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The Green Future Index

A ranking of 76 economies on their progress and commitment toward building a low-carbon future.

2023

Preface

The Green Future Index is a research program by MIT Technology Review Insights sponsored by Kyndryl, Intel, and Iris Ceramica Group. The research was conducted through in-depth secondary research and analysis along with interviews with global experts on climate change, green energy, and technologies that will drive decarbonization. It measures the extent to which 76 countries and territories are moving toward a green future by reducing carbon emissions, developing clean energy, innovating in green sectors, and preserving the environment, as well as the degree to which governments are implementing effective climate policies. The writer of the report was Ross O'Brien; the editor was Michelle Brosnahan. Nicola Crepaldi and Natasha Conteh were the producers. This content was produced by Insights, the custom content arm of MIT Technology Review. It was not written by MIT Technology Review's editorial staff.

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Executive summary

The Green Future Index (GFI) 2023 is the MIT Technology Review's third annual comparative ranking of 76 nations and territories on their ability to develop a sustainable, low-carbon future for their economies and societies.

Encouragingly, the Green Future Index 2023 sees growth in projects and strategies that integrate economic and social development with decarbonization; these efforts are complicated by global disparities in wealth, technology, and expertise. The 2023 rankings reflect efforts to fund carbon removal, sustainable development, and clean power generation in emerging economies and for disadvantaged communities.

The key findings of this year's report are as follows:

1

- **Green Leaders reveal more consistency than progress.** All but three countries in the top ranks for 2023 – Green Leaders – were in the same cohort for 2022. Iceland remains top-ranked, and only one of the top 10 (South Korea, rising from 10th place to eighth) was not European. Just one country moved into the Green Leaders group: Luxembourg (to 16th place from 28th in 2022). All Green Leaders retained their low-carbon attributes, but roughly half saw scores decline during the past year. This suggests that although efforts to reduce carbon in their economies are increasing and policy work is strengthening, early returns are diminishing.

2

- **Jumping around in the Greening Middle.** The 20 countries of the Greening Middle put sustainable policy formulation into action, and many moved forward substantially. These include emerging economies able to link sustainable policies to economic incentives, including South Africa (in 25th place for 2023, up from 31st) and Uruguay (26th, up from 38th in 2022). As in past years, the highest-ranked emerging economy for the Green Future Index 2023 is Costa Rica, in 24th place.

3

- **Wealth matters.** Despite notable efforts to link economic and sustainable development, emerging economies continue to fare poorly in their Green Future Index rankings. Correlating rankings with GDP per capita reveals an uncomfortable truth: wealth contributes significantly to a country's ability to define its low-carbon future.

4

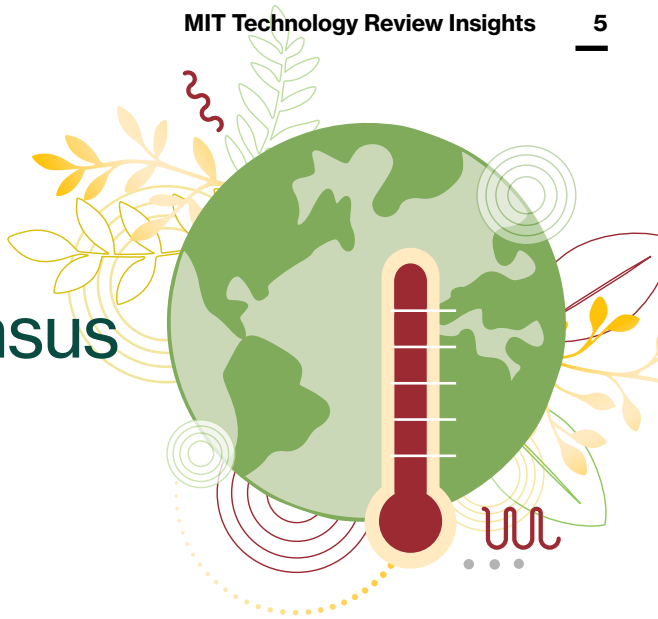
- **Economics alone does not define the future.** Seventeen of the 35 countries that improved scores in 2023 were poorer countries. Argentina and Indonesia saw the biggest increases of all countries for 2023, moving 20 and 21 places respectively, placing them in 48th and 49th overall. Significant commitment to improving a single pillar was behind both increases: Argentina's green society score and Indonesia's carbon emissions score.

5

- **The unbearable weight of carbon.** Economic over-reliance on fossil fuel production or natural resource extraction contributes to lower scores. Most Climate Laggards are weighed down by carbon-intensive industries. Australia is notable for beginning to free itself from its carbon-intensive economy. Its new policy-focused business incentives allowed it to jump 10 places in the 2023 rankings to 42nd place.

02

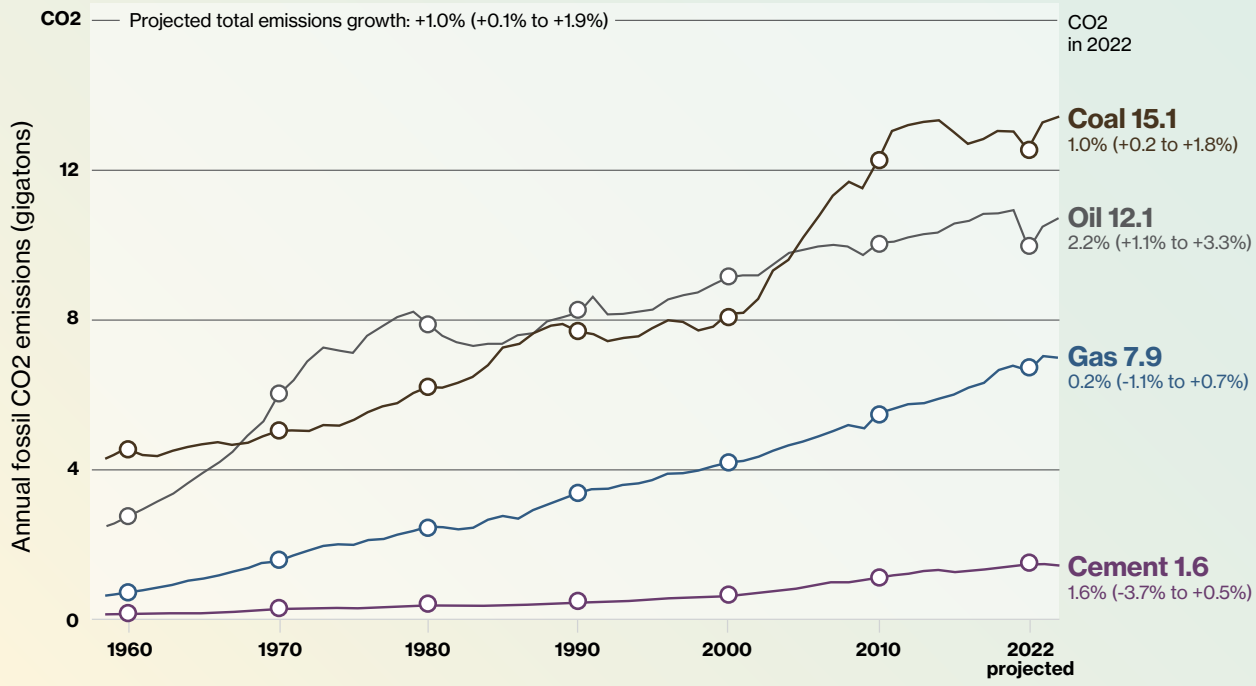
Introduction: Little progress, little consensus



The 2022 United Nations Climate Change Conference, COP27, did not inspire confidence. The optics were often terrible, with 600 oil company executives among its estimated 35,000 attendees,[1] and it was widely reported that many delegates traveled to Egypt on some 400 private jets. More tangibly, the proceedings failed to yield concrete commitments to cap or reduce the use of fossil fuels.

Progress reports on global efforts to fight climate change were similarly dire. A report released by the Global Carbon Project (GCP) during COP27 estimated that hydrocarbon fuel-linked emissions increased 1% in 2022[2] (see Figure 1). A report by the Intergovernmental Panel on Climate Change (IPCC) suggested that, at current global economic activity rates, less than a decade remains before the world exceeds the 1.5 degrees Celsius (1.5C) global warming threshold set by the Paris Accord agreements.

Figure 1: Annual fossil C02 emissions, 1960–2022



Source: Compiled by MIT Technology Review Insights based on data from the Global Carbon Project (GCP) carbon budget, 2023

Addressing environmental loss and damage

COP27 did make significant progress on climate mitigation and adaptation, including an agreement to establish the UN's Food and Agriculture Organization (FAO) Sustainable Transformation Initiative to promote more sustainable global agriculture practices by 2030. The Adaptation Fund, launched in 2007 at COP13 to help developing countries adapt to climate change, gained $230 million in new pledges at COP27.

An equitable, inclusive climate fight

COP27 delegates also agreed to create a fund for loss and damages incurred by emerging countries during climate-related disasters.[3] The nascent initiative aims to deepen support for poor countries through existing channels. More significantly, the agreement represents an important step for climate justice. That's "the principle that the benefits reaped from activities that cause climate change, and the burdens of climate change impacts, should be distributed fairly," according to the Massachusetts Institute for Technology's climate portal.

Climate justice programs have started to form on national, transnational, and regional levels. For example, under the U.S. federal government's sustainability-focused Inflation Reduction Act of 2022 (IRA), the U.S. Environmental Protection Agency (EPA) is starting a $3 billion Environmental and Climate Justice program to issue grants and technical training, primarily for disadvantaged community groups affected by climate change.[4] "There is a real and growing emphasis on community engagement to achieve environmental justice in the U.S. now," says Erin Burns, the executive director of Carbon180, an non-governmental organization (NGO) focused on carbon removal. Burns says a critical mass of funding, legislation, and activism "is really beginning to shape our industry and drive momentum for even greater things."

> "We have to balance the need to increase access to reliable and cost-effective modern energy services with the need to decarbonize the global energy system."
>
> **Lily Odarno**
> Director, Energy and Climate Innovation Program for Africa at the Clean Air Task Force

Western climate policy imperfect fit for the developing world

At a transnational level, implementing climate justice policies is complex, particularly when emerging and advanced economies collaborate. "The global climate movement grew out of the west, and has been pushed as part of a western agenda," notes Lily Odarno, director of the Energy and Climate Innovation Program for Africa at

The social cost of carbon in human lives

If there is a global currency, it may be the social cost of carbon (SCC), which is the damage caused by each extra ton of carbon in Earth's atmosphere, measured in U.S. dollars. The current figure, at $51 was determined in 2010 to help calculate climate policy. In late 2022, the U.S. Environmental Protection Agency (EPA) proposed to increase it to $190.

As a costs vs. benefits policy tool, SCC provides a standard that shapes more than 80 U.S. regulations, with about $1 trillion in gross benefits. Countries such as the U.K., Norway, France, Germany, Canada, and Mexico have implemented similar measures, but calculations vary.

SCC helps track carbon emissions but it also puts a dollar value on human death, and not every death counts equally. According to a National Public Radio report, the SCC means a single climate change-related death in the U.S. is equivalent to about nine deaths in India, five in Ukraine, or 55 in Somalia. The EPA states it "does not place a dollar value on human life," but instead on what people around the globe are willing to pay for reduced risk from climate change, creating a "value of a statistical life."

> "We have to link energy transition to the economic development of communities affected by coal power plant closure, particularly in countries like India or Indonesia where large populations' livelihoods depend on coal mining."
>
> **Noelle O'Brien**, Chief of Climate Change and Disaster Risk Management, Asian Development Bank

the Clean Air Task Force (CATF). She notes the priorities of mature economies that fund climate action in emerging countries often do not take into account the disparities in income and infrastructure between them.

"Africans experience climate change in a very different context," Odarno says. "We have to balance the need to increase access to reliable and cost-effective modern energy services with the need to decarbonize the global energy system. In a continent which could be home to 90% of the world's poor by 2030, we cannot put human development goals on the back burner while we fight climate change."

Gaps in wealth and infrastructure between countries mean efforts to decarbonize economies will vary, even when countries are economically similar. Indonesia and Australia are the world's third- and fifth-largest coal producing countries respectively. Like most extractive industry–intensive economies, both struggle to lessen coal dependency to meet decarbonization goals. In February 2023, Australia's federal government for the first time blocked a plan to develop a new coal mine in Queensland, largely out of concern that construction would affect the Great Barrier Reef, only 10 kilometers away.[5] In contrast, Indonesia is building what President Joko Widodo has called "the world's largest green industrial park," which could cover 30,000 acres in Bulungan, North Sumatra. The government plans to use coal-fired electricity plants during a 10- to 15-year transition period until planned hydropower plants become fully operational.[6]

Measuring climate justice

The Green Future Index 2023 attempts to assess climate justice and efforts to decarbonize economic activity, and how this is affected by global disparities in wealth, technology, and expertise. To do this, the index evaluates national and transnational policy formulation and investment trends. It also evaluates several index indicators on efforts to fund carbon removal, sustainable development, and clean power generation in emerging economies and disadvantaged communities. This includes initiatives such as the Asian Development Bank's (ADB) Energy Transition Mechanism (ETM) program, a series of collaborative finance projects designed to retire coal-fired power plants and create renewable energy programs, creating local economic opportunity. "Such targeted approaches are an important step for us to make our climate work successful," says Noelle O'Brien, chief of Climate Change and Disaster Risk Management at ADB. "We have to link energy transition to the economic development of communities affected by coal power plant closure, particularly in countries like India or Indonesia where large populations' livelihoods depend on coal mining."

The Green Future Index 2023 also examines climate justice through evaluating the shifting geopolitical landscape. Currently, this is centered on Russia's war on Ukraine and its disruptions to natural gas markets. "While the war waged by Russia on Ukraine has had countless negative climate and other impacts, which have reverberated across the globe, one of the consequences … is that it has put a global price on carbon more quickly than multilateralism has done to date," says Kelly Clark, director of Finance and Capital Market Transformation at Laudes Foundation, a provider of philanthropic capital to address climate change and inequality. The 2023 index adds an indicator that measures each country's exposure to, and dependency on, liquefied natural gas (LNG), relative to their ability to shift to cleaner energy sources.

