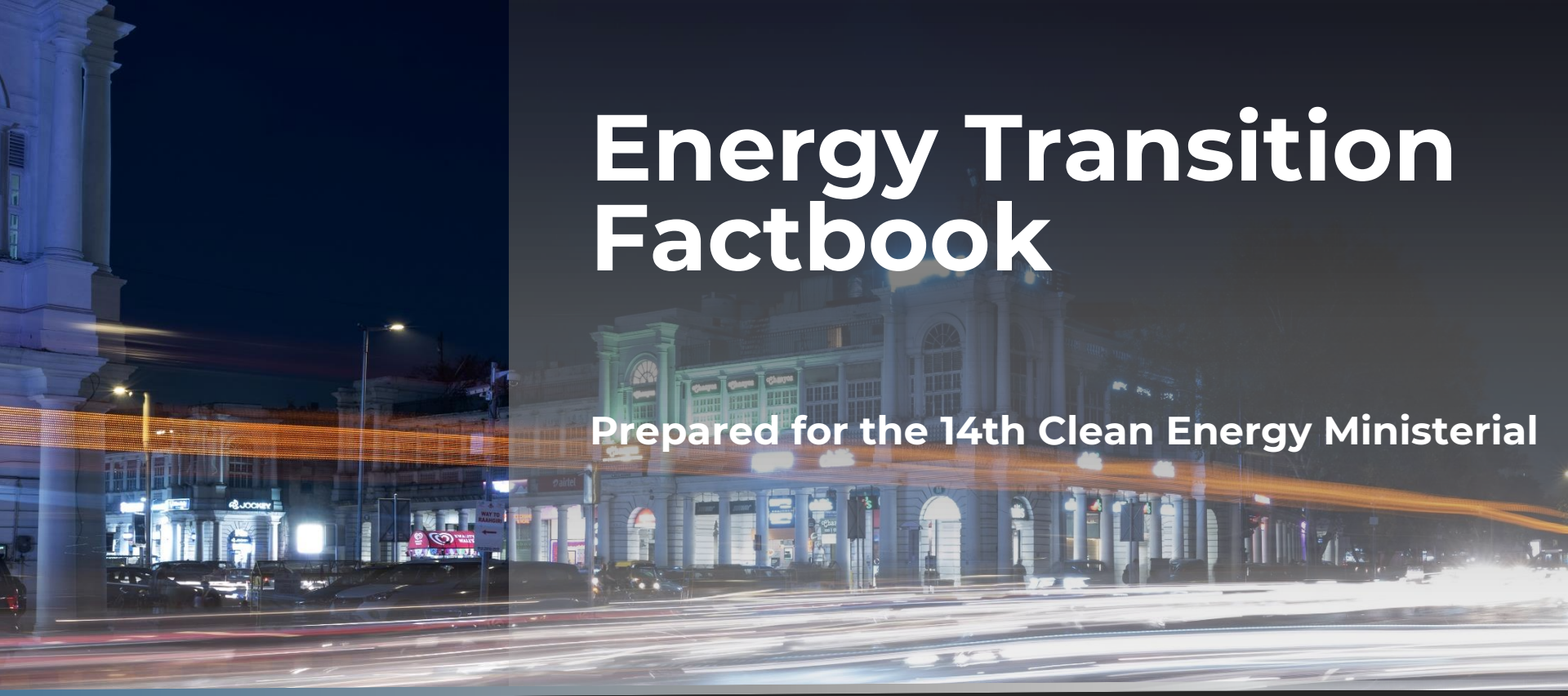


Energy Transition Factbook

Prepared for the 14th Clean Energy Ministerial

BloombergNEF

CLEAN ENERGY MINISTERIAL
Advancing Clean Energy Together

CEM-14/MI-8
INDIA 2023
ADVANCING CLEAN ENERGY TOGETHER

Cover letter

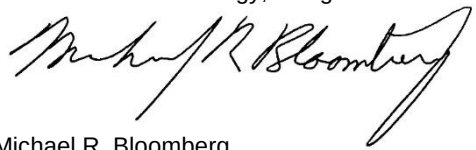
It is my pleasure to share with you the Energy Transition Factbook, which illustrates the critical progress the world is making in transitioning to net-zero emissions – and identifies key trends in the development and deployment of clean energy, including wind power, photovoltaics, electric vehicles, and technologies in earlier stages of development, such as hydrogen and sustainable aviation fuel.

There have been encouraging developments since last year's factbook. Global clean energy investment topped $1.1 trillion in 2022. Global electric vehicle sales exceeded 10 million in 2022 for the first time, and more than one in 10 cars sold today are fully electric or hybrid. The US began implementing the Inflation Reduction Act, the single largest financial commitment in its history to address climate change, which has helped to accelerate investment in new clean energy and EV manufacturing.

This progress has also been shaped by energy security concerns arising from Russia's invasion of Ukraine, since clean energy can allow nations to become more energy self-sufficient, while also driving economic growth and improving public health by reducing air pollution.

Much work remains, of course. Wealthy nations must do more to support developing nations in expanding access to clean, affordable energy. In some nations, market barriers remain prevalent, making it more difficult for businesses and consumers to move to cleaner fuels. But momentum is building toward a future powered by clean energy.

This factbook, using research from BloombergNEF and other sources, provides public and private sector leaders the critical information they need to accelerate the transition to clean energy, along with all the health and economic benefits it will bring.

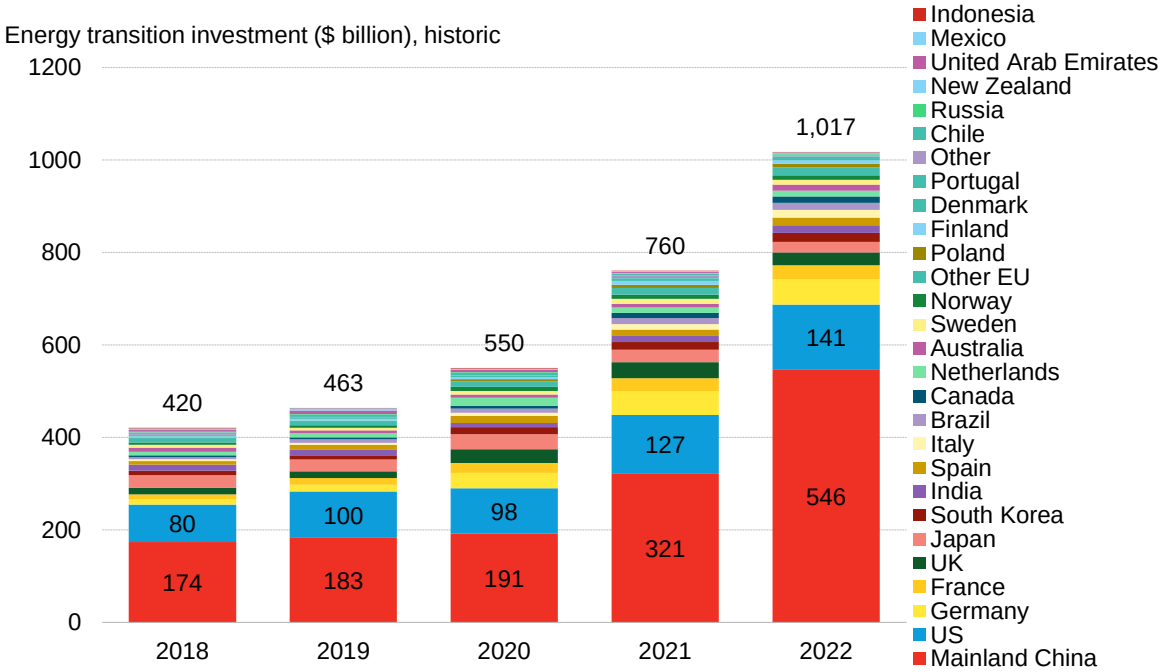


Michael R. Bloomberg

Founder, Bloomberg L.P.
Founder, Bloomberg Philanthropies
UN Secretary-General's Special Envoy for Climate Ambition and Solutions

Energy transition investment in CEM members surged to over $1 trillion in 2022

CEM members' annual energy transition investment



Source: BloombergNEF. Note: 'Other EU' includes European Commission members that do not hold individual CEM membership status.

Between them, Clean Energy Ministerial members, including the European Union, attracted $1 trillion in investment for energy transition technologies in 2022 – a new record.

This marked a 34% jump from the previous record of $760 billion, reached in 2021, and included major investment in renewables, power storage and electric vehicles. Collectively, the members again account for 91% of all energy transition investment worldwide.

Among individual CEM members, mainland China continues to attract the most investment, followed by the US and Germany.

Investment in mainland China spiked 70% year-on-year to $546 billion. Investment also jumped 11% in the US (to reach $141 billion) and 9% in Germany (to $55 billion).

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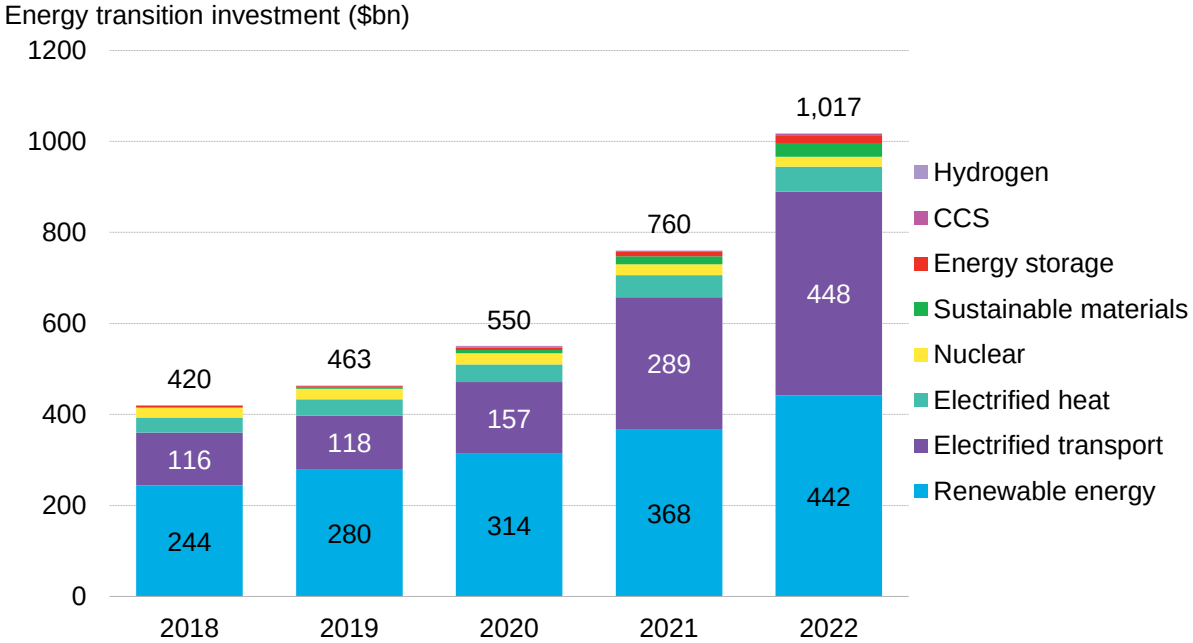
Nine in 10 dollars invested went to renewables or electrified transport

CEM members' annual energy transition investment



Investment in electrified transport in 2022 jumped more than 54% from the year prior, to $448 billion. Transport and renewables were nearly 90% of 2022 investment.

Surging investment in EV supply chains and growing purchases of EVs from consumers allowed the electrified transport segment surge. Investment jumped by $158 billion and global EV sales totaled over 10 million. Renewables was the second largest sector for investment in 2022, attracting $442 billion – 20% higher than the year prior. Expanded deployment of solar capacity remained the key driver of growth.

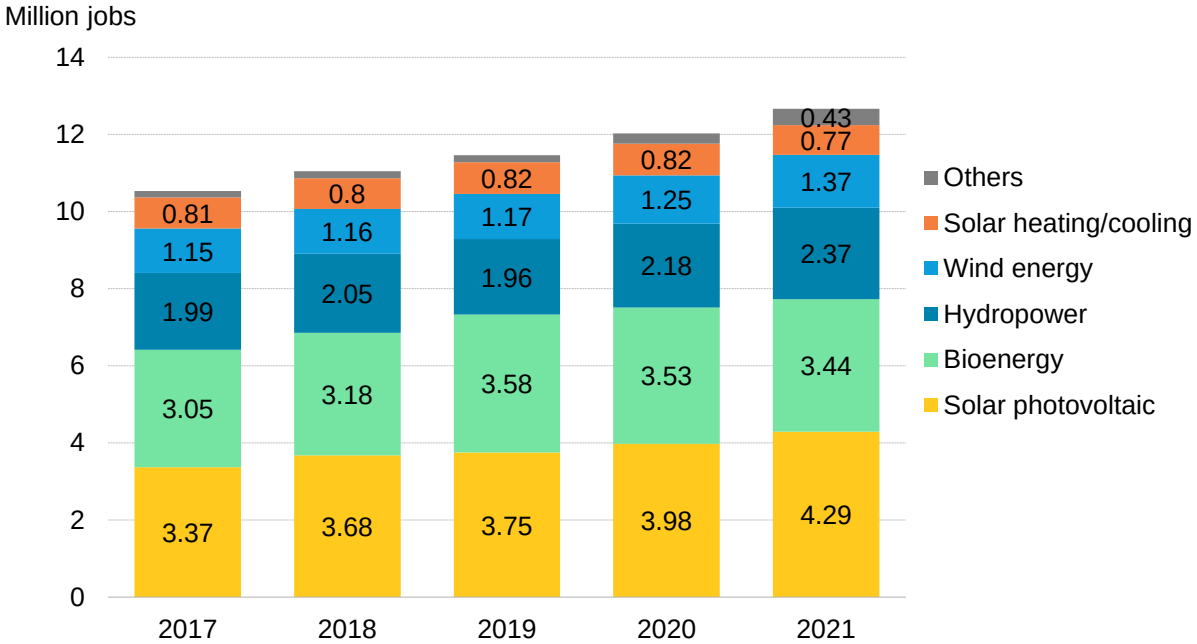
Other segments remain comparatively small but are growing swiftly.

Electrified heat, nuclear, energy storage, sustainable materials, CCS, and hydrogen investment continued to represent just over a tenth of total investment, with certain segments growing at particularly rapid clips. Hydrogen attracted $370 million, up from an estimated $100 million in 2021. Energy storage investment jumped by nearly half, to $15 billion.

Source: BloombergNEF, Marklines. Note: CCS refers to carbon capture and storage. Energy transition investment refers to money spent to deploy clean technologies such as clean energy, electric vehicles, heat pumps, hydrogen and carbon capture. Renewable energy refers to wind (on- and offshore), solar (large- and small-scale), biofuels, biomass and waste, marine, geothermal and small hydro.

Renewable energy now employs 12.7 million people around the world

Global renewable energy employment by technology



The renewable energy sector directly and indirectly employed 12.7 million people in 2021 (the last year for which there is complete data).

The energy transition's worldwide growth has resulted in substantial job creation. The rise in employment has largely been concentrated on the solar photovoltaic (PV), bioenergy and hydropower sub-sectors, which between them represent nearly 80% of all jobs created. Wind power represented another 11% of global renewable employment in 2021.

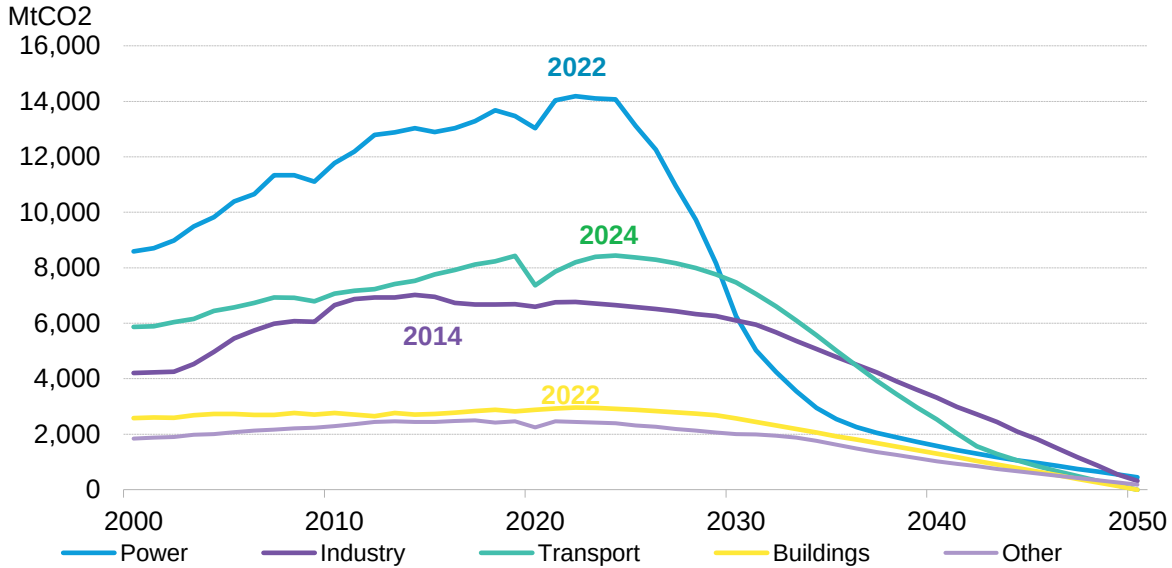
Renewable energy job creation has so far been highly concentrated in relatively few economies.

