The Sustainability Trends Report 2022

generation

September 20 2022

Contents

> “If we could first know *where* we are, and *whither* we are tending, we could then better judge *what* to do, and *how* to do it.”

Abraham Lincoln, June 16 1858

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Introduction

Dear Reader,

Generation Investment Management is pleased to present the sixth edition of our Sustainability Trends Report. This series of annual reports surveys the broad landscape of what we often call the "sustainability revolution". We believe this transition is still in its earliest stages, and that accelerating it is essential to human welfare and to the preservation of the natural world. Each year, we take stock: where does the transition stand now, and where must it go next?

With this year's edition of the report, we introduce a significant reorganisation. Our emphasis is on a deeper analysis of the core drivers of change. To focus more directly on greenhouse-gas emissions — the world's most acute and urgent environmental problem — we have restructured the categories in the document to match the economic sectors by which greenhouse gases are normally reported. In addition, starting this year, we intend to lead off with an essay that captures an of-the-moment set of issues regarding sustainability. For 2022, the essay section focuses on the many ways the war in Ukraine has altered the energy discussion in Europe, raising the possibility that the European Union could lead the world in a faster transition to clean energy.

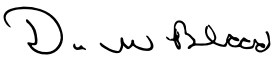
We are encouraged by the climate legislation adopted by the U.S. Congress this year, and believe it will lead to a historic acceleration of the sustainability revolution. It will strengthen the leadership role of the United States in the global effort to solve the climate crisis. We also welcome the dramatic shift in Australia's climate policy, with a new commitment to cutting emissions.

We solicit your comments on this report, and your suggestions on how to improve it in future years. Comments can be emailed to str@generationim.com.

On behalf of the partners and employees of Generation Investment Management and Just Climate,

Al Gore, Chairman

David Blood, Senior Partner



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Key Messages

01 Year in Focus

Two major developments this year have raised the chances of a rapid acceleration in the transition to clean energy. The Ukraine war has thrown the risks of European dependence on Russian fuels into sharp relief, prompting the European Union to raise its goals for renewable energy. Additionally, a new law in the United States could potentially cut emissions to as much as 40 percent below 2005 levels.

CHAPTER 1 ›

02 Power

The first task of the energy transition is to clean up the power grid, so that it can become the backbone for electrified transport and other energy services formerly supplied by fossil fuels. At a global scale, this clean-up has yet to begin. But the rate of emissions growth is trending sharply downward, and we may be only a few years from a global peak in electricity emissions.

CHAPTER 2 ›

03 Transportation

Sales of electric and hybrid cars are approaching 10 percent of all vehicle sales globally, and far exceed that in some countries. There is no longer much doubt that we can and will pull off the electrification of the world's automotive fleet, though the transition is being slowed by shortages of critical minerals like lithium.

CHAPTER 3 ›

04 Buildings

Governments have yet to find the right mix of policies to speed up the transition to a greener stock of buildings. Rates of renovation and energy retro-fitting remain low all over the world. The latest policy idea is to mandate reductions in energy use, jump-starting the renovation market, and laws to that effect are starting to appear.

CHAPTER 4 ›

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05 Industry

Emissions from industries like steel, cement and chemicals remain a major unsolved problem, with few government policies in place to speed the transition. The earliest stages of a green transition in steel manufacture are occurring, however, with plants under construction that will use clean hydrogen as their energy source. At the Glasgow climate summit, numerous governments and large corporations committed to start buying clean industrial products, sending a crucial market signal.

CHAPTER 5 ›

06 Land & Food

Rates of forest destruction and of species extinction remain at worrying levels. Deforestation has been trending downward over the course of decades, with recent reversals in some parts of the tropics. Repeated promises by Western corporations to eliminate forest destruction from their supply chains have so far yielded scant progress.

CHAPTER 6 ›

07 Financing the Transition

Annual investment in the clean economy appears certain to exceed $1 trillion in the next few years. Yet that is not enough to get on a path consistent with the global goal of limiting planetary warming to 1.5 degrees Celsius. So far, most of the money is being spent in rich countries, not those with the most acute need for investment. BloombergNEF calculates that investment will need to reach $2 trillion annually by the middle of the decade, then double again by 2030. In particular, not enough money is flowing into solving the hardest problems, like industrial emissions.

CHAPTER 7 ›

08 Looking Ahead

The urgency of the climate crisis requires the transformation of every sector of the world economy. This transition will be the most significant change in economic history, and the rich countries of the world, which got that way by burning more than their fair share of fossil fuels, have a moral duty to lead the way. We will be watching closely over the next year to see if emerging policies in Europe, the United States and Australia help to create global momentum, leading to the stepped-up action that is so imperative.

CHAPTER 8 ›

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01

Year in Focus

Bombs & promises

The pacification of Europe after 1945 was the greatest achievement of politics in the 20th century. A continent drenched in blood for centuries, then torn asunder by two world wars, was transformed within a generation into a bastion of peace. This transformation was achieved by historic leadership, as politicians of the postwar era sought to knit the continent together to the point that war would become unthinkable. The victorious Allies, having failed to listen to warnings after World War I about the perils of mistreating vanquished countries,[1] heeded those warnings after World War II. France and Germany, savage enemies in the two wars, developed a warm trust in their aftermath, their alliance becoming the beating heart of the unification project that ultimately became the European Union.

The European peace was a tense peace, to be certain, with an increasingly prosperous Western Europe staring across the Iron Curtain at the Soviet Union and its satellite states. Peace was maintained in part by a mutual fear of nuclear annihilation. And while the fractious states of Europe had stopped fighting, they had certainly not stopped arguing — over everything from fishing rights to oil concessions to wine labels to British scepticism towards the unification project. The peace came under strain in 1991, when a series of ethnic conflicts on Europe's southern periphery followed the break-up of Yugoslavia — and served as a warning that the incipient collapse of Communism might unleash old group hatreds and new territorial claims. Yet across the heart of Europe, peace held.

That peace had begun at 2:41 a.m. on May 7 1945, in the French city of Reims, when General Alfred Jodl surrendered the armed forces of Nazi Germany to the Allies. Seventy-six years and nine months later, at 6 a.m. Moscow time on February 24 2022, Vladimir Putin stood in front of television cameras at the Kremlin and shattered the peace of Europe.

A child walks through debris left by an explosion from a Russian missile strike on a civilian neighbourhood in Bakhmut, Ukraine, on July 6 2022.

Image: Narciso Contreras/Anadolu Agency/Getty Images

1. The most prescient such warning was issued by a then-obscure British economist who attended the Paris peace talks at the end of World War I. Writing in 1919, John Maynard Keynes argued that the terms the Treaty of Versailles imposed on Germany were too harsh, and would cause lasting resentment. "If we aim deliberately at the impoverishment of Central Europe, vengeance, I dare predict, will not limp", he wrote in a book called *The Economic Consequences of the Peace*. Ignored by presidents and prime ministers at the time, Keynes was enlisted after World War II as a primary architect of the postwar order.

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As he spoke, volleys of bombs and missiles hurtled toward Ukraine. The Russian Army, though quickly beaten back in its initial attempt to seize the whole of the country, is still on the march, seeking to carve up Ukraine. Seven million refugees have poured across the borders into Poland, Moldova, Romania and other countries,[2] and a third of the Ukrainian population has been displaced internally.[3] All-important grain shipments from Ukraine, one of the world's major suppliers, were blockaded for months, precipitating a global food crisis, with large increases in world hunger. This sudden grain shortage occurred against the backdrop of threats to agriculture from the climate crisis, including increasingly intense summer heatwaves. The North Atlantic Treaty Organization, the military and diplomatic coalition the Allies built after World War II, is shipping arms and other matériel to Ukraine in a direct challenge to Russia. Once again, the spectre of nuclear Armageddon — until recently regarded as a relic of 20th-century history — hangs over the world.

In retrospect, many countries in Western Europe committed a grave error in their relations with the Soviet Union and its successor state, Russia. In the decades of the Cold War, they allowed themselves to become dependent on Russia for supplies of fossil fuels, and particularly gas from the vast fields in Siberia. The Germans, under a policy called Ostpolitik, threw themselves into helping Russia develop these reserves, financing much of the pipeline construction and buying the resulting gas. The theory was that strong commercial ties would tame Russian aggression. The American government fretted over the risks its European allies were taking. As one such pipeline was being considered in 1981, America's Central Intelligence Agency wrote a secret analysis asserting that the project "would provide the Soviets one additional pressure point they could use as part of a broader diplomatic offensive to persuade the West Europeans to accept their viewpoint on East-West issues. Such pressures might be directed, for example, at undermining European willingness to act in concert with the U.S. on economic sanctions against the Soviets or on security issues".[4]

Ronald Reagan, the American president at the time, briefly tried to stop the pipeline, but the Europeans were determined to move forward. The continent was, and still is, densely populated, resource-poor and unable to meet its own energy needs with fossil fuels. European leaders had come out of the energy crises of the 1970s hoping that the Russians, under their plodding Communist government, would be more reliable energy suppliers than hostile Arab and Persian states. Reagan's position was also undermined at home, by lobbying and campaign donations from American fossil-fuel companies, which saw long-term opportunities in Russia.[5]

The European dependency on Russia thus grew for decades, as a spider web of pipelines spread across the Eurasian continent. Their cheerful names — Northern Lights, Blue Stream, TurkStream, Nord Stream, Brotherhood — belied the rising risks. Remarkably, German imports of Russian gas continued to grow even after Vladimir Putin seized Crimea in 2014, dispelling any doubt about his territorial ambitions. By the time the war started in 2022, Germany was getting more than half its gas from Russia.[6]

2. UNHCR The UN Refugee Agency Operational Data Portal: Ukraine Refugee Situation, retrieved on September 1 2022.

Link ›

3. "With all eyes on Ukraine, research offers insights from the world's other 86 million forcibly displaced", UNHCR The UN Refugee Agency, July 4 2022.

Link ›

4. "USSR — Western Europe: Implications of the Siberia-to-Europe Gas Pipeline", National Foreign Assessment Center, U.S. Central Intelligence Agency, 1981. Declassified in 1999.

Link ›

5. Tabuchi, Hiroko: "How Europe Got Hooked on Russian Gas Despite Reagan's Warnings", The New York Times, March 23 2022.

Link ›

6. In 2021, Russia accounted for 55% of Germany's gas imports. "Germany takes new steps to tackle the energy crisis", World Economic Forum in collaboration with Reuters, August 24 2022.

Link ›

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Figure 1: Europe's dependence on Russian gas

Source: Global Energy Monitor

Now, of course, a reckoning is at hand. The Russians are manipulating gas supplies in precisely the way the C.I.A. predicted four decades ago. Europe confronts the stark possibility of running out of gas this winter, while German industry may be forced to shut down to keep German households from freezing. The entire European Union is scrambling to slash dependency on Russian gas, relying in part on American gas to replace it. Russian fossil-fuel exports have fallen as some countries stop buying, but prices have soared to such a degree that Russia may be earning as much or more from its exports as it was before the invasion. Fossil-fuel money from the Western democracies is thus helping to pay for the Ukraine war.

Amidst this historical tragedy, its roots reaching deep into European history, a window of opportunity has opened. If the politicians of today can match those of the mid-20th century for vision and courage, Europe has an opportunity to write a new history for the continent — and for Planet Earth.

Convergence

In the short term, European politicians are scouring the world for fossil-fuel supplies not mined in Russia. The situation poses grave risks for the clean-energy transition. A flood of quick investment into fossil-fuel infrastructure — new pipelines and new import terminals for liquefied gas are already being built — risks locking in dependency on dirty energy for the longer term. Expanded reliance on new fossil-fuel supplies from countries like Venezuela or Saudi Arabia may create new geopolitical vulnerabilities, with the Western democracies essentially swapping one autocratic supplier for others.

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And yet, for the longer term, the dangers of fossil-fuel dependency stand more starkly revealed than ever. The European desire to solve the climate crisis — a problem for which the EU has long aspired to leadership — has now come into alignment with the European need for energy security. How Europe resolves the tension between its near-term supply crisis and its long-term interests will determine whether the EU can maintain its position as the world's leader in battling climate breakdown. Before the Russian invasion of Ukraine, Europe had set ambitious goals to reduce its greenhouse gas emissions — goals so ambitious it was not clear whether they could be met. Now, the EU is moving to accelerate those goals. Meeting the new targets will require a radical, rapid scale-up in renewable energy, along with many other steps, including reductions in demand through hyper-efficient energy use.

The situation demands a rapid increase in the rate at which new renewable-energy supplies are being developed. It requires creating entirely new industries from scratch, like the ability to generate clean hydrogen that can then be used to produce clean steel, fertiliser and chemicals. These goals can only be achieved by persuading a large majority of the European public to embrace them. Over time, meeting them will cost trillions of euros, though it is likely that climate inaction would be more costly still.

Beyond Europe's borders, the entire world has a stake in seeing Europe succeed in this quest. Nowhere else is an urgent security crisis opening the floodgates of potential climate finance the way the Ukraine war is doing. That puts Europe in a position to develop climate solutions that it can then export, and to make those solutions cheap enough that other countries will welcome them. Europe could see large economic gains if it becomes a main supplier of the climate technology the world needs.

How can Europe do this? The answer is clear, because Europe has already done it with some important technologies. A German policy of supporting solar power led to a massive scale-up of that technology, especially after the Chinese rushed in to supply the growing German market. As solar power got bigger, the costs of panels fell radically: by almost 90 percent in a decade. Large subsidies were required at the outset, but as costs fell, so did the subsidy requirement. Likewise, the United Kingdom spent more than any other country on supporting the development of offshore wind power, driving costs down sharply. The Americans, who sat on the sidelines as European governments spent heavily on those technologies, are now seizing on the lower costs and ordering thousands of solar farms in their Southern states, as well as offshore wind turbines along their coasts. The Indian government has likewise seized on cheap panels to commission large solar farms. (See "Wright's Law", below, for an explanation of why these technologies got cheaper as governments spent money on scaling them up.)

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WRIGHT'S LAW

Why do some technologies get cheaper as they scale up? An idea you might never have heard of helps explain it.

The spectacular decline over a decade in the cost of solar panels, of nearly 90 percent, and the lesser but still impressive decline in the cost of wind power, by about 70 percent, were not economic flukes.[7] They were a direct consequence of policies designed to make those energy sources cheaper. The exact magnitude of the declines may have been a surprise, but the general trends were predictable, and indeed they were predicted.

The reason is that it was clear by the early 2000s that these technologies, and others in the clean economy, were following a maxim known as Wright's Law. It is named after Theodore P. Wright, an aviation pioneer who first observed the law at work in the construction of aeroplanes in the 1920s. Stated in modern terms, Wright's Law predicts that every time the total global output of a new item of manufacture doubles, the cost of producing it will decline by a relatively fixed amount. The slope of the decline is called the learning curve for that technology. Over time, many technologies, including solar panels, have been found to have learning rates in the ballpark of 20 percent, but the figure itself is not predictable in advance. It is an empirical fact derived from observing a particular technology as it scales up.

Wright's Law carries a profound implication: if a technology is found to display a learning rate, then public policies designed to scale that technology up will also make it cheaper. The faster the scale-up, the faster the costs will fall. Light bulbs based on light-emitting diodes, for example, displayed a learning rate of about 18 percent — they declined in price by that much every time global production doubled. But, under policies adopted in the United States, India and other countries designed to push them into the marketplace, production of these bulbs doubled many times in the course of a decade. The retail cost of the bulbs in the United States fell from $50 to $1 over that decade.

Once the relationship between scale and cost is understood, subsidies for new clean-energy technologies can no longer be seen as a debatable use of taxpayers' money; they are a means to an end, and the end is to make the clean economy economically competitive with the dirty economy.

This is one reason we are so excited about the potential for greater public spending on clean technologies in the European Union and, under the recently adopted climate bill, in the United States. By scaling technologies that are costly today, these wealthy regions can use their economic clout to make them affordable for the rest of the world.

7. Roser, Max: "Why Did Renewables Become So Cheap So Fast?" Our World in Data, December 1 2020.

Link >

Even as Europe accelerates the deployment of these existing technologies, the continent must work on those that will be needed in the 2030s and 2040s to complete the energy transition. These include methods of storing renewable power for long periods. They include power plants that emit no greenhouse gases yet can be switched on at any time, unlike wind and solar farms. They include advanced electric cars, as well as clean lorries and planes. The needed technologies number in the scores.

There is hope, this time, that European governments will get significant help from the Americans. This past summer, after new climate legislation had been given up for dead, a surprise deal in the United States Congress led to passage of a major bill called the Inflation Reduction Act. Its main provisions focus on the climate crisis, and commit the United States to spending hundreds of billions of dollars in budget outlays and tax breaks to speed the energy transition. American president Joe Biden promised upon taking office that the United States would cut its emissions 50 percent by 2030, from their peak level in 2005. Forecasts by several groups of analysts suggest the new law will help lead to a cut of around 40 percent,[8] and the Biden administration has committed to additional, administrative action to help close the gap.

8. See, for example: "Preliminary Report: The Climate and Energy Impacts of the Inflation Reduction Act of 2022", Zero-carbon Energy Systems Research and Optimization Laboratory, Princeton University, August 12 2022.

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This development in the United States means that country is poised to play a major role in helping to drive clean-energy technology forward. To have both regions pushing hard together for the first time should make the goals that much more attainable.

Nevertheless, it remains true that the political will and the sense of urgency are higher in Europe, and the new goals the EU is considering would put the region ahead of the United States. What might stop the European governments from achieving those goals?

Need for speed

Polls suggest that the German people are highly committed to the energy transition, with 79 percent of the public calling climate change a "very serious problem" in a recent Eurobarometer poll.[9] Yet, for years now, no new onshore wind farm has been built in Germany without objection from nearby residents, with court fights often required to resolve the status of the project. Work on critically needed power lines, to move electricity from Germany's windy north to its industrial south, has slowed to a crawl amid public opposition. In Britain, onshore wind construction has largely shut down, again due to objections from local communities. In countries where wind projects can be built, getting the necessary environmental and other permits can take as long as eight or nine years.[10]

Offshore wind faces similar issues over environmental permits, but it faces some hard physical realities too. Across much of the North Sea, the sea floor is littered with unexploded ordnance from World War II. Specialised crews must investigate and clear any bombs before projects can move forward. Constructing offshore wind farms also requires special boats, and a shortage of these looms as the goals ramp up.[11] The biggest issue is that only a minority of the world's coastlines are suitable for development with the existing technology, in which turbines are planted in the sea floor in relatively shallow water. In most places, the continental shelf drops off too quickly for that. Along these coasts a new technology is required: floating offshore wind. Europe has installed the first such turbines and is poised to lead the way, but the technology is still in its early stages.