These new measurements indicate progress in integrating economic and social development and decarbonization. Addressing climate justice is increasingly important as governments, businesses, and citizens globally strive to understand and address climate change and its devastating effects.

Methodology: **The Green Future Index in 2023**

The Green Future Index 2023 is the third annual comparative ranking of 76 nations and territories (which collectively generate roughly 90% of global GDP) on their ability to develop a sustainable, low-carbon future for their economies and societies. The index was developed through in-depth primary and secondary research processes. Secondary research comprises a continuous review of several hundred articles, research reports issued by climate action organizations and NGOs, government policy documentation, and scientific literature. Primary research consists of nearly 20 in-depth interviews with a range of global climate change specialists: climate scientists and research professionals, technologists, government policymakers, NGO activists, and clean tech entrepreneurs and venture capitalists.

This research process informed an evaluation and selection of distinct sets of country-level data to become the indicators of the Green Future Index; the 2023 edition now comprises 23 such indicators. The indicator datasets were turned into ranked scores in one of two ways. For quantitative metrics, such as growth rates or values, each data point for each country was scaled up or down using minimum-maximum normalization to develop a range of scores across all countries for that indicator. For data that was largely qualitative or nonstandard, a ranking categorization system was developed, and each country was assigned a score. Once all 23 indicators were scored, they were organized into separate pillars.

The data came from a wide range of latest publicly available sources (nearly all of which were updated in 2022). These include the International Energy Agency (IEA), the International Monetary Fund (IMF), the International Renewable Energy Agency (IRENA), the Organization for Economic Co-operation and Development (OECD), the World Bank, the United Nations Food and Agriculture Association (FAO), the World Intellectual Property Organization (WIPO), and the U.S. Energy Information Administration (USEIA).

In some cases, MIT Technology Review Insights researchers expanded and refined existing datasets, conducting additional cross-comparative country-level research to fill in data gaps, or to create rankings out of nonstandard data. This was done specifically for several indicators in the climate policy pillar, including the Policy Pivot (previously known as the Pandemic Pivot), and in a new indicator added to this year's index, which estimates the impact LNG supply issues will have on energy transition (see the section "What is different in the Green Future Index 2023?").

As in past editions, the structure of the Green Future Index 2023 is made up of five pillars:

Pillar 1: Carbon emissions - This pillar measures how effectively countries are curbing carbon dioxide emissions overall, as well as in key sectors. The indicators within this pillar include the following:

- Total carbon dioxide emissions in 2020, in millions of tons, relative to GDP
- Average annual change in carbon dioxide emissions between 2015 and 2020, both in total, and for each of the industry, transportation, and agriculture sectors

Pillar 2: Energy transition - This pillar assesses the contribution and growth rate of renewable and clean, energy generation in each country. The indicators within this pillar include the following:

- Growth of renewable energy production in gigawatt-hours between 2015 and 2020
- Percentage of energy from renewable sources found in 2019's final energy consumption
- Growth of nuclear energy production in gigawatt-hours between 2015 and 2020
- Percentage of nuclear-generated energy found in 2019's final energy consumption

Pillar 3: Green society - This pillar measures the efforts made by government, industry, and society to promote green practices. The indicators measure the following:

- Number of Leadership in Energy and Environmental Design (LEED)–certified green buildings in 2020, per million urban population
- Percentage of recycled solid waste in total waste managed
- Net change in forestation between 2015 and 2020: an indicator that combines the change in acreage of forested land through naturally regenerated primary growth, and changes through planned afforestation projects
- Stock of electric passenger vehicles per million urban population in 2021

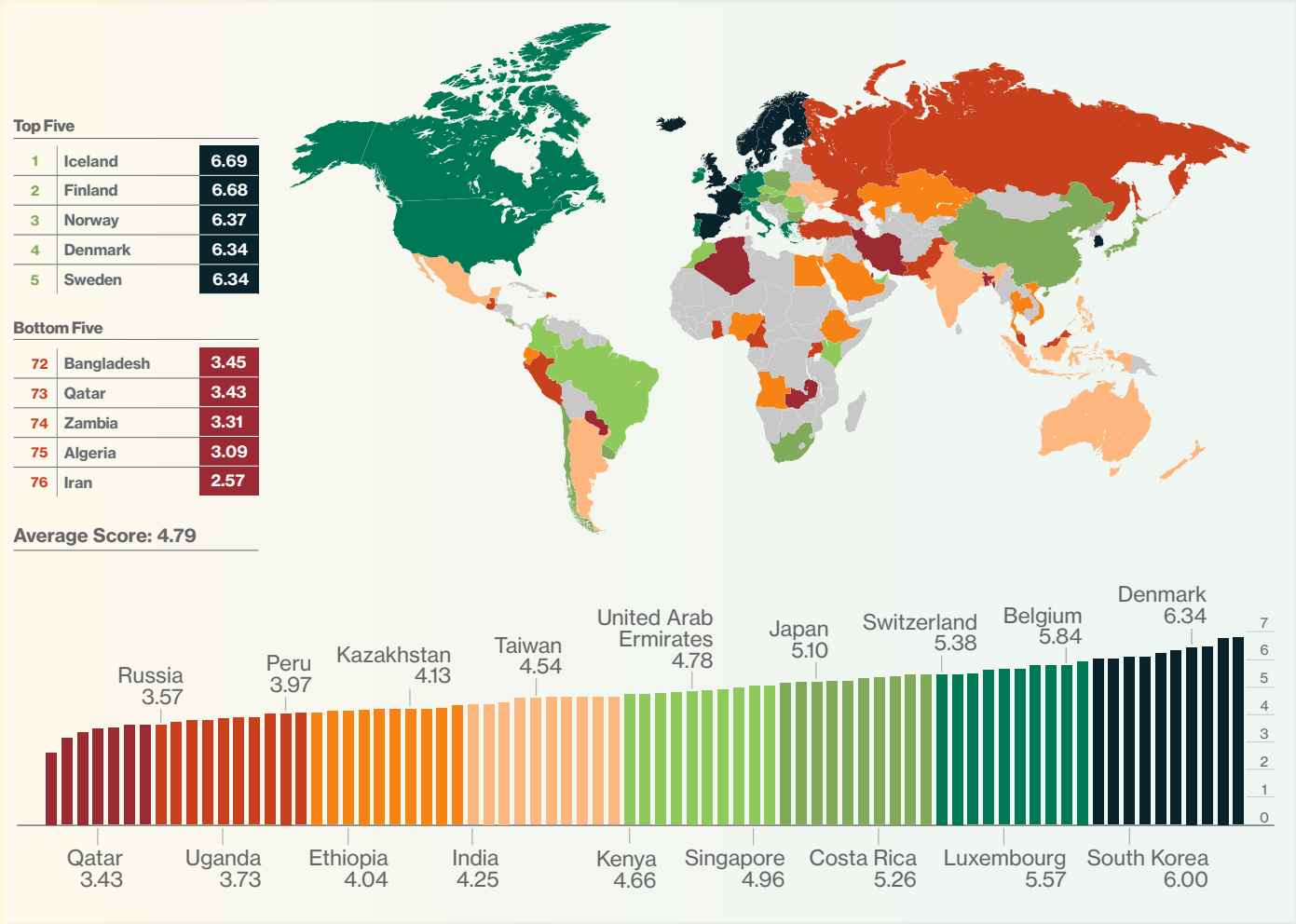
Pillar 4: Clean innovation - This pillar measures the innovation environment for building a low-carbon future, such as the relative penetration of green patents, investment in cross-border clean energy, and investment in food technology. The indicators measure the following:

- Growth in green intellectual property, measured by the increase in patents registered for sustainable technologies or processes and solutions between 2017 and 2021, relative to GDP
- Amount of investment a country received and provided for clean energy efforts between 2016 and 2020, as a percentage of GDP
- Number of food technology (food tech) startups per million of urban population

Pillar 5: Climate policy - This pillar measures the ambition and effectiveness of climate policy, including carbon financing initiatives, sustainable agriculture policy, and the use of pandemic recovery spending to achieve a green economic recovery. The indicators include the following:

- Evaluation and ranking of policy action to reach stated climate goals in compliance with the Paris Agreement and nationally determined contributions (NDCs)
- Evaluation and ranking of policy and regulatory frameworks to promote carbon capture and sequestration (CCS) efforts
- Assessment and ranking of measures taken by each country to create financial incentives for firms and investors to assign a cost to carbon emissions, through the levying of carbon taxes and the creation of a market for carbon bonds and emissions trading systems
- Ranked assessment of sustainable agriculture policies, assessing for comprehensiveness and effectiveness of implementation
- Analysis and ranking of the degree to which covid-19 recovery stimulus packages accelerated decarbonization, resulting in a "policy pivot" along two measures:
  1. Energy transition impact: Scoring countries by the proportion of stimulus spending directed at new energy initiatives vs. fossil fuel projects

Figure 2: The Green Future Index 2023 rankings world map



Source: MIT Technology Review Insights, 2023

2. Green stimulus initiatives: Scoring countries by the percentage of total stimulus spending allocated to sustainable, low-carbon key public infrastructure projects (such as transportation, water, public spaces, and information)

- LNG supply shock stimulus, which evaluates the degree to which each country will accelerate energy transition programs because of its relative exposure to global LNG supply chains

These pillars collectively and comprehensively evaluate each country's green future across two dimensions: the progress it has made on achieving carbon-reduction goals and other climate-friendly societal activities, and the ambitions that the country must achieve to maintain a carbon-neutral economy. The first four progress pillars account for 60% of the weighting in the index. The fifth pillar – climate policy – measures the extent to which investment and policy activities are channeled into green infrastructure initiatives and legislation frameworks. These factors collectively provide the primary impetus for establishing and sustaining a country's green future, and thus this pillar accounts for 40% of the index weighting.

What is different in the Green Future Index 2023?

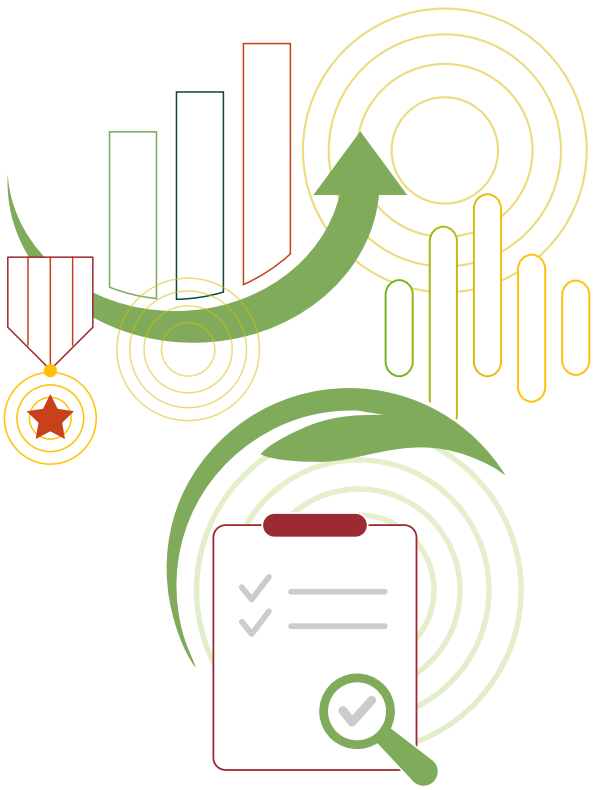
Our assessment of climate change research and policy developments since the Green Future Index 2022 led us to adjust the input data and parameters of some indicators and add an additional indicator to fully capture each country's decarbonization progress. These include:

Pillar 2: Energy transition: Renewable energy is not measured separately from traditional biomass, which centers the measure more precisely on sustainability. Renewable energy share in total, final energy consumption is now calculated using IEA data on modern renewables, which excludes the use of traditional biomass (such as firewood). Focusing this indicator on more efficient renewable fuel categories provides a more precise measure of the sustainability of each country's energy system.

Pillar 5: Climate policy: The new Policy Pivot category replaces and broadens the Pandemic Pivot category as covid-19 programs decline and more green public spending programs emerge. The Policy Pivot also gained a new indicator, the LNG supply shock stimulus.

Both the Pandemic Pivot indicator's subcategories are carried forward into the Policy Pivot category. That's to measure stimulus spending on clean energy or sustainable development as a proportion of overall stimulus spending. A wider range of public investment spending is evaluated, with consideration for transnational funding of sustainable projects. Some previous input measures (such as Vivid Economics' "Greenness of Stimulus") are discontinued.

The LNG supply shock stimulus ranks each country's potential to accelerate energy transition goals, considering geopolitical shocks on global natural gas supplies and prices. Each country's net exposure to LNG imports and relative dependency on LNG and renewable sources in its energy mix is considered. Large exporters of LNG or those with lower LNG dependency in domestic energy consumption are ranked lower, as these economies have few incentives to transition to clean energy. Economies highly dependent on LNG imports have a higher incentive, particularly if they also have a larger installed base of renewables-based energy generation.



Kyndryl

At Kyndryl, we believe that global sustainability challenges must be tackled with a vision to create an inclusive and environmentally sustainable future. We are committed to implementing a sustainability strategy that is integrated with our business strategy by applying industry standards and innovation.

In our first year as an independent company, Kyndryl has built sustainability into the company's DNA, establishing our emissions baseline with external validation, creating our sustainability strategy following the UN's Sustainable Development Goals, and setting our 2040 net-zero targets in line with the leading scientific frameworks and the Intergovernmental Panel on Climate Change. We are doing this all while we build our own roadmap and financial model to meet our company goals.

Kyndryl serves as a trusted advisor to over 4,000 global customers, engaging in partnerships to design, build, manage, and modernize their mission-critical IT systems, and leverages these capabilities to create sustainable solutions for our customers and scale them on a global level. We work with our customers to figure out how to best automate processes and use the mass amounts of data coming from their value chain to highlight opportunities to improve efficiency, resulting in reduced waste and more sustainable operations.

Our sustainability strategy aligns with the company's business strategies and includes consolidating our legacy real estate and data center footprint, modernizing our infrastructure systems, increasing renewable energy use, and engaging with suppliers and partners to use sustainable solutions. Since 2021, we have reduced our data center energy consumption by more than 40,100 MWh (equivalent to >14,000 MTCO2e) while saving $5.47 million, and annually enabling the generation of 18,000 MWh of solar energy.