Mainland China accounted for nearly 40% of global renewables employment, followed by the European Union at 10%.

Source: IRENA Renewable Energy and Jobs Annual Review 2022. Notes: Bioenergy includes liquid biofuels, solid biomass and biogas. Hydropower includes direct jobs only. 'Others' includes geothermal energy, concentrated solar power, heat pumps (ground-based), municipal and industrial waste, and ocean energy.

Electricity and transport sector emissions may be ready to peak

Greenhouse gas emissions by sector and projected peak year under BloombergNEF's long-term Net Zero Scenario



Source: BloombergNEF. Note: Labels show year of peak emissions. 'Other' includes agriculture, forestry, fishing, the energy industry's own energy consumption, and other final energy consumption that is not further specified. MtCO2 stands for million metric tons of carbon dioxide.

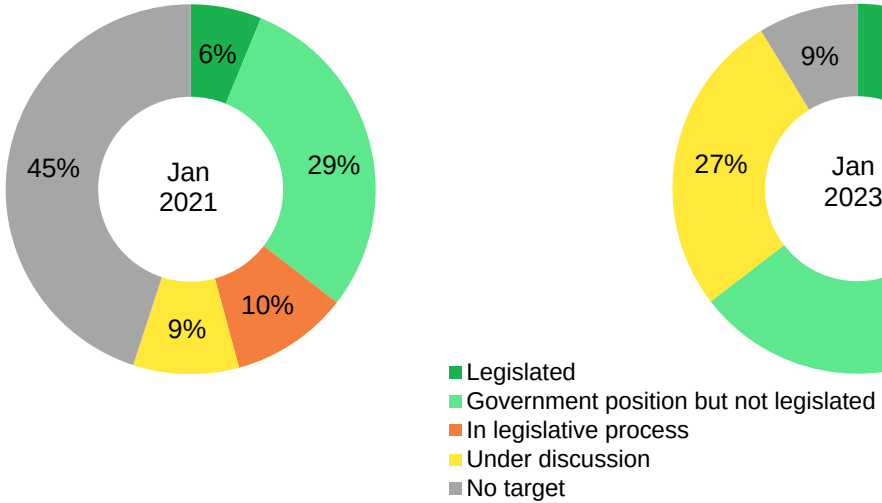
BloombergNEF has modeled multiple scenarios for how the energy transition may unfold over the next three decades. Under the Net Zero Scenario (NZS), global emissions start to fall in 2024 and reach net zero in 2050, consistent with the Paris Agreement goal of limiting global warming to 2C above pre-industrial levels.

In this scenario, the power sector leads the way, as deployment of renewables, nuclear, carbon capture and storage (CCS) and zero-carbon hydrogen all ramp up by 2030. Emissions from the transport sector follow a more gradual downward path, with emissions from cars, trucks, buses, planes and others peaking in 2024. Emissions from buildings will have already peaked in 2022 under the NZS, but their decline to zero will be slow. These trends highlight the need to invest in technologies today to address the 'hard-to-abate' sectors tomorrow.

Over 90% of CO2 emissions now occur in countries where some form of net-zero target is at least under discussion

January 2021

55% with a net-zero target at least in discussion



January 2023

91% with a net-zero target at least in discussion

National governments' commitments to reduce CO2 emissions have increased sharply in the last two years.

Around 91% of the world's population now lives in a country with some form of commitment to achieve net-zero emissions.

One sixth of the world's greenhouse gas emissions now take place in countries with legislated net-zero commitments on the books.

Another 48% of emissions occur where national governments have stated but not legislated net-zero targets.

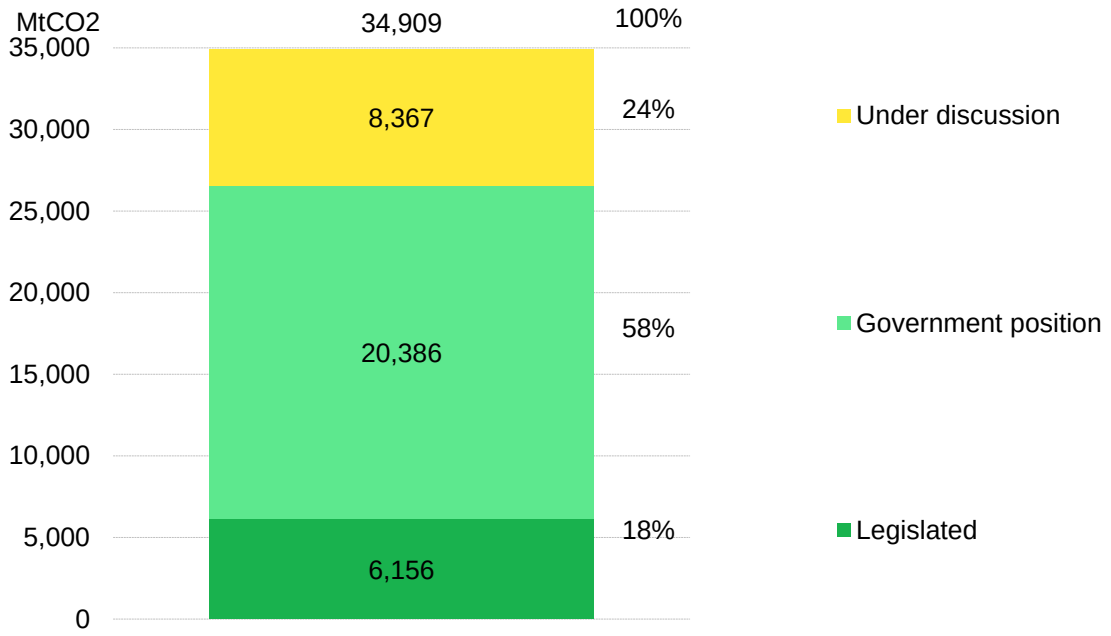
Commitments, as measured in greenhouse gas emissions covered, have nearly tripled in two and a half years.

In January 2020, 34% of global emissions were from nations either contemplating or enforcing net-zero targets. Yet only 2% were accounted for by countries with legally set targets. This latter share rose to 6% by the start of 2021 and is now 17%.

Source: BloombergNEF. Note: 'Under discussion' stage occurs when governments have begun concrete official discussions to implement a target.

CEM members' net-zero pledges encompass 76% of global emissions

Emissions from CEM members covered by net-zero targets



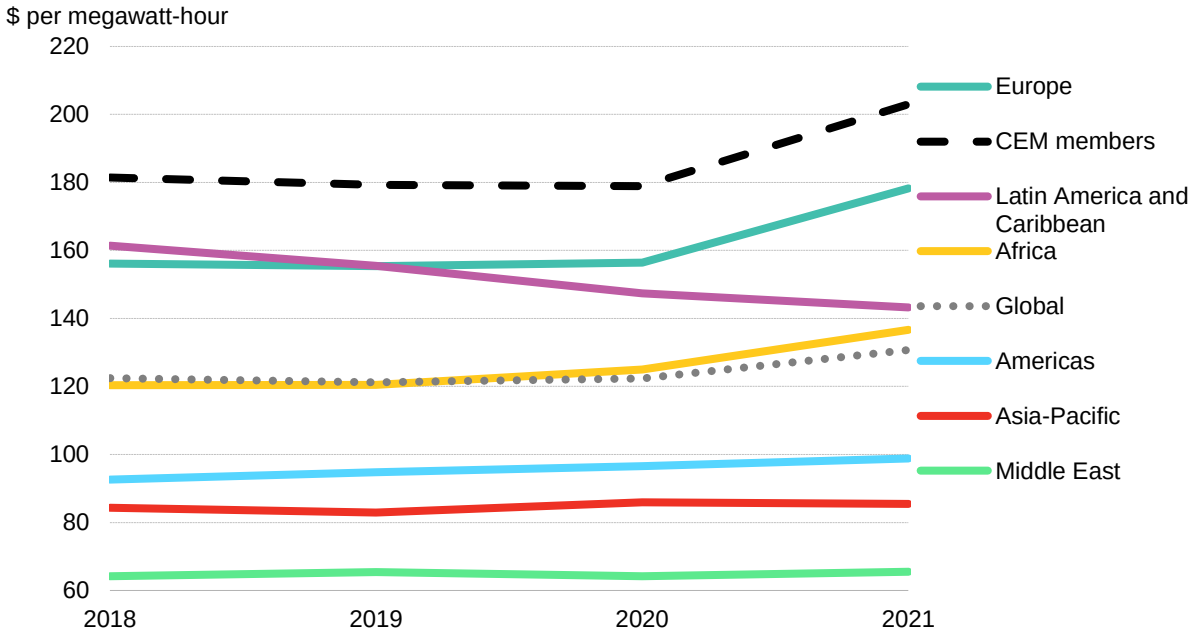
Between them, the members of the Clean Energy Ministerial have made long-term pledges to reach net-zero emissions that cover 76% of global emissions, or 34,909 million metric tons of CO2.

Almost one fifth of CEM members have legislated net-zero targets, while 58% have stated a governmental pledge and another 24% have a target under discussion.

Source: BloombergNEF and WRI CAIT. Note: Pledges as of year-end 2022. Uses 2019 data as baseline emissions. MtCO2 stands for million metric tons of carbon dioxide.

The global energy crisis has elevated power prices

Average electricity prices by region



Global average electricity tariffs rose 7% from 2020 to 2021.

As the COVID-19 receded, global power production jumped 5.6% in 2021, led by Asia. Power generation spiked to 27,300 terawatt-hours (TWh) from 25,800TWh to set a new high following three years of stable electricity demand. Undersupply connected to the rise in demand led to a general rise in power tariffs.

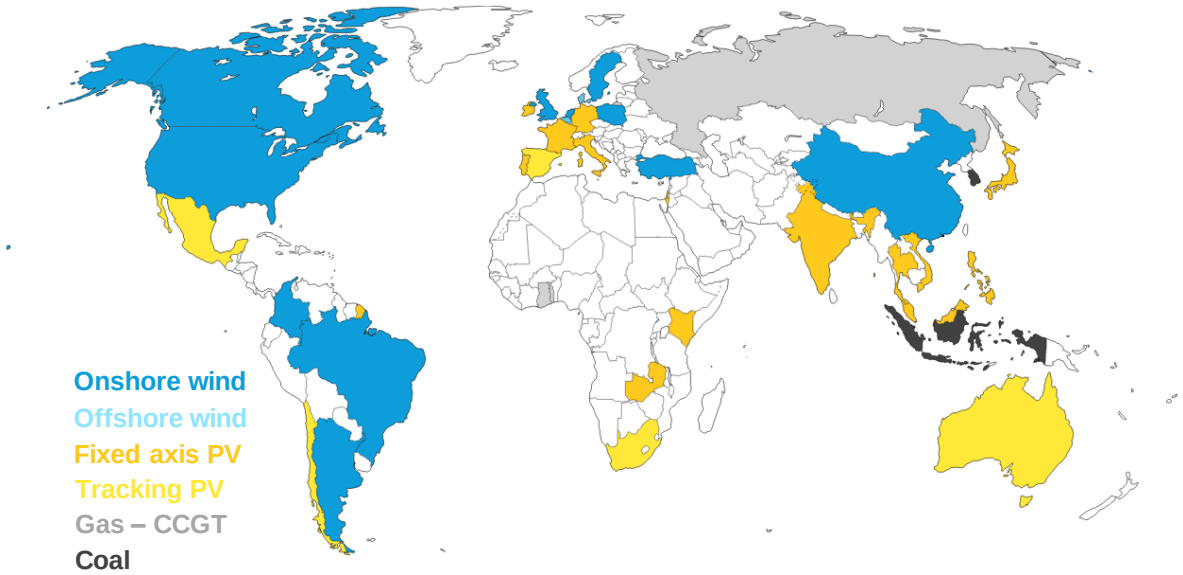
The average tariff paid in CEM members was nearly double the global average.

This largely reflected the sharp spike in power prices in Europe. Overall, tariffs jumped 13% year-on-year in CEM members in 2021.

Source: BloombergNEF. Note: Considers average residential, commercial, industrial and wholesale electricity rates. 'CEM members' considers rates from all CEM status countries and European Commission members.

Renewables are the cheapest power source where two-thirds of the world lives

Cheapest source of new bulk generation ($/megawatt-hour, levelized) by market, 1H 2023



Today, either wind or utility-scale solar is the cheapest source of new bulk electricity generation in economies accounting for 82% of power supply and 85% of global GDP.
Indonesia and South Korea are the only G-20 economies where renewables are not the cheapest form of generation.

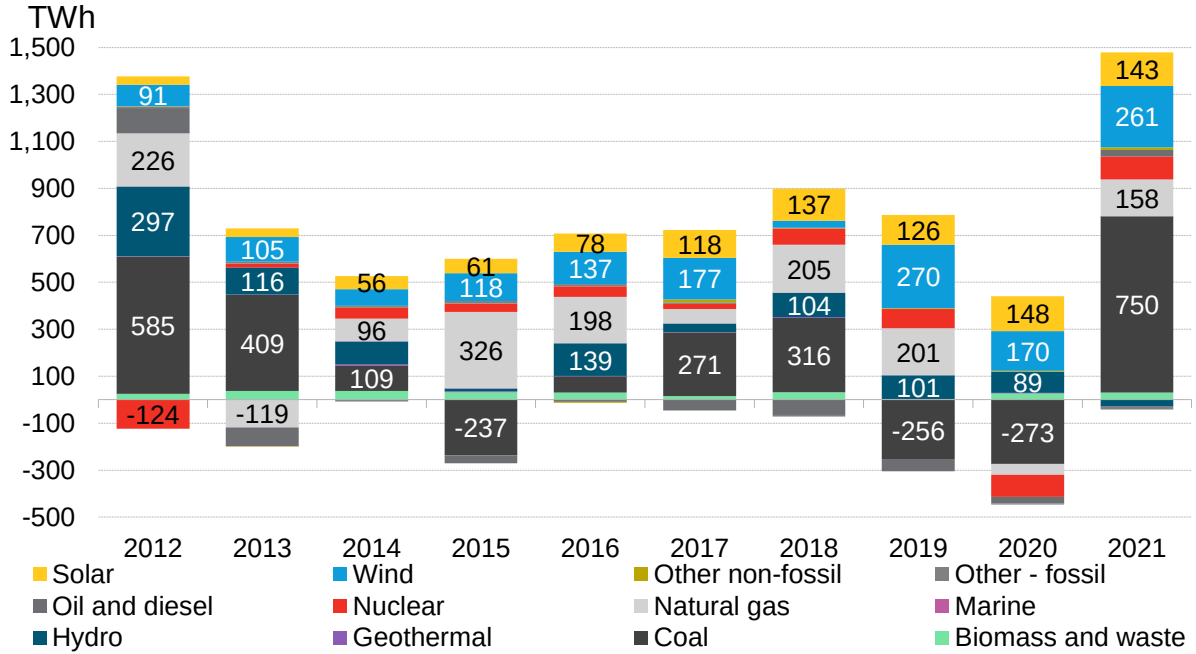
Renewable projects in mainland China deliver the lowest costs seen in the world.
The market is home to the cheapest fixed-axis solar ($39/MWh), onshore wind ($34/MWh) and offshore wind ($66/MWh), thanks to its strong manufacturing capabilities.

Solar and wind are expected to become the cheapest technologies by 2030.
We expect solar and wind to become the cheapest power technologies in the vast majority of G-20 economies no later than 2030 thanks to falling capex and improving efficiency of solar and wind.

*Source: BloombergNEF. Note: The map shows the technology with the lowest levelized cost of electricity (or auction bid for recent delivery) for new-build plants in each market where BNEF has data. LCOEs exclude subsidies, tax credits and grid connection costs, and include a carbon price where applicable. *We do not estimate LCOEs for Russia or Saudi Arabia. We assume that CCGTs are the cheapest new technology to build in Russia given low fuel costs and relative inexperience building renewables.*

Coal-fired power generation has bounced back as Covid-19 has receded

Global year-on-year generation change by technology



Source: BloombergNEF Power Transition Trends report

Global coal-fired power generation surged 750 terawatt-hours in 2021 from the year prior as the global economy began to recover from the effects of the Covid-19 pandemic.