The financing mechanisms to support development of large renewables projects remain a work in progress. For wind farms, the rules effectively require developers to lock in supply contracts for turbines long before construction begins, leaving the turbine makers exposed to commodity risk. This theoretical problem became very real in 2022, as soaring steel and other input prices undermined the economics of contracts signed a few years earlier. The European wind-turbine manufacturers have been losing money recently, a bizarre development at a time when Europe is planning a huge escalation of its clean-energy goals.[12] They may need direct state aid to get through this difficult period, or contracts may need to be reopened to allow for the rising costs.

9. Clean Energy Wire: "Polls Reveal Citizens' Support for Climate Action and Energy Transition", Factsheet, August 5 2022.

Link ›

10. A country-by-country breakdown of permitting times is contained in Figure 5, Page 29, in "Overview of national permitting rules and good practices", WindEurope, July 2021. An open-access version of the chart is at

Link ›

11. Calma, Justine: "Offshore wind projects are outpacing the ships that build them", The Verge, February 3 2022.

Link ›

12. Jacobsen, Stine and Isla Binnie: "Wind turbine makers struggle to find pricing power", Reuters, May 5 2022.

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The European Union has a plan[13] to solve many of the bottlenecks. Anyone who wants to know how serious the bloc is about speeding the transition should watch how that plan develops over the coming year or so. The centrepiece is a requirement that EU member states make a decision on environmental permits for projects within two years of the time a developer files an application. In addition, the EU wants member governments to set aside large "go-to" areas where renewable-energy development will be explicitly encouraged, and to issue permits in those areas within one year of the application being filed. If member governments comply with these requirements, the result will be a radical acceleration in the timeline for renewables development. In the near term, this may be the single most important test of how serious Europe is about its new goals.

The lengthy court fights over projects must also be shortened. Again, the EU has a plan: to codify into European law the principle that renewables development is an overriding public interest. Now, environmental laws meant for the protection of birds, fish or marine mammals often have that legal status, whereas renewables projects do not.

These same fights are playing out around the world, in any country that has adopted strong measures for environmental protection. In other words, the local goal of preserving landscapes and wildlife can come into conflict with the global goal of averting climate breakdown. In a sense, this merely demonstrates how acute the environmental crisis has become: we are out of easy answers, and no one gets a pass on having to make difficult choices and trade-offs. But environmental laws written in the 1970s are proving inadequate for resolving the conflicts in a timely way, and the energy transition cannot proceed at the pace required unless a better balance is struck.

If the people of Europe are serious in their plans to move away from fossil energy, we will see a wave of national laws passed over the coming year to meet the goals the EU has established. We will also see large sums of money begin to move into nascent industries like green hydrogen, green steel, low-carbon cement and so forth.

Even if it can be accelerated, the transition is still going to take decades. Perhaps the question now is whether the great lessons of 2022 will stick in the minds of European leaders long enough for them to make good on the promises they made when the Russian bombs began to fall.

13. European Commission: "REPowerEU: A plan to rapidly reduce dependence on Russian fossil fuels and fast forward the green transition", May 18 2022.

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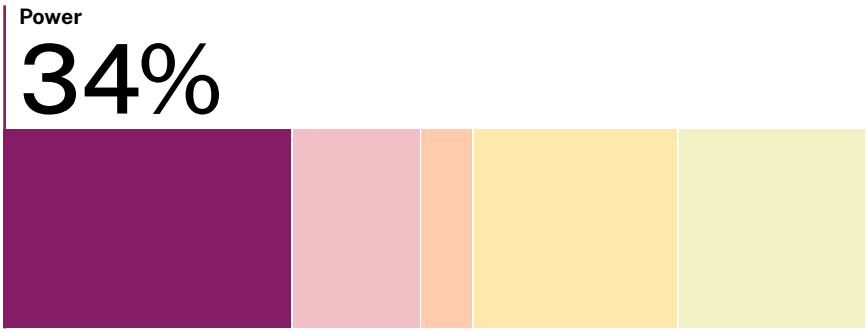
02

Power



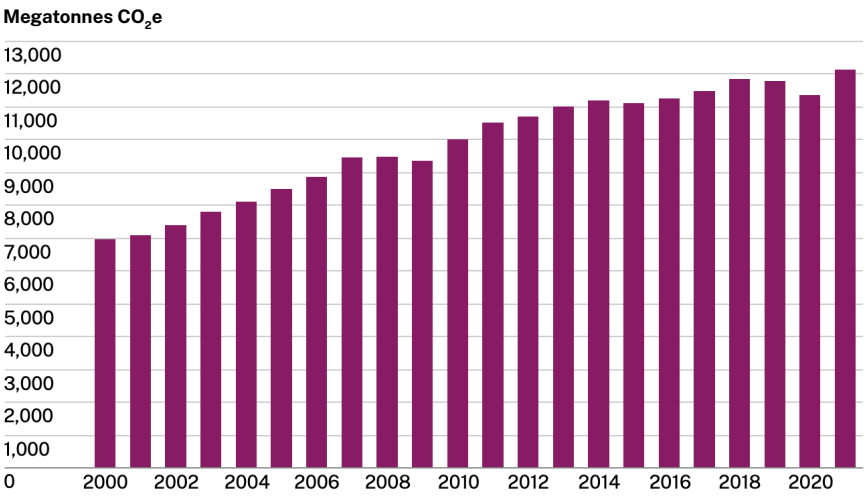
Share of global emissions (IPCC)

Good news wrapped in bad news

The coronavirus pandemic that spread across the world in 2020 resulted in massive economic dislocation, as well as the largest drop in energy demand and in greenhouse emissions ever measured.[1] Calls were issued for governments to focus on green economic growth in the recovery from the pandemic, and there were hopes that a more rapid build-out of renewable energy might mean that 2018 would turn out to be the peak year for emissions from the electricity sector.

Alas, that did not happen. There was indeed a burst of renewable energy construction in 2020, but the economic recovery of 2021 was so robust that power demand soared beyond all previous records. Emissions from the sector hit an all-time high, marginally above the emissions of 2018, according to measurements from two groups that track them. Figure 2 shows the 20-year trend in greenhouse emissions from the world's electricity sector.

Figure 2: Global electricity emissions



Source: Ember

1. "Global energy demand to plunge this year as a result of the biggest shock since the Second World War", International Energy Agency, April 30 2020.

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This continual rise of power emissions is deeply unfortunate. The first and most important task of the energy transition is to clean up the power grid. This is the key to the strategy known as “electrify everything”, in which other economic sectors that now rely on fuel-burning need to convert to running on clean electricity. Electric cars are cleaner than petrol cars under nearly all circumstances, but they will be cleaner still if they are running on a cleaned-up power grid. Likewise, to stop the burning of gas or fuel oil to heat buildings, we must convert to electrical devices called heat pumps, and they too need to draw their power from a clean grid.

Are we, as yet, cleaning up the power grid? The figure above answers the question: at the global scale, we are not.

And yet, hiding beneath this bad news is some good and hopeful news. The power grid is getting cleaned up across entire countries. In the United States, emissions from the power sector are down 22 percent since the year 2000, and in Europe, down 25 percent in the same period.[2] The United Kingdom is rapidly driving coal out of its power mix.

2. Generation analysis of Ember data 2000–2021. Retrieved on September 2 2022.

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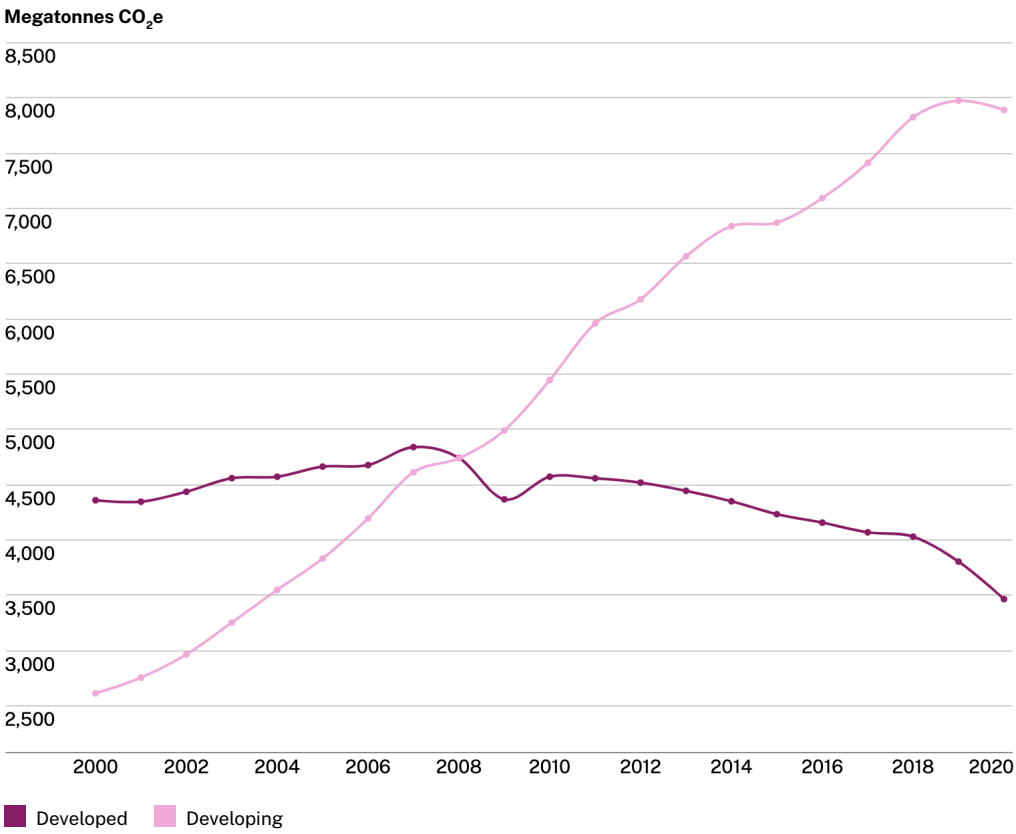
Figure 3: Developed vs developing countries’ power emissions



Developed countries include those listed in Annex 1 of the Kyoto protocol. Developing countries include non-Annex 1.

Source: Ember

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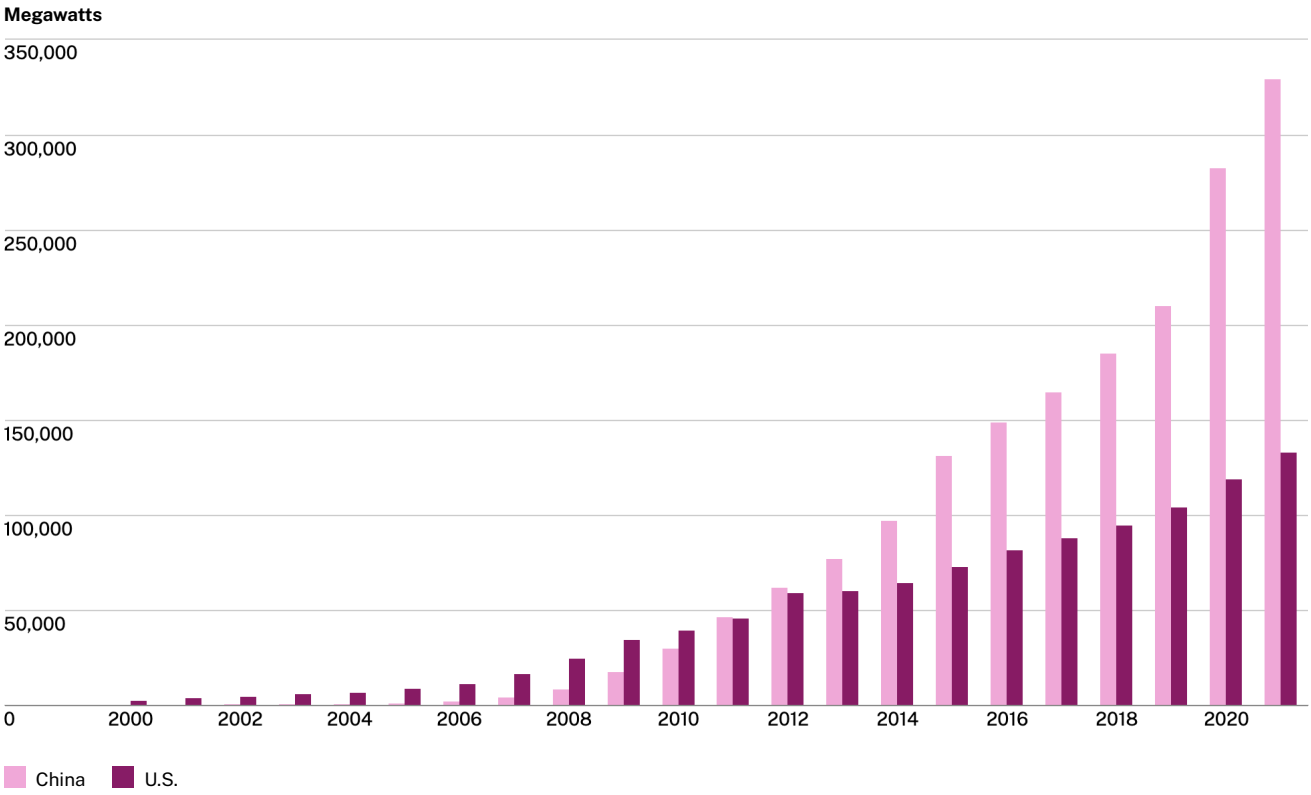
This progress in the highly developed economies suggests to us that the power grid can be cleaned up across the world. If it can happen in one place, it can happen everywhere. Yet at the moment, power demand is rising so fast in the developing world that increased burning of coal is swamping the efforts of countries like China and India to increase their use of renewable power. Those efforts are real: China is building wind and solar farms much faster than any other country. Yet it also continues to build more new coal-burning power plants than the rest of the world combined.

Figure 4: Wind power capacity, China vs U.S.



The chart shows cumulative installed capacity for each country.

Source: BP Statistical Review of World Energy

The most hopeful news hiding in the data is that in places where emissions are not already falling, they are going up more slowly than in the past. This is a robust trend that has lasted for well over a decade, and it is displayed in Figure 5. The same trend can be viewed another way: as a global decline in emissions per unit of electricity produced, as displayed in Figure 6. This decline in the "emissions intensity" of power generation means that, in an important sense, we *are* cleaning up the global grid.

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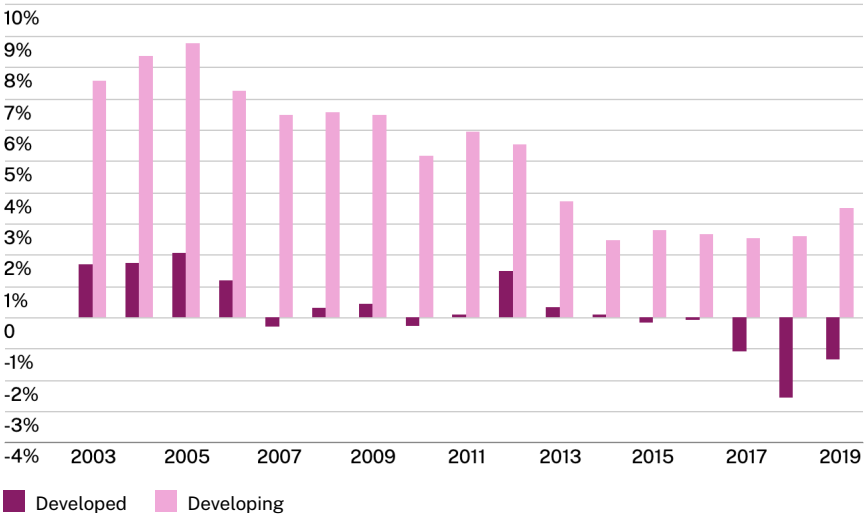
Figure 5: Year–over–year change in electricity emissions

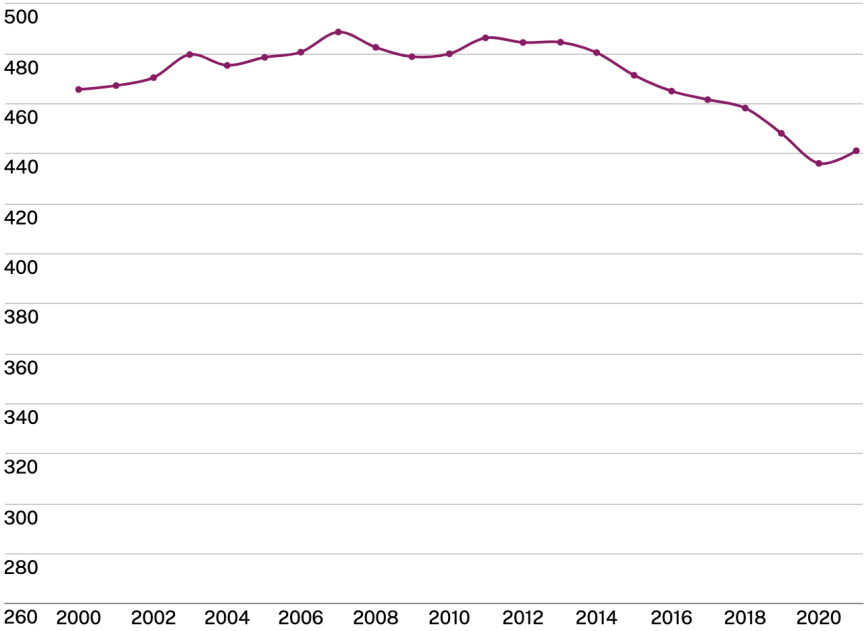


Based on Annex 1 and non-Annex 1 countries, 5-year moving average

Source: Climate TRACE analysis of Ember data

Figure 6: Global emissions intensity of electricity production

Grams CO_2e per kWh



Source: Ember

What matters for the climate, of course, is the absolute volume of greenhouse-gas emissions. The laws of physics are going to take no note of how hard we tried. Yet the falling emissions growth rate implies that we must be near a global turning point. Emissions from global electricity production are almost certainly going to peak, possibly as soon as 2025, and then begin to fall. The question then will be how fast we can drive them to zero at a global scale.

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Renewables begin to shine

In the countries where power emissions are declining, how is that being achieved? The answer varies from country to country. In the United States, for example, major reductions came from shutting down coal-burning power plants in favour of gas-burning plants, as new gas production made that fuel cheaper than coal. Increasingly, though, the reason for falling emissions in many countries is the growth of wind and solar farms. Wind power in particular has played a major role. The difficult politics in the United States regarding climate change sometimes obscure how large a contribution the Americans have made to the development of onshore wind power as an industry. Some Republican-controlled states in the windy middle of the country have made astonishing progress. Of the electricity being generated in Iowa, 58 percent is coming from wind turbines. The figure is 45 percent in Kansas, 41 percent in Oklahoma and 34 percent in North Dakota. Texas, the second-largest American state by population, now gets 20 percent of its power from the wind.[3] In these states, the economic logic of wind power has trumped political ideology. For the United States as a whole, more than 8 percent of electricity is now coming from wind turbines.[4] The law the United States Congress just passed should drive that number up considerably in the next decade.