Kyndryl works with our alliance partners to apply environmental solutions with our customers and to create collaborative opportunities to collectively manage the impacts of climate change. We have established over 20 strategic alliances with organizations such as Microsoft, Google, and AWS. We work with our alliance partners to migrate our customers to the cloud, reducing energy usage by as much as 85%[1] and reducing emissions through the cloud's use of ~100% renewable energy.

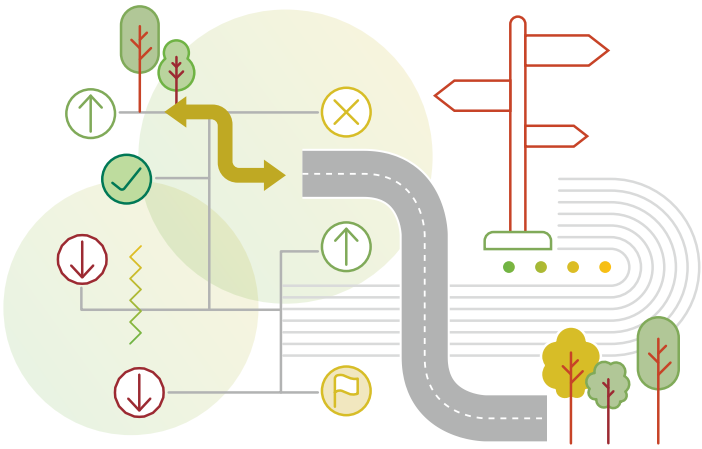
Our culture is built on how we work together and deliver value to the world, and it's grounded on the principles of collaboration, mutual responsibility, and excellence. That's why we launched Kyndryl's Green Guild in 2022, an employee-led and customer-facing program that leverages Kyndryl Vital and Kyndryl Consult and our alliance partners to co-create and innovate new sustainable offerings and business solutions.

As a new company, our first step was to create the foundation for our sustainability strategy inclusive of our net-zero targets. The second step is to ensure that our employees embrace our sustainable values through ongoing education, training, and action. Kyndryl will continue to strive to develop sustainable solutions to manage climate change today and far into the future.

Faith Taylor
Global Sustainability Officer
Kyndryl

1."Cloud Reduction in Cloud" by S&P Global Market Intelligence, 2022.

03 Changing fortunes



The Green Future Index 2023 rankings reveal more consistency than progress. Of the top 20 scorers – the Green Leader cohort – all but three were in this group in 2022 (see Figure 3). Moreover, most top 10 scorers also held top 10 spots in 2022. Iceland, which retains the number one position in the index, ranked first in the carbon emissions pillar and the energy transition pillar. Luxembourg is the only country with significant movement toward the Green Leaders: it showed considerable state resolve in decarbonizing its economy. In November 2022, Luxembourg's cabinet approved a package of energy transition incentives that included new subsidies for solar installations.

Momentum slows among leaders

All Green Leaders retained their low-carbon attributes: consistent efforts to reduce emissions and increase use of renewables in their energy systems, commitments to increase sustainability in transportation and public utilities through green policies, and directed investment. But roughly half saw scores decline, including a sizable drop in

The UN's urgent climate to-do list

Though GHG emissions are rising, existing solutions can help meet climate goals this decade, according to a March 2023 report from the UN's Intergovernmental Panel on Climate Change (IPCC). Actions taken now will be visible in global temperatures within 20 years, the IPCC says. The IPCC report calls out four ways to fight climate change in the near term:

1) Wind and solar power. Weakening the grip of fossil fuels for energy production means embracing renewables. Wind and solar are among the cheapest energy sources – cheaper than maintaining existing coal power plants in the U.S.

2) Cut methane emissions from oil and gas production and food waste. Methane is about 80 times more powerful than carbon dioxide as a greenhouse gas. The value of the captured methane could more than pay for the cost of oil and gas methane-removal technology.

3) Protect natural carbon sinks. Twenty percent of global emissions comes from agriculture, forestry, and changes in land use. Preserving and recovering natural ecosystems can slow climate change.

4) Energy efficiency for transportation, buildings, and industry. Using public transit and bicycling, and more efficient vehicles, aviation, shipping, and appliances can end up paying for themselves.

Source: AR6 Synthesis Report: Climate Change 2023, UN Intergovernmental Panel on Climate Change, March 2023

Figure 3: The Green Future Index country rankings, 2023

Green Leaders

The 20 countries making the greatest progress and commitment toward building a low-carbon future.

RANK 2023		RANK 2022			RANK 2023		RANK 2022			RANK 2023		RANK 2022		
1	—	1	Iceland	6.69	8	↑	10	South Korea	6.00	15	↓	12	Ireland	5.69
2	↑	6	Finland	6.68	9	↓	7	France	5.99	16	↑	28	Luxembourg	5.57
3	↑	5	Norway	6.37	10	↑	13	Spain	5.92	17	↑	22	Greece	5.56
4	↓	2	Denmark	6.34	11	↓	8	Germany	5.92	18	—	18	Portugal	5.52
5	↑	9	Sweden	6.34	12	↓	11	Belgium	5.84	19	↑	21	United States	5.39
6	↓	3	Netherlands	6.22	13	↑	17	Italy	5.70	20	↓	14	Switzerland	5.38
7	↓	4	United Kingdom	6.12	14	↑	15	Canada	5.69					

Greening Middle

The 20 countries that are making progress or commitment toward building a green future.

21	↓	16	Poland	5.38	28	↓	19	Japan	5.10	35	↑	46	Slovakia	4.81
22	↑	23	Austria	5.37	29	↓	24	Hungary	5.09	36	↑	41	United Arab Emirates	4.78
23	↑	25	Bulgaria	5.31	30	↑	33	Chile	5.08	37	↓	36	Morocco	4.73
24	↓	20	Costa Rica	5.26	31	↓	27	Czech Republic	4.97	38	↓	34	Brazil	4.70
25	↑	31	South Africa	5.23	32	↓	29	Singapore	4.96	39	↑	47	Romania	4.66
26	↑	38	Uruguay	5.13	33	↑	45	Hong Kong, China	4.89	40	—	40	Kenya	4.66
27	↓	26	China	5.12	34	↓	32	Colombia	4.83					

Climate Laggards

The 20 countries that are making slow and uneven progress or commitment toward building a green future.

41	↓	39	New Zealand	4.57	48	↑	68	Argentina	4.31	55	↓	48	Thailand	4.12
42	↑	52	Australia	4.56	49	↑	70	Indonesia	4.29	56	↓	51	Saudi Arabia	4.11
43	↓	30	Israel	4.56	50	↓	42	India	4.25	57	↑	58	Kuwait	4.05
44	↑	53	Philippines	4.56	51	↓	43	Nigeria	4.18	58	↓	35	Ethiopia	4.04
45	↑	54	Mexico	4.54	52	↑	63	Ecuador	4.14	59	↓	50	Angola	4.01
46	↓	37	Taiwan	4.54	53	↑	56	Vietnam	4.13	60	↓	59	Egypt	3.99
47	↑	61	Ukraine	4.38	54	↓	49	Kazakhstan	4.13					

Climate Abstainers

The 16 countries that will be left behind in the green future through their lack of progress and commitment toward developing a modern, clean, and innovative economy.

61	↑	66	Dominican Republic	3.98	68	↓	65	Malaysia	3.67	75	—	75	Algeria	3.09
62	↑	67	Peru	3.97	69	↑	72	Guatemala	3.57	76	—	76	Iran	2.57
63	↑	69	Turkey	3.83	70	↓	64	Russia	3.57					
64	↓	44	Cameroon	3.82	71	↑	74	Paraguay	3.55					
65	↑	71	Ghana	3.80	72	↓	62	Bangladesh	3.45					
66	↓	57	Uganda	3.73	73	—	73	Qatar	3.43					
67	↓	55	Pakistan	3.72	74	↓	60	Zambia	3.31					

Source: MIT Technology Review Insights, 2023

Figure 4: The Green Future Index 2023 leaders' and laggards' scores listed with income levels

GFI 2023 Top 10

RANK	COUNTRY	GDP PER CAPITA (current US$) 2021	2023 SCORE
1	Iceland	68,727.6	6.69
2	Finland	53,654.8	6.68
3	Norway	89,154.3	6.37
4	Denmark	68,007.8	6.34
5	Sweden	61,028.7	6.34
6	Netherlands	57,767.9	6.22
7	United Kingdom	46,510.3	6.12
8	South Korea	34,997.8	6.00
9	France	43,659.0	5.99
10	Spain	30,103.5	5.92

GFI 2023 Bottom 10

RANK	COUNTRY	GDP PER CAPITA (current US$) 2021	2023 SCORE
67	Pakistan	1,505.0	3.72
68	Malaysia	11,109.3	3.67
69	Guatemala	5,025.5	3.57
70	Russia	12,194.8	3.57
71	Paraguay	5,891.5	3.55
72	Bangladesh	2,457.9	3.45
73	Qatar	66,838.4	3.43
74	Zambia	1,137.3	3.31
75	Algeria	3,690.6	3.09
76	Iran	4,091.2	2.57

Source: Compiled by MIT Technology Review Insights based on data from the World Bank's World Development Indicators, 2023

top-ranked Iceland's score. Although efforts to reduce carbon are increasing and policy work is strengthening, early returns are slightly diminishing.

There is movement, and significant rank-jumping, among the Greening Middle, the 20 Green Future Index members ranked 21st to 40th. These countries put sustainable policy formulation into action. They include a number of emerging economies, but mainly those with strong export economies able to link sustainable policies to economic incentives. Uruguay and South Africa, for example, saw their 2023 rankings rise 12 and six places respectively. Uruguay's agriculture and forestry sectors account for a significant portion of its exports, and almost three-quarters of its carbon emissions. Efforts to decarbonize these sectors include implementing a carbon-neutral certification process for its beef exports to Europe. South Africa's National Treasury put forward a Green Finance Taxonomy in April 2022 and set standards for sustainable and green economic activities to increase its attractiveness to foreign investors.

Economic weakness weighs on carbon reduction

The highest-ranked emerging economy in the Green Future Index 2023 is once again Costa Rica, in 24th place. Costa Rica is committed to making its eco-friendly economy a competitive advantage, and continues to be an outlier among emerging economies for its considerable efforts linking sustainability and social welfare. The Costa Rican Association of Pension Operators and the Superintendency of Pensions works with the UN to develop sustainable development investment programs for institutional investors and pension funds.

Notable efforts to link economic and sustainable development aside, it is clear emerging economies continue to fare more poorly in Green Future Index rankings than richer peers. Correlating each country's ranking with its GDP per capita reveals an uncomfortable truth: wealth contributes significantly to the ability to define a low-carbon future (see Figure 4). According to the index, high green society scores correlate with country GDP numbers at 76%, and high climate policy scores correlate with national GDPs at 64%.

Other factors caused countries to lag, such as economic overreliance on fossil fuel production or natural resource extraction. These factors can dampen the will to implement decarbonization programs. From Argentina to

Indonesia, and Nigeria to Saudi Arabia, most countries in the next 20 places – the Climate Laggards – are weighed down by carbon-intensive industries.

A few bright spots

Nevertheless, Australia, a country with an economy based on rocks and crops and until recently led by a climate-skeptic government, shows policy focus and business incentives can create a significant shift toward a green future. Australia jumped 10 places in the 2023 rankings to 42nd place. Although Australia's wealth is a contributing factor, some poorer countries among Climate Laggards are also improving.

Argentina and Indonesia both saw marked increases in their 2023 rankings: 20 and 21 places respectively, placing them in 48th and 49th overall. Significant commitment to improve one pillar was behind both increases. Argentina's green society score rose, in large part to a substantial greening of its transportation sector. Indonesia has been successful reducing its carbon emissions through deforestation reduction efforts. Indonesia's success allowed it to resume a climate financing deal with the Norwegian government in October 2022, which disbursed $56 million to fund tropical forest preservation and enhancement, with the aim of creating a carbon sink by 2030.[7]

The final quadrant of Green Future Index rankings is the Climate Abstainers, which fail to commit to significant policy change or increase decarbonization practices. This group contains several countries that embody this moniker – notably Russia in 70th place and last-ranked Iran. For others, the Climate Abstainer label may not be as apt: Peru (62nd) or Malaysia (68th) are not without significant sustainability aspirations. But for all these last-placed countries (nearly all of which saw scores fall from 2022 levels), not a single pillar showed improvement. Low income levels are a particular burden for most countries in this cohort. Some, such as flood-ravaged Pakistan, expend scant resources fighting a rearguard action against climate change–induced disasters. Lack of will is not the key determinant for a country's poor performance in the Green Future Index 2023.

Fires in the Amazon create a massive CO2 source

Like the ancient Yucatan, Sahara, and Outback, the Amazon's eco-cycle is breaking down.

During the past 50 years, about 17% of the Amazon rainforest has been repurposed for crops or cattle. Emissions from deforestation are outrunning the forest's capacity to absorb carbon.

Measuring the Amazon's carbon levels is usually done by extrapolating from satellite and tree measurement data. But since the Amazon is about the size of the continental U.S., these estimates are problematic. To get better empirical data, Luciana Vanni Gatti, atmospheric chemist at Brazil's National Institute for Space Research, samples carbon directly from the air, with the help of bush pilots and a device from the U.S. National Oceanic and Atmospheric Administration.

When she started in 2010, Gatti expected carbon readings to decline over a given spot at lower altitudes, but measurements from about 80% of the Amazon showed rising carbon levels approaching the canopy. Gatti published her findings in *Nature* in 2021 and results showed Amazonian net carbon emissions averaged 300 million tons of carbon per year, about the same as the nation of France.

Gatti says emissions from slashing and burning are the culprit. As rainforest is burned to make way for human activity, the Amazon's natural weather system becomes warmer and drier. This continued damage could cause ecosystem collapse – possibly in only decades – just as ancient human activity turned the Yucatan, the Sahara, and the Outback from lush landscapes to desert scrubland.

04 Carbon emissions and energy transition

The first pillar of the Green Future Index 2023 – carbon emissions – examines the latest available data on each country's carbon emissions levels, and how they have changed during the last half-decade. Most leaders in this pillar, which have all successfully reduced emissions levels, are wealthy European (and often Nordic) countries (see Figure 5). Overall GFI leader Iceland is first place in the carbon emissions pillar, with a perfect score in three out of its five pillar categories. Finland ranks third, and Sweden places eighth. These countries do not rest on their low-carbon laurels: Iceland's government is working to streamline the construction of wind farms and will put forth new legislation to that effect in 2023.