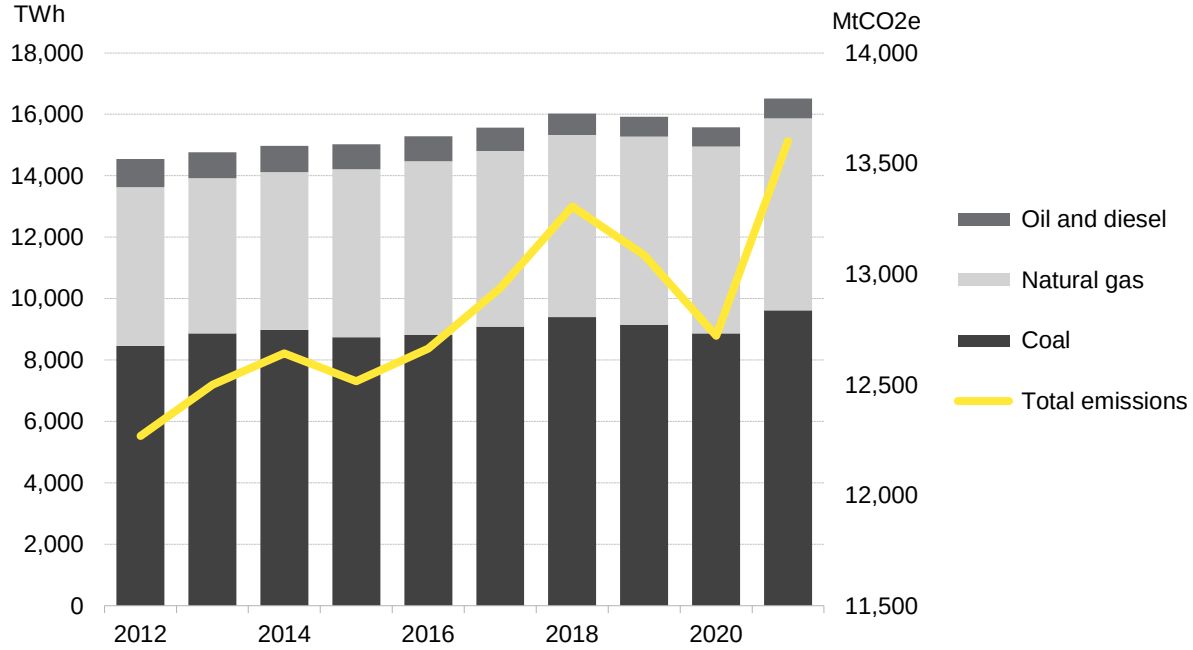
The rebound came after two years of decline, in part due to weaker overall electricity demand. In mainland China, the net change in coal-fired generation was up 395 terrawatt-hours (TWh). But it was hardly alone, as demand for coal-fired power also increased in India (up 153TWh) and the US (up 21.4TWh).

Wind and solar posted their biggest ever single-year growth in contribution to new generation.

Output from the two technologies jumped 404TWh year-on-year. Wind contributed an additional 261TWh to reach 1,864TWh, or 6.5% of all generation globally. Solar's contribution rose by 143TWh, crossing the 1,000TWh threshold for the first time to reach 3.7% of global generation.

Record demand and fossil-fuel burn propelled power-sector CO2 emissions to an all-time high

Global fossil fuel power generation vs. global emissions



Source: BloombergNEF Power Transition Trends report

As the global economy recovered from the pandemic in 2021, CO2 emissions from the power sector jumped 7% from the year prior to reach a new all-time high of 13,601 million metric tons of carbon dioxide equivalent (MtCO2e).

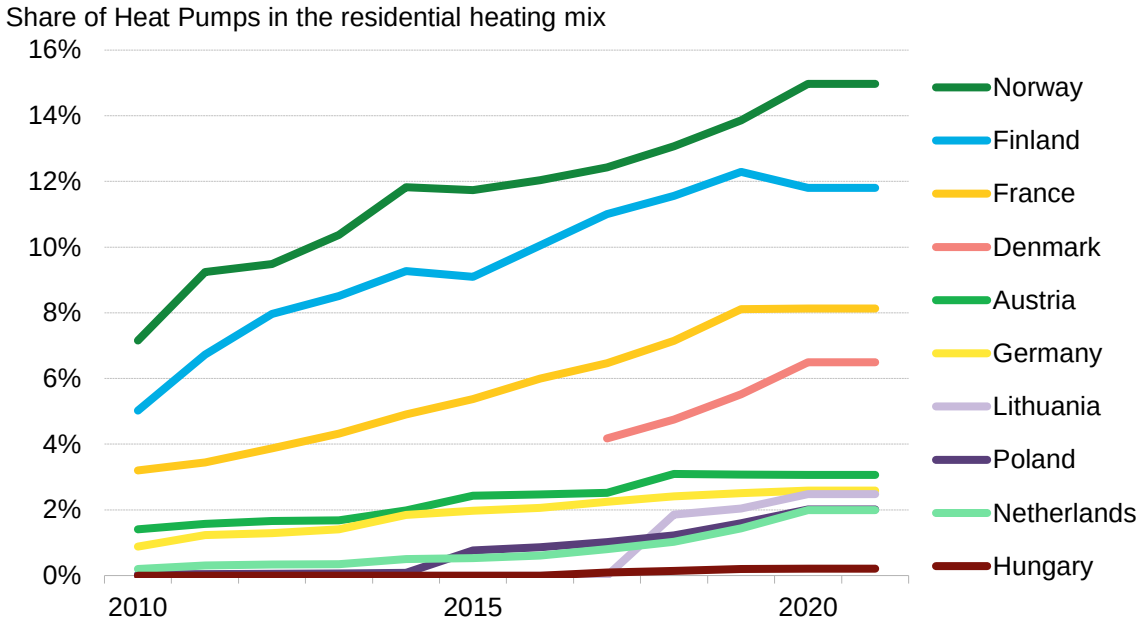
The total far surpassed the previous pre-pandemic high of 13,305MtCO2e, set in 2018, and came after declines in 2019 and 2020.

The jump was due to record volumes of generation from coal and natural gas in 2021.

Coal-fired electricity generation totaled 9,622 terawatt-hours (TWh), far exceeding the previous high of 9,401TWh set in 2018. Natural gas combustion also reached a record of 6,2423TWh in 2021, surpassing the previous peak of 6,131TWh set in 2019. Even oil combustion for electricity generation increased to 646TWh in 2021, although it remains far below the recent peak of 924TWh in 2012.

Energy security concerns are speeding residential heat pump adoption

Top 10 countries by heat pump share of total heating



As energy concerns continue to grow, particularly in western Europe, interest in finding ways to generate heat using electricity has surged.

BNEF tracked $53 billion invested in electrified heat in 2021, up 10.5% from the year prior. Across Europe, the US and elsewhere, residential heat pump sales hit 6.4 million units. This was almost 50% higher than in 2017.

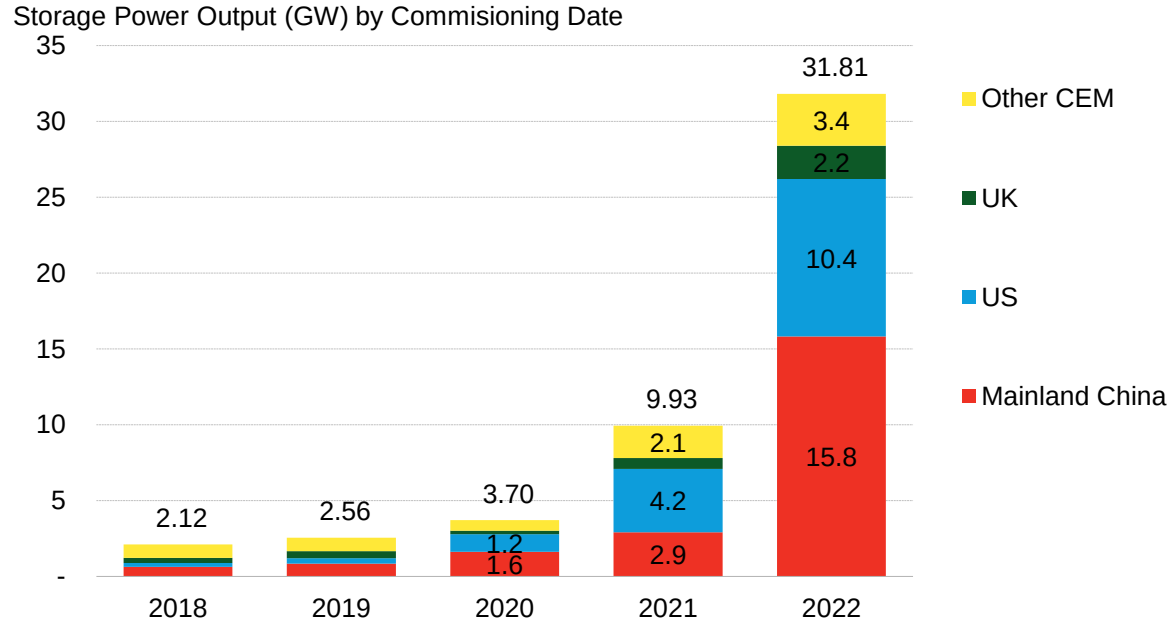
Heat pump uptake usually leads to reduced energy consumption as a heat pump produces two to three times more heat than traditional electric heaters using the same amount of electricity.

In very cold countries, such as Canada, the more expensive ground-source heat pumps work better but have yet to gain wide popularity. The International Energy Agency (IEA) projects in one of its scenarios that 55% of all heating could come from heat pumps in 2050.

Source: BloombergNEF, IEA. Note: Share is calculated on the % of final energy consumption for total heating. Includes residential heating only.

Battery deployments more than tripled in CEM members in 2022

Annual newly commissioned utility-scale battery storage capacity in CEM members



Source: BloombergNEF. Note: 'Other CEM' includes other CEM members and the European Union. GW stands for gigawatts.

Over 31 gigawatts of new battery storage capacity was added to grids in Clean Energy Ministerial members in 2022, up from 9.7 gigawatts added in 2022.

The rapid growth highlights the importance of storage for global grids, particularly as renewable energy penetration rates rise.

Mainland China accounted for just over half of the overall market.

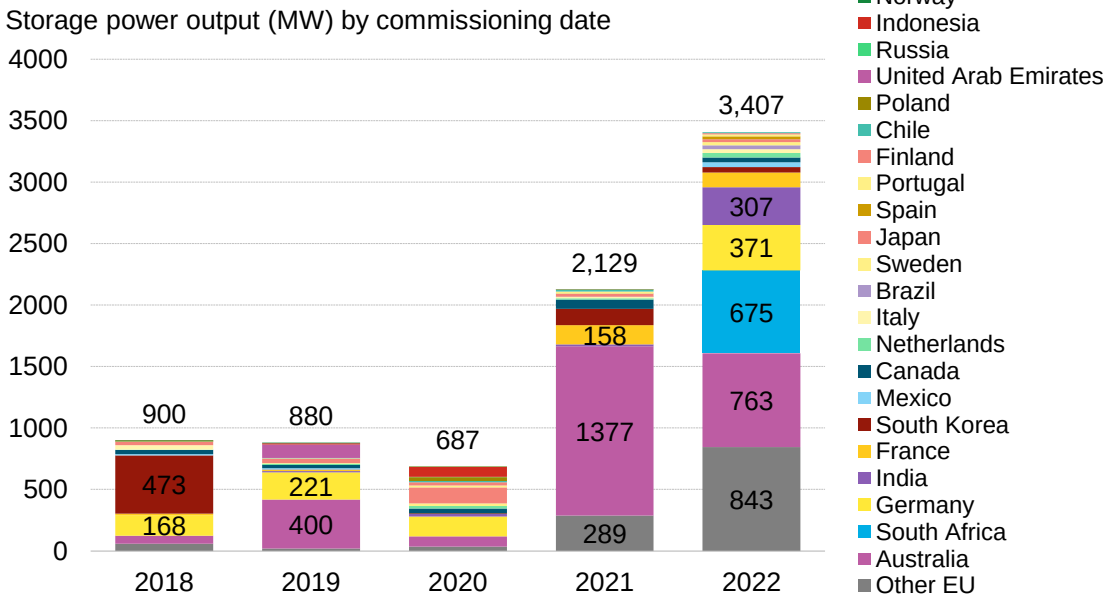
Installations in mainland China more than quintupled from the year prior, to 15.8 gigawatts.

The US, which was the world's largest demand market in 2021, dropped to second place in 2022.

Nonetheless, the US market more than doubled year-on-year as 10.4 gigawatts were installed. The UK market also tripled in size, to 2.2 gigawatts, in 2022.

Batteries are being deployed in a growing list of economies

Annual newly commissioned utility-scale battery storage capacity in other CEM members



At least 22 Clean Energy Ministerial members installed at least 1 megawatt of power-storage capacity in 2022, up from 20 in 2021.

A growing number of countries are finding use for large-scale batteries on the grid.

On a capacity basis, mainland China, the US and the UK accounted for 89% of all storage installed in 2022.

However, total capacity installed in other CEM members grew by more than half, to 3,407 megawatts, in 2022. Australia (which installed 763 megawatts), South Africa (675MW), Germany (371MW) and India (307MW) were the largest of these markets. Key drivers of growth have included the need for greater grid flexibility as variable renewable generation grows, and new policy supports.

Source: BloombergNEF. Note: Excludes mainland China, the UK and the US. MW stands for megawatts.

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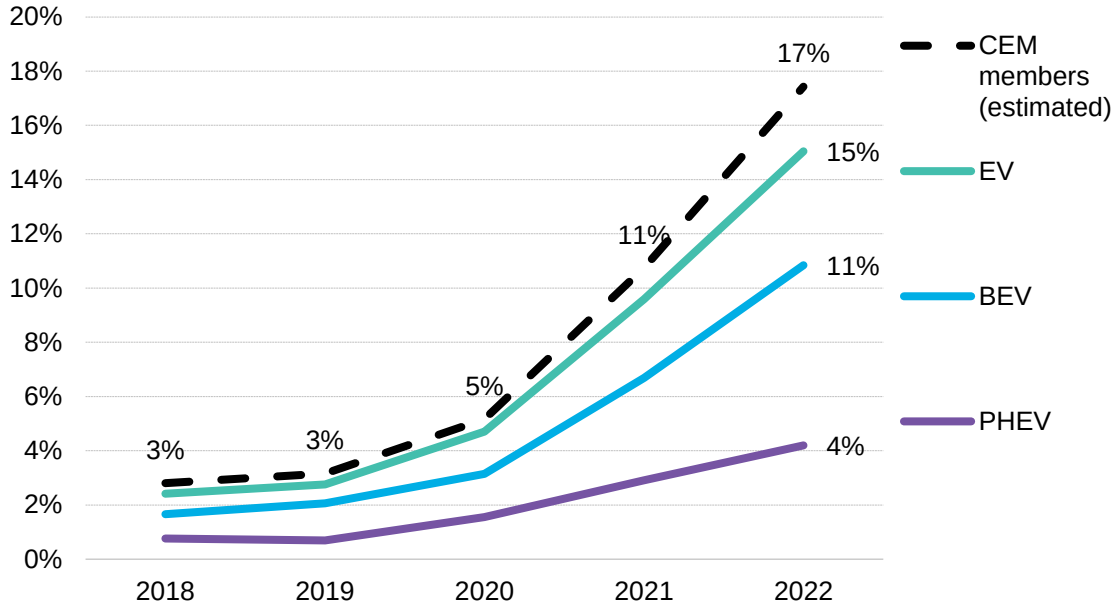
Approximately one in six cars sold today can plug into a wall

Global and CEM members' electric vehicle sales as a share of total car sales



Approximately 17% of automobiles sold in 2022 could plug into the power grid.

One in nine (11%) were pure battery-electric vehicles (BEVs), while one in 25 (4%) were plug-in hybrid electrics (PHEVs). In all, 10.4 million electric vehicles were sold in 2022, up 60% compared to 2021. In mainland China, passenger EV sales surged 92% in 2022. North America and South Korea followed, each marking 48% year-on-year growth. In Europe, the growth rate was 17%.

About seven in 10 EVs sold each quarter are pure battery electric.

Around 72% of all EVs sold in 2022 were BEVs, up from 70% in 2021.The balance were PHEVs.

Nearly a fifth of all passenger vehicles sold in CEM members were plug-ins.

Around 13% were BEV and 5% PHEV.