Solar power is playing a growing role, supplying as much as 10 or 12 percent of electricity in some countries with favourable solar insolation. Australia has the highest solar uptake in the world, with one in four homes having solar panels; coupled with utility-scale systems, they will soon supply 10 percent of the country's electricity. That uptake has occurred despite an Australian federal government that was hostile to renewable energy, though more favourable policies were promulgated by the Australian state governments. With the recent change of national government, Australia may be poised for a real take-off of solar and wind power, though it continues to be one of the world's major exporters of fossil fuels.

Nuclear reactors remain a major source of low-emissions electricity in much of the world, though their future role is unclear. The share of nuclear generation in the global electricity mix peaked in the 1990s and has been falling since. Public ambivalence toward nuclear power in the Western democracies led to a shutdown of new-reactor construction from the 1980s onwards. Supply chains in those countries deteriorated, critical expertise was lost, and their recent efforts to restart nuclear construction have been problematic. A project in the American state of South Carolina was abandoned after wild cost overruns; one corporate executive there has been imprisoned for lying to the public, and others have pleaded guilty or are under indictment.[5] Losses exceed $8 billion. A project in the neighbouring state of Georgia is nearing completion, but only after runaway cost overruns. France, a supposed reservoir of nuclear knowledge, has had just as much difficulty building reactors in recent years, with Electricité de France involved in deeply troubled projects at Flamanville in Normandy, at Olkiluoto in Finland and at Hinkley Point in the United Kingdom. This summer, the French government decided to bail out the company and take full ownership of its shares.

3. The wind penetration for any American state can be obtained by visiting this site maintained by the Energy Information Administration of the U.S. Department of Energy: https://www.eia.gov/state/. Pick a state from the dropdown and then click the "analysis" tab. Figures for Kansas, Oklahoma, North Dakota and Texas were retrieved on September 2 2022.

4. The figure was 8.3 percent in 2020. "Land-Based Wind Market Report: 2021 Edition", United States Department of Energy, Page vii.

Link ›

5. Collins, Jeffrey: "First executive to head to prison in doomed South Carolina nuclear project", The Associated Press, October 11 2021. Retrieved via Greenville News at

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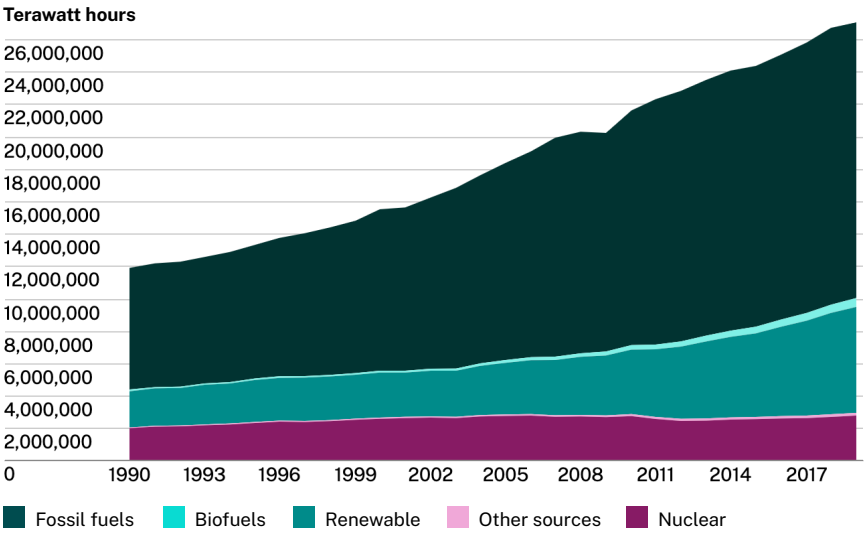
China, Russia and South Korea have been more successful at building new nuclear plants, although the South Korean industry was marred by a scandal over fake certificates for nuclear-reactor parts. Not even China seems to be able to build reactors fast enough to keep up with rising power demand. Moreover, Chinese reactor designs have not really been tested by a crisis.

Figure 7: Global electricity generation by source

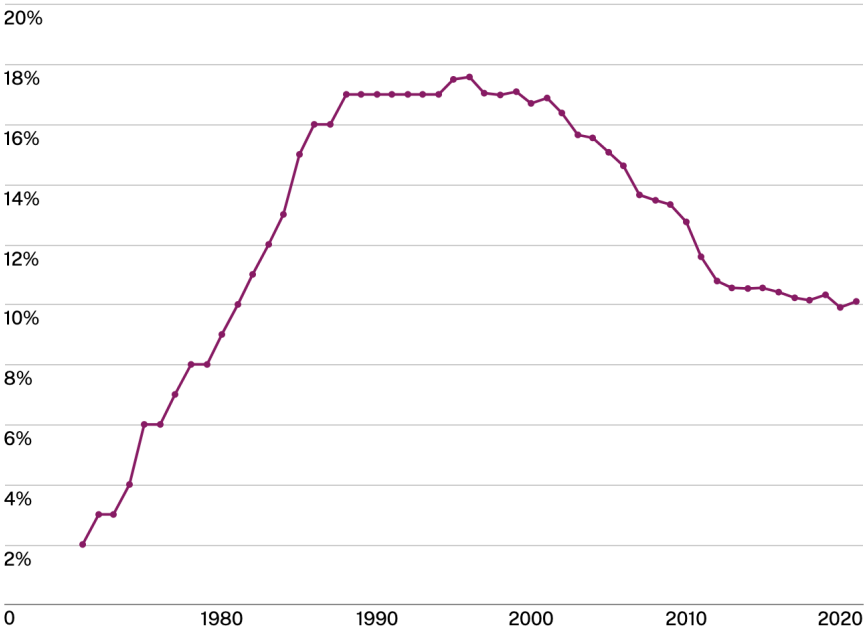


Renewable includes wind, solar, and hydro.

Source: International Energy Agency

As demonstrated in Figure 7, nuclear power has remained a fairly steady source of electricity since 1990. However, as overall power demand has grown it is losing market share, as we can see from Figure 8.

Figure 8: Nuclear power as % of global electricity generation



Source: International Energy Agency

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As an answer to the energy transition, the biggest problem with nuclear power is cost. The main value of these plants is their ability to operate at all times, but the price is high: as much as four or five times the cost of electricity from solar panels and wind turbines. In recent periods of low wholesale power prices, some nuclear plants have been unable to operate economically, and have shut down. The new climate law in the United States launches a regime of federal subsidies for nuclear generation to stop this from happening, a stopgap measure while the country figures out if it wants to commit to a programme of new nuclear construction. Before the federal programme was adopted, some states created bespoke programmes featuring subsidies or other measures to salvage their ageing nuclear plants. In California, where consensus had been reached to shut down the state's last operating nuclear-power station, at Diablo Canyon, the Legislature recently voted to reverse course and keep it operating.[6]

6. Luna, Taryn: "Lawmakers approve $1.4-billion loan for PG&E to keep Diablo Canyon nuclear plant open", The Los Angeles Times, September 1 2022.

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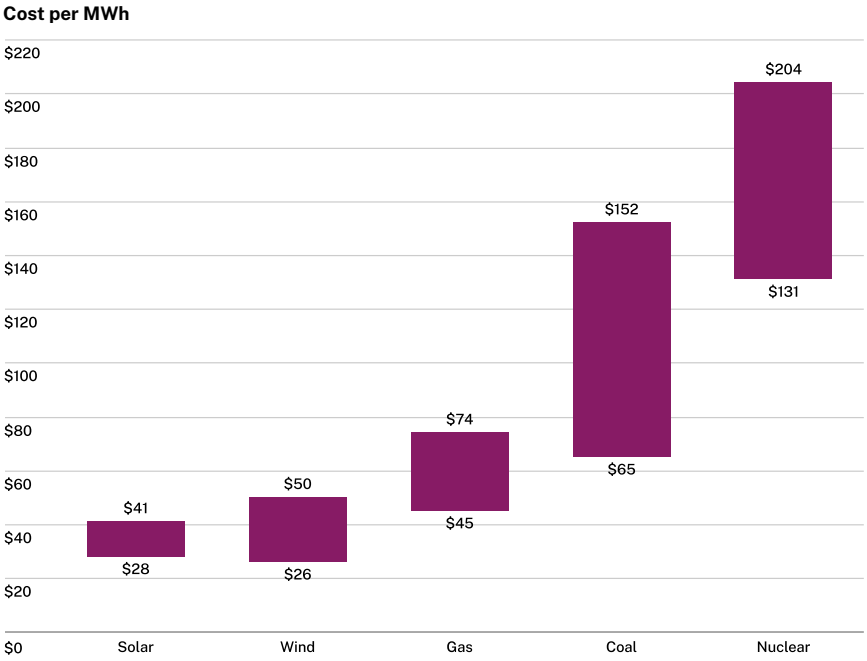
Figure 9: Levelised cost of electricity comparison



This chart shows the average global cost of generating new electricity from various sources. It does not take into account the cost of balancing out fluctuations from renewable sources, which may become significant as their penetration of the grid rises.

Source: Lazard

Efforts are underway to develop a new generation of nuclear plants that would be easier to build, and safer and more economical, but these new designs are as yet unproven.

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For the near term, we believe wind and solar farms will continue to be the backbone of plans to clean up the power grid. Once environmental approvals are granted, they can be built quickly, at a predictable cost. Within this decade, we should begin to see a major contribution to power grids from offshore wind farms. For many of these projects, the major rate-limiting step is not the cost of capital, nor is it the physical difficulty of construction; it is the pace at which the environmental permits are issued. Speeding that up needs to be a worldwide focus. However, another bottleneck has cropped up, and it is rapidly growing in importance.

New renewable-energy farms need permission to connect to the power grid and sell their electricity. In some parts of the world, lengthy queues have developed as project sponsors try to win this approval. The issue is to some extent physical: electric utilities have been caught flat-footed by the surge in renewable energy, and did not spend enough money building power lines to handle it. But the problem is also bureaucratic: utilities that are heavily invested in dirty energy still perceive clean energy as a threat to their profits, and thus have no incentive to speed the connection procedure. This problem has become most acute in the United States, where waiting times are now measured in years in some states, but it is spreading around the world. Federal regulators in Washington have signalled that they are about to take the issue on, and governments everywhere need to do the same. If the issue with environmental permits gets solved, these connection delays could become the single biggest drag on the transformation of the power sector.[7]

7. Penrod, Emma: "Why the energy transition broke the U.S. interconnection system", Utility Dive, August 22 2022.

Link ›

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As the penetration of renewable electricity grows, so will the need to wrestle with its primary limitation: the intermittency of sunshine and wind. For now, the answer is to use fossil-fuel plants, as sparingly as possible, to fill in gaps in the supply of power. This is a role gas-fired power plants are already playing in some countries. Grid-sized batteries are also playing a growing role, particularly in helping to store solar power for nighttime use, with sunny jurisdictions like California and South Australia leading the way. At times, batteries now inject more power into the California grid than the state's one remaining nuclear-power station. But batteries are still costly, and for years to come, their main role is likely to be smoothing out daily power fluctuations. We still need a method to cope with conditions described by the delightful German word *dunkelflaute*, or dark doldrums — meaning longer periods when little power is likely to be available from wind and solar farms. The electricity may be stored as heat in big, insulated piles of rocks or sand, or it may be stored as compressed air in underground caverns, then converted back into power. It could be converted into hydrogen, which could then be turned back into power in turbines or fuel cells. Such methods would inevitably entail round-trip efficiency losses, but they may nonetheless prove to be the cheapest ways to cope with the problem. A more intensive and serious development programme, with major investments and public policy to support it, is required on long-duration electricity storage.

Another approach may be to move power long distances, so that low wind or solar in one region or country can be made up with electricity from another. This is already happening in Europe, where a string of new undersea interconnection cables between countries is creating a more robust power market.[8] Yet in many parts of the world, new power lines on land provoke intensive resistance. At least some new ones are clearly going to be needed, so the public opposition to power lines is yet another political problem that must be solved if the energy transition is to proceed at the pace required.

8. Reed, Stanley: "A Widening Web of Undersea Cables Connects Britain to Green Energy", The New York Times, January 4 2022.

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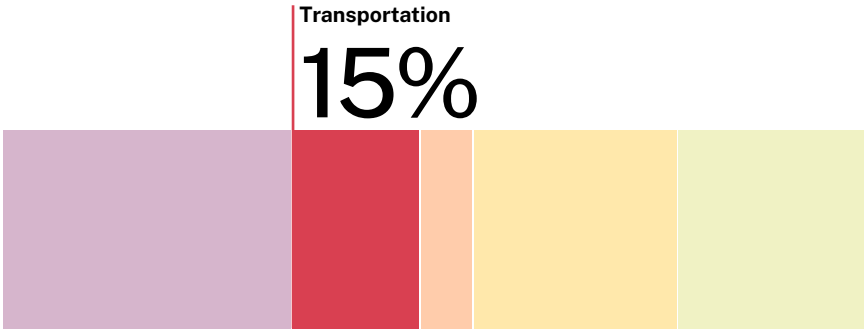
03

Transportation



Share of global emissions (IPCC)

Ready for lift-off

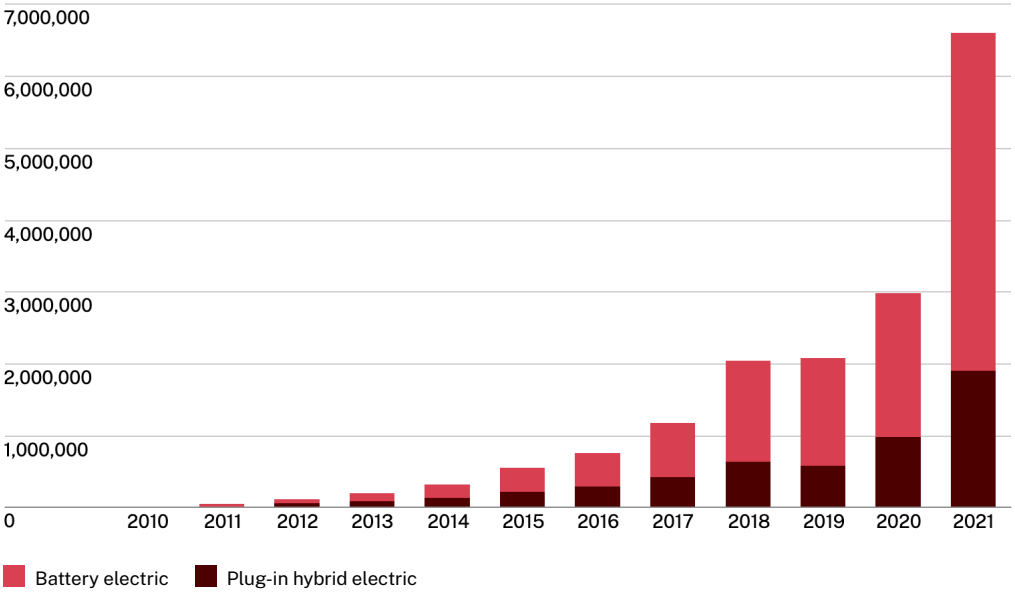
In the birth and development of new technologies, their initial penetration can seem exceedingly slow; sometimes decades are required before they make any real dent in the marketplace. However, scholars of technology have found that once a new technology passes a market share of 5 to 10 percent, it often takes off, climbing a rapid adoption curve.

At a global scale, electric cars have reached that point. Indeed they now represent about 9 percent of car sales worldwide, 17 percent of sales in Europe and 16 percent in China. In Norway, which adopted highly favourable tax policies toward electric cars, basically the entire new-car market has gone electric. Even in the United States, a country excessively wedded to petrol cars, electric models now represent nearly 5 percent of sales, meaning the market may be poised for take-off there, too.[1]

1. International Energy Agency: "Global EV Outlook 2022", May 2022.

Link ›

Figure 10: Global electric car sales



Source: International Energy Agency

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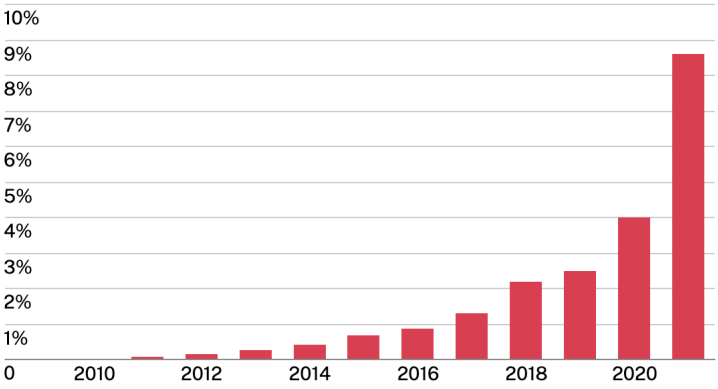
Figure 11: Global electric car market share

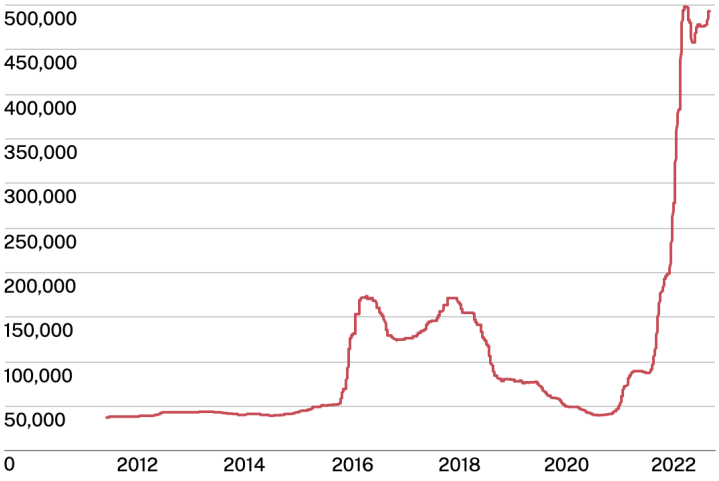


Source: International Energy Agency

There is reason to think sales of electric cars would be even higher if it were possible to build them fast enough. Car manufacturers report that they are constrained by supply, not by demand. Soaring requirements for the critical minerals needed in batteries, including lithium, have not been immediately met by rising mine output. Prices for lithium carbonate, the basic raw material of batteries, soared nearly 500 percent from late 2021 into 2022, though they have come down somewhat recently. Virtually every electric car manufacturer in the world has waiting lists for the most popular models. In the United States, the single most popular light-duty vehicle on the market is the Ford F150 series of trucks. When Ford announced an electric model, the F150 Lightning, it planned to produce 40,000 units a year; runaway customer demand has forced the company to quadruple that goal.