Climate-forward Nordic companies play a role in reducing emissions. In December 2022, Swedish fast-fashion retailer H&M signed the country's largest-ever solar power purchasing agreement with a new solar park being built at Hultsfred Airport in Sweden.

Hong Kong rose to fourth place. Its economy is dependent on fossil fuels for electricity, and it is a major shipping hub, which has historically meant little momentum for carbon reduction or removal. Lowered energy intensity in its transportation sector (electric vehicles make up a respectable 5% of its installed base) seems to be having a positive impact. Notably, two resource-extractive countries in Africa are also now low-carbon emissions leaders: Angola, ranked second, and Cameroon, ranked 10th. Angola recently launched a National Strategy on Climate Change to hasten its transition to a low-carbon economy by 2035.

Many countries in the middle tiers of the carbon emissions pillar show diligent efforts to improve. Ireland, ranked 21st in the pillar, missed its carbon emissions–reduction targets in 2019 and 2020. In July 2022, the Irish government announced binding sectoral targets to cut carbon emissions from agriculture by 25% by 2030.

Carbon emissions laggards comprise Asian and African nations. Fossil fuel producers Vietnam and Nigeria are the lowest and second-lowest ranked countries in carbon emissions.

Although Vietnam continues to rank poorly, it is one of many emerging countries receiving multilateral aid to address its challenges. The International Group of Seven (G7) pledged $15.5 billion in public and private financing to help Vietnam source 47% of its electricity from renewables and, by 2030, reduce its coal-fired capacity targets by 18%.

Is there progress?

The UN's Emissions Gap Report 2022 estimates the NDCs of member states submitted since COP26 form less than 1% of the world's projected global emissions in 2030.[8] Reducing emissions is proving difficult for businesses, utility operators, and other organizations which operate large complex operations, even as pressure mounts for them to commit to carbon-neutral targets.

Carbon credits, offsets, and other market tools for decarbonization are maturing and becoming more integrated into ESG reporting for corporations. Carbon-neutral targets and broader climate-friendly agendas

Figure 5: Leaders and laggards in the carbon emissions and energy transition pillar for 2022 and 2023

PILLAR 1: Carbon emissions

A high score means a low emissions growth rate.

2023	RANK	2022	COUNTRY	SCORE
1	—	1	Iceland	8.53
2	↑	17	Angola	8.05
3	↓	2	Finland	7.30
4	↑	21	Hong Kong, China	7.28
5	↑	8	Greece	7.20
6	—	6	Argentina	7.20
7	↑	11	Luxembourg	7.17
8	↓	5	Sweden	6.97
9	↑	12	Belgium	6.88
10	↑	16	Cameroon	6.87

2023	RANK	2022	COUNTRY	SCORE
67	↓	53	Iran	5.13
68	↑	72	Pakistan	4.90
69	↓	58	Malaysia	4.86
70	↓	64	China	4.67
71	↓	67	Russia	4.49
72	↓	71	Zambia	4.45
73	↓	66	Turkey	4.35
74	↑	75	Ethiopia	4.32
75	↑	76	Nigeria	4.07
76	↓	73	Vietnam	3.83

PILLAR 2: Energy transition

A high score means that renewable energy is growing quickly and contributes a higher share of the overall energy mix.

2023	RANK	2022	COUNTRY	SCORE
1	↑	13	Iceland	5.42
2	↑	10	United Arab Emirates	5.31
3	↑	25	Norway	5.09
4	↑	18	Sweden	4.94
5	↑	8	Kuwait	4.72
6	↑	20	Finland	4.70
7	↑	16	Uruguay	4.48
8	↑	12	Saudi Arabia	4.46
9	↑	24	Brazil	4.44
10	↓	8	South Korea	4.30

2023	RANK	2022	COUNTRY	SCORE
67	↓	15	Guatemala	2.37
68	↑	71	Russia	2.36
69	↑	74	Egypt	2.31
70	↓	4	Nigeria	2.13
71	↓	62	Philippines	2.00
72	↓	67	Kazakhstan	1.95
73	↓	7	Kenya	1.81
74	↓	30	Bangladesh	1.64
75	↑	76	Qatar	1.57
76	↓	75	Singapore	1.45

Source: MIT Technology Review Insights, 2023

mean business leaders increasingly need visibility over all activities that generate carbon emissions. Voluntary carbon-cutting targets usually stipulate reductions in Scope 1 or Scope 2 emissions.[9]

The purchase of voluntary carbon credits has been a stopgap, although concerns about greenwashing and the quality of carbon credits chilled the market in 2022. BloombergNEF estimates firms bought just 155 million offsets in voluntary carbon markets (VCMs) globally, down 4% from 2021, largely because of growing concerns about low-quality credits.[10]

Carbon-neutral targets and broader climate-friendly agendas mean business leaders increasingly need visibility over all activities that generate carbon emissions.

Carbon market research firm AlliedOffsets estimates that in 2022, 201 million carbon credits were retired (credits purchased to fulfill a carbon offset requirement, removing it permanently from the market).[11] This isn't much of an increase considering 196 million were retired in 2021 (which was 60% more than 2020). However, VCMs continue to grow, particularly in emerging markets. China launched a national scheme in July 2021 and by December 2022, the Shanghai Environment and Energy Exchange noted a carbon credit trading volume of more than CNY 10 billion (US$ 1.4 billion) in August 2022, nearly 14% of the world's total.

The dark side of carbon credits?

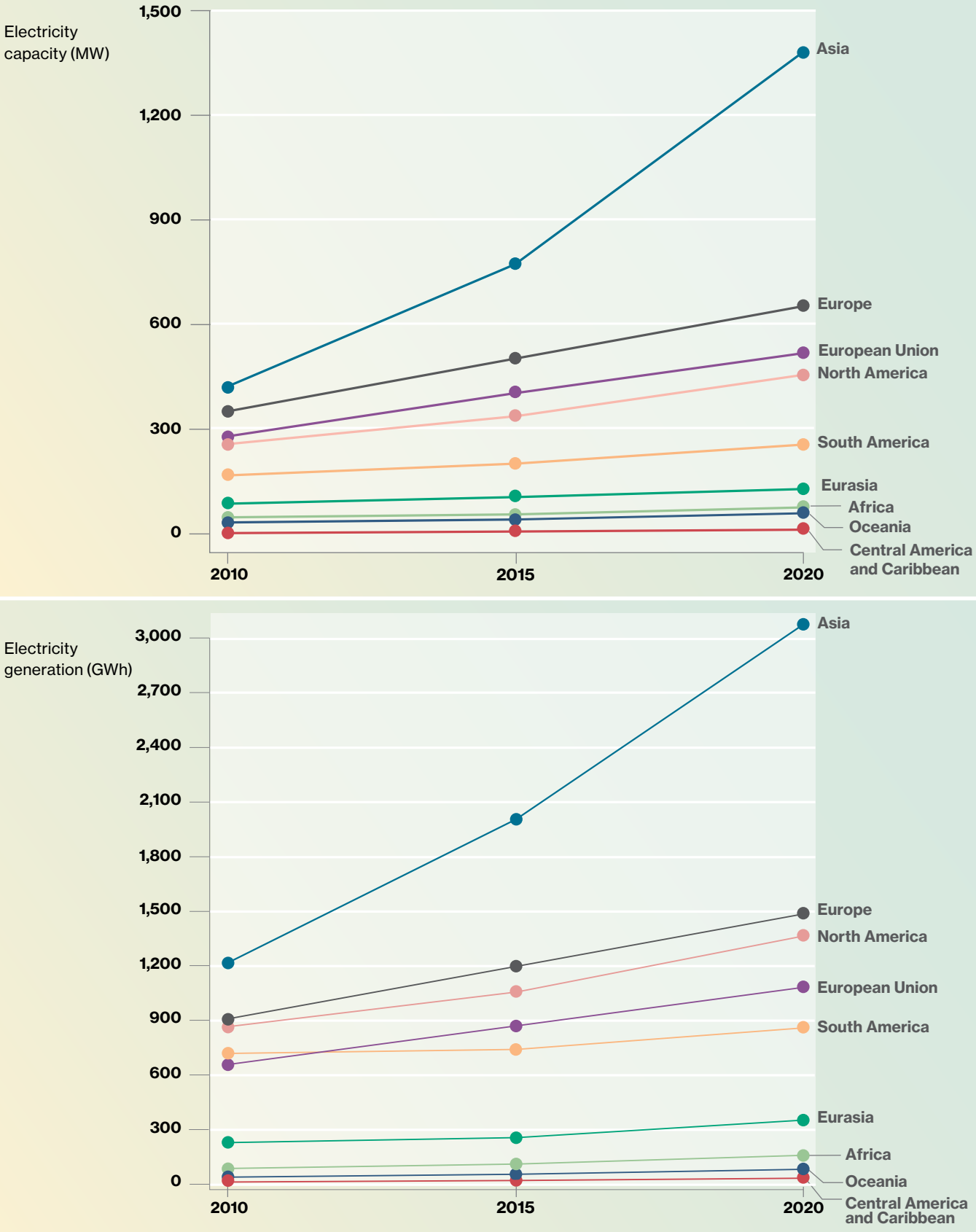
The falloff in carbon credits is a concern for the VCM industry, given the rise in carbon emission reporting, regulatory, and capital market requirements. Another concern is that, increasingly carbon credits are generated from questionable sources and quality. Many analysts believe the oil and gas industry, in an effort to tap into almost $ 400 billion in emissions-linked tax credit programs in the U.S. IRA legislation, will ramp up internal carbon sequestration projects alongside enhanced oil exploration efforts.[16]

Emerging markets take on carbon trading

Applying climate justice methods will require financial infrastructure to fund climate resilience efforts, which will move billions of dollars from rich to poor countries. As policymakers in emerging economies seek to develop upstream refineries to capture the added value of processing raw minerals, there is a growing move to develop carbon trading platforms. These efforts depend on deforestation reduction and other carbon credit–creating programs to play a larger role in economic development. Egypt opened Africa's first VCM in December 2022, modifying its capital markets law to create a platform on the Egyptian Stock Exchange.[12] Egypt's entry coincided with an announcement at COP27 to launch the Africa Carbon Markets Initiative (ACMI), a program to connect financiers, credit buyers, and program developers across several African countries to produce 300 million carbon credits annually by 2030.[13]

New trading platforms are emerging in the Asia-Pacific, home to eight of the top 10 carbon credit marketplaces, according to climate technology firm Co2nsensus.[14] Malaysia's main stock exchange, Bursa Malaysia, launched the Bursa Carbon Exchange in December 2022, which it touts as the world's first carbon market to trade in sharia-compliant products.[15] In October 2022, the Hong Kong Exchange launched its Core Climate carbon credit marketplace. Hong Kong aims to become a leader in green and sustainable finance by leveraging its financial connectivity to China's emissions trading system (ETS) markets – currently the world's largest. In 2021, Hong Kong issued US$ 29.5 billion (CNY 202.6 billion) in green bonds.

Figure 6: Renewable generation capacity and electricity transmission by region, 2010–2020



Source: Compiled by MIT Technology Review Insights based on data from the International Renewable Energy Agency (IRENA), 2023

"There are a lot of reasons to be skeptical about oil companies investing in carbon removal," says Erin Burns of Carbon180. "Carbon removal should be focused on legacy emissions – it should not be a tool to continue putting CO2 in the atmosphere and continuing to burn fossil fuels," she says. Burns also notes carbon removal projects must consider environmental justice principles: "How are these projects being deployed? Are they being placed in communities that want them? Are companies being thoughtful about not just current but historic human rights violations or implications?" She is concerned large hydrocarbon companies will not hold these core principles or prioritize community engagement.

Some oppose tying ESG components to carbon credits, which might dilute the credits' value. These requirements are "quite difficult to price, and pragmatically don't do much to solve the central challenge of saving the planet by limiting temperature increases," cautions Tom Ford of UK-based Land Carbon Associates. Land Carbon packages carbon credits created by natural carbon sequestration, derived from their management of peatland restoration projects. Land Carbon rewets and recontours peatland damaged by desiccation and erosion, largely on the grounds of whisky distilleries in the Scottish Highlands.

Ford says an increase in ESG-linked credits run the risk of obscuring carbon offsetting. "Companies looking for carbon offsetting should primarily be concerned with the calculable, demonstrable amount of carbon that they're actually offsetting," Ford says. These attributes, he says, should be understood separately from the economic value of the carbon credit. If not, Ford says, VCMs may struggle to attract buyers.

Expanding energy transition

The world continues to expand clean energy generation capacity. The transition away from hydrocarbons is one of the few clear sustainability success stories. IRENA estimates more than 81% of new power generation capacity installations were renewable in 2021, up more than 9%.[17] During the last decade, total global electricity-generation capacity from solar, wind, and other renewable sources more than doubled. The total volume of clean power generated has grown 85% (see Figure 6).

Asia excels in renewables

IRENA reports that Asia – primarily China – continues to lead the world in new renewable energy-generation capacity, with 60% of new installations and nearly half of clean energy production globally. Scandinavian nations continue to lead in terms of overall transition of energy systems to renewable sources. They hold four of the top six places in the energy transition pillar rankings (see Figure 5). In addition to extensive efforts to convert primary electricity generation to renewable sources, Nordic countries have aggressive programs to remove fossil fuels from other economic sectors. Norway remains the largest per-capita consumer of electric vehicles (EVs) in the world, and it recently joined the Clean Energy Marine Hubs Initiative, which aims to foster green fuels to reach energy transition goals in the shipping sector.

Other high-income countries improved in the energy transition pillar, such as the U.S., which is significantly ramping up renewable energy investment, specifically with the IRA legislation,[18] the largest clean energy program in American history. Eighth-place, Saudi Arabia announced plans for building seven gigawatts of clean energy-generation capacity in 10 new solar and wind power projects in its 2023 budget.[19]

Saudi Arabia is an outlier among fossil fuel economies. Many laggards in this pillar – Nigeria, Russia, and Qatar – remain slow to pivot to renewables because of economic dependency on hydrocarbons. Singapore ranked as the single worst nation in energy transition. Like fellow Asian financial hub Hong Kong, Singapore seeks to be a Green Leader through finance and innovation, but struggles with fossil fuel dependency. Natural gas continues to make up

> "We love to use electricity, but in a world where it is fueled by gas, our processes must change."
>
> **Frederic Godemel**
> Executive Vice President of Power Systems and Services, Schneider Electric

nearly 95% of the country's primary energy mix, making it vulnerable to supply shocks caused by the Russian war against Ukraine.