Source: BloombergNEF, Marklines, Jato, Bloomberg Intelligence. Note: CEM member data does not cover all CEM members. 'EV' encompasses both battery-electric vehicles (BEV) and plug-in hybrid electric vehicles (PHEV)

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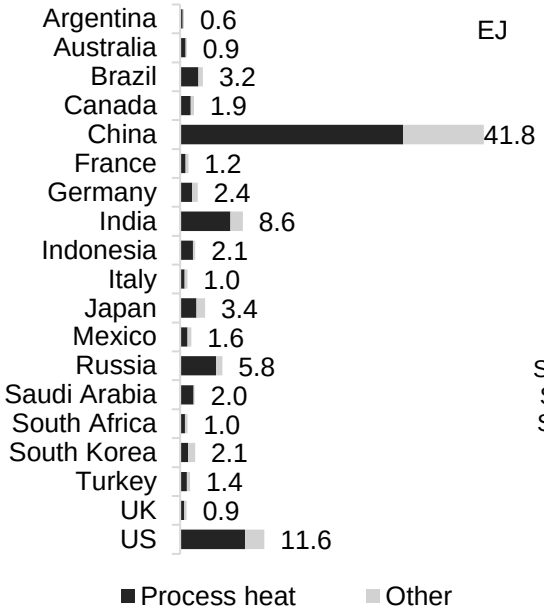
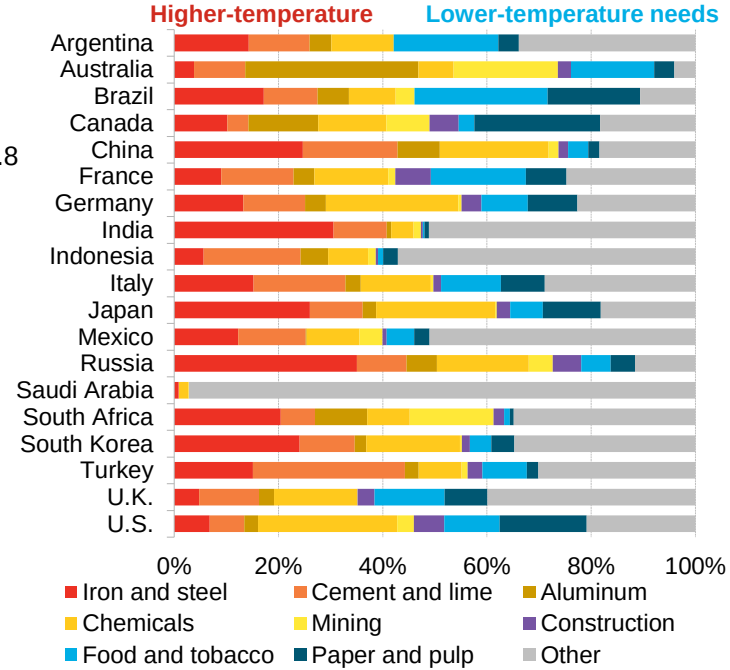
Industry faces specific decarbonization challenges

Industrial energy consumption by type



Industrial energy consumption by sector



Industry represents a substantial share of energy use and greenhouse gas emissions.

Industry accounts for approximately 29% of all global energy use, and around a fifth of all greenhouse gas emissions.

The majority of industrial energy consumption is used to produce process heat.

Process heat is the energy input of thermal manufacturing processes, such as steam reformation of methane to produce ammonia or smelting to produce steel.

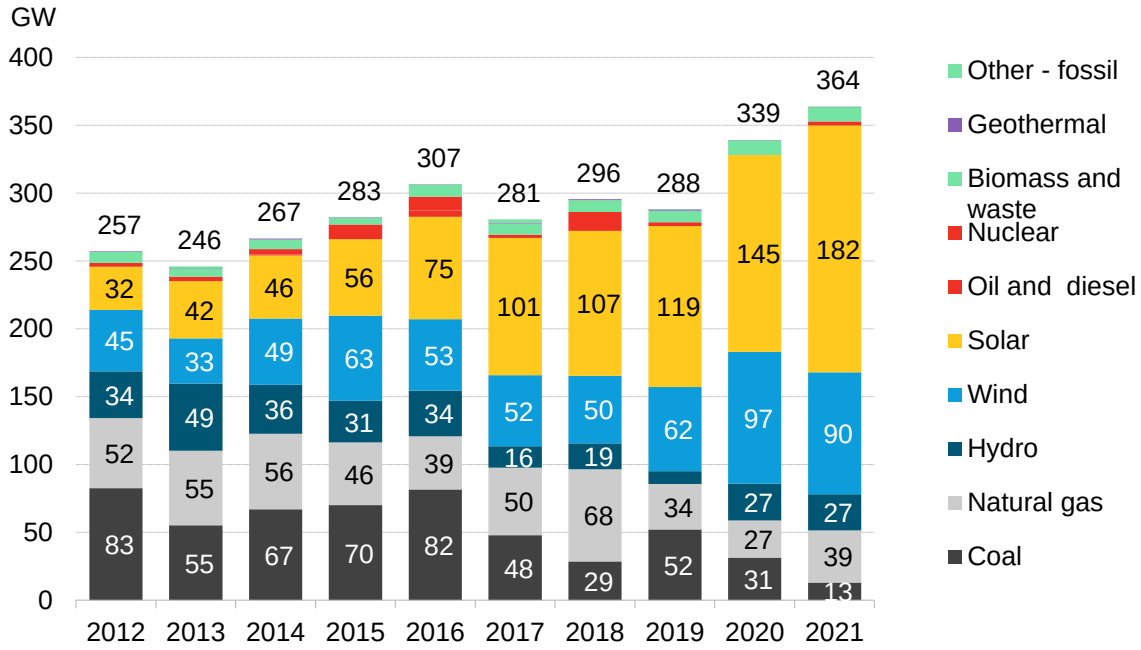
Countries face different challenges in decarbonizing industry.

These challenges range from scale (mainland China is by far the largest industrial energy consumer) to particular heat demand (some countries have mostly high-temperature heat demand, which makes it harder to find lower- or zero-carbon substitutes).

Source: Global CCS Institute, BloombergNEF. Note: EJ is exajoules.

Renewables now dominate annual capacity additions

Annual new power-generating capacity additions, global



Source: BloombergNEF

2021 (the last year for which BNEF has complete data) was another record for the installation of zero-carbon power-generating technologies.

No less than 86% of the world's new nominal capacity fed into the grids that year came from renewables (wind, solar, hydro and other technologies) and nuclear power.

Solar installations set another annual record.

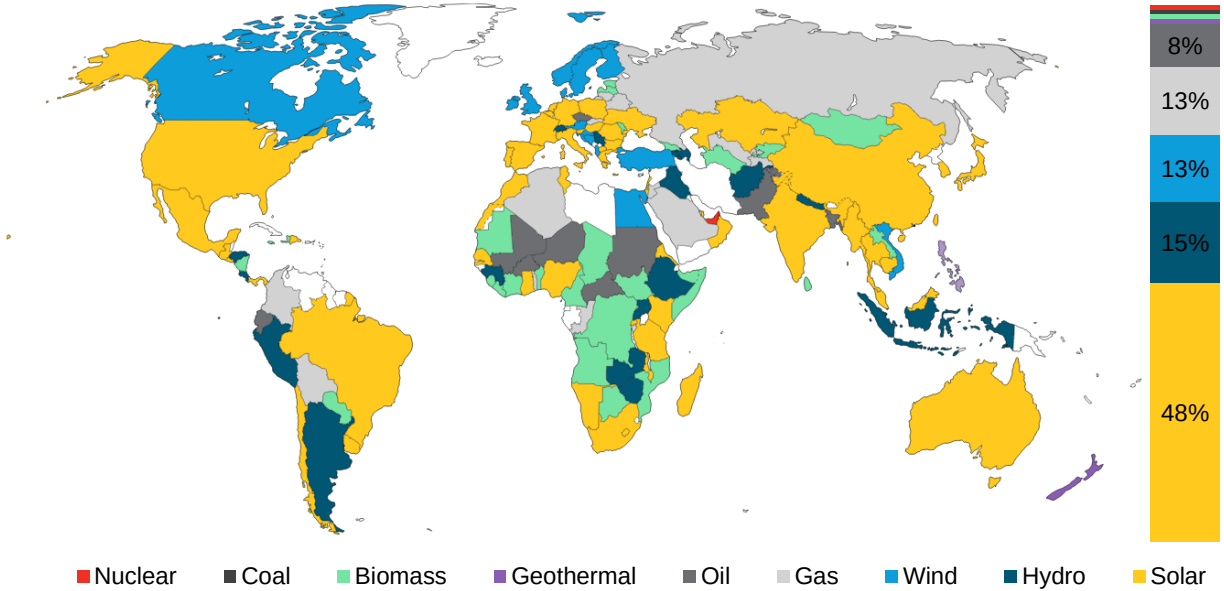
Installations of residential, commercial and industrial, and utility-scale solar rose to 182 gigawatts (GW) in 2021, up 26% from the 145GW record the year prior.

However, wind power capacity additions declined for the first time since 2017-2018.

A total of 90GW of new wind power were added to grids globally in 2021, down 7GW from 2020.

Renewables are the top choice for most economies today

Most popular new power-generating technology installed in 2021 (by capacity)



Solar is now the world's most popular new power-generating technology in the most economies.

In 53 of the 112 economies where BloombergNEF could confirm new-build activity in 2021 (the last year of complete data), solar was the top technology added, as measured in nameplate capacity. That is up from 14% of economies in 2012.

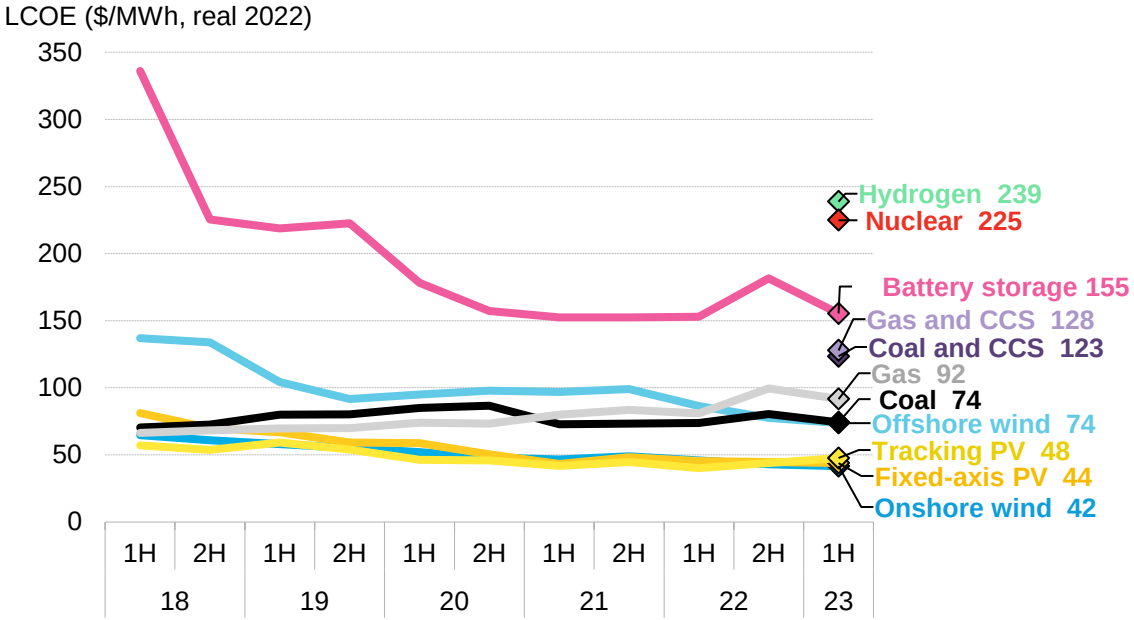
The solar phenomenon is occurring both in front of and behind the electricity meter.

These figures include residential, commercial, industrial and utility-scale solar additions.

Source: BloombergNEF. Note: Map colored by which technology was most installed in 2021 alone. Chart depicts the percentage of economies that installed the most MW of each technology. It is based on economy-level data for 136 economies, but excludes economies that have not recorded any capacity additions. Solar includes small-scale PV.

Onshore wind and solar PV remain cheapest technologies, offshore wind starts undercutting fossil fuels

Global LCOE benchmarks, 2018-23



Onshore wind and solar remain the cheapest new-build technologies for producing electricity, a position they have held since 2018.

Onshore wind and solar cost declines have slowed due to more expensive materials and shipping and financing costs. Slower cost reductions are also consistent with the maturing of these technologies. Every doubling of module capacity, which drives a 28.5% cost decline, takes longer to achieve.

Offshore wind costs are now on par with coal, at $74/MWh globally.

BNEF expects offshore wind LCOEs to continue to fall as the technology matures.

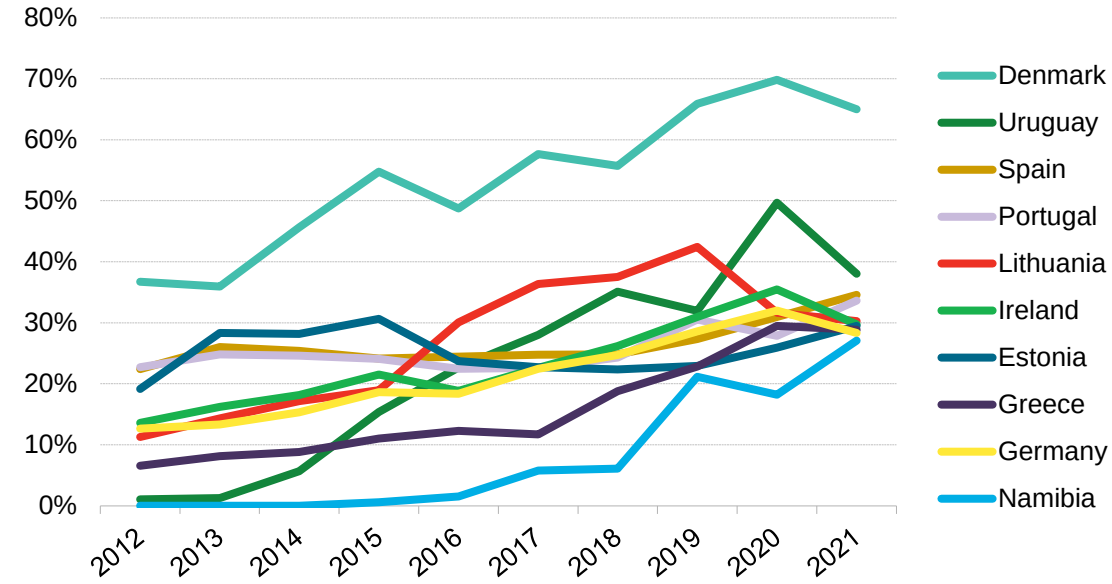
Low-carbon dispatchable technologies, such as carbon capture and storage (CCS), nuclear and hydrogen, are needed to decarbonize the power sector.

Coal and gas with CCS cost $121/MWh and 126/MWh, respectively. A combined-cycle plant burning hydrogen costs $239/MWh, and nuclear generation costs $225/MWh on average.

Source: BloombergNEF. Note: LCOE stands for levelized cost of electricity. The global benchmarks are capacity-weighted averages using the latest country estimates – apart from nuclear, hydrogen and CCS, which are simple averages. Offshore wind includes offshore transmission costs. Coal- and gas-fired power include carbon pricing where policies are already active. LCOEs do not include subsidies or tax-credits. LCOEs shown by financing date. PV stands for photovoltaic, MWh stands for megawatt-hour.

Wind and solar are making unprecedented contributions to national grids

The world's top 10 nations for wind/solar penetration through 2021



Source: BloombergNEF

As wind and solar capacity additions continue to grow, so too do their contributions to countries' power grids.

In 2021 (the last year with complete data), 10 nations met over a quarter of their electricity demand with wind and solar power. Denmark has long been the global leader in this respect. Renewables met 65% of demand there last year.

In most of these countries, the renewables' share of contributions in 2021 actually slipped compared to the prior year.

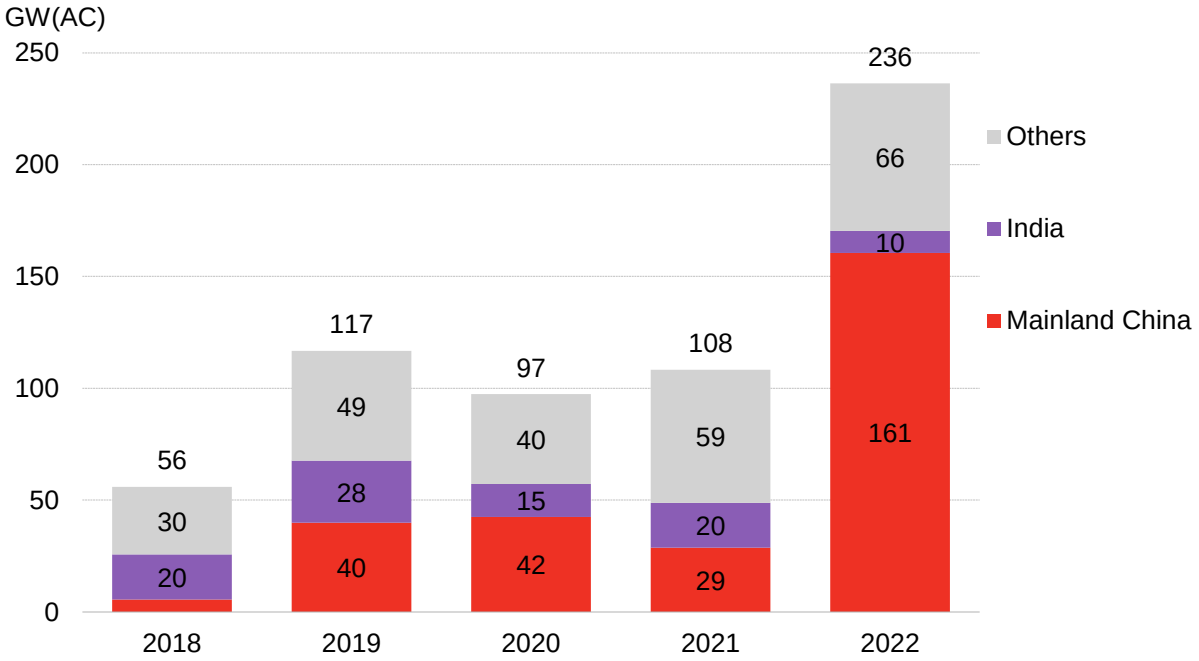
As economies recovered from Covid-19 lockdowns, top-line electricity demand jumped. As a result, renewables' percentage of total generation in these countries dipped somewhat, even in some cases where their absolute contributions as measured in megawatt-hours grew.

