocurrency for car sales only "when there's confirmation of reasonable (~50 percent) clean energy usage by miners with positive future trend," Musk said in a tweet.

Bitcoin mining—the process of creating new bitcoins and updating the digital ledger that tracks transactions—consumes vast amounts of computing power and electricity. To earn bitcoins, miners solve increasingly difficult puzzles. The faster and more efficiently they do so, the more bitcoins they get and the harder it becomes to mine new ones. This is "what drives Bitcoin's status as a store of value—the fact that it is so hard to mine," says Fahad Khan, an economist at the Asian Development Bank.

It's also what gives bitcoin mining an outsize role in climate change. Cambridge University's

Bitcoin Electricity Consumption Index calculates that miners burn about 73 terawatt-hours of electricity a year—double Denmark's usage (see chart). The frenetic computing by hundreds of thousands of bitcoin miners spews more than 64 million tons of carbon dioxide into the atmosphere annually—a carbon footprint comparable to that of Montenegro, estimates Alex de Vries, an economist at the Netherlands' central bank. A single bitcoin transaction may emit as much carbon as more than 1.8 million Visa purchases.

Cryptocurrencies can be dramatically cleaner, says de Vries, who is also the founder of Digiconomist, an online platform focusing on the unintended consequences of digital trends. Making a fundamental but feasible change in how blocks are created could all but eliminate the power drain of cryptocurrencies. While the change may not be universally adopted, the idea has promise. Bitcoin rival Ethereum—the second-largest cryptocurrency by market capitalization—plans to go in this direction.

The Bitcoin Mining Council—a network of independent miners—maintains that as much as two-thirds of miners' energy use already comes from sustainable sources. It attributes that figure to a survey in which just 32 percent of the network participated.

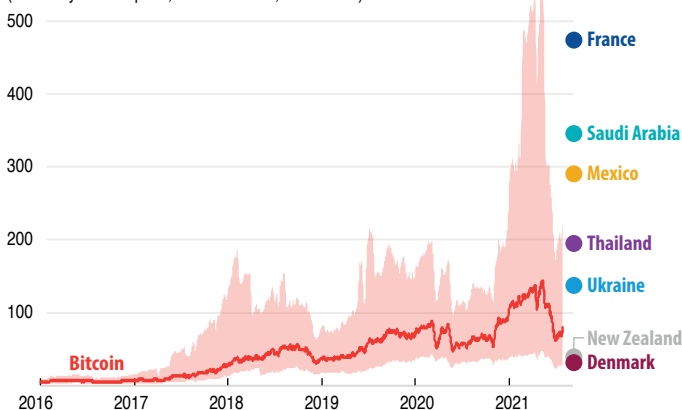
"It's not clear at all what's included in their survey," de Vries says. "Countries just don't have the capacity to supply renewable energy for mining." Miners "have no incentive to care about clean energy" and will flock to wherever electricity is cheapest and supply is stable, he says.

In October, more than 65 percent of bitcoin miners were based in China, where they could use hydroelectricity in the summer but mostly drew on the country's coal-fired power stations or ran their own generators on diesel or heavy fuel oil. Now that there is a government clampdown, many miners are relocating to countries like Iran and Kazakhstan, where electricity comes almost entirely from fossil fuels.

Energy guzzler

The Bitcoin network uses more electricity than several countries do, adding to the demand for coal-fired power.

(electricity consumption, terawatt-hours, annualized)



Sources: Cambridge Bitcoin Electricity Consumption Index; and International Energy Agency.

Note: Shaded area represents lower and upper bound estimates. Lower bound assumes miners use the most energy-efficient equipment—vice versa for upper bound. Best-guess estimate is calculated within this range and assumes miners use a mix.



Technicians inspect equipment at a bitcoin mining facility in Quebec, Canada.

'Proof of'...what?

The Bitcoin system of solving complex puzzles to verify transactions is known as “proof of work.” An alternative approach is known as “proof of stake.” Rather than miners, it involves “validators” who put down a “stake” in the form of their own cryptocurrency. In return, validators get the right to create or verify new transactions and update the blockchain.

Validators are rewarded with cryptocurrency in proportion to the stake they’ve put down. If they attest to a block with false transaction or data history, they lose their stake. Validators are selected at random, so they’re not competing and don’t need as much computing power.

“It’s just a matter of having a device with an internet connection,” de Vries says. “That’s why people say you can reduce the energy consumption by around 99.95 percent.”

Several high-profile blockchains, such as Cardano, EOS, Polkadot, and Tezos, use some form of proof of stake. But their market shares are relatively small compared with those of Bitcoin and Ethereum. That’s why Ethereum’s move to proof of stake is a big deal. If successful, the move could encourage others to follow, reducing crypto’s carbon footprint.

The shift will not be easy. Designing a proof-of-stake blockchain that is scalable and preserves security and decentralization—two of cryptocurrency’s seminal principles—is nearly impossible.

It’s what Vitalik Buterin, co-founder of Ethereum, calls the “scalability trilemma.”

“You can’t have the most perfect outcomes for all three characteristics,” the Asian Development Bank’s Khan says. “At best you can have two. You can’t have one cryptocurrency that solves everything.”

Will Bitcoin make the shift? “I don’t think proof of work is going away” Khan says.

A single bitcoin transaction may emit as much carbon as more than 1.8 million Visa purchases.

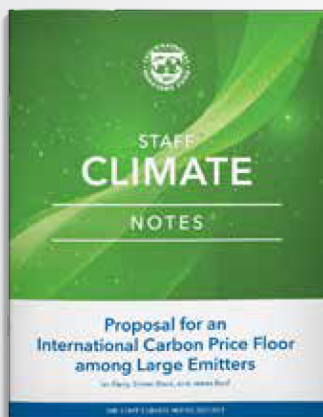
“The use case of Bitcoin is very different from Ethereum,” says John Kiff, a former financial sector expert at the IMF. “Bitcoin really does hope one day to be a unit of account or money of some sort, but Ethereum doesn’t aspire to that.” Ethereum’s goal is ultimately to replace internet third parties, such as Facebook and Google, with decentralized applications and contracts that use its ether currency.

Bitcoin is largely where cryptocurrency’s energy consumption problem lies, and a Bitcoin shift to proof of stake is improbable. But the supply of bitcoins is finite—only 21 million can ever be in circulation. At some point, the mining will stop. The future may thus turn a little greener. **FD**

ANALISA R. BALA is on the staff of *Finance & Development*.



EXTRAORDINARY CHALLENGES CALL FOR UNPRECEDENTED EFFORTS



Limiting global warming to 1.5 to 2°C requires cutting emissions by a quarter to a half in this decade. An international carbon price floor (ICPF) could jump-start emissions reductions through substantive policy action, while circumventing emerging pressure for border carbon adjustments.



TAKE ACTION. To learn more, read the Proposal for an International Carbon Price Floor among Large Emitters (IMF Climate Notes, Volume 2021-Issue 001).

English
Finance & Development, September 2021

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