Figure 12: Global price of lithium carbonate

Chinese yuan per metric tonne



Source: Bloomberg

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The rising popularity of electric cars may be the single best piece of news for the energy transition in 2022. There is no longer much doubt that we can, and will, achieve a mass conversion to electric cars. This is a critical development for advanced economies like those of the United States and Germany, where private transport represents a significant and rising share of emissions; in fact, transportation is now the top source of emissions in the United States.[2] In a petrol car, roughly 80 percent of the energy in the fuel is wasted as heat; when the full production chain is analysed, electric cars are at least twice as efficient, and so their rapid adoption is desirable under nearly all circumstances. It is even more desirable if they can be run on a cleaned-up electric grid, and as we have seen, grids in Europe, the United States and other advanced economies are getting cleaner.

2. Environmental Protection Agency: "Inventory of U.S. Greenhouse Gas Emissions and Sinks, 1990-2020", April 14 2022.

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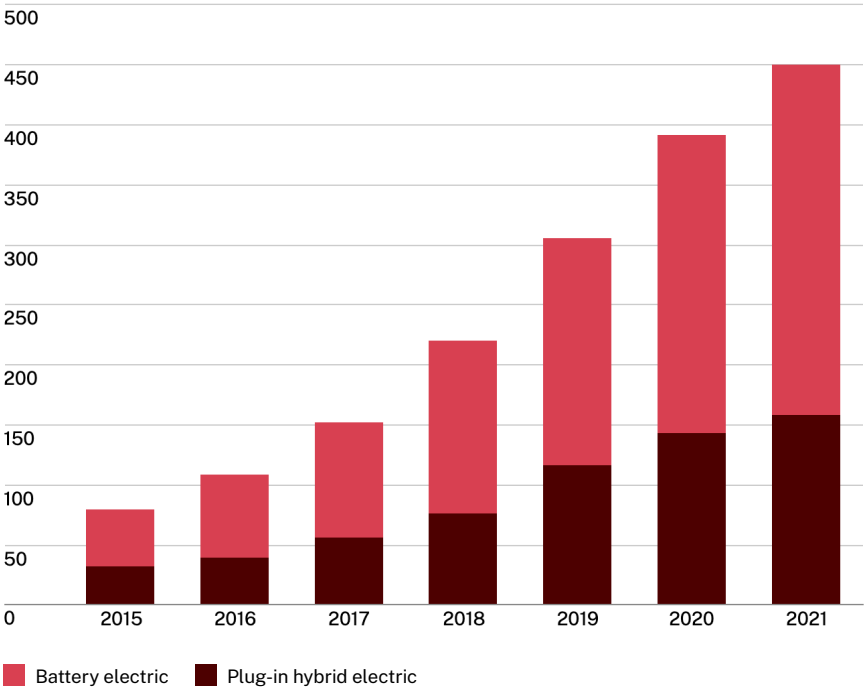
Figure 13: Number of available electric car models



Source: International Energy Agency

Many problems still need to be solved, however. No country has built enough chargers for electric cars. Few have adopted "right to charge" policies to guarantee that chargers will be built in apartment buildings and in urban streets. The cars themselves need to improve; on extended journeys, charging still takes too long.

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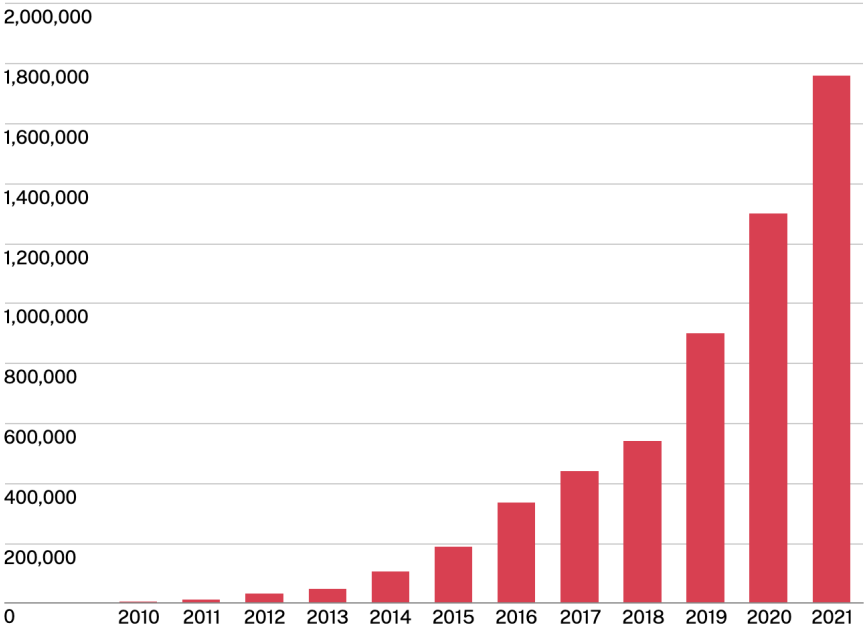
Moreover, even if the new-car market switches rapidly to electric drive trains, it will be a long time before all the cars on the road are electric. Cars are, of course, long-lived assets, with well-made models now running for a decade or longer. This point only heightens the urgency of the switch; if petrol cars are still being sold in the 2030s, it will certainly be well into the 2050s before we can get them all off the road.

Figure 14: Global publicly available EV charging points



Source: International Energy Agency

Governments face a difficult choice about how much money to spend solving these problems. Should tax money really be spent on subsidising private transport when public transport is chronically starved for capital? This is another example of the hard decisions we face: the suburbanisation of the world is not going to be undone quickly, and so electric cars are the only way to clean up automotive emissions in the near to medium term. But surely the longer-term answer is to build denser cities with better public transit systems.

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Whither heavy transport?

Even if light-duty transport is beginning to look like a reasonably solvable problem, the situation is murkier for heavy transport. A global agreement is in place to force ships to begin cleaning up their exceedingly dirty “bunker fuel”, but it is not yet clear how they can eliminate emissions entirely. In aviation, a very weak global agreement has been adopted that is expected to force airlines to buy offsets for some of their emissions, but that must be viewed as a stopgap measure at best. Electric aeroplanes may play a limited role on short routes, but batteries are just too heavy to power a plane on long trips. The long-term answer will almost certainly be to develop more sustainable forms of jet fuel. Vegetable oils can be converted into jet fuel, and significant investments have been announced to build factories that can do this, but costs are still high and it is unclear how quickly the airline industry will move to adopt the technology. Once again, a big push is needed from public policy to pull these fuels into the marketplace and begin scaling them to reduce the cost. Strong environmental and ethical standards are also needed in the way the vegetable oils are produced, since they could easily compete with food production. In principle, a system like this could have much lower greenhouse emissions than jet fuel derived from petroleum, but that needs to be proven, not assumed.

Another vexing problem is what to do about lorries. Around the world, most goods in trade move by lorry, not by rail. It is not yet clear how lorries could be electrified and their emissions eliminated. Running them on compressed hydrogen cannot yet be ruled out, though it would be inefficient, given the energy losses involved in producing green hydrogen. Batteries may reach a point of development where they can do the job alone. This is by no means certain, but we may get a test of the proposition soon; Tesla has showed off a prototype of a heavy lorry and is promising to begin commercial production before the end of this year.

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Prototypes of Tesla's heavy-duty electric lorry, due to go on sale this year.

Image: Mariusz Burcz/Alamy

Another possible approach may be to equip lorries with small batteries and power them along most of their journey through overhead electrical lines. This would be similar to the way trams already operate in much of the world. The small battery would carry the lorry through the last few kilometres of its journey. Small trials of such a system have been run already, but no government has made a major commitment to test the approach at scale. Which of these potential techniques is likely to be the cheapest and the most environmentally benign in the long run is still entirely unclear.

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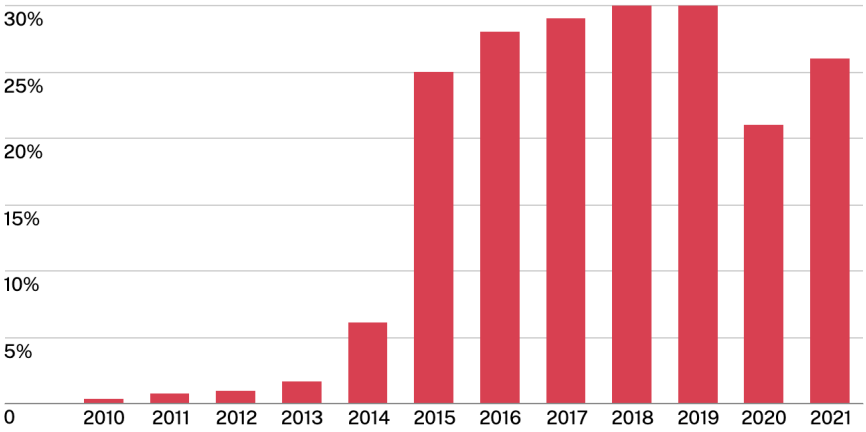
One bright spot when it comes to heavy transportation is the potential for electrifying buses. For a century, cities across the world have used overhead lines to supply power to buses with electric motors, known as trolley buses. Anybody who has visited San Francisco has likely ridden a trolley bus. But this kind of system has limits, with the installation of the overhead lines being too costly in areas of low population density. Now, batteries are permitting the electrification of more buses. Because they run fixed routes that take a predictable amount of time, and can be scheduled to return to a depot and recharge as necessary, buses are an ideal early target for the electrification of heavy transport. For now, battery-powered buses are more costly up front than fuel-burning buses, but the lower operating costs can offset that to a degree. The city of Shenzen, in China, has already converted its entire municipal fleet to run on batteries. The earliest stages of this conversion are also beginning for school buses in the United States and other countries.

Figure 15: Electric buses as a share of bus sales in China



Source: International Energy Agency

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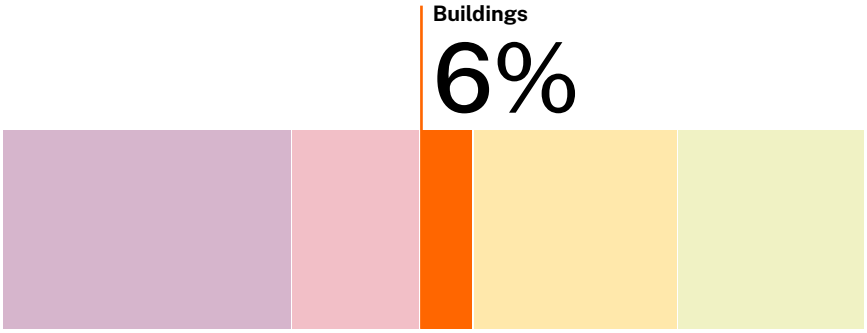
04

Buildings

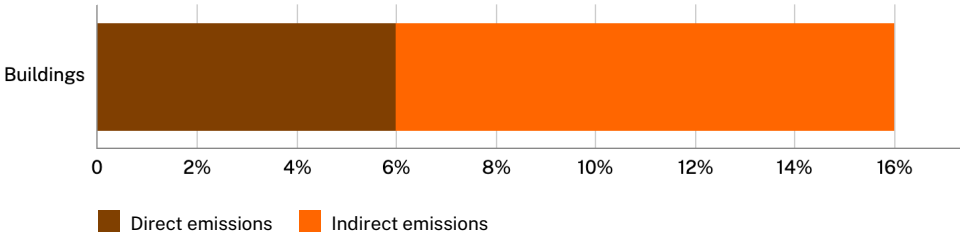


Share of global emissions (IPCC)

Fresh ideas needed

Among the more vexing problems of the energy transition is the task of eliminating emissions from the world's buildings. Because they burn fuel for heat and hot water, buildings are directly responsible for 6 percent of global emissions. But they also consume a substantial share of the world's electricity, making them indirectly responsible for a much larger share of emissions.

Figure 16: Direct building emissions, plus emissions from power and heat used in buildings



Source: IPCC

The technological path to eliminating the direct emissions is clear: all the energy services in buildings need to be converted to electricity, with heating and (where necessary) cooling provided by devices called heat pumps. These are machines that heat or cool a building not by generating heat but by moving it around, in the same way a refrigerator does but at a larger scale. They can be 300 to 400 percent efficient, meaning they can inject an amount of heat energy into a building three to four times larger than the electricity they use to do so. To further minimise electricity usage and the cost of operating these units, buildings need to be tightly insulated, with air gaps sealed, and draughty windows may need to be replaced.

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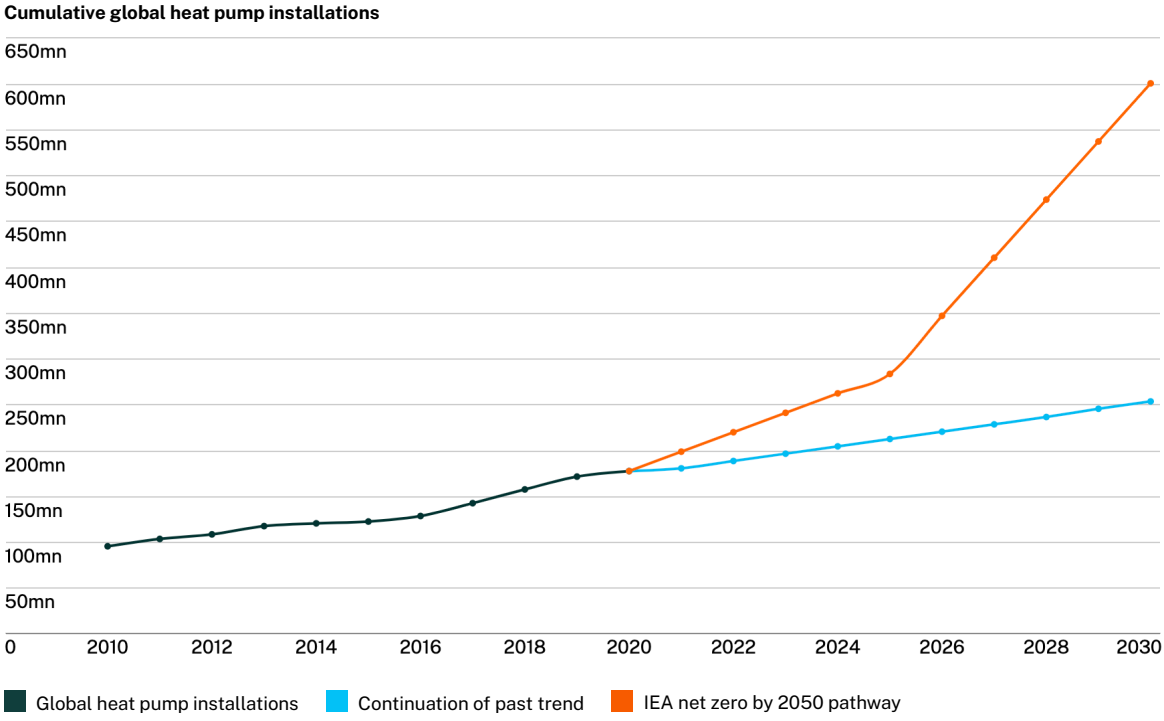
Figure 17: Heat pumps are lagging



Heat pump sales are growing but are far below where the International Energy Agency calculates they need to be to be in line with a 1.5° pathway.

Source: International Energy Agency

If the technological path is clear, the legal path is anything but. Ownership of buildings is fragmented, and any public policy designed to speed up the transition of buildings must grapple with this complexity. To cite a simple example, the owner of an apartment building has the right to decide what kind of appliances it will have and what efficiency standards they will meet, but it is the tenants who must pay the energy bills. This gives the owner no incentive to fix up the building or install efficient appliances, while the tenant with a direct financial stake in those decisions has little or no ability to influence them — a problem known as the "split incentive". Similar problems apply in commercial buildings, but they are afflicted by another difficulty: serious expertise may be required to run the complex air-handling systems in larger buildings, and it is often lost as buildings age and change hands. Research has found that many commercial buildings operate far below their maximum potential efficiency.

Decades of work on these problems has led to limited progress. As a result, many experts have recently concluded that the only way to achieve society's goals will be to impose legally enforceable mandates on building-energy use. In the past few years, such mandates have begun moving onto the statute books, but there is a long way to go to achieve universal coverage of the building stock.

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An obvious and immediate task is stop constructing new buildings that are going to need fixing in a few years — that is, to adjust the building codes and related requirements now, so that newly constructed buildings are fit for purpose in 2050. Dozens of towns in California, and a handful elsewhere in the United States, have banned the installation of new gas hook-ups in buildings, requiring that they be all-electric when constructed. California also requires solar panels on all new homes, to offset as much of the electricity use as possible. In many jurisdictions around the world, however, building codes are woefully out of date, and need to be revised to incorporate the latest standards in energy efficiency.

A worker manoeuvres into place a panel containing thermal insulation and advanced windows and doors, as old buildings in France are renovated to be more energy-efficient.

Image: Fabrice Singevin/Energiesprong International

The International Energy Agency has recommended that no gas boilers or furnaces be installed in newly constructed homes after 2025, and several European governments have announced policies consistent with that ambition. But getting gas out of existing homes is an entirely different matter — one that governments have yet to tackle with any courage. The worldwide renovation rate for buildings is in the order of 1 percent a year; the International Energy Agency calculates that the rate needs to jump to 2.5 percent to meet climate goals.[1] At the rate the United Kingdom, to cite one country, is installing heat pumps in old homes, the job will be done in 600 years.[2] This sluggish renovation of existing buildings must be tackled with creative public policy.

1. International Energy Agency: "Building Envelopes," 2021

Link ›

2. Vaughan, Adam: "UK's slow heat pump efforts will take 600 years to meet 2050 target", New Scientist, July 12 2022.

Link ›

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Intervene at time of sale?

One option is to impose requirements that apply whenever a building is sold. The law may decree, for instance, that part of the sales proceeds be set aside for use by the new owner to bring a building up to standard. Direct subsidies for the installation of heat pumps and insulation are another intervention, though these would need to be sizeable to motivate building owners to action. We are likely to get a test of how well such a policy works in the United States, under the new climate law adopted this summer in that country. Homeowners who undertake an extensive package of efficiency improvements, including installation of a heat pump, may be able to claim tax credits approaching $5,000. That is 25 times the money that was available to homeowners under previous legislation.

A new home gets high-quality insulation to save energy.

Image: Adobe

A new type of law is being adopted by forward-looking jurisdictions in the United States. Several cities — including Washington, D.C. and New York City — have established “building energy performance standards”, essentially requiring year-by-year reductions in the energy use of buildings. For now, the laws apply to large offices and other commercial buildings, and should create an expanded market for renovating buildings and running them properly. The European Union has adopted a scheme in which larger buildings are assigned a letter grade according to how much energy they use, but these ratings are widely perceived as inaccurate, and it is not clear whether this name-and-shame policy has stirred any increase in renovations. The EU is beginning to consider mandates, but only for the worst-performing buildings.