Transitioning to renewable resources

The ability of a given country to transition to renewables is complex and nuanced, says Anuradha Annaswamy, senior research scientist and director of the Active-Adaptive Control Laboratory at MIT. This global group is focused on producing electricity from wind, solar, and other variable renewable energy sources reliably and resiliently. Local geography and natural resources can be instrumental, Annaswamy explains. "Some countries' electricity grids may need to be completely overhauled, but if you have a great hydro system like in Brazil, the grid just might need a smaller tweak, relatively speaking, to get going."

Digitalization, Annaswamy says, is key to increasing renewable energy system reliability: "Operational technology, just as much as IT, is needed to integrate both generation and consumption systems, so that an operator can accurately balance demand and generation supply."

Frederic Godemel, executive vice president of Power Systems and Services for Schneider Electric, also sees technology as integral to increasing sustainability on the demand side. "We love to use electricity, but in a world where it is fueled by gas, our processes must change," Godemel says. "Electricity generated from wind and solar is neither stable, nor aligned with peaks in demand. To reconcile the unpredictable production of green energy with our economic and social lives, you have two choices: permanent societal discipline in energy use," which he argues is impractical to maintain, "or digital automation solutions which optimize energy consumption."

Renewables' difficulties

Investment in operational systems is vital to combat the weak points of renewable energy systems. Clean power grids are usually made up of small and disparate generation facilities – far-flung offshore wind farms or rooftop solar panels connected to the grid across several cities and towns. This creates a greater attack surface for cyberattacks on critical infrastructure, which have grown significantly in the age of ransomware. Climate change–induced extreme weather events also increase outages. "Natural disasters, which are increasing in frequency and intensity, and cyberattacks are hard to recover from, which makes the resilience of the grid paramount," Godemel says.

"The grid is a very complex, large-scale physical system, where failures in one place can affect operations elsewhere," he says. The increase in rooftop solar installations is a heartening statistic that shows high penetration of renewables can be realized, but the injection of electricity from multiple points of the grid in an unpredictable manner can increase complexity and grid reliability. "Operators now worry about all the different devices on their network, because electricity transformers are designed for one-directional power flow," Godemel says.

The growth of EVs adds further challenges, but Annaswamy believes they also provide tremendous new energy transition opportunities. "The same bidirectional flow challenge is compounded if EVs flood a market and everybody starts plugging in at 11:00 p.m. – now you've got this entirely new load pattern change," Annaswamy says. Researchers at the Active-Adaptive Control Laboratory are creating systems to accurately forecast EV load patterns. "But every EV means another battery connected to the grid, and while you have to worry about charging it – you can also discharge it." Significant research is also going on in the field of vehicle-to-grid (V2G) managed charging, she says. "This will give grid operators more control – such as when there is an outage, you could use all of these batteries as backup resources. EVs can become assets that basically help with the grid's overall power balance," she explains.

Cooperation and resilience

Annaswamy says it is critical for the electricity and transportation sectors to come together to implement new sustainable energy solutions. EV-intensive countries like Denmark and Norway are "really fairly ahead in renewable integration," she says. Such integration can expand shared economy concepts, such as increasing dynamic routing, and pricing of public transportation, which can reduce a community's carbon footprint for each passenger mile and address the issue of energy justice. "Imagine a shared mobility service made up of a fleet of buses and autonomously driven vehicles, which

The race to transition energy grids in Africa

The Clean Air Task Force (CATF) mission is to catalyze energy transition in Africa. It runs several projects, and shines light on research and innovation. "Most companies making strides in Africa's clean energy markets are Western. Local companies struggle to access these emerging opportunities. We want to advance a zero-carbon energy agenda which benefits local players," says Lily Odarno, director of the CATF's Energy and Climate Innovation Program for Africa. Her team's goal is "to begin looking at zero carbon technologies from an African perspective, localize the lessons, and ensure adoption of these technologies makes sense for the continent." This is a balancing act with African development goals, Odarno adds.

For 25 years, Odarno says, approximately 80% of Africa's energy has been fossil fuel based. Forty percent of the world's newest natural gas reserves are in sub-Saharan Africa, she says. "Let's not assume that all this is going to stay in the ground just because of COP27."

The NGO helps explore geothermal power in Africa, "super-hot rock technology," which requires drilling about three kilometers deep. Odarno believes this will catalyze geothermal energy in Africa and could help meet the need for abundant, carbon-free energy available 24 hours per day, 365 days per year.

With the U.S. DoE's Office of Fossil Energy and Carbon Management, CATF explores carbon management technology in Nigeria. Odarno sees this as an important opportunity for Nigeria's Ministry of Science Technology to explore CCS technologies, particularly for its energy-intensive cement and fertilizer industries.

transforms mass transit into a mass customized mobility system," Annaswamy says. "Such a system could be designed so you can meet equity considerations, such as serving disadvantaged communities to help them get to hospitals or grocery stores."

The ADB, O'Brien says, raised its cumulative climate financing ambition through 2030 from $80 billion to $100 billion to mitigate emissions and build climate and disaster resilience. ADB's efforts include support for developing member countries to pursue climate mitigation and achieve their NDCs by investing in phasing out coal, power generation from renewable sources, energy storage, energy efficiency, and low-carbon transport. The Asia Pacific region, O'Brien says, is already strengthening its resiliency with climate risk assessments and other innovative adaptation measures. However, progress and financing does not yet match the pace of increasing climate risk. Development design and funding must be considered, as it is strongly linked to adaptation. Well-designed development increases climate resilience with access to infrastructure, basic services, livelihood support, and financial services for vulnerable populations. As climate-related extreme weather events increase, more projects must be intentionally designed with climate resilience as the primary objective, O'Brien says. She believes "investing in adaptation is fundamental for ensuring that you have more resilient infrastructure and to address the increasingly devastating impacts climate change is having."

Recently, the ADB and Indonesian partners signed off on an early retirement plan for the first coal-powered plant under the ETM program. The memorandum of understanding opened discussions to retire Cirebon-1, a 660-megawatt power plant owned by West Java's Cirebon Electric Power. ADB hopes to create a replicable model for others in Indonesia and Asia.

Spotlight on LNG:

Will supply shocks catalyze transition?

Geopolitics has a substantial cumulative effect on the global petrocarbon supply chain, particularly in the natural gas sector. The Russia/Ukraine war has pushed the world to reexamine its energy requirements, even if it has not yet directly resulted in significant acceleration of renewable energy projects. Since the Russian invasion of Ukraine in February 2022, the future of LNG has been in jeopardy. The war, and Europe's reaction to it, has halted pipeline exports of natural gas from Russia to Europe. Previously, Russia supplied Europe with one-third of its gas requirements. Supply disruptions caused LNG spot prices to more than double in most markets during 2022.

Sharp price increases have forced almost all regions to decrease LNG consumption during 2022, especially in the Asia-Pacific. And as the war enters its second year, concerns have increased about a global energy crisis. In 2022, Europe's demand for LNG from anywhere but Russia increased 65%, drawing supply away from the Asia-Pacific, and raising fears that emerging countries will switch to higher emission fossil fuels to plug short-term gaps.

Russia's aggression also affected Argentina, one of the world's most LNG-dependent economies (see Figure 7). Natural gas makes up almost two-thirds of its primary energy mix. Argentina produces its own supply of shale gas from the Vaca Muerta shale formation, but heavily relies on imports, and its LNG import bill rose threefold last year.

Europe turns to fossil fuels

The UK and U.S. formed an energy security and affordability partnership to reduce the UK's (somewhat modest) reliance on Russian imports, increase stability in global energy markets, and increase collaboration on renewable energy projects. Similarly, starting in 2026, Germany will buy two million tons of LNG annually from Qatar for 15 years, which is 3% of Germany's annual energy consumption. Germany is building four emergency floating LNG terminals to increase its energy supply resilience. Germany's role as an LNG transit hub has increased, as LNG imports from Norway replaced cut-off Russian LNG imports.

Overall, Germany and other European countries are forced to increase reliance on fossil fuels, specifically coal. Across the EU, 26 coal plants were brought out of retirement in 2022.[20] During the first six months of 2022, Germany generated 82.6 billion kilowatt hours of electricity from coal, 17% more than in the same period of

X2+

The halt in LNG pipeline imports after the Russian invasion of Ukraine caused LNG spot prices to more than double in 2022.

2021. But the war is sparking an energy supply re-evaluation. Europe is leaning into solar production; the EU estimates solar-powered energy generation will increase between 45 gigawatts and 52 gigawatts annually through 2030.

The shift to renewables in emerging countries is significant. Although Europe's energy markets were expected to bear the brunt of Russia's aggression, the EU avoided an energy crisis thanks to warmer-than-expected winter weather, the ability to recommission older fossil fuel capacity supplies, and speedily reorienting its energy supply chains. In other LNG-dependent countries, such as Pakistan and India, rising prices contributed to electricity outages – and accelerated renewable power generation plans.

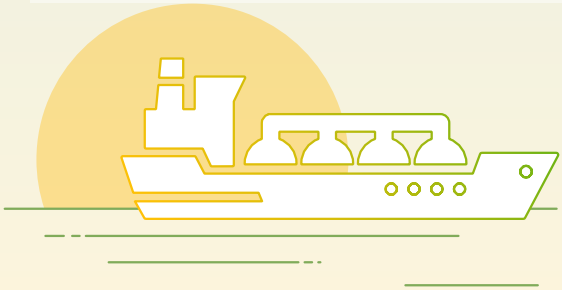
The Indian government in February 2023 announced a $4.3 billion renewable energy investment plan.[21] The intention is to commit $30 billion to add 328 gigawatts of clean power to its grid by 2030,[22] in large part to break dependency on natural gas.

Figure 7: GFI 2023 LNG Supply Shock Stimulus Score

The degree to which each country will accelerate energy transition programs because of its relative exposure to global LNG supply chains.

Top 10 (most likely to accelerate)	
1. Sweden	8.00
2. Brazil	7.77
3. Finland	7.59
4. Iceland	7.50
5. Uruguay	7.45
6. Denmark	6.69
7. Portugal	6.43
8. Italy	6.15
9. Chile	6.13
10. Germany	6.07

Bottom 10 (least likely to accelerate)	
67. Israel	1.66
68. Australia	1.65
69. Malaysia	1.48
70. Nigeria	1.45
71. Kazakhstan	1.40
72. Taiwan	1.31
73. Iran	1.22
74. Algeria	1.03
75. Russia	1.00
76. Qatar	0.83



Source: Compiled by MIT Technology Review Insights with data from the IEA, USEIA, Enerdata, and Worldometer, 2020

Intel

The enormity and complexity of climate change is more than any one company can tackle alone. Organizations face many challenges as they work toward decarbonization—from cost and complexity to lack of reliable data and constantly changing regulations. Over the next two years, 80% of corporate boards anticipate an increase in sustainability investments, and 40% of customers say they will buy sustainable hardware.

In a market teeming with alliances and pledges, real impact demands strategic collaboration and shared innovation. As one of the world's leading semiconductor design and manufacturing companies, Intel is uniquely positioned to drive change and empower the technology ecosystem. Through our center of excellence, our expertise can manage outcomes with our customers and the ecosystem to accelerate sustainable solutions.

Below are recent examples of Intel's collaborations that are bringing speed and scale to combat climate change.

Collaborating for grid modernization

By leveraging our comprehensive technology and unique ability to convene an ecosystem of utilities, governments, and technology, Intel can transform energy grids across the globe and bring reliable, renewable power to all.

In Europe, we're working with eight major electric utilities to develop a flexible, manageable smart grid called the Edge for Smart Secondary Substation (E4S) Alliance. In the U.S., we're working with Southern California Edison to transform electrical substation relays into virtualized applications – decreasing deployment and maintenance costs while providing cybersecurity services for a more flexible, safe, and modern grid. In Malaysia, we are collaborating with Tenaga Nasional Berhad on digitalization of its electric grid, with a focus on virtualized computing infrastructure and applications for the substation and grid system.

Lowering emissions in information and communications technology (ICT)

A founding member of SEMI's Semiconductor Climate Consortium, Intel also helps unite the industry and streamline critical efforts to get the entire semiconductor value chain to net-zero greenhouse gas emissions. Intel also collaborates extensively with supply chain organizations to help set electronics industry standards, develop audit processes, conduct training, address third-party anti-corruption issues, and more. The ICT industry is working to provide meaningful solutions expected to reduce global carbon emissions by 17% by 2030.

Applying ICT learnings

Intel is working to help other industries reduce their own footprints, including through "intelligent efficiency" solutions, such as IoT sensors and neuromorphic computing systems. These technologies power market-ready solutions that help countries and communities prepare for and adapt to climate change, including building management, EV charging, utility substations and microgrids, and data center management innovations, such as immersive cooling and disaggregated architectures. Alongside key data center partners, Intel is contributing to the Open Compute Project (OCP) to advance circularity, establish carbon footprint metrics, and set reduction goals.

Collective investment for a sustainable world

At Intel, we are optimistic because we know we can effect change. We can shape a restorative future by engaging in collaboration globally and empowering our customers and partners through sustainable offerings.

This is why we're working with our customers, competitors, industry, investors, and NGO peers to reduce emissions and help everyone hit sustainability targets. Together we can create the era of sustainable computing and protect our planet.