Most nations where the share of wind/solar energy is above 25% are in Europe.

However, Uruguay (38%) and Namibia (27%) also exceeded this threshold in 2021.

Clean energy auctions are growing in popularity with mainland China and India leading

Annual renewable energy auction volumes



Source: BloombergNEF. Note: Chart only shows auctions for utility-scale projects. Auctioned capacity based on alternate current (AC). GW stands for gigawatts.

Utility- or state-run reverse auctions for contracts to deliver zero-carbon power have helped spur least-cost clean energy build around the globe.

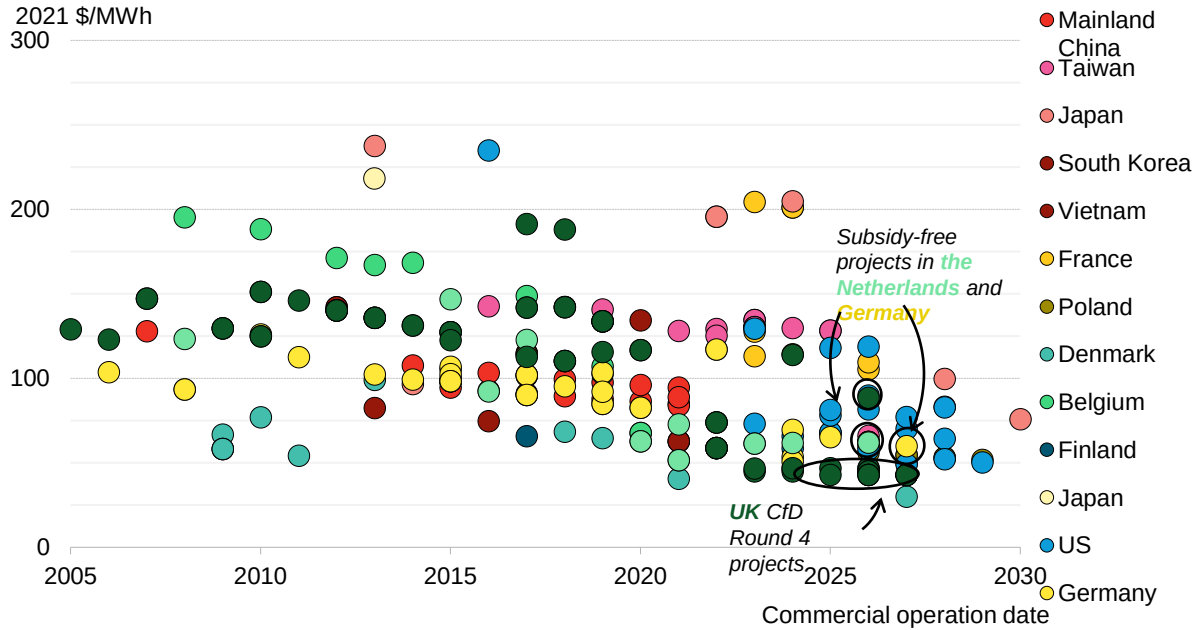
In 2022, global auction activity more than doubled, largely due to a major jump in activity in mainland China.

India, an auctions pioneer, was the second-largest individual market for such activity in 2022.

A total of 10 gigawatts (GW) of projects won contracts to deliver power in 2022, down from 20GW in 2021. The government has stated plans to tender 50GW every year from fiscal year 2023 through fiscal year 2027 with at least 10GW being wind power. This is part of the government's larger goal of achieving 500GW of non-fossil fuel capacity by 2030. As of February 2023, India had 169GW of wind, solar, hydro and bio-energy, according to the Ministry of New and Renewable Energy.

Government-organized tenders are fueling an offshore wind capacity boom

Offshore wind power delivery contracts signed under tenders



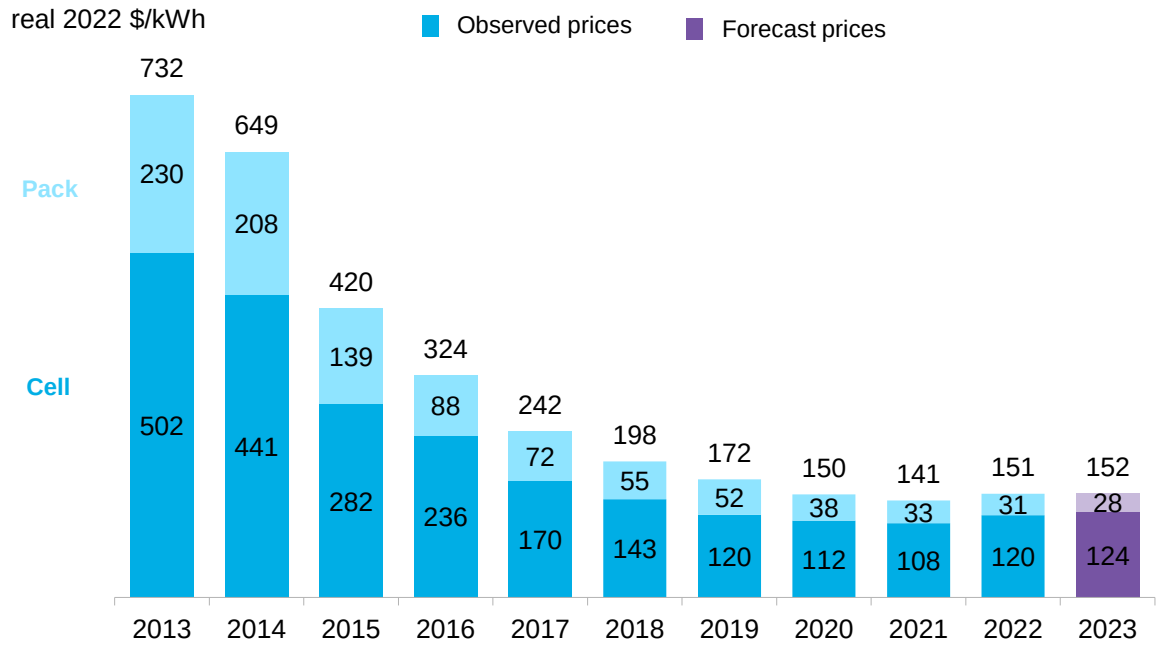
The UK, Germany and the Netherlands announced major auction results in 2H 2022, awarding 8.7 gigawatts of capacity between them.

The UK allocated capacity at a record-breaking strike price. The Netherlands awarded a subsidy-free project that will be linked to hydrogen and other technologies. Seabed leasing activity was scarce, but more rounds are anticipated in 2023. In all, 43.8 gigawatts of offshore wind contracts are expected to be awarded through mid-2024, fueling build to the end of the decade. Government-organized tenders promote growth and long-term confidence in markets.

Source: BloombergNEF. Note: To levelize prices, we consider tariff price and length, inflation, a merchant tail assumption and a 25-year project lifetime. The calculated tariff price is the average tariff over the full life of the project. For a project's merchant tail and zero-subsidy projects, we assume that the previous three-year average power price stays flat in real terms. In Germany7 and the UK8 we use BNEF's realized power price forecasts. MWh stands for megawatt-hours.

The decline in battery prices has paused

Near-term lithium-ion battery cell and pack price forecast



Source: BloombergNEF.

2022 marked the first time BNEF recorded a year-on-year rise in battery pack prices.

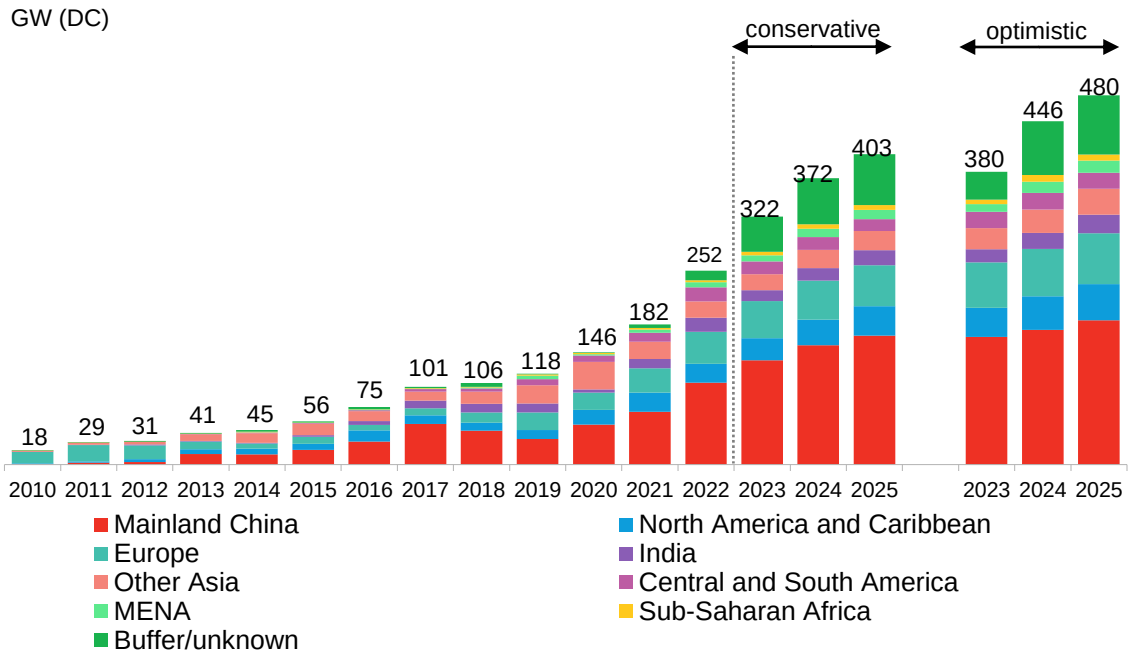
The volume-weighted price of lithium-ion battery packs across all sectors averaged $151 per kilowatt-hour (kWh), up 7% from 2021.

But inflated battery prices may be partially offset by incentives such as the US Inflation Reduction Act, which awards up to $45/kWh for battery cells and modules produced in the US.

Meanwhile, stationary storage, which has been especially impacted by higher battery prices, will continue to grow, thanks to policy support across major markets such as the US, mainland China and Europe. Stationary storage has relatively small volumes compared to EVs, meaning that storage providers and project developers have less leverage to negotiate prices than large automakers and are thus impacted more strongly by battery price inflation.

Solar is on track for a net-zero pathway despite challenges

Recent global solar PV demand



A fall in prices for photovoltaic equipment is now rippling through the solar value chain as manufacturers' capacity expansions materialize and competition heats up.

Between 322-380 gigawatts of new solar capacity will be installed in 2023, BloombergNEF estimates. BNEF's mid-case scenario of 344 gigawatts would represent a 36% increase from 2022. Mainland China alone is expected to add a staggering 154 gigawatts of solar this year.

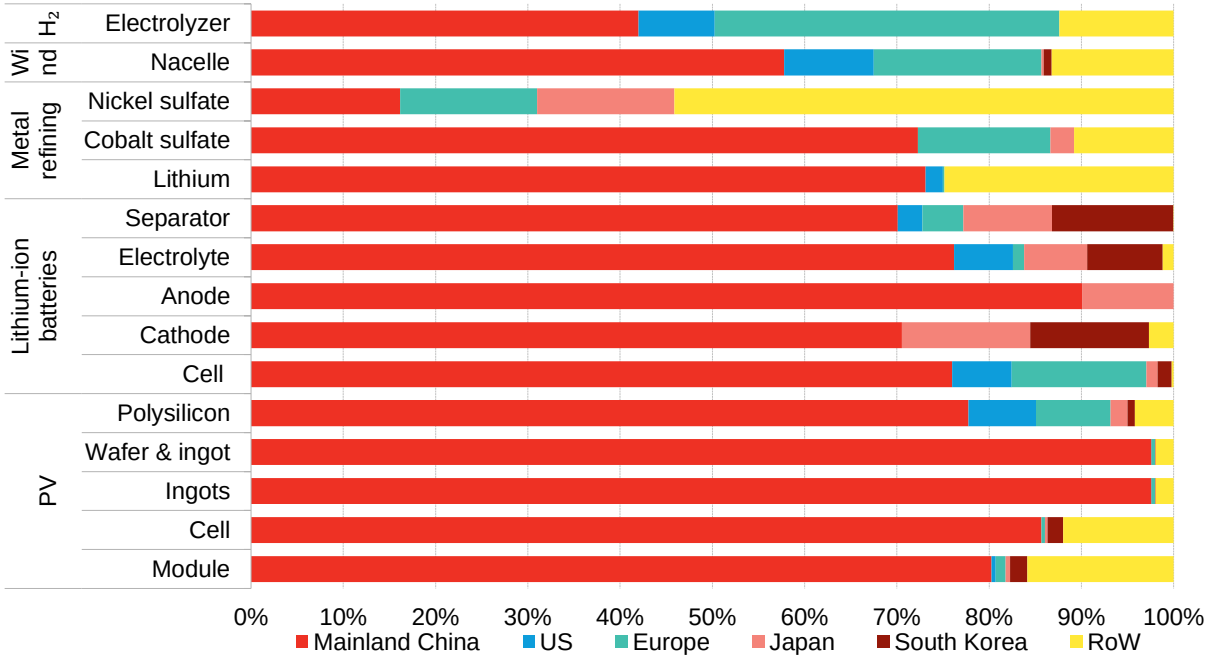
The path to 2030 is firming up for many historically smaller markets around the world.

Thailand and the Philippines are putting in place auction plans for solar build between 2024 and 2026, while South Africa, Pakistan and Ukraine all see solar as part of the solution for their current power crises.

Source: BloombergNEF. Demand projections portrayed in direct current (DC). GW stands for gigawatts. PV stands for photovoltaic. MENA stands for Middle East and North Africa.

Clean energy equipment production remains geographically concentrated

Clean energy manufacturing capacity by location, 2022



Source: BNEF. Note: By factory location. Solar photovoltaic (PV), hydrogen and battery components expressed in megawatts (MW), megawatt-hours (MWh), square meters (m^2) or metric tons. Nickel is the class 1 variety, and lithium is in lithium carbonate equivalent. H_2 is hydrogen. Data as of October 2022, except electrolyzers, which refer to 2021, and nacelle data, which are for 2020. RoW stands for rest of world.

Mainland China remains the dominant player in most segments of the battery and solar value chains.

This includes the refining of cobalt and lithium, metals used in batteries. It also includes battery components (electrolytes, anodes, cathodes and cells) and solar components (polysilicon, wafers, ingots, cells and modules).

The global supply chain for wind turbine manufacturing is more geographically dispersed.

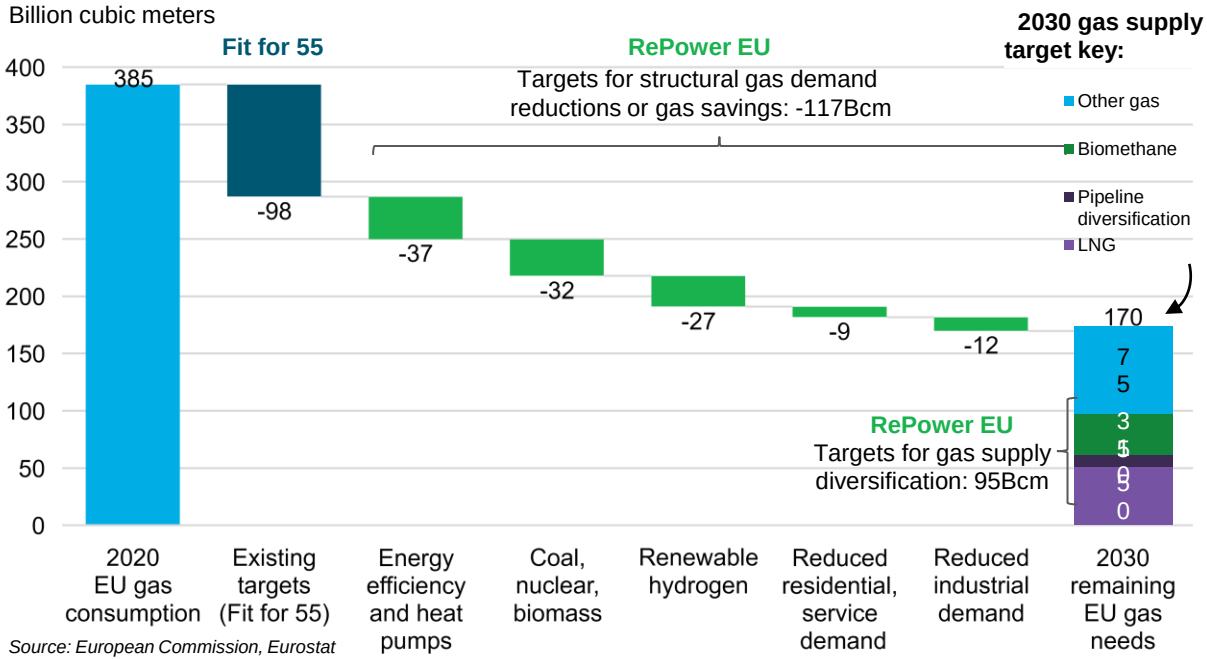
Mainland China accounts for just over half of production of nacelles worldwide, but the US, Europe and others also produce such equipment in large volumes.