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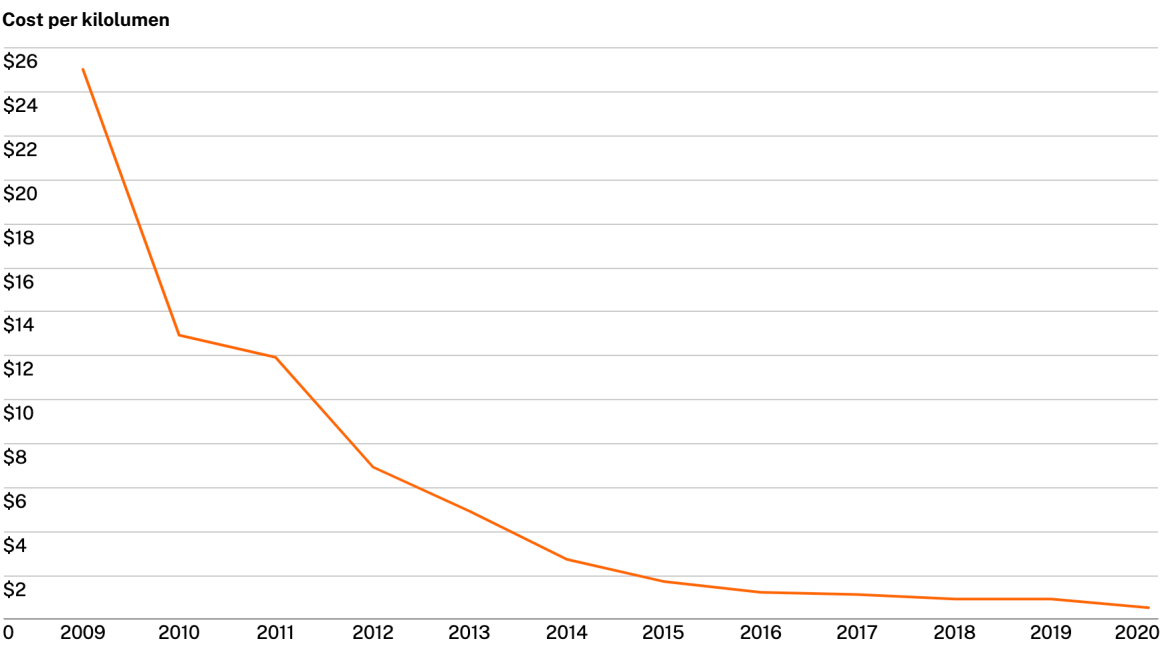
The building-energy problem has become exceedingly urgent, for the simple reason that so little progress has been made in solving it. We hope that governments around the world are closely watching the policy experiments being undertaken in the leading jurisdictions, and stand ready to copy the ones that work. It can be done: a decade ago, governments made a strong push to get building owners and consumers to adopt new light bulbs based on light-emitting diodes, or LEDs. The result was a dramatic scale-up in the market and an equally dramatic march down the price curve for LED technology. That success shows what can be done with creative public policy when governments really try.

Figure 18: The price of LED lights has fallen drastically



Price shown is for cool white LEDs.

Source: U.S. Department of Energy

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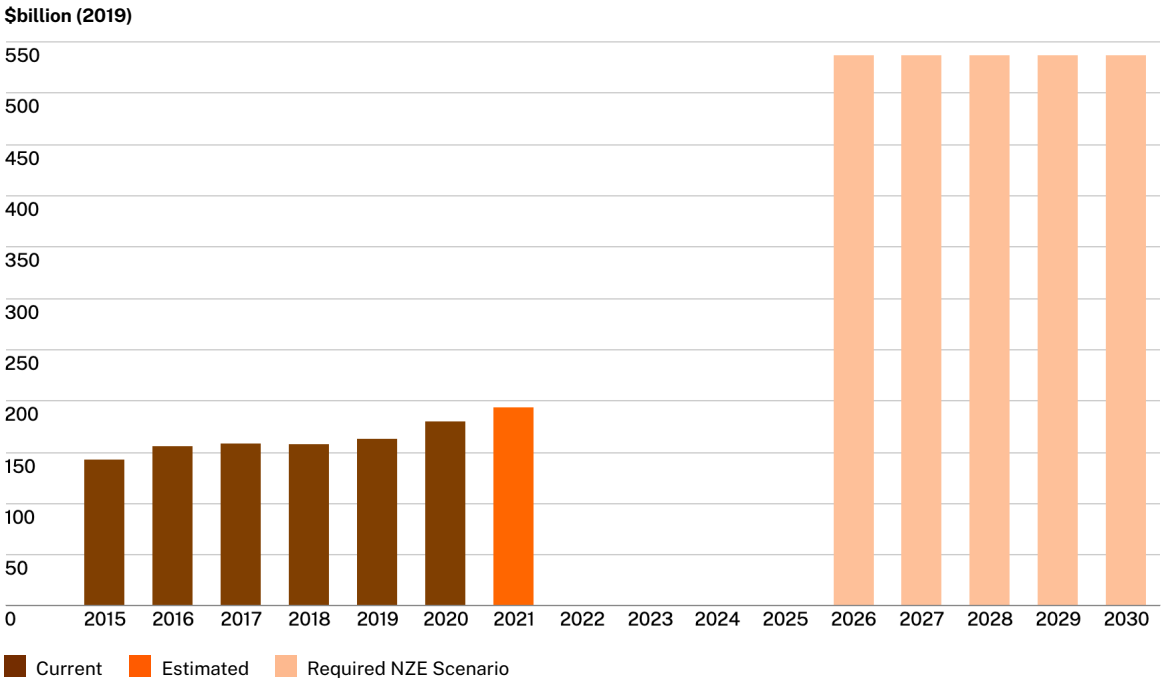
One additional problem relating to buildings needs to be tackled with haste. A rising proportion of their energy use comes from "plug loads" — the devices that tenants bring with them into buildings. The advent of always-on, internet-connected devices has created a huge vampire load on the electrical grid. Some progress has been made in requiring these devices to be as efficient as possible, and governments around the world need to join forces to keep toughening those rules. In addition, far more effort needs to be made to give buildings and the devices in them the ability to respond to conditions on the electrical grid. When the grid is short of power, smart devices could power themselves down, or could be set to turn off lights, turn thermostats up or down, or tell electric cars the best time to charge. Some research has found that electrical demand at peak times could be suppressed by as much as 20 percent through such methods, giving the grid a far greater ability to balance out fluctuations from wind or solar power.[3] But the necessary rules and technologies to make this happen at scale are still in the early stages; accelerating them is among the most imperative tasks for the years ahead.

3. Hledik, Ryan, Ahmad Faruqui, Tony Lee, John Higham: "The National Potential for Load Flexibility: Value and Market Potential Through 2030", The Brattle Group, June 2019.

Link ›

Figure 19: Energy efficiency investment in buildings



2026–2030 figures represent the annual investment required under IEA's Net Zero Scenario.

Source: International Energy Agency

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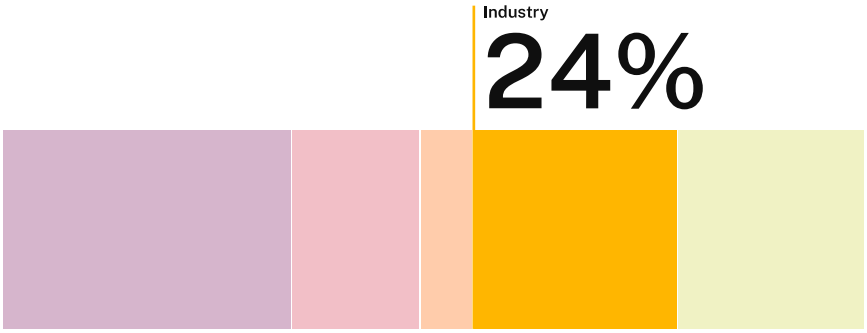
05

Industry



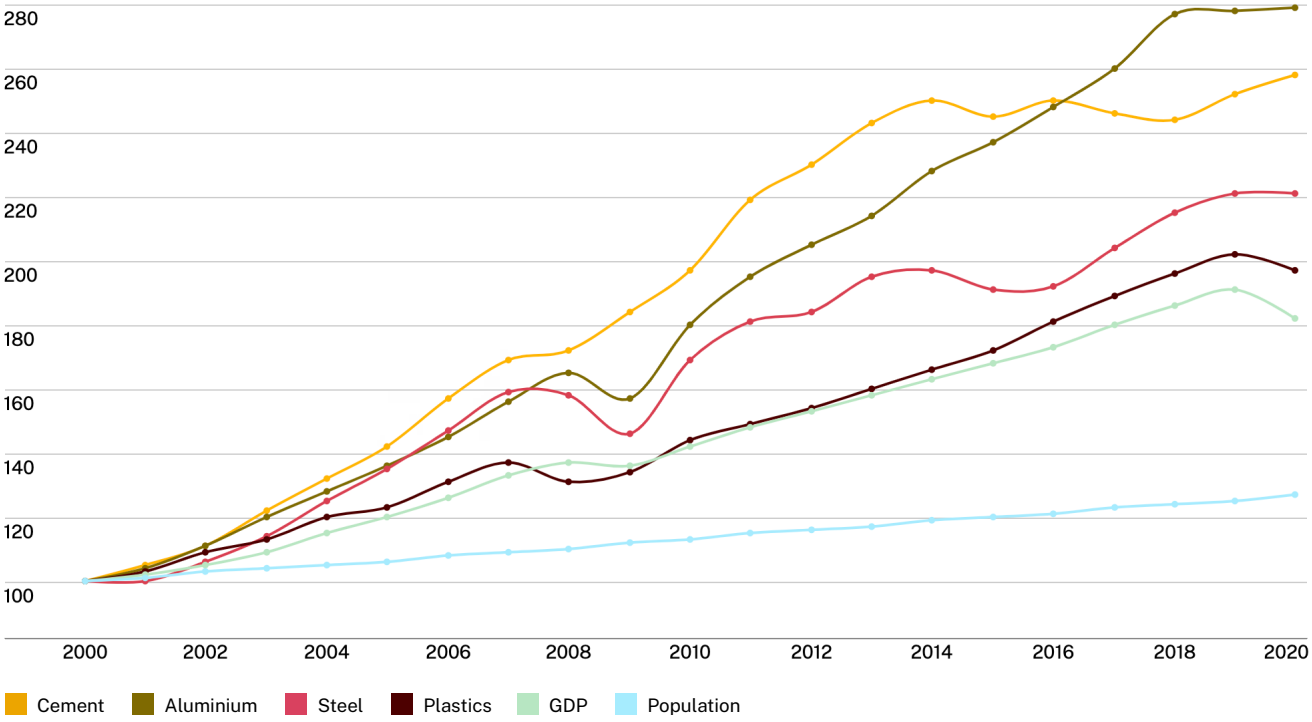
Share of global emissions (IPCC)

The building blocks of civilisation

Cement, iron and steel: these materials are the fundamental building blocks of modern society. Every building, every bridge, every car constructed in the world requires one or more of them. Hundreds of kilograms of them are produced every year for every person alive on the planet. And they are among the largest sources of greenhouse gases, together responsible for about 10 percent of carbon dioxide emissions. Industry as a whole is responsible for nearly a quarter of emissions.

Figure 20: Global demand for materials

Index, 2000 = 100



The chart shows that the global demand for materials has been rising much faster than the world's population — a reflection of rising living standards.

Source: International Energy Agency

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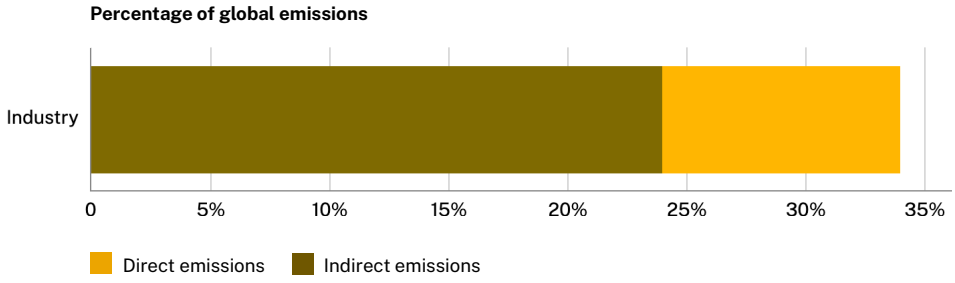
The production of iron, most of which is used to make steel, requires extreme heat in a blast furnace to convert iron ore to pure metal, and that heat is usually obtained by burning coking coal, with the resulting carbon dioxide dumped into the air. The bulk of the emissions from cement comes from the process of turning limestone (calcium carbonate) into clinker, the basic ingredient of Portland cement. The limestone is heated to the point that the carbon is driven off, again in the form of carbon dioxide. Portland cement is mixed with sand and rocks to form concrete, the world's most ubiquitous construction material.

Those are not the only emissions from global industry, of course. Manufacturing consumes a large fraction of the world's electricity, and is therefore indirectly responsible for substantial emissions from that sector. Industry also produces process emissions from activities like plastic and fertiliser production. Nitrogen fertiliser is essential to global food security, but it is also fossil gas by another name — its production depends entirely on using gas as a source of both hydrogen and process heat, with the waste carbon dioxide dumped into the air, amounting to more than 1 percent of global CO_2 emissions.

Figure 21: Direct emissions from Industry and indirect emissions from electricity and heat production



Source: IPCC

These sectors must be cleaned up, but the thinking about how to do it is still primitive. The clearest and most obvious pathways involve steel. Existing steel products can be recycled, and recycled steel supplies a significant share of the market in advanced economies. The recycling is done by means of electric-arc furnaces that melt the scrap back into liquid steel. The enormous power demands of these furnaces have historically been met by burning fossil fuels, but the power can be supplied with renewable energy. An immense solar farm has just been constructed next to one of the most important steel mills in the western United States, and other mills are known to be studying this approach.

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Evraz Rocky Mountain Steel, the largest electricity consumer in Colorado, is now getting much of its power from an immense solar farm next door. The farm was developed by Lightsource BP, half-owned by BP, the oil company.

Source: Jim West/Alamy

Recycled steel has significant limitations, however. It is always contaminated with copper and other metals, which renders it unsuitable for making many types of products. The search for a technical solution to this problem is underway, but none has been commercialised, and it may not be achievable at reasonable cost.[1] This could mean that economies are always likely to require some virgin steel, even after they come out of the high-growth phase of economic development.

Several possibilities exist for cleaning up the production of virgin steel. The one with the most momentum is to use green hydrogen, produced by electrolysis of water using renewable power, to displace fossil fuels in blast furnaces. A steel plant under construction in Sweden has already produced sample lots using this method, and it aims to bring fossil-free steel to full commercialisation in 2026. Some German steelmakers are also experimenting with green hydrogen. These early producers are finding buyers willing to pay a premium: the manufacturers of electric cars, for example, would like to market their products as made with fossil-free steel. It is as yet unclear, however, what green steel will ultimately cost to produce, or exactly how much of a market premium it will be able to command to offset the higher cost.

1. Gao, Zhijiang, et al: "Review of impurity removal methods in steel scrap recycling", The Journal of Solid Waste Technology and Management, November 1 2021.

Link ›

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The Hybrit fossil-free steel plant in Luleå, Sweden.

Image: Getty Images

Market signals needed

Accelerating the steel transition requires developing additional markets, and the same is true for industry more broadly. Right now, industries are getting almost no market signal telling them they have to make cleaner products. The majority of farmers are not yet demanding clean fertiliser, just as the majority of builders are not yet demanding clean cement. The market signals have been so weak for most industries that, for years, they barely budged on emissions targets, though the cement industry has recently put forward a plan to cut emissions 25 percent by 2030 and near to zero by 2050.[2]

The path forward is therefore to create a market demand for cleaner industrial products. Early steps in this direction have recently been taken. Much of the cement and steel in the world are bought by governments for large infrastructure projects like roads and bridges. California has adopted policies to begin requiring emissions reductions in bulk materials that it buys. This same type of demand signal, from both governments and large companies, is expected to spread around the world under a collaboration that was announced at the climate summit in Glasgow in 2021.[3] We hope that consumer-products companies, electronics manufacturers and others are studying these developments closely, and preparing to begin making their own demands, as the market starts to develop.

2. Harvey, Fiona: "Cement makers across world pledge large cut in emissions by 2030", The Guardian, October 12 2021.

Link ›

3. U.S. Department of State: "Launching the First Movers Coalition at the 2021 United Nations Climate Change Conference", Fact Sheet, November 4 2021.

Link ›

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For much of industry, the best technical path to cleaning up emissions is still unclear. Cement can be made with alternative chemistries featuring lower emissions, and although a few of these have come out, they have so far failed to make a significant dent in the market. It is possible that the only way to fully clean up the supply chain for cement will be to capture the carbon dioxide emissions emerging from cement plants and bury them underground, which would inevitably add significant costs in a low-margin industry. Getting any major development work done on the approach may therefore require some combination of government mandates and subsidies. The historical record on carbon capture is discouraging for advocates of this method: costs have barely declined, while early projects have seen enormous cost overruns and other failures. New methods of carbon capture are under development, however, offering some hope that a way forward can be found.

Another promising approach that may be useful in the near term is simply cutting the volume we use of these materials. Nearly all buildings are over-engineered; policies requiring that the “embedded emissions” of buildings be calculated and lowered may prompt developers to take a hard look at how much cement and steel they really need. Nitrogen fertiliser is over-applied in much of the world, and more judicious use could be made of it. We are still in the early days of public policies designed to cut single-use plastics, which not only create greenhouse emissions but are polluting the world’s oceans. As the market for green hydrogen develops, it could be used to displace fossil gas and cut emissions in the chemicals industry.

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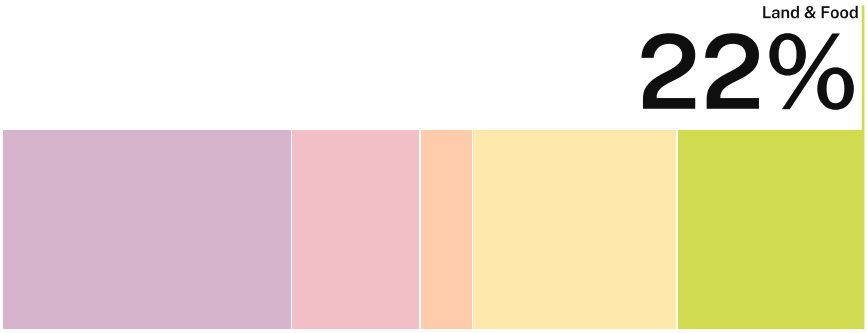
06

Land & Food



Share of global emissions (IPCC)

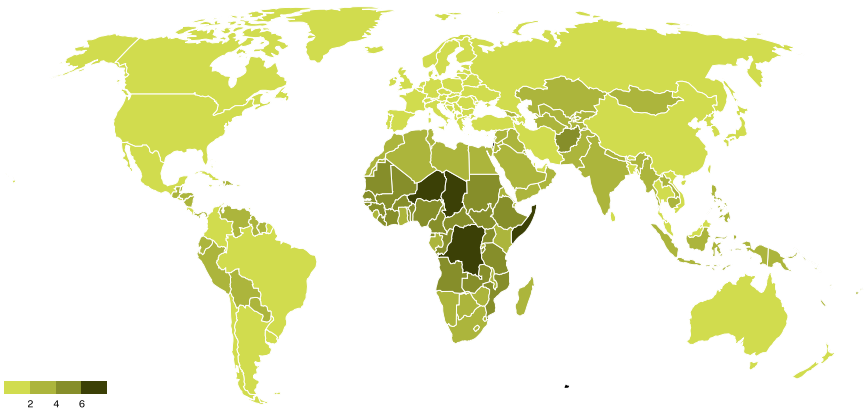
Can nature be saved?