Christoph Schell
EVP & Chief Commercial Officer,
Intel Corporation

05 Green society and clean innovation

Efforts by government, industry, and society to promote green practices are measured in the Green Future Index 2023's third pillar. As in past years, most green society leaders are European, including top-ranked Ireland and third-place Germany (see Figure 8). Ireland's score reflects its world-leading progress in reforestation (after Denmark and the Czech Republic, also in the green society pillar's top 10). The Irish government is pursuing reforestation to increase its national forest cover to 18% by 2050, from roughly 11% as of March 2023. In October 2022, however, Forestry Industries Ireland predicted the country would again miss its targets by a wide margin.[23]

EU members collectively benefit from its policy resolutions to speed up low-carbon societal and economic activities. These include biodiversity provisions in the European Green Deal, a European Commission target to convert 10% of Europe's agriculture area to high-diversity landscape by 2027. It also includes accelerating transition to low-carbon mobility; in February 2023, the EU Parliament voted to ratify a bill banning new sales of fossil fuel-powered cars by 2035.[24]

Asia's green societies stay strong

Three Asian economies – South Korea, Singapore, and Taiwan – remain among green society leaders for 2023. All have strong government resolve to define sustainability targets and coordinate outcomes with civil society. South Korea's government convened a Carbon Neutrality and Green Growth Commission in May 2021, and in March 2022 passed a Carbon Neutrality Act to make changes in energy, economic, and social behavior. This included a

Ghana's biodiversity opportunity

Ghana was the biggest mover in the Green Future Index 2023 (rising seven places to 65th place), partly because of its improving green society score. Underpinning Ghana's green society goals is a 2016 commitment to reforest 2 million hectares by 2030. According to the International Union for Conservation of Nature, 628,000 hectares have been replanted, the bulk of it on farmland, increasing biodiversity in agricultural spaces.[32]

International cooperation is important: Ghana is implementing low-methane rice production techniques under a November 2020 deal with Switzerland.[33] And while sustainable agriculture and forestry efforts are growing, they are complicated. Ghana's resource-intensive relationship with China pushes back on these efforts, despite China's efforts at cooperation. Ghanian rosewood, an endangered hardwood sought after by Chinese furniture makers, may still be harvested and shipped there in great quantities despite a 2019 ban on exports.[34]

Figure 8: Leaders and laggards in the green society and clean innovation pillar for 2022 and 2023

Pillar 3: Green society

A high score means a better overall performance in the indicators covering green buildings, recycling, forestation, and low meat and dairy consumption.

RANK 2023		2022	COUNTRY	SCORE
1	↑	3	Ireland	7.64
2	↓	1	South Korea	7.37
3	↑	4	Germany	7.14
4	↓	2	Singapore	7.06
5	↑	11	Denmark	6.82
6	↓	5	United States	6.81
7	—	7	Taiwan	6.80
8	↑	9	Czech Republic	6.79
9	↑	12	Sweden	6.76
10	↓	6	Iceland	6.74

RANK 2023		2022	COUNTRY	SCORE
67	↓	65	Ethiopia	4.35
68	↑	71	Algeria	4.28
69	↓	50	Cameroon	4.21
70	↑	75	Kazakhstan	4.21
71	↑	73	Nigeria	4.08
72	↑	74	Pakistan	4.08
73	↓	63	Uganda	3.84
74	↓	72	Zambia	3.76
75	↓	64	Iran	3.55
76	↓	69	Angola	3.54

Pillar 4: Clean innovation

A high score in this pillar means a higher relative number of green patents, investment in cross-border clean energy initiatives, and investment in food tech.

RANK 2023		2022	COUNTRY	SCORE
1	—	1	Finland	7.73
2	—	2	Iceland	7.44
3	↑	5	Netherlands	7.32
4	—	4	Singapore	7.32
5	↓	3	Sweden	7.28
6	—	6	Norway	6.97
7	↑	8	South Korea	6.88
8	↓	7	France	6.83
9	—	9	Belgium	6.68
10	↑	19	China	6.58

RANK 2023		2022	COUNTRY	SCORE
67	↓	62	Philippines	4.58
68	↓	64	Hungary	4.27
69	↓	67	Romania	4.20
70	↓	66	Czech Republic	4.20
71	—	71	Guatemala	4.17
72	↓	68	Australia	4.08
73	↓	69	Saudi Arabia	3.99
74	↓	72	Iran	2.89
75	—	75	Malaysia	2.65
76	—	76	Algeria	1.65

Source: MIT Technology Review Insights, 2023

$1.9 billion climate fund to support its 2050 net-zero target. For Singapore, increased financial market participation, particularly on strengthening ESG reporting, is an important green goal: beginning in 2023, financial, agriculture, food, and energy companies listed on the Singapore Stock Exchange need to make climate-related disclosures.

The majority of lower green society scores belong to emerging African nations. Angola, Zambia, and Uganda all rank poorly, due to inability to fund low-carbon transportation or agriculture initiatives or curtail deforestation. However, some multilateral institutions are beginning to work environmental actions into broader aid packages: in January 2023, the World Wide Fund for Nature (WWF) proposed a debt-for-nature swap proposal to Zambia, which replaces up to $1 billion in existing debt with cheaper financing in exchange for environmental protection guarantees.[25]

Tech drives carbon reduction

Technology investment by public institutions and commercial enterprises has helped to lower carbon intensity. Smart buildings, green buildings, and energy management systems along supply chains are appearing in emerging economies keen to merge construction development and sustainability goals. There is increased promotion of LEED certification, the most common green building rating system.

In 2022, China and India had the world's first and second-largest number of LEED-certified projects globally, encompassing 16 million square meters and 10.4 million square meters of built space.[26] Other emerging markets embracing LEED include Brazil, Mexico, and the Philippines. Shanghai and other Chinese cities have linked smart sustainable development to their post-covid economic recovery plans; multinationals announcing new green project plans in Shanghai include Honeywell and Maersk. India's Income Tax Act allows for 100% depreciation on investment in solar panels, waste management, and other sustainable assets, and the Indian Renewable Energy Development Agency (IREDA) provides low-interest loans for green-certified buildings.

Confronting the failure of recycling

The global conversation about the efficacy of plastic and other waste recycling continues as sustainability advocates bemoan poor progress. The technical challenge of repurposing plastics is an obstacle, as is

380M

The world produces about 380 million tons of plastic annually, 50% from single-use items.

industrial capacity needed to address the problem. Japan's Yano Research Institute recently estimated the volume of plastics recycled in the EU, the U.S., and Japan at more than 16 million tons in 2022, projecting it will rise to more than 21 million tons by 2030.[27] This growth is driven by advances in chemical decomposition processes to return plastics to component chemicals, instead of repurposing plastic waste into new materials. This is a tiny amount compared to the estimated 380 million tons of plastic the world produces annually,[28] half from single-use items.

Biotrade could boost emerging economies

Emerging technologies are being developed to help scale plastics reuse efforts. Anellotech, a U.S.-based company, developed its Plas-TCat process technology to turn mixed waste plastics into primary chemicals that make plastic packaging for feedstocks. Plas-TCat is developed with input from R Plus Japan, a consortium of 30 Japanese firms from across Japan's chemical and packaged goods sectors.[29] Anellotech is developing a similar process to convert mixed waste textiles directly into chemical feedstocks to produce polyester and nylon.[30]

Nature-based solutions are becoming more important to green society efforts, notably forestation, achieved

through naturally regenerated primary growth areas and protected biodiversity areas. Global trade is seen as important to these efforts; for nearly two decades, the UN Commission on Trade and Development (UNCTAD) has worked with governments to promote its Biotrade principles and criteria, guidelines that support sustainable trade in biodiversity-derived products. UNCTAD estimates global Biotrade was valued at nearly $3.7 trillion in 2021 and grew annually at 29% over the preceding decade.

UNCTAD trade data shows sectors such as medicine, pharmaceuticals, and personal care ingredients have seen Biotrade revenue grow at faster rates than traditional trade in animals and plants for food, construction, and furnishing. Pharmaceuticals grew by 70% during this time. By contrast, global trade in biofuels shrank by one-third during the last decade. This indicates sustainable, high-value natural products can contribute income for emerging countries, and may grow in importance for their economic development.

Back to nature

The importance of preserving natural areas needs to be understood in relation to reducing carbon emissions and improving environmental conditions. “After fossil fuel burning, the major source of emissions in the emerging world is deforestation,” says Manuel Pulgar-Vidal, global leader of Climate and Energy at WWF. It is challenging for national environmental ministries to implement effective policy to reduce emissions, he says, compared to energy transition projects where there is investment and clear decarbonization targets. “Clear carbon pricing policies and flexible financing are essential for making emerging economies more strongly dependent on international climate cooperation using nature-based solutions," he says.

However, these are preconditions, says Pulgar-Vidal. Once solid international pricing mechanisms are established, “multilateral discussions must overcome a credibility gap” in emerging markets for carbon-accounting agreements, he says. That’s due to differences between how various

Clean tech financing expands in Asia

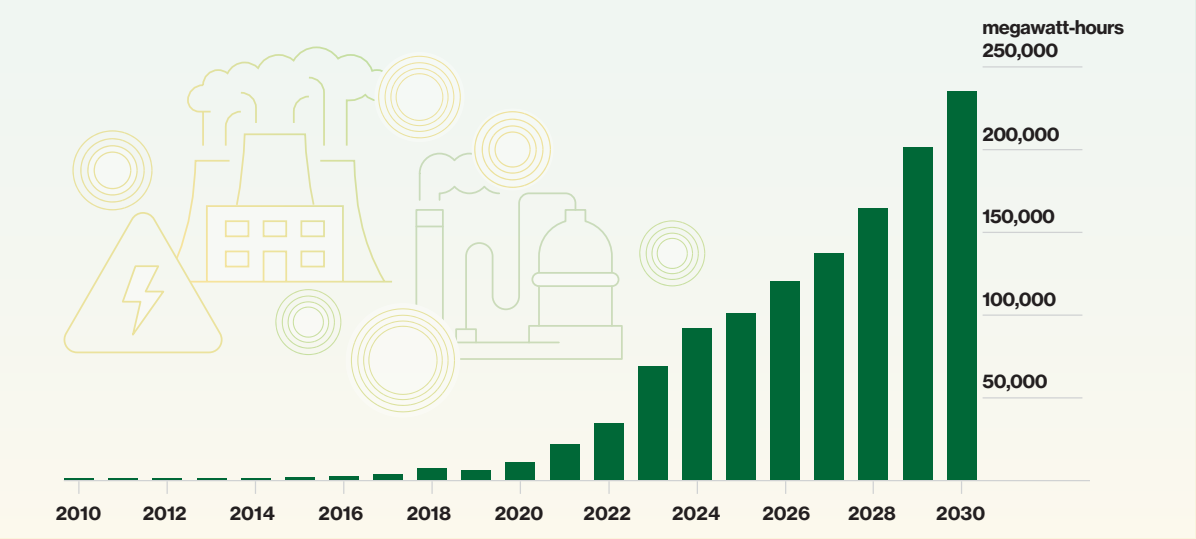
Venture capital (VC) in clean tech is rapidly expanding across Asia; DealStreetAsia estimates more than $1 billion went to green technology ventures in Southeast Asia in 2022. There are numerous clusters emerging for new technology, including food tech in Singapore and hydrogen technology in Australia, South Korea, and Japan.

Part of the growing interest in sustainable technologies is driven by carbon-friendly policy commitments, which have helped many sectors – renewable energy in particular – become mature businesses quickly. “Investment dollars follow the policy support,” according to Toby Chan, a partner in Hong Kong – based Audacy Ventures, a climate technology investment firm. “As wind, solar, and other renewables roll out in volume, there is less. Now investors realize that this is an established asset class: no longer for just for sustainability’s sake, but something they can make real money on.”

The success of renewable energy for electricity generation, Chan believes, spurred interest from Asian VC in related sectors. “Now investment needs to help build out the infrastructure ecosystem, such as in energy storage and smart grid technologies, both of which are critical as more intermittent energy comes online,” Chan says (see Figure 9). Audacy has a stake in Ampd Energy, a Hong Kong – based developer of repurposed EV batteries deployed designed to replace diesel fuel for off-grid clean energy for construction sites. Chan says alternative fuels for new mobility in the marine and aviation sector is also heating up in Asia – one example is H3 Dynamics, a Singapore-based developer of zero-emission hydrogen-electric propulsion systems for the aviation sector. Another example, Chan says, is JetZero Australia, which produces sustainable aviation fuel from sugarcane waste.

Figure 9: Energy storage capacity

Energy storage capacity means energy can be saved for future use, allowing for a more reliable and flexible energy system.



Source: Compiled by MIT Technology Review Insights based on data from BloombergNEF, 2023

governments and institutions value the carbon sequestration impact for nature-based projects. "Nature-based standards should evolve from a voluntary basis to a regulatory basis," Pulgar-Vidal says.

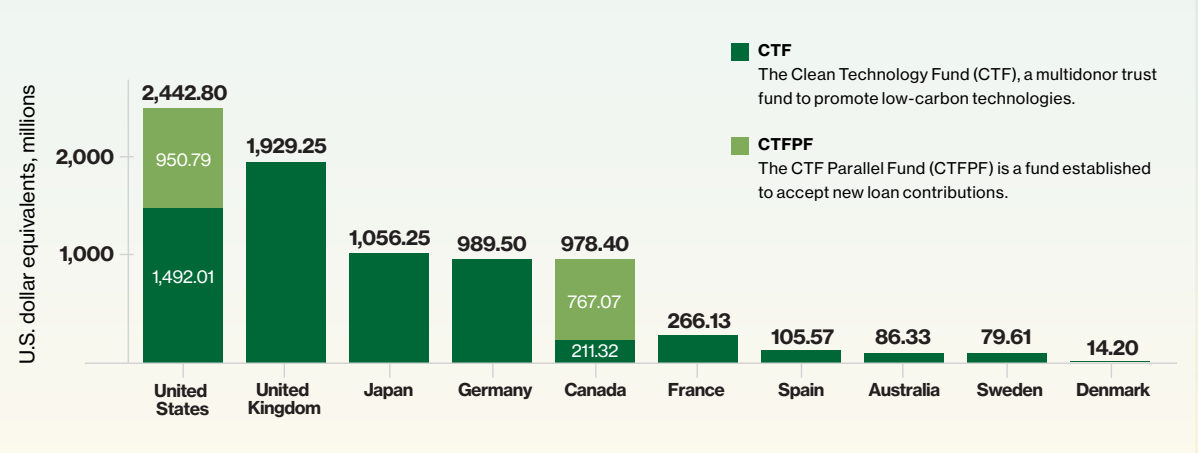
Although this is a work in progress, it will help create nature-based solutions that integrate with the issuing nation's overall economic development. "At a certain level of emissions, it is clear that any intervention to manage forests and basic ecosystems could be just as useful to fulfill NDCs as would energy transition," Pulgar-Vidal says. Bolivia, for example, could use nature-based solutions and "they could account for 100% of their emissions." However, deforestation for mining or cattle ranching in Bolivia are also primary drivers for economic growth. "If you simply promote biodiversity without a greater sense of the economy and the culture of a country, it really will not make any sense. You cannot focus just on addressing the climate challenge, you also have to focus on the idea of the overall market conditions and on social considerations" to make such arrangements profitable and sustainable, he says.