The manufacturing of electrolyzers for use in the production of zero-carbon hydrogen is spread relatively evenly across regions.

Mainland China accounts for the largest share of such activity but Europe is also a major player.

The EU's goal of halving its natural gas usage will rely on clean energy and other sources

European Commission targets for EU natural gas consumption by 2030, based on the REPowerEU package



Source: European Commission, Eurostat

The EU has set an ambitious goal of transitioning away from reliance on Russian gas imports by 2027.

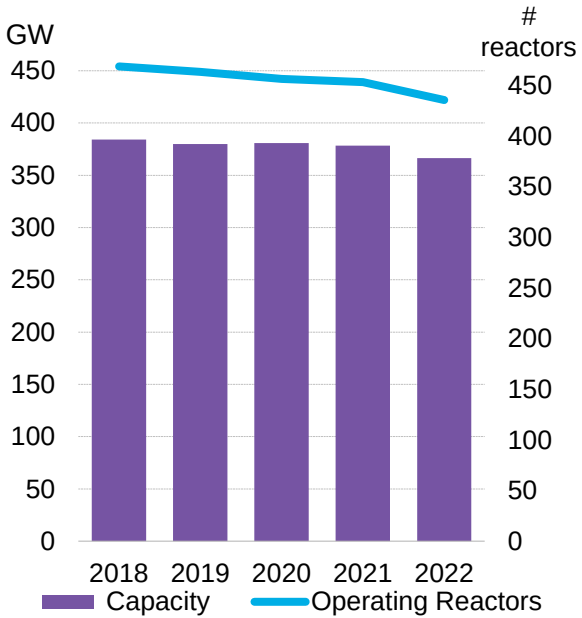
To get there, the EU plans to cut demand sharply through greater energy efficiency and expanded use of heat pumps, and by upping production from coal, nuclear and biomass sources. It also expects contributions from renewable hydrogen and lower demand from both residential and industrial consumers. Finally, it seeks to diversify the sources for the natural gas it will continue to burn.

Clean energy isn't the only sector getting a boost.

REPowerEU implies a rebound in coal power by 2030, due to high gas prices and policy responses expected to keep coal plants operating longer. Efforts to diversify gas supplies also depend on Europe attracting more liquefied natural gas (LNG).

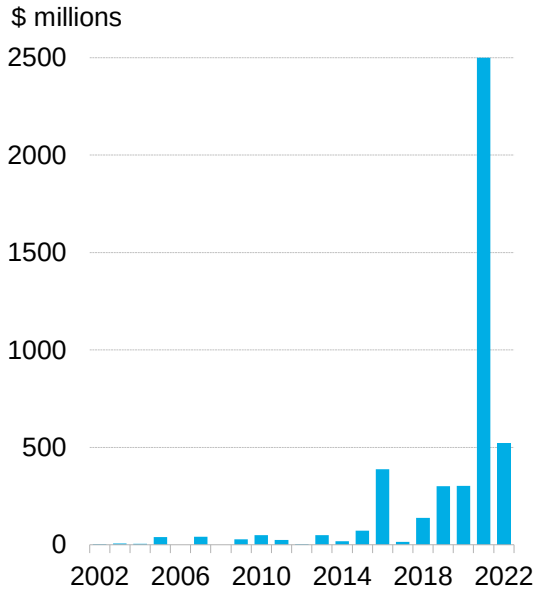
Conventional nuclear capacity is sliding, but newer technologies are attracting capital

Global nuclear deployment, 2010-2022



Source: BloombergNEF. GW stands for gigawatts.

Private investment in companies developing fusion technologies



Source: BNEF, company reports. Note: 2022 data up to November.

The number and capacity of conventional nuclear power plants operating around the world has remained essentially flat since the start of the last decade.

Today there are 422 plants operating globally with a combined capacity of 378 gigawatts. National aspirations for net-zero, the higher cost of natural gas and energy security concerns prompted by the war in Ukraine, however, are creating policy shifts and market pull for carbon-free, dispatchable baseload generation. The need to supply around-the-clock, zero-carbon power remains in both the short and long term.

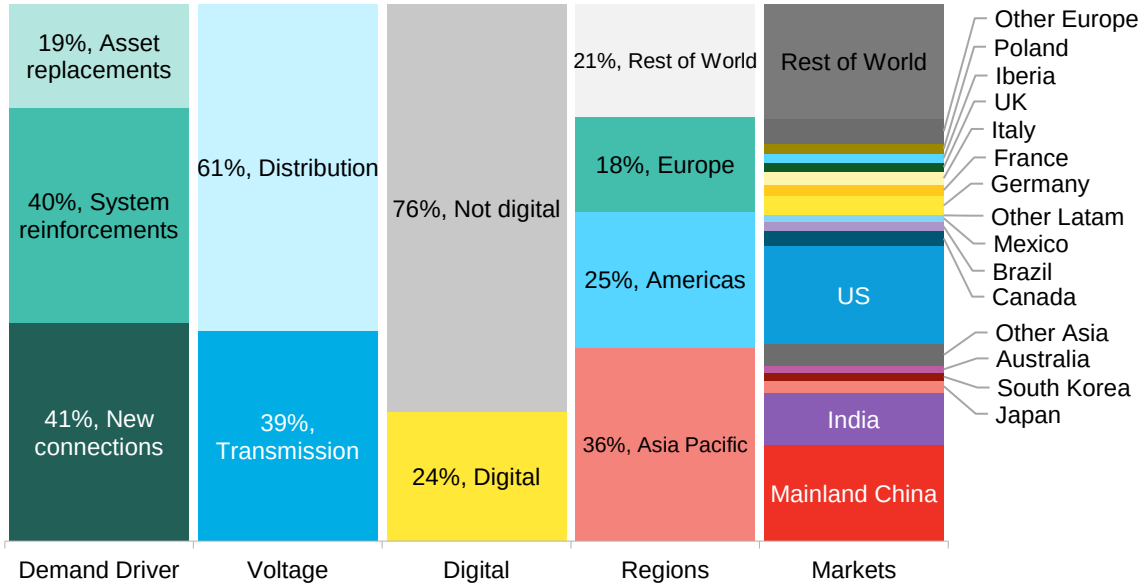
Firms seeking to develop either small modular reactor (SMR) or fusion technologies have attracted substantial new, private investment in recent years.

Notably, Massachusetts-based Commonwealth Fusion Systems raised $1.8 billion in 2021 from a large group of investors that included Tiger Global, Bill Gates, Google, Temasek and others.

Net zero will require at least $21 trillion in grid investment by 2050

Split of the $21.4 trillion projected to be needed over 2022-2050 under BloombergNEF's Net Zero Scenario

Share of total grid investment



Source: BloombergNEF

BloombergNEF has modeled multiple scenarios for how the energy transition may unfold over the next three decades. Under the BNEF Net Zero Scenario (NZS), at least $21.4 trillion will need to be deployed in support of electricity grids by 2050 to achieve a global net-zero trajectory.

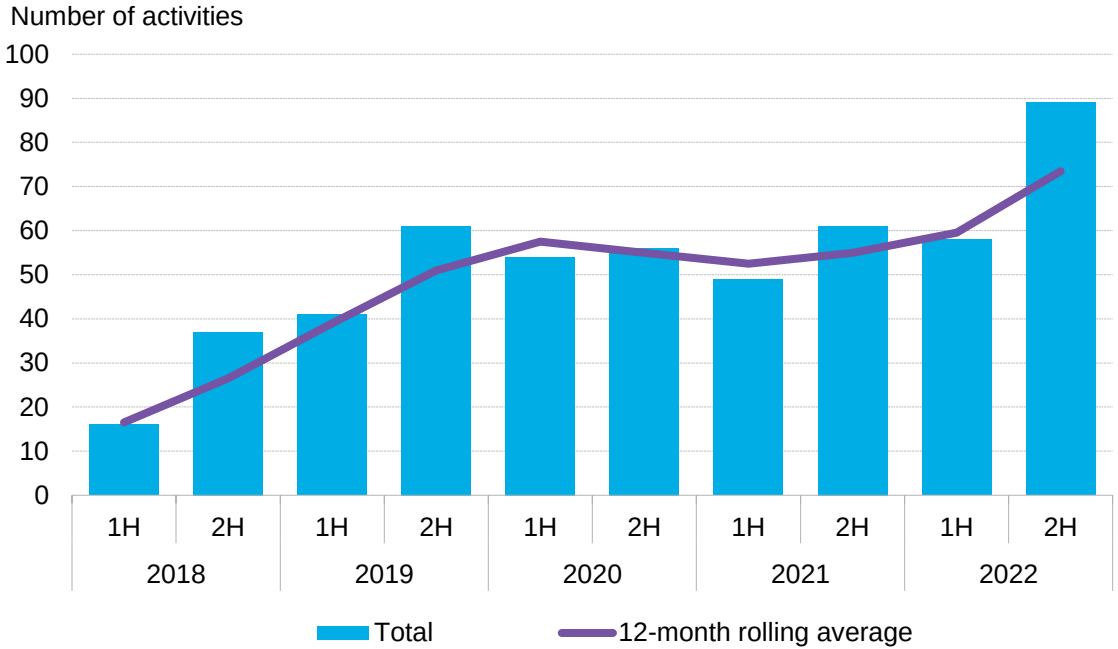
Yet grid investment has fallen short in recent years, resulting in bottlenecks that slow the deployment of renewables and electrification. Looking ahead, the US and China are poised to account for the largest shares of future grid investment at approximately 18% apiece.

Some $274 billion was invested in the power grid in 2022.

This annual spend needs to rise to nearly $1 trillion by 2050 for a net zero trajectory that supports more power generation capacity, serves new demand and replaces existing infrastructure.

Utilities are integrating digitalization into their operations

Projects and partnerships in the power sector



BloombergNEF tracked 147 new activities started and partnerships formed by utilities, oil, gas and other energy companies in the energy sector in 2022.

There was a record number of mature digitalization activities, indicating that utilities increasingly see digitalization as a way to create long-term value, and are moving beyond pilots and projects to scale technologies. Connectivity, analytics software and cloud/data had the largest shares.

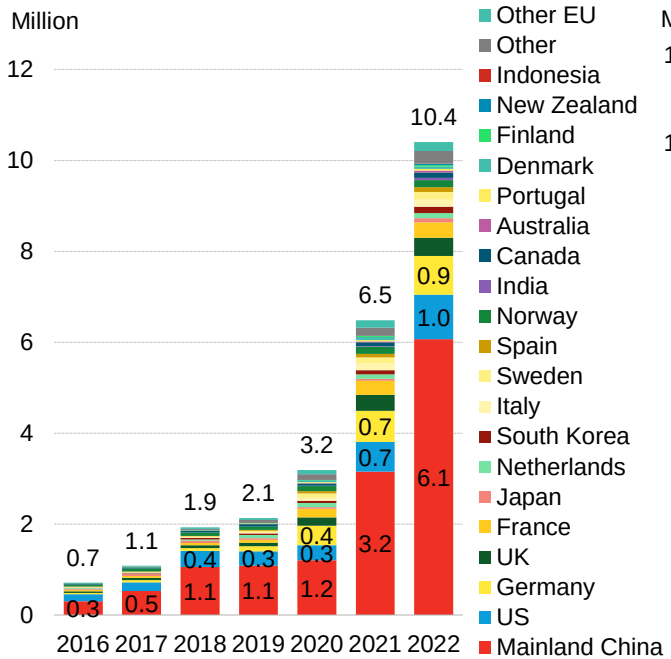
BNEF tracked 147 digital activities by companies in the power sector, of which 65% were mature (product development and integration, versus pilots and projects), up from 54% in 2021 and 35% in 2020.

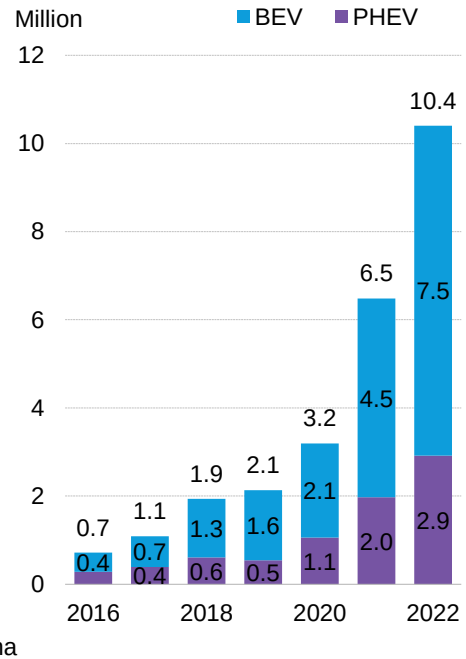
As activity matures in some areas, such as analytics software, projects and research for supporting tech, such as cybersecurity, usually develop in parallel.

Source: BloombergNEF. Initiatives include analytics software, automation, cloud/data, communications, connectivity, and internet-of-things software.

Global EV sales jumped 60% to top 10.4 million in 2022

New EV sales by major market/region, drive train





Source: BloombergNEF, Marklines. Note: BEV stands for battery-electric vehicles, PHEV stands for plug-in hybrid electric vehicles

Global sales of four-wheeled electric vehicles (EVs) continued to surge in 2022, driven by higher gasoline prices, subsidies, expanded vehicle model choices, fuel economy standards and other factors.

Sales of battery-electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs) topped 10.4 million in 2022, up from 6.5 million in 2021.

Mainland China was once again the biggest market, with annual sales nearly doubling to 6.1 million in 2022.

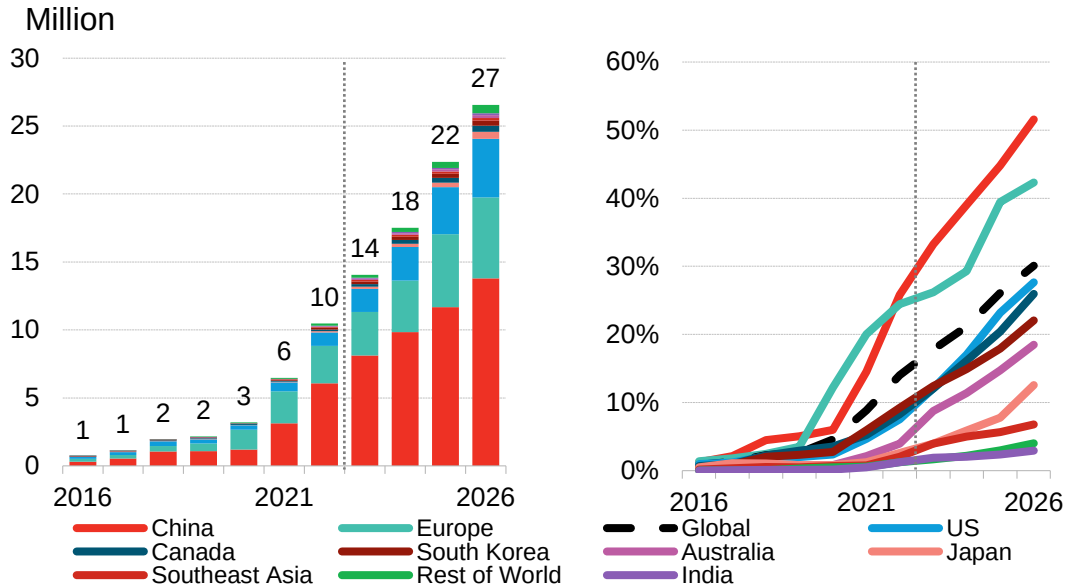
Mainland China has been the top market for sales for seven years running. The US market continued to grow swiftly and topped 1 million for the first time in 2022. Germany was not far behind, with over 900,000 EVs sold.

The ratio of BEVs to PHEVs sold remained about the same.

Approximately three in every 10 EVs sold are plug-in hybrids, while the rest are purely electric.

Some countries have already achieved mass-market adoption of EVs

Global near-term passenger EV sales and share of new passenger vehicle sales by market



Source: BloombergNEF. Note: Europe includes the EU, the UK and EFTA countries. EV includes BEVs and PHEVs. 2023-2026 are BNEF forecasts.