The global population explosion of the 20th century continues to have a profound effect on the Earth and its environment. The United Nations forecasts that the world population will reach 8 billion on November 15 2022, and will continue rising to peak at 10.4 billion in the 2080s.[1] However, the rate of growth has slowed dramatically compared to the mid-20th century. The "demographic transition" — the shift from the high birth rates and high childhood death rates characteristic of premodern societies to a regime of low birth and death rates — is nearly complete. Only a few areas of the world, including parts of South Asia, some Middle Eastern countries and most of Africa south of the Sahara Desert, still exhibit high rates of population growth.

1. United Nations, World Population Prospects 2022, July 2022.

Link ›

Figure 22: Global fertility rates, 2021



Rates are children per woman. Replacement fertility is approximately 2.1 children per woman, so large parts of the world are now below this level.

Source: UN World Population Prospects

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The people responsible for most of the historical emissions leading to climate change — and certainly for the bulk of the *per capita* emissions — are the 1 billion or so people who live in the wealthy, developed countries. The United States alone, with less than 5 percent of the world population, is responsible for 20 percent of historical emissions, more than any other country.[2] Catching up fast on emissions are the residents of middle-income countries like China and India, where fossil-fuel use is booming as those countries climb out of poverty. India will shortly surpass China as the world's most populous country, but it appears to have both the ability and willingness to bring fertility down over the next decade or so in the country's remaining hotspots. Whether runaway global warming can be averted depends more on whether these countries can leapfrog to clean energy than it does on their population trajectories.

The population explosion has had its most profound influence on the course of climate change through the increase in the global demand for food. In the 19th and early 20th centuries, forests were chopped down across the Northern Hemisphere so that land could be converted to farming. This trend long ago ran its course as northern agriculture grew more intensive and efficient, and many of those northern forests are now regrowing, helping to soak up a significant fraction of humanity's carbon emissions.

The cycle is now playing out in the tropics, where deforestation is an acute problem, as Figure 23 shows. Three basins account for most of the world's tropical forests: the Amazon in Brazil and neighbouring countries, the Congo basin in Africa, and the islands of the Indonesian archipelago. Under previous governments, Brazil succeeded in cutting the deforestation rate in the Amazon, but the gains have been partially reversed under the far-right government of Jair Bolsonaro. Deforestation in Indonesia has been occurring at very high levels, with entire landscapes being denuded in order to plant palm-oil farms to supply the global market. Outside pressure has helped to bring it down somewhat. Much of the deforestation in the Congo basin was historically done by families gathering wood for subsistence cooking, but commercial deforestation there is rising. Among the coming stresses on the forest are new concessions for the production of oil and gas.[3]

2. Evans, Simon: "Analysis: Which countries are historically responsible for climate change?", Carbon Brief, October 5 2021.

Link ›

3. Maclean, Ruth and Dionne Searcey: "Congo to Auction Land to Oil Companies: 'Our Priority Is Not to Save the Planet'", The New York Times, July 24 2022.

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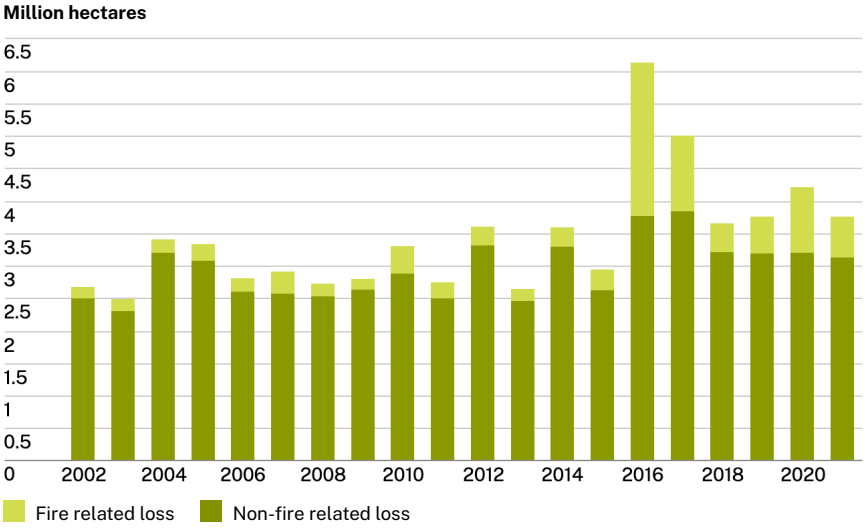
Figure 23: Tropical primary forest loss



Non-fire related loss can occur from mechanical clearing for agriculture and logging, as well as natural causes such as wind damage and river meandering. All figures are calculated with a 30 percent minimum tree cover canopy density.

Source: Global Forest Watch

Overall, global deforestation has been declining for the past several decades, with ups and downs.[4] It needs to stop immediately, not only to permit continued uptake of greenhouse gases, but to salvage what is left of the biological richness of life on Earth. (See "The Sixth Extinction" below for further discussion.)

4. For a detailed overview of forest loss and forest transitions, see Ritchie, Hannah and Max Roser: "Deforestation and Forest Loss", Our World in Data, 2021.

Link ›

THE SIXTH EXTINCTION

The world's biological richness is being lost at a frightening rate. This is a distinct problem from the climate crisis, and must be tackled with policies fit for purpose.

In the context of the climate crisis, the world's forests are often discussed and valued for their ability to absorb some of humanity's carbon pollution, helping to limit the risk of runaway global heating. But trees are much more than standing sticks of carbon. Forests are the primary habitat for many of the world's unique plants, fungi and creatures.

Thomas Lovejoy, an Amazon research scientist who died recently, was among the first people to use the term "biodiversity" in the 1980s. In the years since, it has become all too clear that an ongoing, catastrophic loss of that diversity is among the world's major environmental challenges. The world's hotspots of biodiversity, and therefore the places where the losses are most acute, are the tropical forests of Amazonia, the Congo Basin and Indonesia.

The pace of the losses is hard to characterise, since humanity has no clear fix on historical rates of extinction that can be used to compare with the modern rate. But as far as scientists can tell, species are now being lost hundreds of times faster than they were during relatively stable periods of Earth's history. There appears to be a real possibility that we have embarked upon the sixth great extinction of plants and animals in Earth's history, this one precipitated by human mismanagement of the environment.

A great deal of human activity contributes to this loss. The oceans are still being fished in ways that are wholly unsustainable. Water pollution and the spread of toxic chemicals into the environment appear to be major factors. But the biggest single issue is certainly the loss of habitat, due to human land clearance for agriculture. In short, we are wiping out creatures and plants by destroying the only places they can live.[5]

The effort to save the world's forests must be seen in this context. They are not just carbon sinks, and their salvation cannot be financed by pretending that forests are offsetting industrial emissions in the global North. The forests are worth saving for their own sake, and the citizens of rich countries ought to be willing to pay poor tropical countries to keep them intact.

5. For a detailed analysis of the human factors causing the extinction crisis, see Kolbert, Elizabeth: "The Sixth Extinction: An Unnatural History", Macmillan Publishers, 2015.

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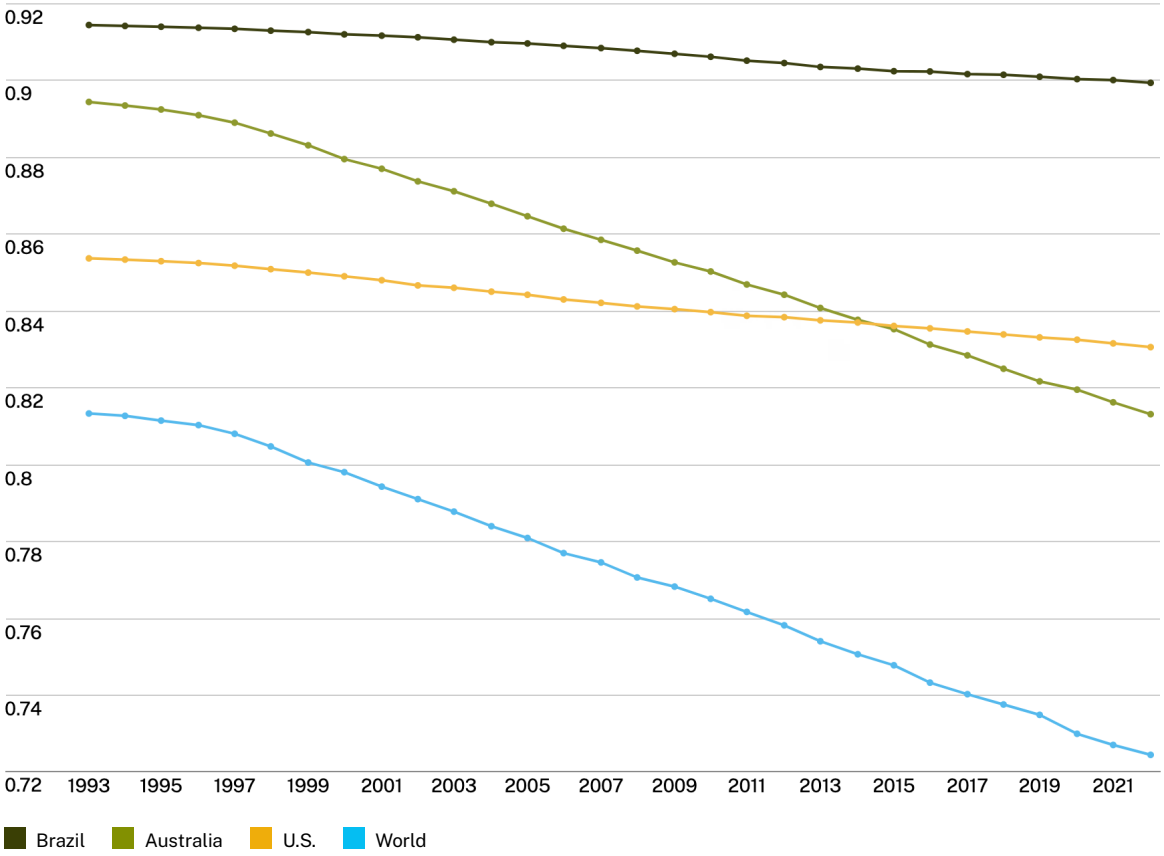
Figure 24: Red-list index (RLI) species diversity



An RLI value of 1.0 equates to all species qualifying as Least Concern (i.e., not expected to become extinct in the near future). An RLI value of 0 equates to all species having gone extinct.

Source: Our World in Data

At the heart of the continuing deforestation is a broken promise on the part of the rich world's governments. They know they ought to be willing to pay poor countries to preserve their forests, and indeed they have been promising to do so for decades. But they have never come up with a mechanism for raising money in the sums required: tens of billions of dollars per year.

The expansion of agriculture is a major reason forests are chopped down, but farming is a large contributor to climate change even when it occurs on land cleared long ago. It requires fossil fuels, it requires nitrogen fertiliser that can volatilise into a greenhouse gas, and methane emissions from activities like cattle-farming and rice-growing have an outsized effect on planetary warming in the near term.[6]

6. Note that methane and carbon dioxide operate on far different time scales. The half-life of methane in the atmosphere is about a decade, whereas some of the carbon dioxide emitted today is likely to remain in the atmosphere, heating the climate, for many hundreds of years. The other major greenhouse gases have their own distinct atmospheric lifetimes, creating considerable difficulty in comparing them. See Mooney, Chris: "Why we're still so incredibly confused about methane's role in global warming", The Washington Post, May 2 2016.

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The reason the population explosion of the 20th century did not result in mass starvation was the spread around the world of high-yielding methods of cultivation, a historical development known as the Green Revolution. Varieties of wheat, rice and other crops were developed that could benefit from heavy applications of nitrogen fertiliser, producing immense increases in yields.[7] Yet the Green Revolution had its downsides: excessive fertiliser use is a problem in many countries, including the United States and parts of Europe. It is most acute in China and India, where subsidised fertiliser is one of the legacies of the Green Revolution. These excessive quantities of fertiliser not only volatilise into a greenhouse gas; they also pollute streams and rivers. Hundreds of seasonal "dead zones" caused by fertiliser run-off now occur where rivers meet the sea.[8] Meanwhile, even as fertiliser is overused in the global North, too little of it is available in the global South, greatly suppressing crop yields there.

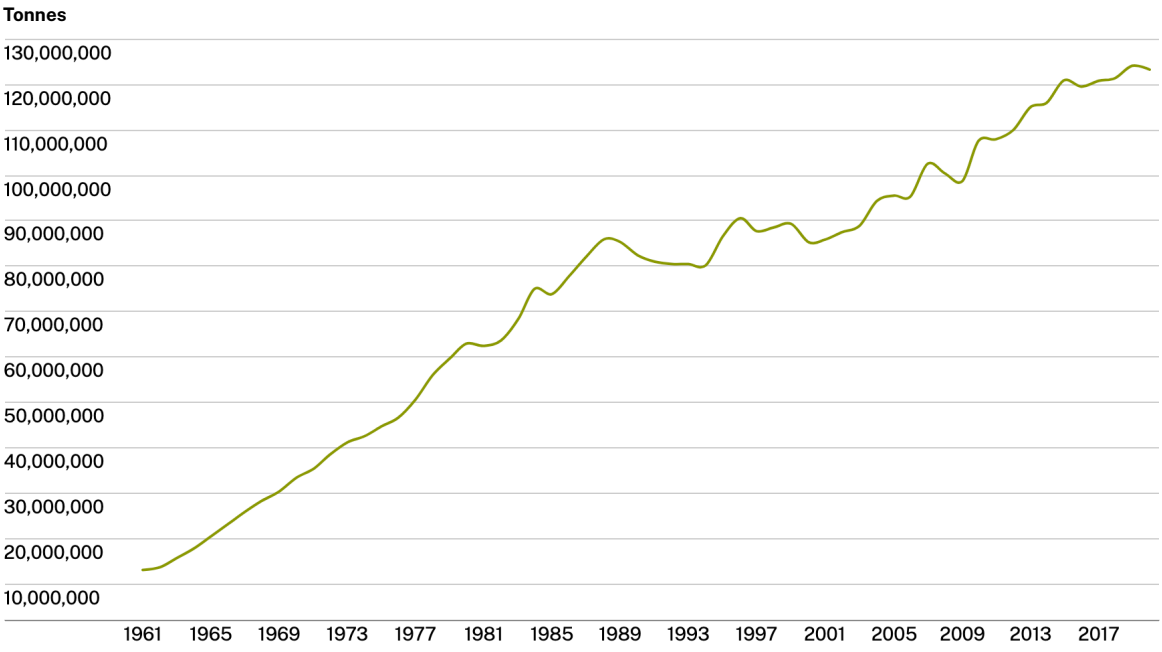
7. For a capsule history of the Green Revolution, see Gillis, Justin: "Norman Borlaug, plant scientist who fought famine, dies at 95", The New York Times, September 13 2009.

Link ›

8. The use of nitrogen pulled from the air and converted in factories into a reactive form is essential to global food security, but its environmental implications are profound. For a summary of the issues, see Smil, Vaclav: "Global population and the nitrogen cycle", Scientific American, July 1 1997.

Link ›

Figure 25: Global production of nitrogen fertiliser



Source: Food and Agriculture Organization of the United Nations

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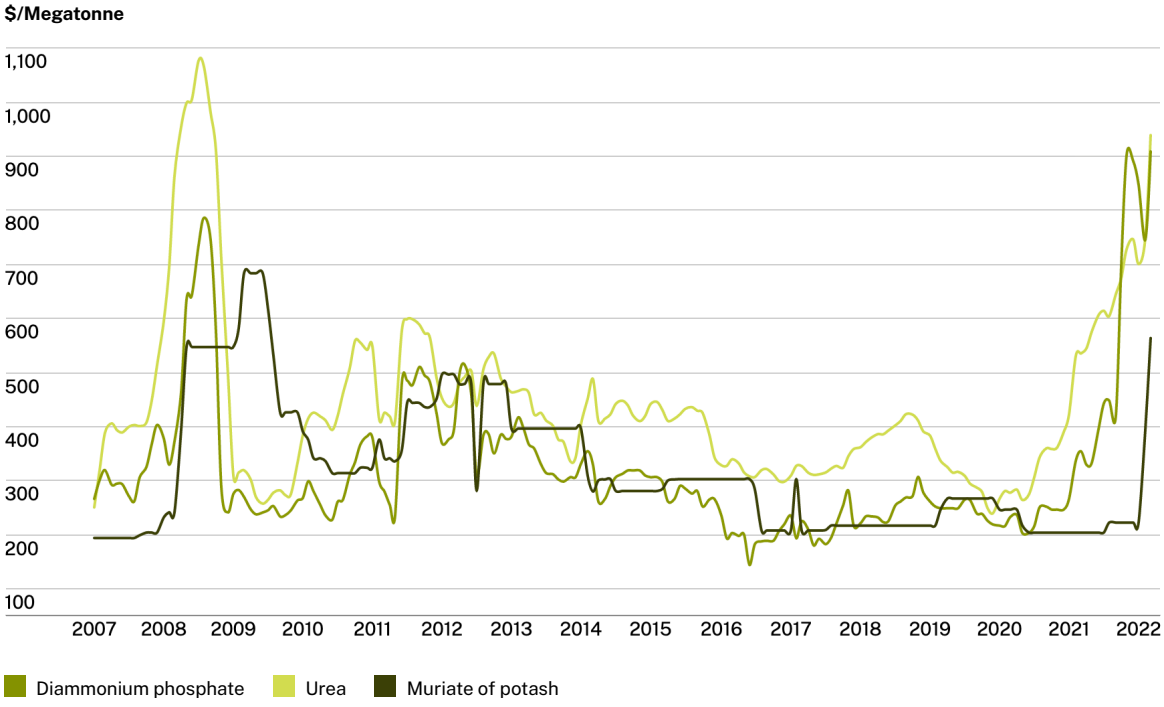
Figure 26: Fertiliser prices



Source: World Bank

A critical issue, one that governments have been reluctant to confront, is the rising worldwide demand for meat as more and more consumers move into the middle class. Meat consumption in rich regions like the United States and Europe is excessive, far beyond the protein levels required for adequate nutrition; if global consumption rises to such levels, the increase in emissions will be enormous. But it is not at all clear what public policies could hold back the rise in meat consumption in developing countries, or cut that consumption in the West, largely because governments have been so reluctant to experiment. A group of researchers at Oxford University has proposed a "meat tax" as one way to get at the problem.[9] A handful of countries, and the European Union, have begun discussions on the idea or announced tentative plans to move forward with special taxes for meat or meat and dairy products, though it appears the initial policies will be modest. The bright spot in this picture is that many countries are seeing a change in consumer preferences, away from beef in favour of chicken, which is still environmentally costly, but much less so than cattle production.