Forestry management in China finds new footing

China is trying to make these changes on a global scale in the forestry industry, increasing efforts to manage forest resources in sustainable ways, and to work with nations from which it imports forestry products. This began with changes during the last two decades. "China introduced the Natural Forest Protection Program [NFPP] in 2000 and the natural forest commercial logging ban in 2017. The logging ban was necessary to restore and regenerate the forest after overharvesting, but might not be a long-term solution," says Sun Xiufang, a China-based policy analyst at the forestry NGO Forest Trends. China is keen to increase the productivity of its timber industries, and Sun estimates the country's current stock volume per hectare

> "Clear carbon pricing policies and flexible financing are essential for making emerging economies more strongly dependent on international climate cooperation using nature-based solutions."
>
> **Manuel Pulgar-Vidal**
> Global Leader of Climate and Energy, World Wide Fund for Nature

Figure 10: World Bank Clean Technology Fund commitments, 2022



Source: Compiled by MIT Technology Review Insights based on data from the World Bank Clean Technology Fund, 2023

is around 87 cubic meters vs. a global average of 137 cubic meters. "There is still room for improvement," she adds, pointing out that better logging practices and use of alternative building materials in construction will also reduce China's emissions.

Internationally, China has been taking its role as a net importer of lumber seriously, Sun says, working with countries to increase sustainable forest management practices. She estimates China's timber consumption has been primarily sourced from imports since 2014, and imports now make up over half of the total timber supply. In July 2020, China amended its Forestry Law to increase sustainable practices at home. A new amendment, Article 65,[31] banned buying or processing illegally sourced timber, "and while this article does not specify imports, it is firmly implied, and serves as the basis for China's international forestry efforts," she says. Most of China's imports are from African nations, and Sun notes there are efforts to promote sustainable forest management practices with many trading partners.

Clean innovation: Catalyzing green, global solutions

European nations are the clean innovation pillar leaders, primarily driven by efforts to invest in technology-enabled sustainability solutions and to expand clean energy grids. In September 2022, top-ranked Finland approved a legislative package that includes technical requirements for construction of low-carbon buildings to improve the built environment, which account for about one-third of the country's GHG emissions. The Netherlands, ranked third for 2023, announced a target of 70 gigawatts of offshore wind energy production by 2050.

South Korea, the only Asian leader in the clean innovation pillar, continues to lead the world in cleantech patents. It also leads in cross-border clean energy and sustainable technology development.

South Korea continues to lead the world in clean tech patents (proportionate to the size of its economy). South Korea is also a leader in cross-border clean energy and sustainable technology development; in February 2023 the Korean Agency for Infrastructure Technology Advancement signed a new agreement with the city of Masdar in the United Arab Emirates to develop smart city and hydrogen energy solutions.[35]

Many laggards in clean innovation are economies associated with high technology: Taiwan, Malaysia, Israel, and Iran all rank poorly in this pillar. The showing of several Asian economies is also out of step with the region's growing clean tech venture capital market.
Some laggards have developed significant clusters of

sustainable technology start-ups. Israel remains the world's food tech hub; $1.1 billion in venture capital was invested in the sector in 2021 and 2022.[36] More than 500 companies are developing alternative protein, advanced growing techniques, and other sustainable food innovations, giving the country a higher food tech startup density than any other country. However, Israel's overall clean tech patent registrations are low, and it fares poorly as an investor or a recipient of cross-border investments in renewable energy capacity. Its low score in this pillar, as a more tech-savvy country, reflects its isolationist posture.

Green innovators strive to integrate domestic innovation sectors globally, which fund efforts to develop clean technologies multilaterally. A growing pool of international finance is available for these efforts; the World Bank introduced a Clean Technology Fund and a Strategic Climate Fund in 2022, and has secured more than $7.9 billion in commitments from member nations,[37] nearly half from the U.S. and the UK (see Figure 10).

Appetite for food tech wanes

Reimagining meat and dairy production and consumption continues to be a thorny issue for most societies. The number of food technology startups is rising, and alternative meat producers have been attractive to investors. Sales of plant-based meat substitutes fell 14% in the U.S. (the primary market) in 2022,[38] and startups like Beyond Meat have seen valuations tumble. However, the UN estimates global meat demand will grow by 15% by 2031.[39]

A likely reason for the drop-off is globally high inflation; in a 2022 report, the Good Food Institute estimates the average price of plant-based meat was 43% higher than animal-based products. Entrenched societal dietary habits are a more significant factor, and despite the growing income gaps in the world, poorer societies are as a whole becoming wealthier, and tend to take on eating habits of richer countries. Sustainable animal protein development is emerging as a complementary solution to reducing carbon-intensive food production. For example, Urchinomics is a Netherlands-based startup producing high-value seafood in restored kelp forests in rural coastal communities globally. It has also begun to issue carbon credits.

Urchinomics: High-priced sustainability at the high end of the market

A Netherlands-based startup, Urchinomics, is turning sea urchin barrens — marine deserts caused by sea urchin overpopulation — back into kelp forests with the capacity to sequester carbon. "We are producing a new supply of sea urchins, and we're using this as the economic driver to generate marine ecosystem restoration," says Brian Tsuyoshi Takeda, CEO and founder of Urchinomics. In January 2023, the company began commercial production at a 35-ton ranch site in Nagato, Japan, in collaboration with seafood processor Maruyama Suisan.

Takeda says producing a premium-priced protein allows the company to quickly develop a restorative business (in both climate and revenue). "When you go into sushi restaurants, the two most expensive items are blue tuna and sea urchins. The first is an increasingly endangered fish, and is highly trophic, representing the transfer of food and energy from one organism to another organism, typically predators, and uses a lot of energy," he says.[40] "The other is abundant, low trophic, and its consumption contributes to the restoration of the environment." Producing a larger volume of an expensive seafood, he reasons, "creates an economic transfer from high-end consumers to local fishing communities and the project funds the ecosystem restoration work." Urchinomics secured the world's first voluntary carbon credits for kelp restoration, under standards set by the Japanese government's Japan Blue Economy Association.

Iris Ceramica Group

Ceramics are our history, our present, and our future. For more than 60 years, we have been ambassadors of a culture that considers this material as one of the most noble and high performing in nature: able to evolve, define spaces, resist the passage of time. Constantly committed to technological research for re-engineering ceramics, we aim to deliver pioneering solutions that improve the interaction between humans and the environment. Our high-end materials demonstrate how ceramics can play an active role in creating a sustainable attitude and culture inside businesses.

Our values are rooted in our respect for the environment and its resources, and today the equation "Economy=Ecology," coined by my father Romano Minozzi, chairman and founder of Iris Ceramica Group, translates into the concept of "Ecopreneurs." We are "ecological entrepreneurs," because we believe that growth can only be real when it proceeds in harmony with the environment and with people: only a sustainable economic system can guarantee the balance between social and environmental well-being.

In compliance with environmental, social, and governance (ESG) criteria, for years we have been applying solutions targeting energy savings, adopting the best practices in the field of air and water emissions and using renewable energy sources. We concretely help to promote a low-carbon future also through significant investments in totally unique technologies and systems. This is also demonstrated by the project for the world's first green hydrogen–powered ceramics factory: the H2 Factory. We are using this project to set a new manufacturing standard for the ceramics industry, actively contributing to the 2050 carbon neutrality goal. We believe that, to live in a truly sustainable way, bold actions and investments are needed for us to improve.

With our continuous R&D activities and our sustainable soul, represented by the concept Shaping the Future, we work with a view to building a better today and tomorrow. And this has also led to our 4D Ceramics – pioneering, full-body natural ceramics – which, impressed into the very matter, embody our values and namely, sustainability, innovation, excellence in quality, on which our three pillars are based: we stand for Planet, People, Participation.

We work in a climate of dialogue and cooperation with all the players in the supply chain, with our stakeholders, our customers, and especially our staff, whose safety, enhancement, and well-being are our priority. We believe that culture is the driver of every transformation, and that before any ecological or energy transition, there has to be a cultural transition, and one of strategic thought. Our profound sense of responsibility towards the community, environmental resources, and people guides our actions towards the promotion of culture and sustainability values.

This is why we set up the Iris Ceramica Group Foundation: through participation in and support of cultural, social, and environmental initiatives, it works concretely to create value for the community, protecting fragile categories and fostering inclusion, solidarity, and equality. Underlying this is the thought and desire to create a way of doing business where ethics, growth, and technology are all part of the same project.

Federica Minozzi
CEO
Iris Ceramica Group

06 Climate policy

Decarbonization financing initiatives, sustainable agriculture policy, and the continued use of post-pandemic recovery spending continues to drive green economic recovery. Climate policy, the fifth pillar of the Green Future Index, is its most heavily weighted, reflecting the importance clear policy directions and public funding have in catalyzing low-carbon action in business and society.

Policy is proving increasingly effective in promoting sustainability in emerging and advanced economies.

The political will and coordination of the EU is creating a virtuous cycle that drives climate action. Eight out of the top 10 nations in the climate policy pillar are EU states, led by Denmark, which has one of the most aggressive decarbonization policy positions in the world. In June 2022, the Danish government pledged to raise carbon taxes for businesses operating in Denmark, and those operating outside EU will see carbon taxes raised from €24 (US$ 29) per ton carbon dioxide (tCO2) to €100 (US$ 121) by 2030 – one of the highest rates in the world (see Figure 11).

Stemming carbon leakage across borders in the EU

In December 2022, the Council of the EU provisionally adopted its carbon border adjustment mechanisms (CBAMs) regulation. CBAMs are a mechanism to encourage countries to establish carbon pricing policies – and to keep carbon-producing industries from using borders to escape their decarbonization commitments.

According to the Clarity and Leadership for Environmental Awareness and Research (CLEAR) Center at the University of California, Davis, "carbon leakage is a situation where a company decides to move their production from a country with stringent policies, to a country that is more lenient, leading to an increase in GHG emissions."[41] Combatting carbon leakage with CBAMs also combats unfair competition.[42]

CBAMs target specific sectors that produce and import carbon-intensive products such as cement, aluminum, fertilizers, electric energy production, iron, and steel. The regulation is designed to work in harmony with existing EU trade and decarbonization rules.

The Council expects to establish a minimum threshold to exempt small transactions from CBAM regulations, such as those with a value of less than €150 (US$ 182). This exception, which would excuse a "negligible" portion of GHG emissions in the EU, is meant to reduce complexity.[43]

Figure 11: Leaders and laggards in climate policy pillar for 2022 and 2023

Pillar 5: Climate policy

A high score means a stronger relative performance in the climate policy, carbon pricing, suitable agriculture, and pandemic pivot indicators.

RANK 2022		2021	COUNTRY	SCORE
1	↑	2	Denmark	7.17
2	↑	4	United Kingdom	6.99
3	↑	22	Finland	6.88
4	↓	2	Spain	6.76
5	—	5	Netherlands	6.74
6	↑	9	Canada	6.59
7	↑	11	Norway	6.54
8	↑	14	France	6.50
9	↑	11	Italy	6.19
10	↓	7	Poland	6.18

RANK 2022		2021	COUNTRY	SCORE
67	↓	59	Guatemala	2.29
68	↓	53	Russia	2.27
69	↓	62	Turkey	2.08
70	↑	72	Bangladesh	2.01
71	—	71	Qatar	1.99
72	↓	69	Zambia	1.98
73	↓	65	Cameroon	1.98
74	↑	75	Angola	1.85
75	↓	74	Paraguay	1.65
76	↓	73	Iran	1.20

Source: MIT Technology Review Insights, 2023

All policy is local

Sandra Uwera Murasa, global CEO of NGO Fairtrade International, says climate regulations do not adequately address small producers. Fairtrade International focuses on empowering small farmers and traders, creating climate-resilient agriculture and sustainable livelihoods at the grassroots level worldwide. It works with 1.95 million producers.

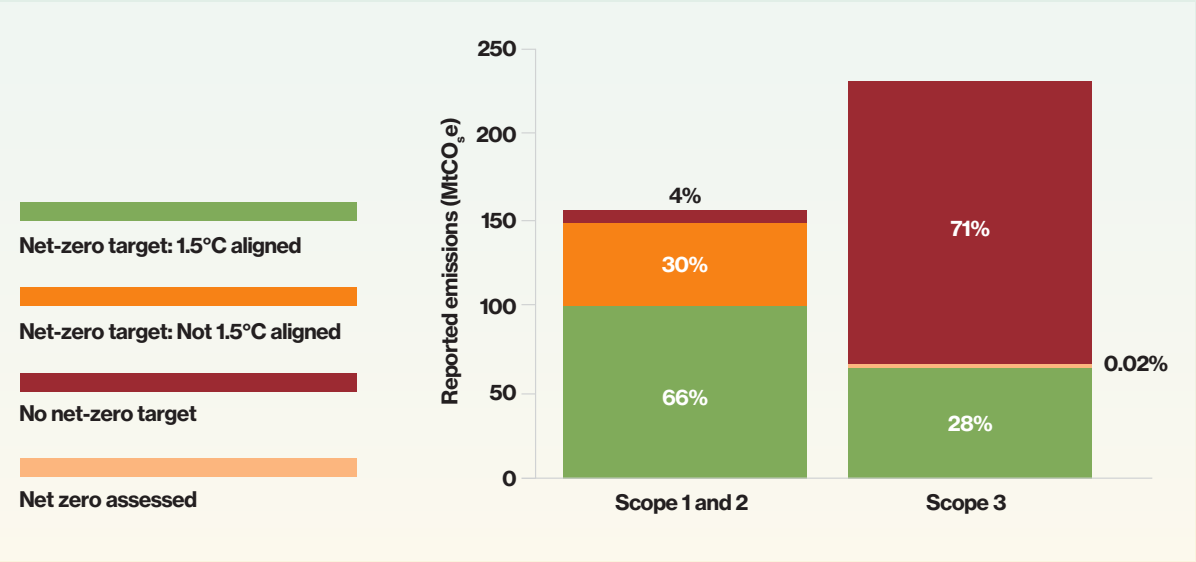
Murasa says because small stakeholders aren't at the table with policymakers at engagements such as the World Economic Forum, penalties designed to push sustainability don't connect as expected. "The biggest challenge is that the cost of implementation for a lot of these rules, requirements, and regulations are transferred at the supply chain level to small producers and traders," Murasa says.