EV sales are projected to continue surging in the next few years, rising from 10.4 million in 2022 to almost 27 million in 2026.

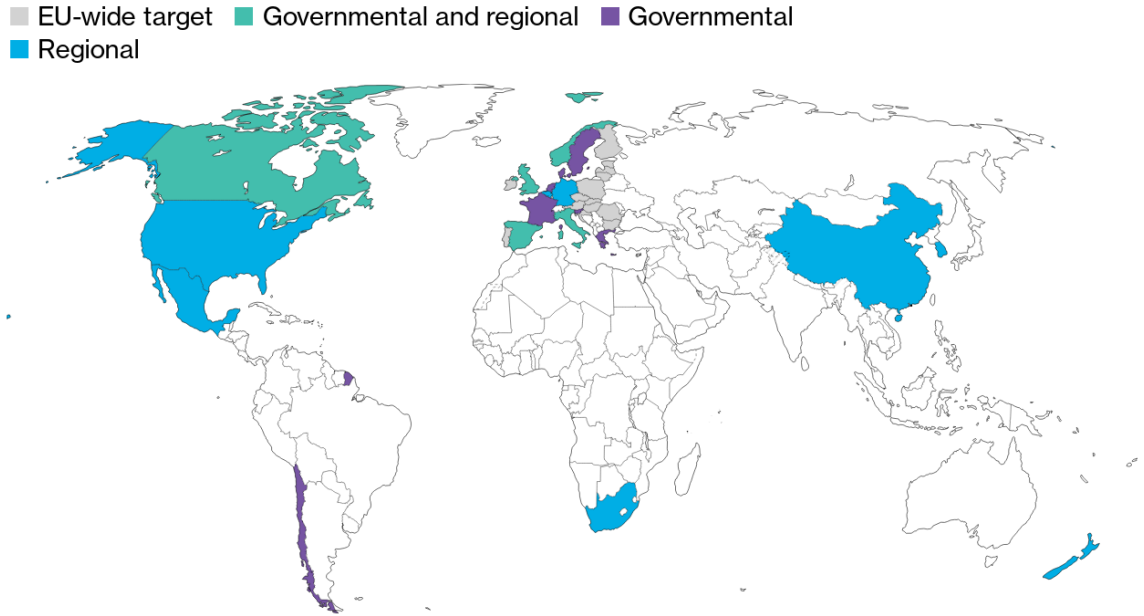
In the US, a major push from the Inflation Reduction Act means EVs account for nearly 28% of passenger vehicle sales by 2026, up from 7.6% in 2022. The EV adoption gap between developed and emerging economies continues to grow in the near term, but Japan significantly lags other wealthy economies.

The EV share of new passenger vehicle sales jumps from 14% in 2022 to 30% in 2026.

The percentages in some markets are much larger, with EVs reaching 52% of sales in mainland China and 42% in Europe. Some of the major European car markets move even faster, with the Nordics at 89%, Germany at 59% and the UK at 49%.

Governments are mandating phase-outs of internal combustion engines

ICE vehicle phase-out targets in CEM members



As of the end of March 2023, some 21 governments had set dates to eliminate internal combustion engine (ICE) vehicle sales.

Nearly all are CEM members. Thirty-three regional and municipal authorities also have such goals in force.

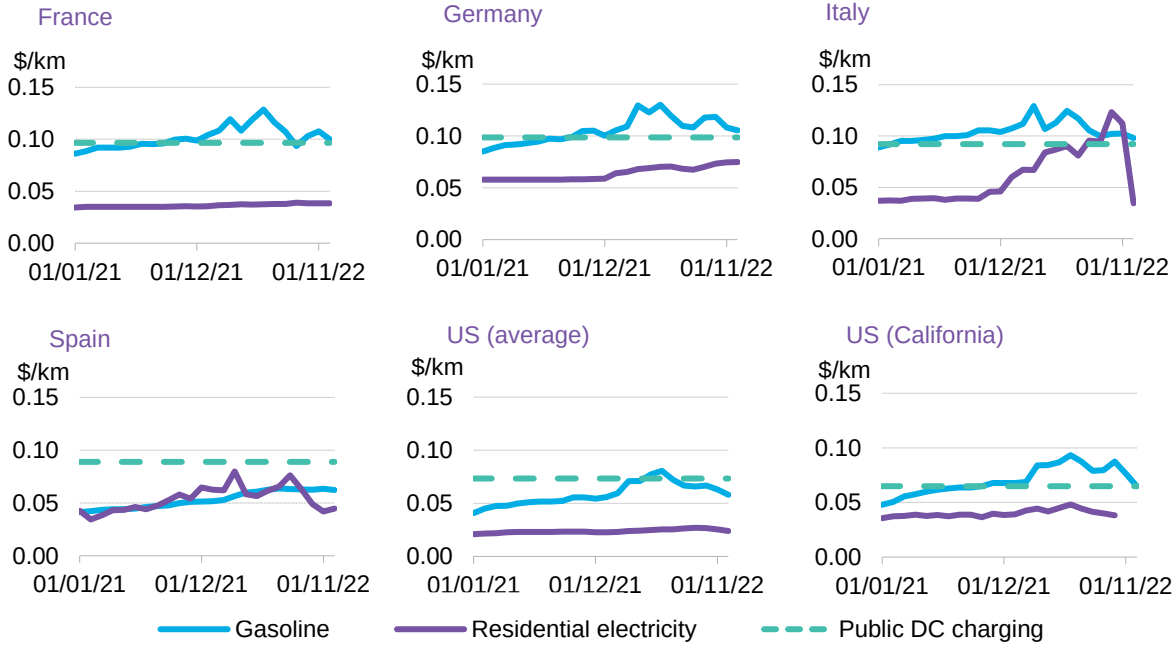
Among the most notable commitments to date is the European Commission's proposal to phase out ICE vehicle sales in the EU by 2035.

Regional and state level ICE phase-out targets are important as well. These targets can have real impact, especially in economies where larger mandates have yet to be implemented. The US currently has no phase-out target, but state-level ICE phase-out targets already cover about 40% of 2021 new passenger car sales in the country.

Source: BloombergNEF. Note: Includes CEM members and the European Union. Economies indicated as 'EU-wide target' are part of the EU-wide phase-out pledge but have yet to indicate economy-level commitments. For more, see BNEF's Electric Vehicle Outlook.

Higher gasoline prices have improved the economics of EVs

Comparison of gasoline, residential electricity, and average public charging prices



Higher fossil-fuel costs are allowing consumers to enjoy substantial savings by owning EVs.

'Sticker price parity', or the point at which an EV is lower-priced in the showroom than its ICE rival, is probably still the most important determinant of EV adoption. Yet total cost of ownership (TCO) matters too. Surging wholesale electricity prices have pushed up charging costs, especially at public fast chargers, but in many countries, fast charging has remained competitive with conventional fuels.

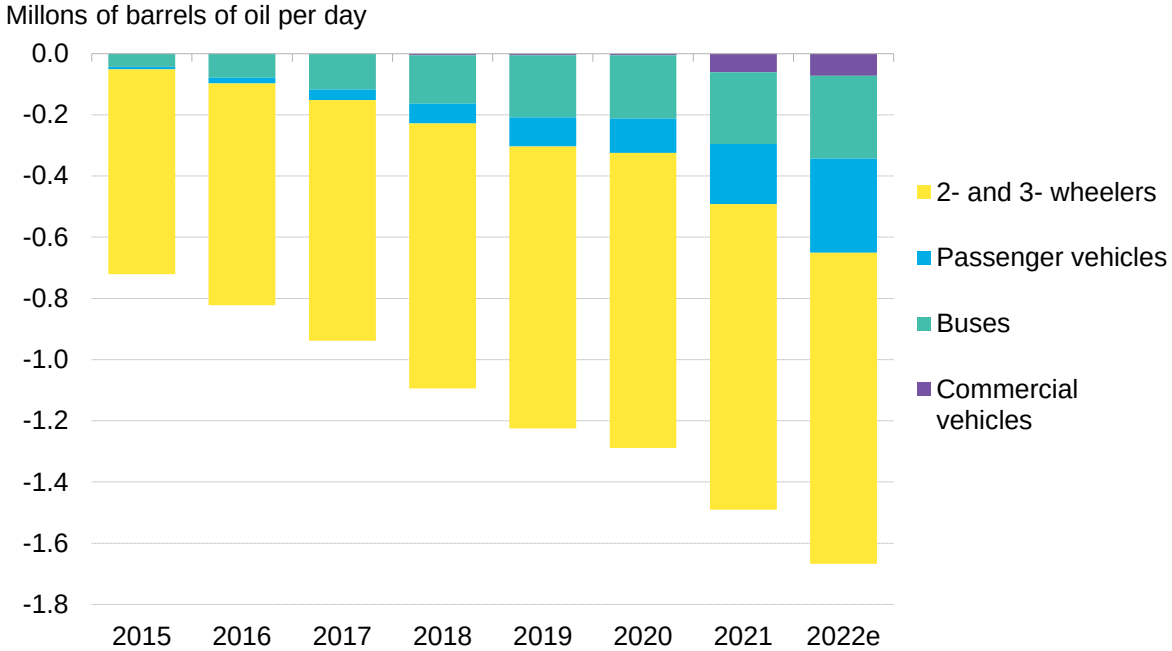
In most markets today, the average per-kilometer cost of charging an EV at a public fast charger is similar to using gasoline, while residential charging costs are significantly lower.

The main exception is Spain, where public charging costs are considerably higher than gasoline, reducing the incentive to switch from ICE vehicles to EVs. In Italy and Spain, the price per kilometer when charging with residential electricity surpassed the gasoline equivalent for a few months in 2022, before falling back below it. The decline in prices happened due to government subsidies that have been introduced in both countries to counteract residential electricity price rises

Source: Bloomberg, BloombergNEF, Eurostat, Eco-Movement, EIA, Energy Price Index. Note: km stands for kilometers. DC is direct current.

Electrified transport is subtracting nearly 1.7 million barrels of global oil demand daily

Oil demand avoided by electric vehicles and fuel-cell vehicles



Source: BloombergNEF, IEA. Note: total for 2022 is an estimate.

Oil use avoided due to the growing popularity of electrified transport has doubled since 2015.

The adoption of electric vehicles and fuel-cell vehicles avoided almost 1.7 millions of barrels of oil a day in 2022 – about 3.8% of total demand from the road transport sector. Global oil demand in road transport is expected to reach roughly 43.9 million barrels a day in 2022, a slight increase over the past year. The avoided oil demand in 2022 corresponded to emitting 3.91 million tons of carbon dioxide equivalent.

Two- and three-wheeled EVs accounted for 61% of the oil demand avoided in 2022.

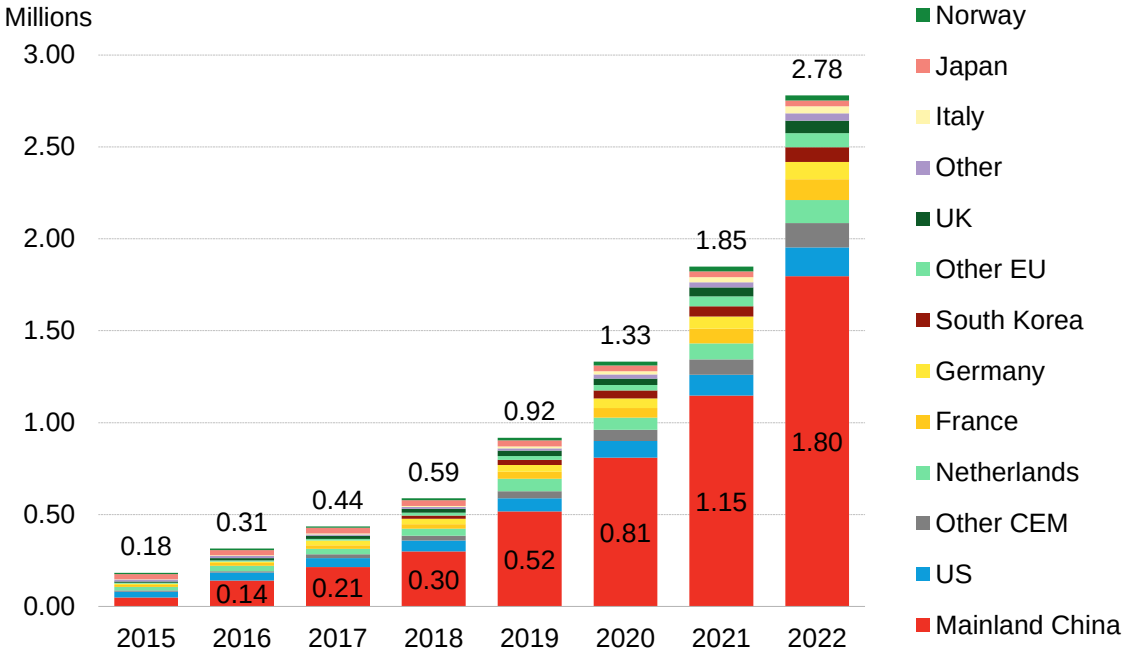
This is due to their rapid adoption, particularly in Asia.

Passenger EVs are expected to surpass buses in 2022 to represent 18% of total oil demand avoided.

The other two segments remain consistent with last year's data: buses accounted for 16% of avoided oil demand in 2022, and commercial vehicles accounted for just 4%.

There are more than 2.7 million public EV charging connectors worldwide

Public EV charging connectors installed



Source: BloombergNEF

A total of 2.78 million charging points had been installed worldwide as of year-end 2022.
Annual installations grew by about half from 2021 to 2022. Electric utilities, oil and gas majors, governments and pure-play charging network operators are all investing heavily.

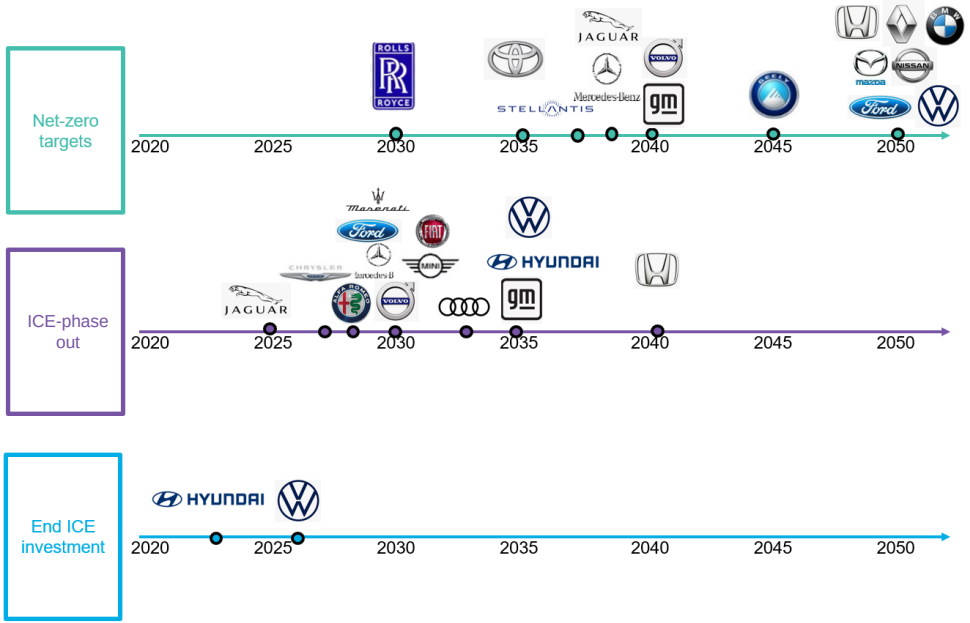
The charging market remains fragmented.
An absence of network standards and physical format standards means that the market has yet to consolidate and is likely to remain fragmented for some time.

Viable business models are emerging.
However, critical questions remain outstanding for network operators, such as the optimal speed for charging, ideal location of public chargers, and the best approach to billing customers.

Mainland China and Europe lead in terms of absolute connectors available.
Mainland China had 1.8 million chargers as of year-end 2022, while Europe had 0.6 million.

Automakers expand promises to decarbonize and produce EVs

Automakers' drivetrain development targets



Since 2020, 17 automakers, ranging from high-volume sellers such as GM to smaller brands like Rolls-Royce and Maserati, have announced internal combustion engine (ICE) phase-outs.

Four have set an end date for ICE vehicle sales in Europe specifically but have been vague regarding global ambitions.