9. Funke, Franziska, et al: "Is meat too cheap? Towards optimal meat taxation", forthcoming in Review of Environmental Economics and Policy; retrieved on September 3 2022 as Working Paper 2022-01 of the Institute for New Economic Thinking at the Oxford Martin School, University of Oxford.

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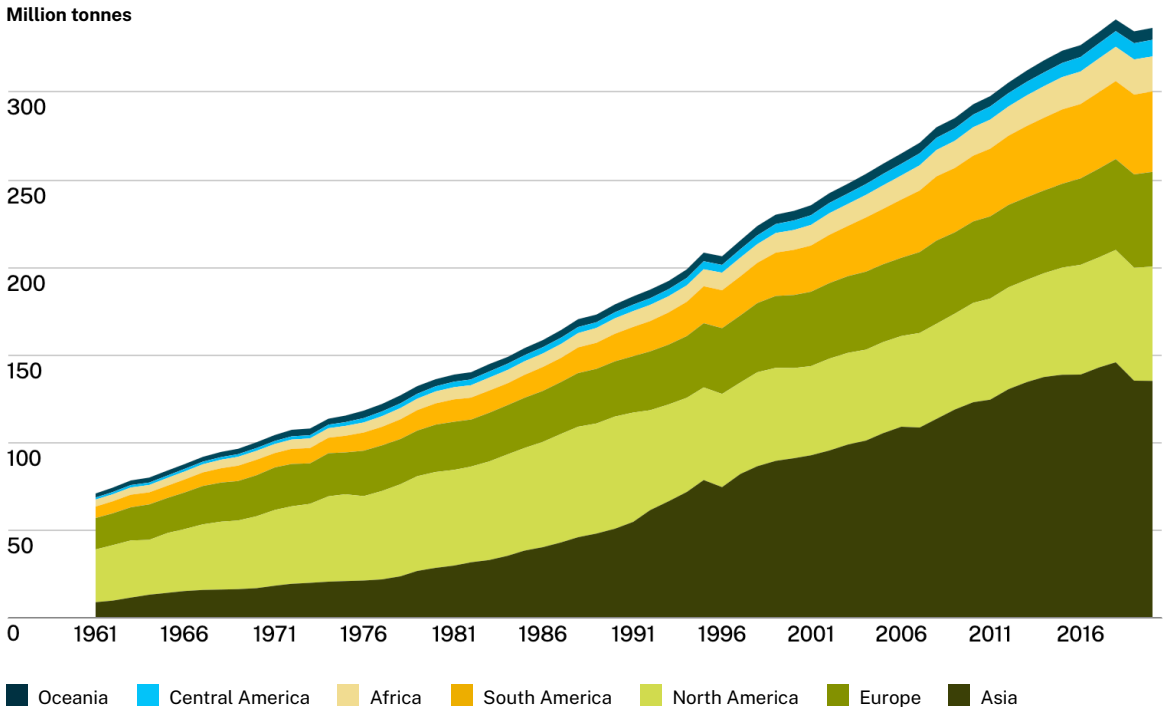
Figure 27: Global meat production



Source: Food and Agriculture Organization of the United Nations

Progress has been made developing plant-based meat substitutes that many consumers find appetizing, and this trend needs to continue. Over the horizon, it may become possible to grow actual meat tissue in bioreactors in an economical and environmentally benign way, creating a direct substitute for meat. However, little evidence has been published yet regarding such systems and how they would operate; it is unclear, in particular, what inputs would go into the bioreactors to be converted into proteins and fats in the meat cells. One scientific paper has warned that under certain circumstances, the production of meat in bioreactors could actually have worse environmental effects than farms growing beef cattle.[10] This newborn industry must subject itself to outside scrutiny and environmental benchmarking if it is to win public trust.

Confronting the many problems associated with modern agriculture, many people dream of replacing it with something entirely new. But the reality is that entire countries depend on intensive, modern food production for their existence. While we are unlikely to move entirely away from conventional food systems — they are certain to continue growing with rising populations — we can take important steps towards making agriculture more sustainable. We need an intensive global focus on the overall environmental performance of the food system, using methods like regenerative agriculture and sustainable intensification to produce more food with less damage to the wild lands that are left. They are priceless treasures that must be preserved.

10. Lynch, John and Raymond Pierrehumbert: "Climate impacts of cultured meat and beef cattle", Frontiers in Sustainable Food Systems, February 19 2019.

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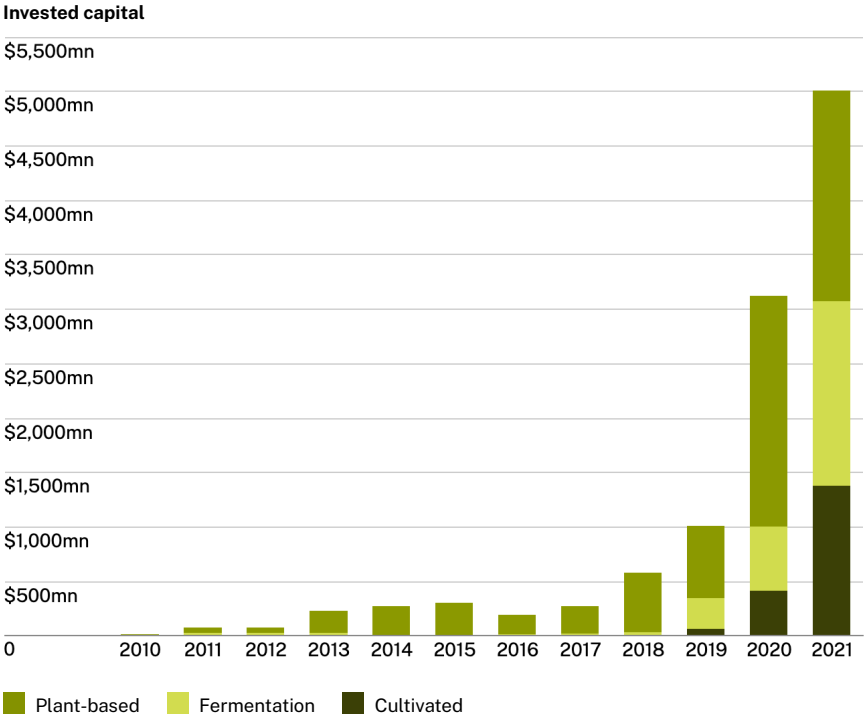
Figure 28: Alternative protein investment trend



Source: The Good Food Institute

Among the most promising opportunities of coming decades is to turn nature into a greater ally in the fight against global overheating. Trees and other plants already absorb some 30 percent of humanity's emissions of carbon dioxide.[11] Planting more trees across degraded lands and on the margins of agricultural land could have enormous benefits, though doing it at scale will require large amounts of money. Other potential interventions include managing soils in a way that they accumulate carbon, turning the land surface into a giant carbon sponge. That can be done with methods like planting cover crops, but it costs farmers more money than they see in immediate economic benefits, so it will likely be necessary to pay the farmers to manage their land differently.

11. Friedlingstein, Pierre, et al: "Global carbon budget 2021", Earth System Science Data, April 26 2022. Best estimates of all anthropogenic carbon fluxes are contained in Figure 2.

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Such nature-based solutions are already being turned into projects that create carbon "offsets", which are essentially certificates that are sold into a voluntary market of companies and people wanting to reduce their emissions. However, some of these offsetting programmes have received intensive scrutiny and criticism on the grounds that they promise more than they deliver, such as "saving" forests that would not have been cut down anyway.[12] One of the great challenges of our time is finding ways to steer more private money into these kinds of projects, while at the same time setting strong rules to guarantee their environmental integrity.

12. For one example of such scrutiny, see Elgin, Ben: "These trees are not what they seem", Bloomberg Green, December 9 2020.

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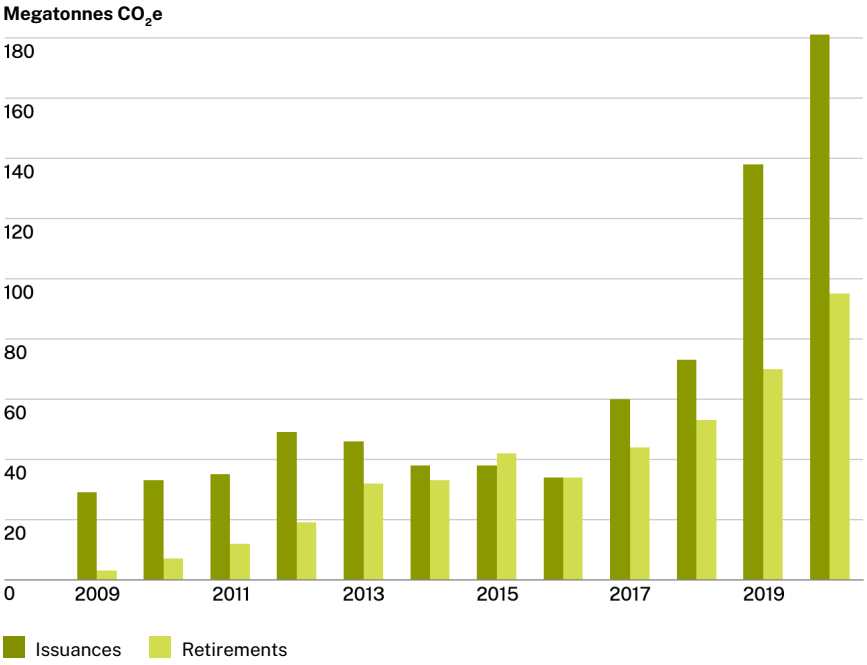
Figure 29: Growth in voluntary carbon markets



One carbon credit represents one ton of carbon dioxide equivalent (CO_2e) avoided or sequestered.

Source: Taskforce on Scaling Voluntary Carbon Markets

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07

Financing the Transition

Finding capital to save the planet

The transition to a world of low emissions poses a significant risk, as well as a huge opportunity, for everyone involved in deciding how to allocate capital in the economy.

For investors as well as for the public at large, climate change is no longer a problem of the future. Meeting the global goal of limiting warming to 1.5 degrees Celsius will require cutting emissions approximately in half by 2030, a mere eight years from now, and it will require that emissions fall nearly to zero by 2050.

Thus, decisions made by investors today will have a huge effect on whether these goals can be met. Unfortunately, climate action today remains undervalued. To address this, Generation expanded upon the familiar concept of the time value of money to consider the *time value of carbon*. The idea is that cuts in emissions that occur now are far more valuable to the world at large, and to individual companies, than promises of cuts in the future. The reason is that the remaining "carbon budget" — the amount that can be emitted while keeping global warming below the goals of 1.5 or 2 degrees Celsius — is rapidly being depleted. Putting off serious action now — that is, pushing all the hard work into the future — creates a risk that companies in the future will have to take wildly expensive steps to meet climate targets, if they can still be met at all.

Heading towards $1 trillion

Even though investment in the clean economy is still far from what will ultimately be needed, it is rising at a brisk clip. Bloomberg New Energy Finance calculated that in 2019, worldwide investments in clean energy and clean transport totalled $506 billion. The figure jumped by $89 billion in 2020, and again by $160 billion in 2021, to a total of $755 billion. The growth in clean transportation has been particularly impressive, with investment jumping 77 percent in a single year. A decade ago, clean transport was attracting essentially no investment; for 2021, the figure hit $273 billion.[1]

China is leading the world in clean-economy investments, spending $266 billion a year. The United States comes in second, spending $114 billion a year,

1. BloombergNEF: "Energy Transition Investment Trends 2022", Page 6.

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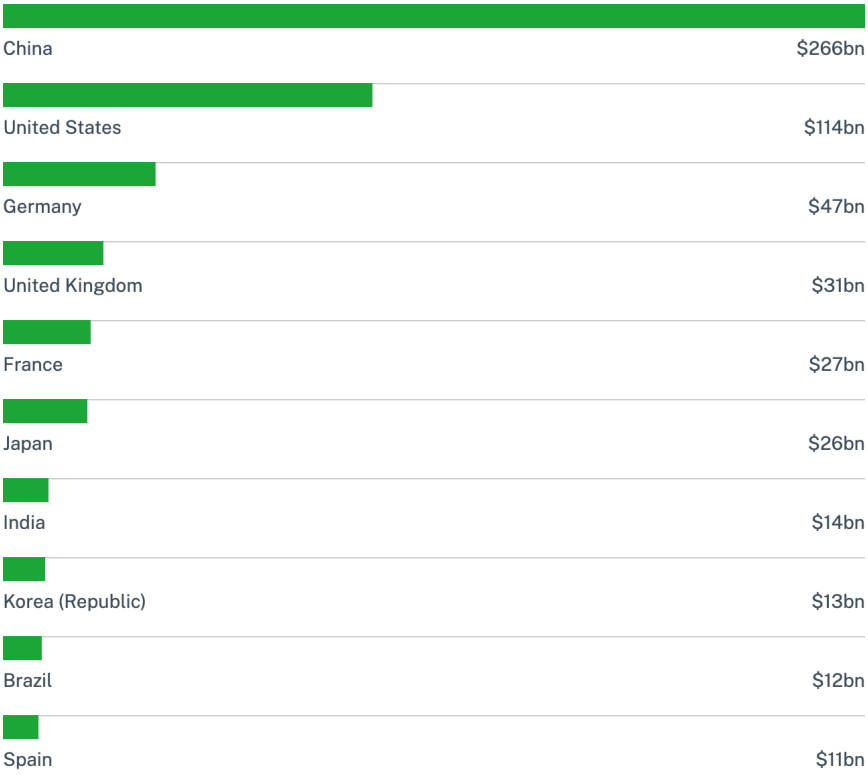
Figure 30: Global investment in energy transition by country, 2021



Source: BloombergNEF

less than half as much as China. Germany is a distant third, at $47 billion. Annual investment in the clean economy appears certain to exceed $1 trillion in the next few years. Yet that is not enough: to get on a path consistent with the 1.5-degree goal, BloombergNEF calculates that investment needs to reach $2 trillion by the middle of this decade, then double again by 2030.[2] Given the new climate bill in the United States and the new commitment to the energy transition in the European Union, investment in both regions should jump sharply, so that the BloombergNEF targets are not beyond the realm of plausibility. That company's calculations are not far off figures published by the International Energy Agency to meet the same temperature target.[3]

2. BloombergNEF: "Energy Transition Investment Trends 2022", Page 9.

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3. International Energy Agency: "World Energy Investment 2022", Page 25.

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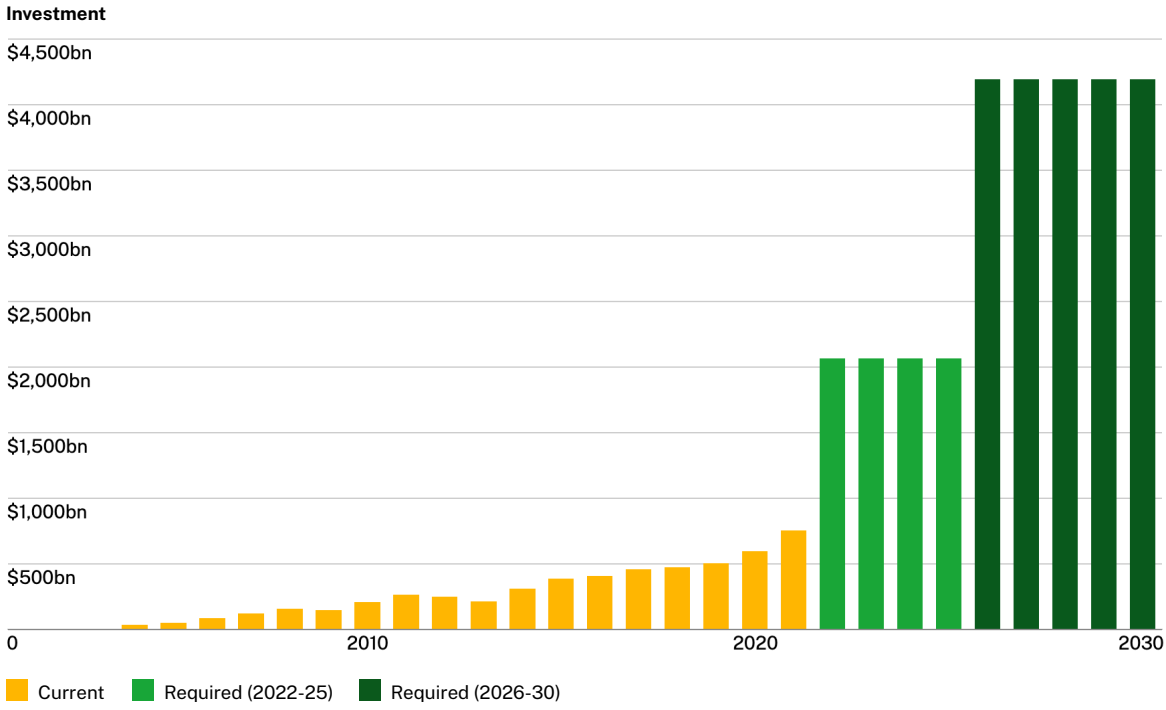
Figure 31: Global investment in climate solutions through 2021, compared to investments needed for a 1.5°C scenario



Source: BloombergNEF

All the wrong places

While the rising investment in the net-zero transition is encouraging, far too little money is going into solving the hardest problems. Instead, much of climate finance, public and private, is flowing into a narrow set of investable solutions whose business models have been proven. We call this the impact gap, with several sectors mentioned above — steel, cement, agriculture and others — still starved for the capital needed to develop more sustainable practices.

An additional issue is that, with the exception of China, these growing sums are being spent largely in the advanced economies. It is necessary for them to drive their emissions to zero, of course, but far from sufficient. Under current climate policies, future emissions growth in the developing world is expected to swamp declines in the rich countries, meaning total global emissions will continue to rise.