"We want stakeholders to come together and create financial support mechanisms to help these farmers to comply with the due diligence requirements," Murasa says. "These are not just one-size-fits-all mechanisms."

Policymakers and governments must set aside support, regionally and internationally, to build resilience for farmers facing climate change–related challenges such as flooding, she says.

One key to this is technology. Digitalization of agriculture can seem expensive to small farmers, she says, but its regional benefits make it economical. Technology and climate data can be used to make better decisions about basic practices like crop choices, and can help forecast and plan for climate events. This improves crop yield and quality, she says.

Figure 12: Australia's ASX200 listed firms, total net-zero carbon commitments



Source: Compiled by MIT Technology Review Insights with data from the Monash University ClimateWorks Centre Net Zero Momentum Tracker, 2023

The pressure for global standards

Europe's commitment to developing carbon border adjustment mechanisms (CBAMs) is seen as an important step to set international standards for valuing greenhouse gas (GHG) emissions. These efforts can also be counter-productive for fighting climate change on a global scale, says Jean-Marie Paugam, deputy director general of the World Trade Organization (WTO). "Unilateral policymaking may not necessarily be protectionist, but mechanisms such as CBAMs or the Inflation Reduction Act, while they are legitimate efforts to combat climate, are not coordinated at a multilateral level," he says. "Fragmenting global trade, ultimately, will not be helpful for reducing emissions."

Paugam believes there is a role for transnational dialogue to create global standards for specific, high-emissions industries. Pointing to the steel industry, which the WTO estimates creates 8% of global emissions, he says: "The steel sector alone has 20 different decarbonization standards globally. We need to find the locus where all these standards converge. Developing this from a global trade perspective, rather than a region-by-region customs perspective, will yield a more effective discussion to achieve, if not global harmonization on carbon prices, at least convergence." In March 2023, the WTO will convene an event with its stakeholders to discuss formulating global steel decarbonization standards, such as a multilateral implementation of low-emission technologies and sharing of emissions data.[44] Paugam believes if such efforts are successful, similar dialogues could begin on other high-emissions sectors, such as agriculture.

The only non-European within the top 10 of the policy pillar is Canada, at sixth place. Canada's 2030 Emissions Reduction Plan includes $6 billion in clean tech investments, energy transition subsidies, and $1.6 billion in funding for pollution reduction and job creation programs in indigenous communities.[45] Canada faces pressure from an economy heavily dependent on fossil fuels and mining resources. In 2022, it increased oil production by about 25% and gas production by about 7%.[46]

Australia is increasing its policy commitments to reduce its extractive-resource dependency. In January 2022, climate change minister Chris Bowen revised the government's emissions policies, requiring 215 of Australia's largest industrial facilities to reduce emissions levels by about 5% annually until 2030. Although this is a small number of the country's companies, the government's growing focus on reducing carbon is having a wider impact on the business environment. Monash

University's Climateworks Centre found that in December 2022, more than half of companies in the Australian Stock Exchange's ASX200 index, which collectively account for one-third of Australia's operational emissions, have committed to net-zero targets within the next two decades (see Figure 12).

Spending for new initiatives is rising

Tax and spending directed at new energy initiatives or other green stimulus initiatives for low-carbon key public infrastructure projects is growing substantially. The U.S. IRA policy is the cornerstone: while the largest climate policy package to date is less than a year old, its scale has reoriented public spending and pushed up the U.S. in the climate policy pillar (from 18th place to 14th) and its overall Green Future Index rankings (from 21st to 19th).

Other green policy innovation is occurring in waste management. Slow progress in recycling means many societies have turned to regulations aimed at lowering plastic production and consumption through bans, taxes, or extended producer responsibility requirements. In some cases, emerging markets are leaders in antiwaste regulations: Bangladesh was the first nation to implement a plastic bag ban, more than two decades ago,[47] and the UN Environment Assembly noted that 34 of Africa's 54 nations have a plastic bag ban in place.[48]

European countries are crafting legislation directed toward waste production located higher up in the value chain. The UK levied a plastic packaging tax on use of virgin plastics in April 2022. In the same year, Germany passed legislation that will require single-use plastic manufacturers to pay into a central waste management fund, beginning in 2025.

Elsewhere, leading nations in the climate policy pillar are exploring highly targeted subsidy programs to increase sustainable development. In the UK (ranked second in the pillar), the government is issuing grants from £500,000 (US$ 605,785) to £1.5 million (US$ 1.8 million) from a £12.5 million (US$ 15 million) fund for sustainable agriculture and horticulture projects. Emerging countries that do not have economic or policy capacity to address climate change comprehensively can often access multilateral funds and technical support.

Morocco is 36th place on the climate pillar (and 37th overall). However, the Moroccan government has worked with global trading partners to develop clean energy transition programs and domestic clean tech manufacturing capacity, particularly in wind energy. Its receptiveness to international cooperation has yielded close to $300 million in climate fund disbursements since 2003, according to climate NGO Heinrich Böll Stiftung,[49] making it the second-largest climate financing destination in the Middle East and North Africa region, after Egypt.

High Seas Treaty agreement will protect 30% of oceans by 2030

After nearly two decades, the United Nations finalized its High Seas Treaty to preserve natural marine environments in March 2023. The treaty protects the two-thirds of the ocean outside national boundaries. This legislation was slowed by disagreements on funding and fishing rights.[50]

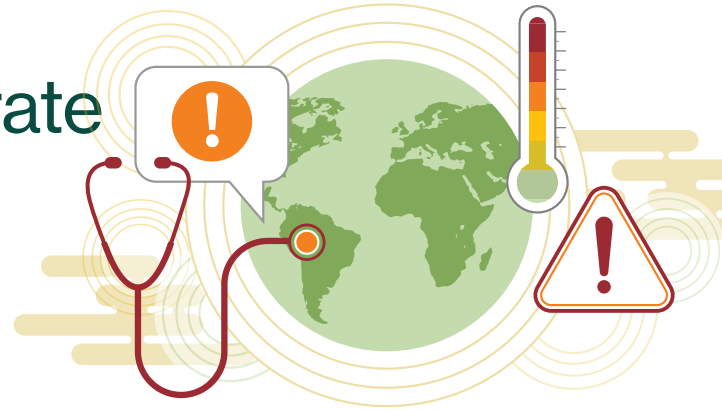
The treaty will limit fishing, control marine traffic in shipping lanes, and regulate marine exploration and mining from seabed deeper than 200 meters. It will also oversee how nations share marine genetic resources: ocean plants and animals used for food, medicines, and other processes. The extent of protection was hotly debated, and some details remain unresolved.[51]

The new proposal applies to the high seas, where all countries have rights to research, fish, and run shipping. Only 1.2% of these waters are currently protected. Marine life there is exposed to the effects of climate change, pollution from ocean traffic, and overfishing. The International Union for Conservation of Nature (IUCN) estimated in its most recent assessment that 10% of marine species are at risk of extinction.[52]

The UN will refine the agreement before it is implemented, and individual countries must then ratify it before it takes effect.

07

Conclusion: Desperate for decarbonization



Each year, the climate science community measures and records vast amounts of data on the impact of carbon emissions and GHGs on planetary health. This data reveals momentous new thresholds with depressing regularity. In May 2022, CO2 levels measured by the U.S. NOAA at its Atmospheric Baseline Observatory in Mauna Loa in Hawaii surpassed 420 parts per million (see Figure 13).[53] This is the highest level of atmospheric carbon humans have ever experienced, and is a stark indication that humanity is not winning the war on climate change.

Tim Flannery, professor at the University of Melbourne, prefers to draw a different set of conclusions. "To understand what 420 parts per million of CO2 really means, you have to go back to the last time in Earth's history when that much was in the atmosphere: the Pliocene period," he says, referring to the period about 2.6 million to 5.3 million years ago. Flannery, a paleontologist, has excavated and studied several Pliocene sites in Australia to determine that the continent's entire east coast was once rainforest, "and a hell of a lot wetter and cooler than it is today."

Flannery says the past several years have seen unprecedented rainfall and massive growth of vegetation, "which means that everyone's carbon offsets are going fantastically," indicating Australia may be returning to a Pliocene state. At the same time, severe droughts and fires, which routinely plague the continent, suggest the opposite. He adds: "Australia may end up wetter and cooler 10,000 years from now, or it could be next year. We know the long-term biodiversity and climate outcomes, but we're struggling to understand the short to medium term."

A clean, healthy, sustainable environment is a human right

The UN General Assembly (UNGA) passed a nonbinding resolution in July 2022 to recognize a clean, healthy, and sustainable environment as a human right. The vote was 161 member nations in favor, and zero against, but eight states – Belarus, Cambodia, China, Ethiopia, Iran, Kyrgyzstan, the Russian Federation, and Syria – abstained.

UN Secretary-General António Guterres expects the resolution to spur more action to confront environmental injustice, close gaps in environmental protection, and empower the vulnerable, such as environmental rights workers, children, youth, women, and indigenous peoples.[54]

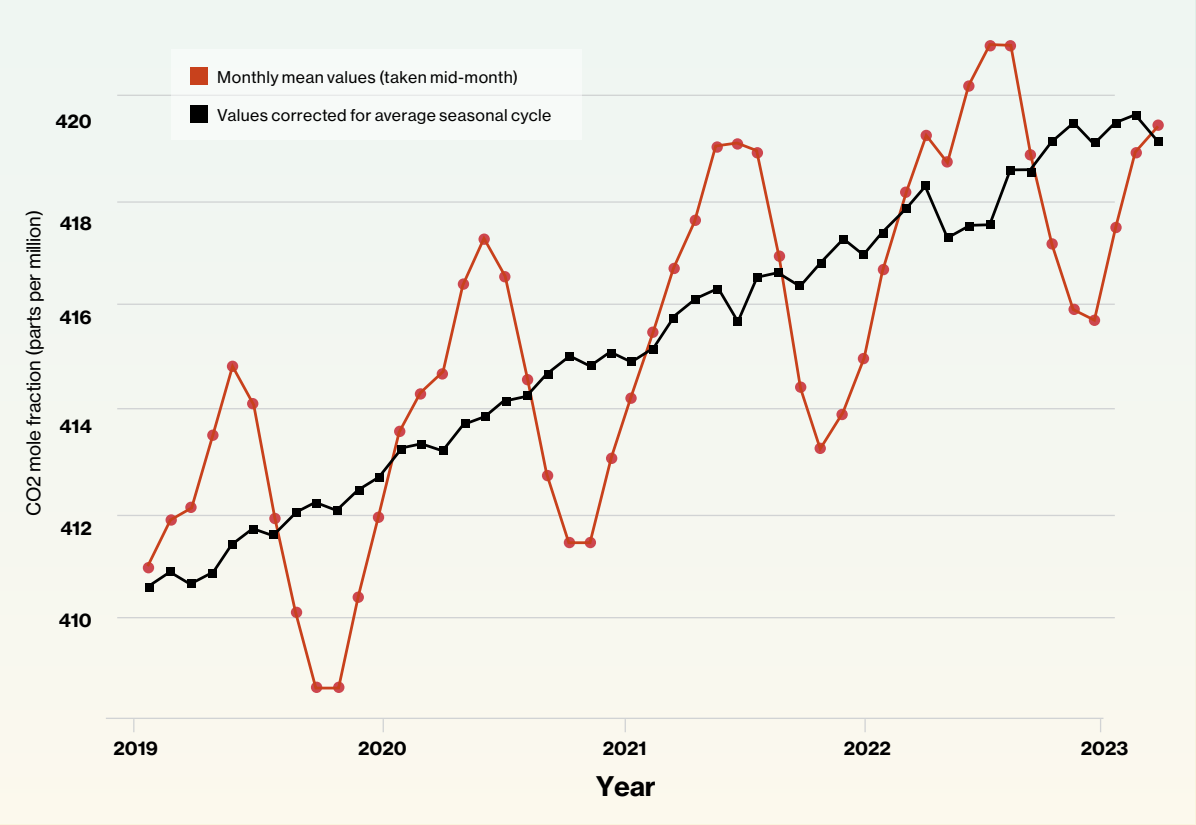
The world's responses to survive climate change, and adapt to its eventual outcomes, are similarly dynamic. Governments and societies must continue to decarbonize as fast as possible. They must also continue to experiment with a vast array of technologies, business practices, and

societal approaches. As the Green Future Index 2023 illustrates, the world's ability and resources to do so are not equally distributed. Green Leaders are wealthy and endowed with renewable energy resources, which create systemic advantages in creating and maintaining sustainable, low-carbon economies. In contrast, poorer (and often fossil fuel – dependent) countries are often caught in a permanent state of catch-up, forced to expend scarce resources to support growth.

This is where environmental action on a global scale becomes critical. COP27's loss-and-damage fund was a significant gesture, and one that will hopefully catalyze real change. Green Leaders, and most within the Greening Middle, are motivated to assist those farther down the rankings – and not only for reasons of altruism. Government policy mandates energy transition and carbon-reduction investments. Businesses in a globalized world of commerce are guided by carbon accountability with each passing quarter, either through ESG reporting requirements or demands from climate-aware customers and stakeholders.

Carbon neutrality will soon be as important a metric as profitability. And this is driving firms to invest in the tools and practices to lower their Scope 1, 2, and 3 emissions. It is also motivating governments and firms globally to invest in biodiversity, energy transition, and carbon removal projects in poorer countries to build up global stocks of carbon credits. Green Leaders will increasingly share expertise and invest capital in sustainable projects, cross-border renewable energy development programs, and food tech investments, because doing so is both economically viable and equitable for all.

Figure 13: Monthly mean CO2 readings at Mauna Loa Observatory, 2019 – present



Source: Compiled by MIT Technology Review Insights based on data from Scripps Institution of Oceanography at the University of California, San Diego, 2023

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