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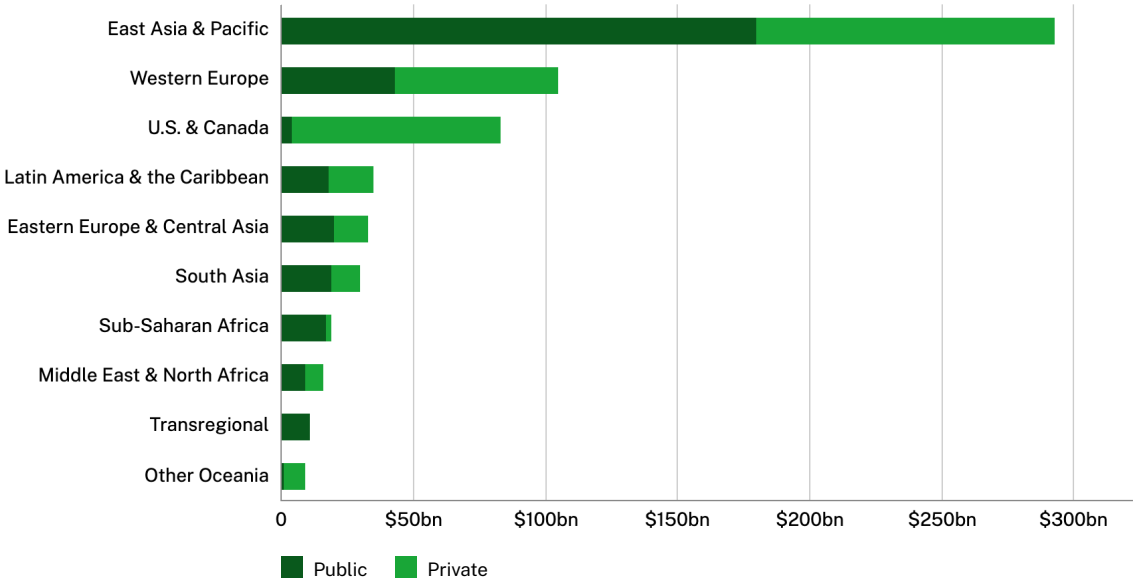
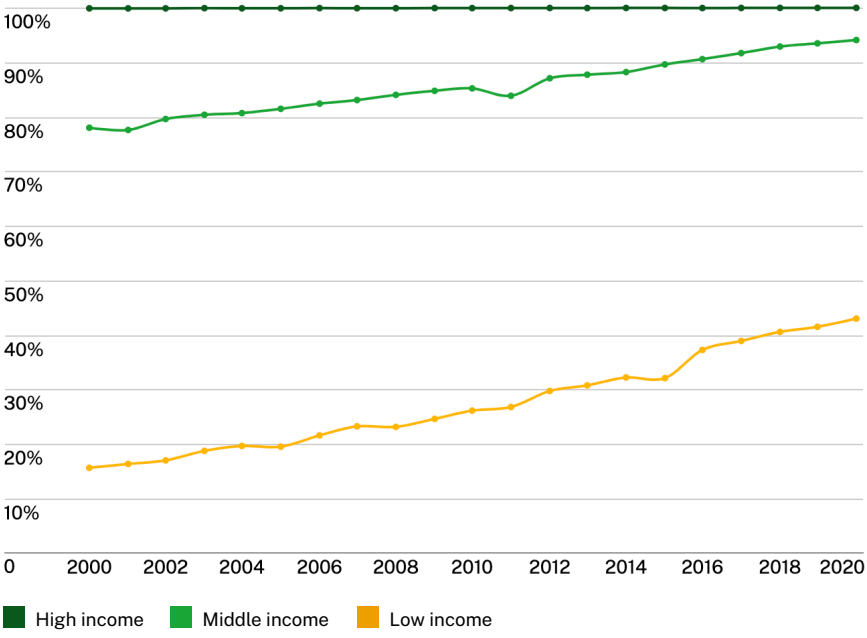
Figure 32: Destination region of climate finance, 2019/2020 annual average



Source: Climate Policy Initiative

This means there is an urgent need for a radical increase in climate finance flowing to the developing world. Some 800 million people in the world still lack access to electricity. Bringing power to them is among the highest priorities of their governments — and the world at large. If these countries are to skip the high-emissions phase of development and jump directly to clean energy, they need to be putting up wind farms, solar panels and grid-sized batteries at a fast clip. Yet they are struggling to do so.

Figure 33: Access to electricity (% of population)



Source: World Bank

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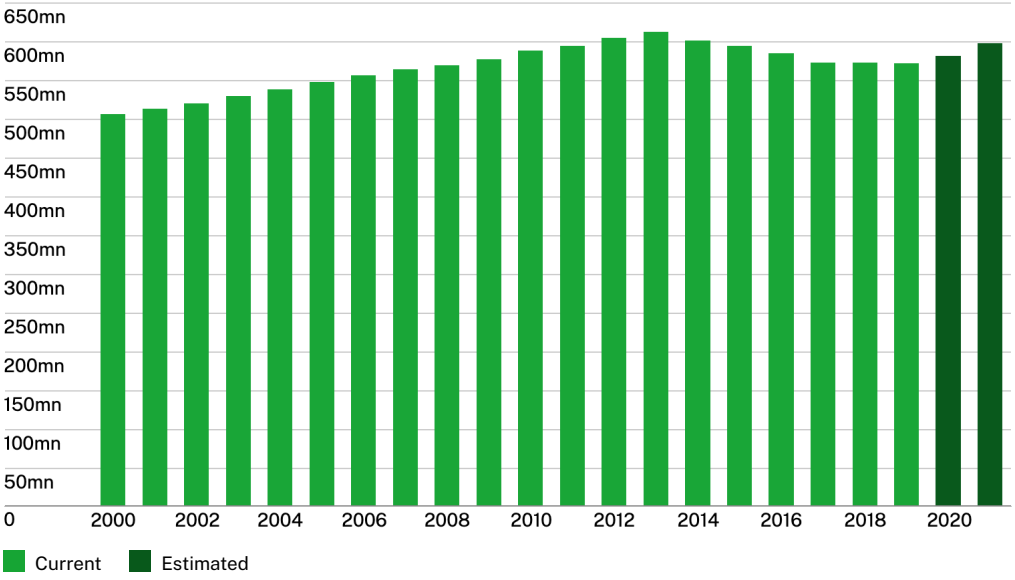
Figure 34: People without access to electricity in sub-Saharan Africa



Hundreds of millions of people still lack access to electricity, one of the world's most pressing moral problems. The number of deprived people had been declining, but ticked upward in recent years due to the COVID-19 pandemic. Planning of new grid connection projects slowed during the pandemic and 15 million sub-Saharan Africans who recently gained basic electricity access lost the ability to pay for it.

Source: International Energy Agency

A major reason is high interest rates for these kinds of projects in the developing world. Where wind or solar farms can be financed in the rich countries at something like four or five percent interest, the interest rates in poor countries are sometimes seven times greater. There are serious reasons for the gap, mainly a perception among investors that these assets are riskier in countries with unstable governments and currencies, high levels of corruption and a weak commitment to the rule of law. Yet the gap urgently needs closing.

Global development banks have an essential role to play in identifying and managing climate risks, including systemic risks, as well as accelerating the transition to a sustainable economy, including partnering with the private sector and mobilising much larger flows of climate finance. Net-zero banking should become the organising principle for central banks and development banks across the world.

In addition, natural climate solutions, including carbon sequestration in soils and forests, can and must play a large role in developing economies. However, the current state of thinking around carbon markets and other financial incentives to protect existing carbon sinks as well as encourage additional sequestration opportunities is underdeveloped — it is crucial that this is accelerated quickly while putting in place the appropriate guardrails to ensure environmental integrity.

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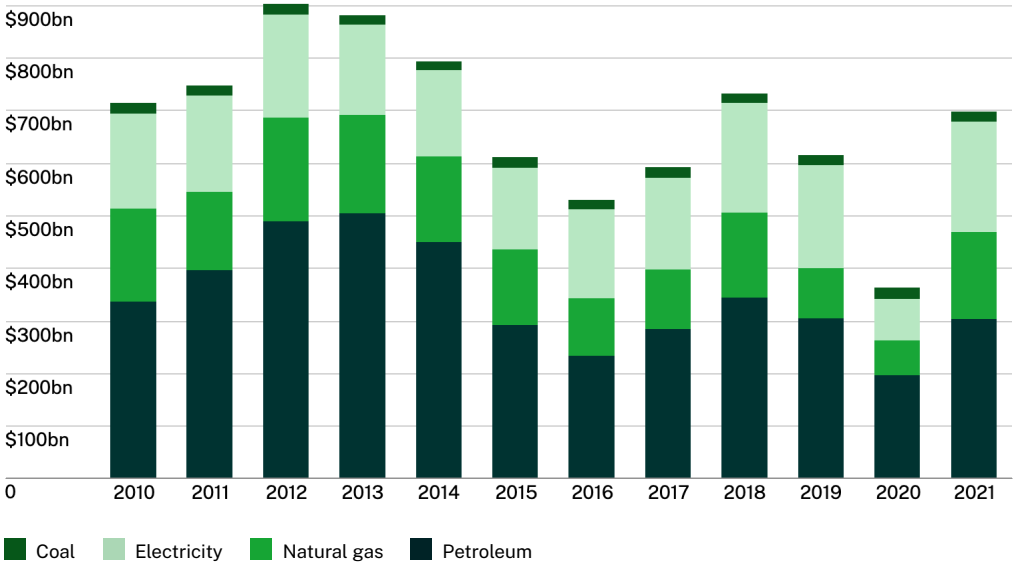
Anti-climate finance

Getting the economic incentives right requires another big step, mainly on the part of governments: an end to what could be called anti-climate finance. By that we mean subsidies for the production and consumption of fossil fuels. The fossil-fuel industry has received extensive government aid throughout its history. Today, in rich countries, the direct subsidies for fuel production are relatively small, but in some middle-income countries, governments have long spent enormous sums to subsidise prices for consumers. This is a volatile and sensitive issue: attempting to cut these subsidies often results in street protests or riots, and governments can and do fall if they try to cut too fast. Some progress had been made in reducing fuel subsidies, but that is rapidly being reversed due to the global energy crisis precipitated by the Ukraine war. Rich countries that had long eschewed consumer subsidies are now adopting them as the public faces soaring energy bills. In a joint report, the International Energy Agency and the Organization for Economic Cooperation and Development calculated that subsidies almost doubled in 2021, to nearly $700 billion per year. This short-term response to a crisis is understandable, but once the price situation begins to normalize, these new subsidies must be reversed and those of long standing must be wound down.

Figure 35: Fossil fuel support



Estimates of fossil fuel subsidies published jointly by the International Energy Agency and the Organization for Economic Cooperation and Development, covering 51 economies. Data are expressed in constant 2021 U.S. dollars; 2021 data are preliminary.

Source: OECD & International Energy Agency

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The opportunity

The urgency of the climate crisis requires entire sectors to be transformed: energy, agriculture and food, fishing and ocean protection, forestry, the built environment, mobility and transport and other carbon-intensive businesses such as chemical processing, metallurgy, cement and heavy manufacturing. In addition, industries not typically associated with climate change — like technology, healthcare, finance and investment management itself — will be materially affected as we decarbonise. This transition will be the most significant change in economic history. The sustainability revolution will be as far-reaching as the Industrial Revolution and could well match the speed of the digital revolution.

At the United Nations climate-change conference in 2021, investment firms with an astonishing $130 trillion of assets under management committed themselves to the net-zero transition.[4] That means they have pledged to press the companies in which they invest to get on track with global climate goals, and to use those same goals to guide which investments they make in the first place. To make good on those commitments, we need a system in which all financial institutions and allocators of capital integrate the climate emergency into their decisions across all classes of financial assets and all sectors of the economy.

4. Stein, Jeff: "Financial firms announce $130 trillion in commitments for climate transition, but practical questions loom", The Washington Post, November 3 2021.

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08

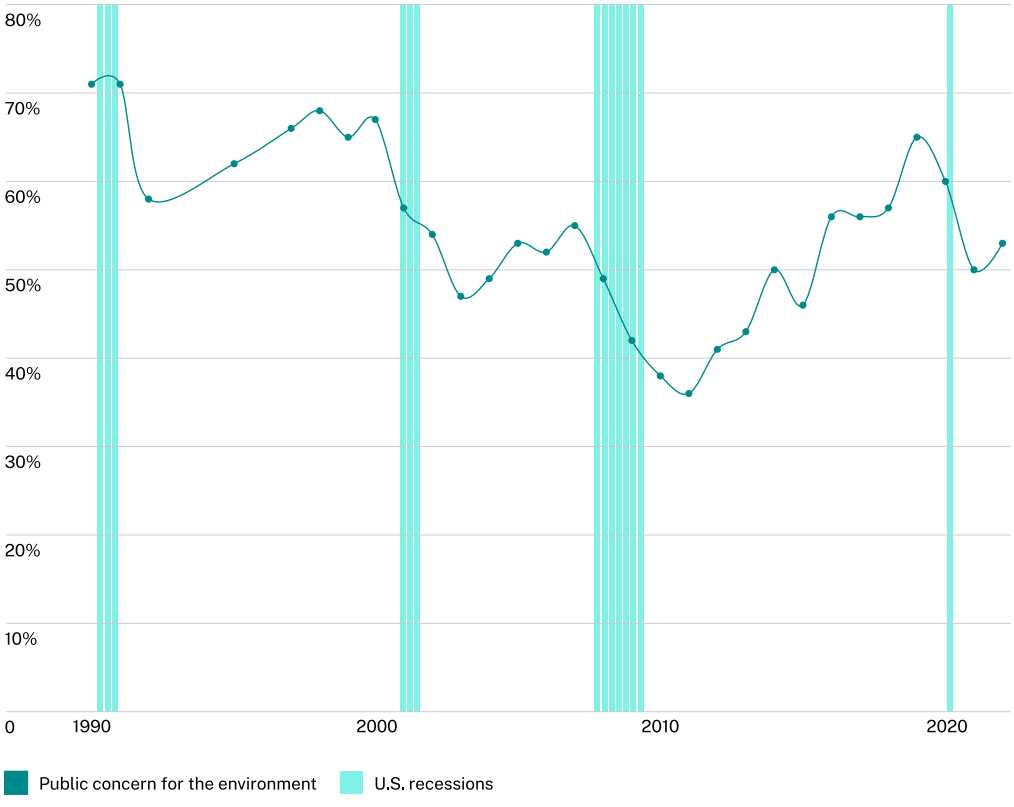
Looking Ahead

Political turbulence coming

The developments we highlighted at the beginning of this report are highly encouraging. The new climate law in the United States should put that country on track to reduce emissions roughly in line with the requirements of the Paris Agreement. The new European Union targets for 2030, motivated by an urgent desire to be free of Russian fossil fuels, also represent a large step forward.

But no one should harbour any illusions: these gains are fragile. They come, of course, after decades of slow action by the large emitting countries, so that there is no margin for further delay. The need to cut emissions is now beyond urgent, but in both Europe and the United States, the newfound commitments to doing so will come under attack, and will need to be defended in a difficult political environment. For decades it has been clear that public concern about the environment weakens in times of economic distress, and we have certainly entered such a period.

Figure 36: Environment vs economy in the public mind



In a long-running poll question in the United States, the Gallup organisation asks people to choose between environmental protection or economic growth as their highest priority. This chart shows the percentage of people putting environmental protection on top. Support for the environment tends to weaken in times of economic distress.

Source: Gallup, National Bureau of Economic Research

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The coronavirus pandemic, the subsequent supply-chain disruptions, and the Russian invasion of Ukraine have led to levels of price inflation not seen since the 1970s. Europe could well run out of gas this winter, and if supplies grow critically short, entire industries may be ordered to shut down so that households have heat. In the United States, where sensitivity to petrol prices is great, inflation has become an albatross around the neck of President Joe Biden. Over the summer, he was the least popular American president at that point in his term since Jimmy Carter, though a recent string of legislative victories has improved his standing in the polls.[1] Biden faces legislative elections in November that will determine whether the Democratic Party retains control of Congress. If the Republican Party takes over, it is likely to try to weaken or defund the new climate law.

Likewise in Europe, it is not clear how well the new climate targets will survive public distress over inflation. The wild run-up in gas prices has already sent governments scrambling for new supplies of gas, sometimes requiring them to sign contracts running for decades. A flood of investment money from Europe may flow into unlocking gas and oil reserves in Africa.[2] In principle, the current turmoil surrounding supplies of fossil fuels ought only to strengthen the political commitment in Europe to move away from them as rapidly as possible. But will it work that way in reality?

All of these questions have profound implications for investors, of course. Generation Investment Management remains as committed as ever to its founding principle of approaching the investment landscape through the lens of sustainability. As the coming year unfolds, we will be paying close attention to several issues:

- How does the political climate develop in response to the ongoing economic distress? We have seen a rise in right-wing populism around the world in response to recent economic hardship. The populists are rarely committed to climate action, and indeed are often committed to rolling it back.

- Do the fears of fuel shortages in Europe lead to a large new wave of investment in long-lived fossil-fuel assets, like gas pipelines? If that happens, it will make achieving the world's climate goals all the harder — or require that these new assets be shut down long before the end of their useful lives, creating a risk on the balance sheets of the companies and financiers behind these assets.

- Will the countries of the European Union move from rhetoric to action regarding their newly strengthened goals for clean energy? If we do not, within a year, see the beginning of a wave of new national laws designed to streamline the permitting of renewable-energy projects, we will know that this push has been bogged down.

1. "How Unpopular is Joe Biden?", FiveThirtyEight, retrieved September 3 2022.

Link ›

2. Munshi, Neil, Paul Burkhardt and William Clowes: "Europe's rush to buy Africa's natural gas draws cries of hypocrisy", Bloomberg, July 10 2022.

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- As emission cuts lag, we are increasingly worried about the risk of a disorderly transition away from fossil fuels. We have already seen episodes of disorderly capital flight, as when nearly the entire American coal industry went through bankruptcy reorganisation in the decade from 2010 to 2020. A rushed and disorderly transition, if it comes to that, will make risks hard to predict, assets hard to price, and could become chaotic enough to pose systemic risks to the economy and the financial system.

- Oil and gas companies are reaping bumper profits due to the high prices provoked by the Ukraine war. Many of them now claim to be committed to the energy transition, and these high profits give them a chance to prove it by stepping up their investments in green energy. Will they do so, or will they show their words to be empty by spending the money on share buybacks and stock dividends?

- Will we see fresh leadership from the World Bank, the International Monetary Fund, and other development banks to tackle the problem of creating a just transition for the world's poor people? Their intervention is badly needed to create a path for renewable-energy development in poor countries at reasonable interest rates, so that hundreds of millions of people gain access to clean electricity and modern energy services.

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Credits

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Gallup, National Bureau of Economic Research

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Critiques and errata notices are most welcome and can be sent to: str@generationim.com

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