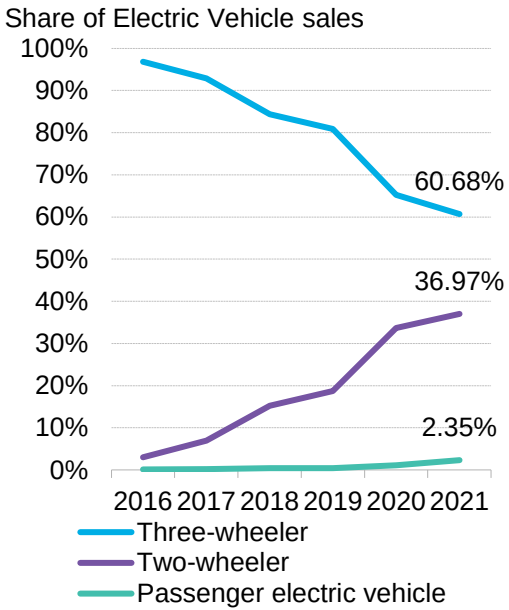
Automakers that have announced ICE phase-out targets to date represented 28% of global passenger vehicle sales in 2022.

Among those that have made commitments, only mainland China-based BYD has achieved its goal. The company stopped selling ICE vehicles in March 2022.

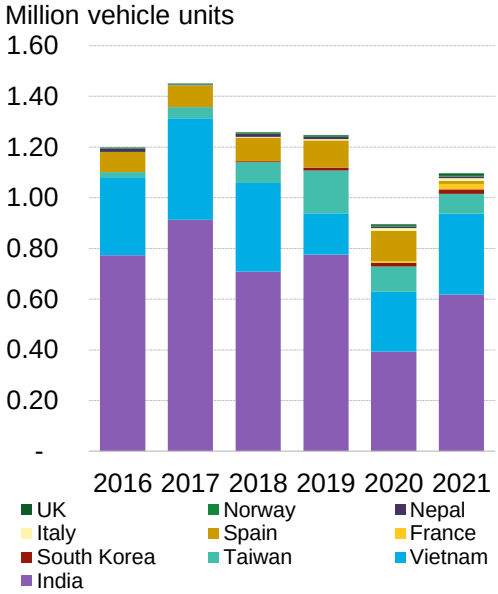
Source: BloombergNEF. Note: Ford, Hyundai, Stellantis and VW ICE phase-out target is for Europe only. On November 9, 2021, Ford signed the COP26 declaration on accelerating the transition to 100% zero-emission cars and vans, which called for working toward an ICE phase-out globally by 2040 and in leading markets by 2035. Excludes interim targets. Net-zero target scope varies by company, as some only cover Scope 1 and 2 emissions.

India's electric vehicle market regains its footing

India share of electric vehicle sales by type



Top 10 global battery-electric two- and three-wheeler markets (excluding mainland China)



Outside of mainland China, India has been the top demand market for two- and three-wheeled electric vehicles since at least 2016.

Demand for such vehicles slumped in 2020 as the pandemic took hold, but it bounced back by 9% in 2021 to reach 617,000 units. Global sales also suffered from the pandemic, reaching just 14.6 million units in 2021, far below the 18.7 million sold in 2019.

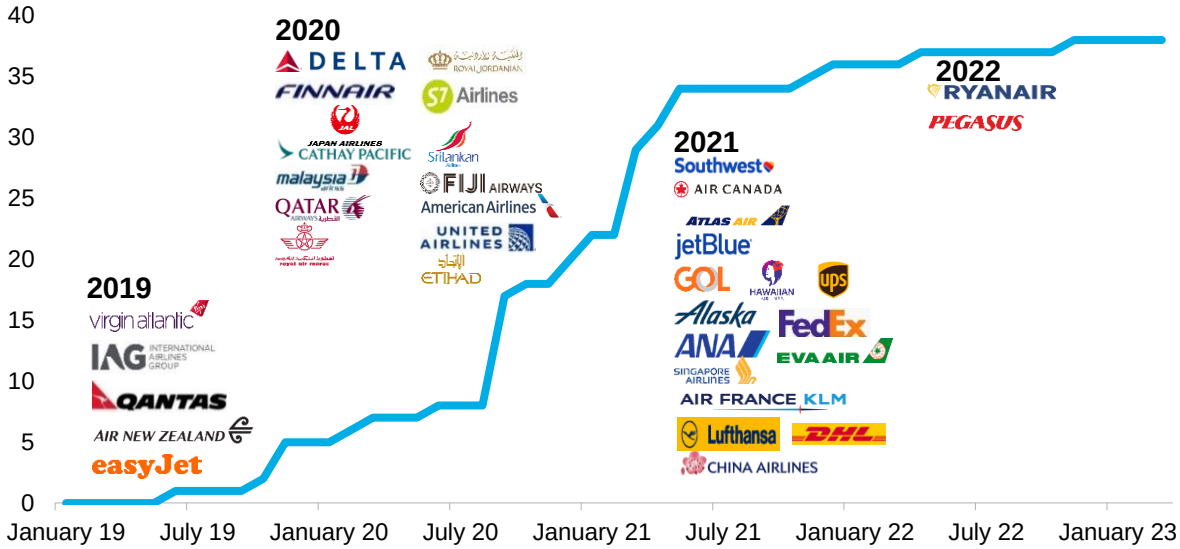
The market for four-wheeled electric vehicles in India remains in its infancy, partly due to the vehicles' high cost.

However, India passenger EV sales more than tripled from 2020 to 2021 to 15,000 units. In developing markets, affordability is one of the main barriers to EV adoption by consumers. Once price competitiveness is reached and other main hurdles are overcome, the market rapidly shifts to EVs.

Source: Society of Indian Automobile Manufacturers, Society of Manufacturers of Electric Vehicles, Bloomberg Intelligence, BloombergNEF. Note: Includes sales of low-speed models.

Over three dozen airlines have pledged to hit net zero

Airline net-zero targets by announcement date



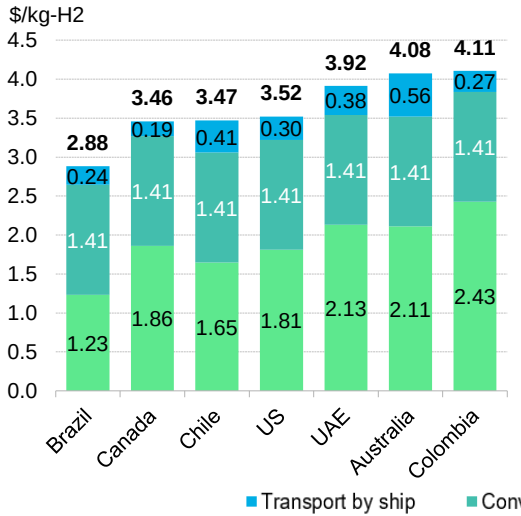
Decarbonization has taken center stage in the aviation sector over the past two years, with a growing number of airlines and airports setting targets to cut net emissions to zero.

As of June 2022, 38 of the world's top airlines – more than half of those tracked by BloombergNEF – have committed to achieving net-zero emissions by 2050 or before. In October 2021, the International Air Transport Association (IATA) set an industry-wide goal to reach net-zero carbon emissions by 2050, a step up from its previous ambition of a 50% reduction in emissions by 2050. Some airlines have set net-zero target dates significantly earlier than 2050: for instance, US carriers JetBlue and Alaska Airlines both aim to reach net zero by 2040.

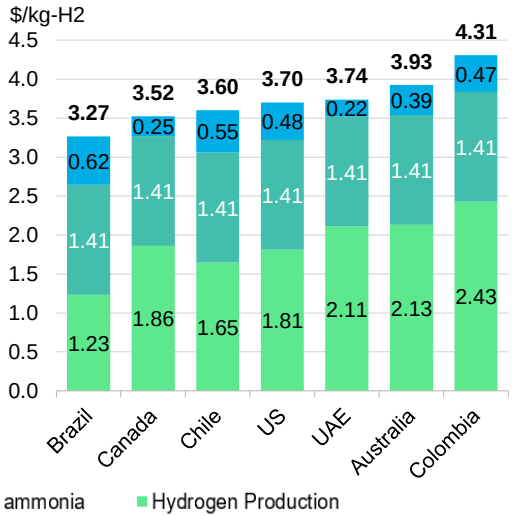
Source: BloombergNEF, company announcements.

Brazil has resources to deliver lowest-cost ammonia to Europe and Japan

Green ammonia unsubsidized delivery cost to Europe (Rotterdam), 2030



Green ammonia unsubsidized delivery cost to Japan (Tokyo), 2030



The race is on to develop the first major projects that produce then export the zero-carbon hydrogen contained in ammonia.

Projects in Latin America are likely to compete with projects in Australia, Canada, the Middle East and possibly the US for the mantle of lowest-cost provider.

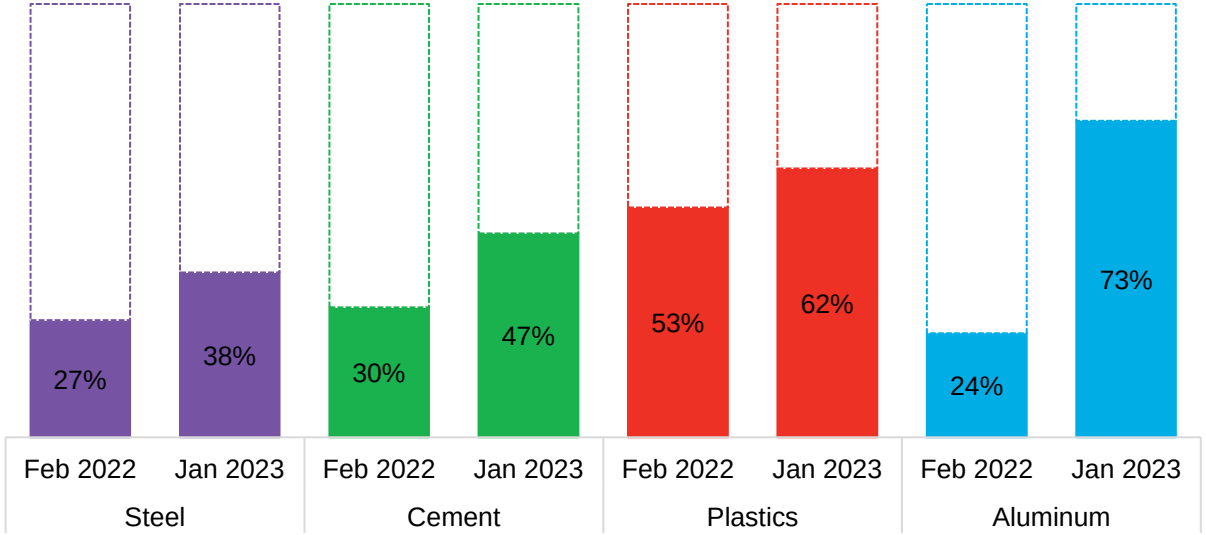
For delivery to key ports in Europe (Rotterdam) and Japan (Tokyo), BloombergNEF estimates projects in Brazil could by 2030 deliver the most competitive green ammonia in the world – without subsidies taken into account.

Brazil ammonia delivered to Tokyo is also the most competitive globally, at $3.27/kg NH_3, even with a considerably greater distance between the two ports. Much attention to date has focused on the port of Pecem in Brazil's Ceara state.

Source: BloombergNEF. Note: Costs are in $ per kilogram of hydrogen. Ammonia contains 17.6% hydrogen by weight. Brazil exports from Pecem. Canada exports from Quebec to Rotterdam and from Vancouver to Tokyo. Chile exports from Antofagasta. US exports from Houston. UAE exports from Ruwais. Australia exports from Dampier. Colombia exports from Cartagena. Hydrogen production assumes levelized cost of hydrogen (LCOH) using western alkaline electrolyzer for each country.

Materials producers have stepped up their commitments to decarbonization

Global share of CO2-intensive materials covered by net-zero targets



Corporate commitments to decarbonize CO2-intensive materials steel, cement, plastics and aluminum have grown.

The plastics industry was an early leader in decarbonization pledges due to investor pressure on oil companies, with a 53% capacity share covered by net-zero targets by February 2022 and a 62% share covered by 2023.

Aluminum now has more capacity covered by net-zero pledges, of all the tracked materials, in part because the decarbonization pathway is much clearer.

The lower shares for steel and cement are partly due to uncertainty among Chinese producers about their path to net zero, despite pressure from the government to achieve carbon neutrality.

Source: BloombergNEF

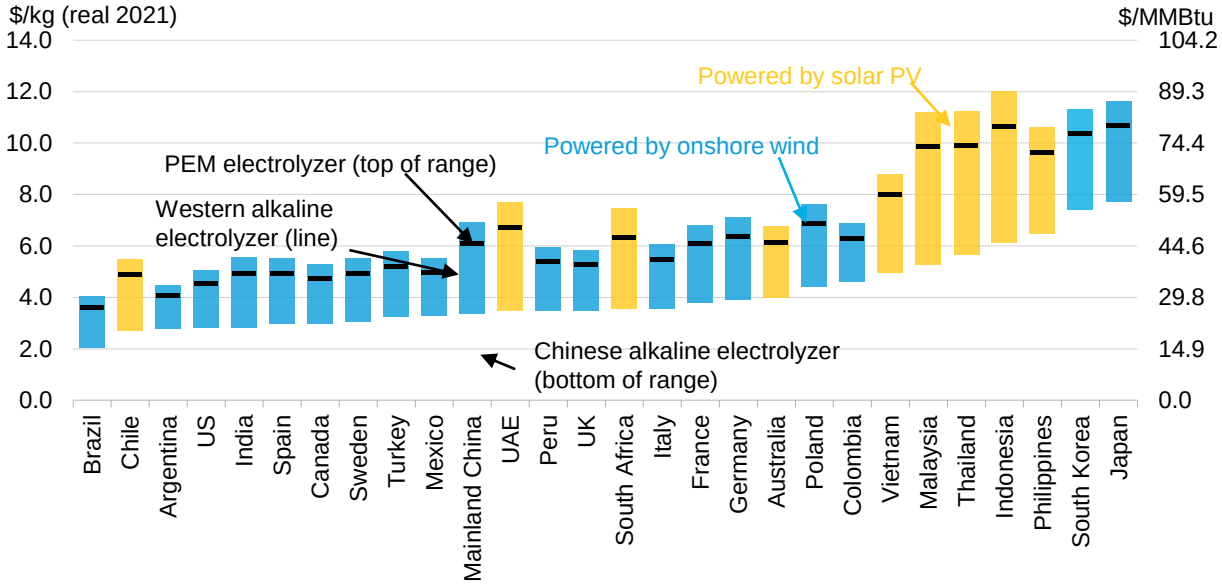
The potential for decarbonizing heat varies widely but can bring major benefits to large sectors

	Sector	Status		Ease of heat decarbonization		
		Temperature	Major fuel	Efficiency gains	Fuel switching	New technology or process
Big prizes (but hard to achieve)	Iron and steel	High	Coal	Hard	Hard	Medium
	Non-metallic minerals (cement)	High	Coal	Hard	Medium	Hard
Medium prizes (medium size difficulty)	Chemicals	High	Coal	Medium	Medium	Hard
	Non-ferrous metals (aluminum)	High	Electricity	Medium	Easier	Hard
Small prizes (but easiest to achieve)	Food and tobacco	Low	Gas	Medium	Easier	Medium
	Pulp and paper	Low	Renewables	Medium	Easier	Easier

Source: BloombergNEF, IEA

Hydrogen from renewables remains expensive, but costs vary widely by market

Levelized cost of hydrogen from cheapest available renewable power in 28 markets, 2022



Source: BloombergNEF. Values at the bottom show cheapest hydrogen using a Chinese alkaline electrolyzer, values atop the range show cheapest values using a proton exchange membrane electrolyzer, and black lines show cheapest values using a Western alkaline electrolyzer. Electricity source is either solar or wind, whichever is cheaper. MMBtu is million British thermal units.

Natural resources are the key to producing low-cost hydrogen with renewable power.

Brazil operates onshore wind projects with some of the highest capacity factors in the world. Partly as a result, it has the world's lowest potential levelized cost for zero-carbon hydrogen at $2.01-4.05/kg. Chile, thanks to its exceptionally sunny conditions in some areas, also has the potential to produce hydrogen at relatively low cost ($2.77-$5.48 /kg).

The cost of the equipment used to produce hydrogen – *electrolyzers* – is critical in the final levelized cost of producing the fuel.

Alkaline electrolyzers manufactured in mainland China tend to have the lowest cost, while proton-exchange membrane (PEM) electrolyzers tend to be the most expensive. Equipment costs are declining, however. India has the potential to be among the lower-cost producers of zero-carbon H2.

Six policy signposts for zero-carbon hydrogen development

Signpost	Explanation	Progress in 2H 2022
1) Net-zero emission targets are legislated	Makes it clear hard-to-abate sectors will need to decarbonize	Countries emitting over 92% of global CO2 have a net-zero target in force or under discussion
2) Hydrogen strategies and targets are set	Sets targets for H2 production and use, builds investor confidence	42 countries have H2 strategies, up from 34 in July 2022 and 27 in January 2022
3) Government-backed investment mechanisms are available	Provides R&D and performance-based funding for hydrogen projects	Total funding up 16% from July 2022, and 46% from January 2022
4) Decarbonization incentives for end-use sectors are put in place	Raises the chance that industrial, power and transport sectors adopt H2	South Korea is close to implementing the world's first hydrogen consumption mandate
5) Standards on H2 use are harmonized, regulatory barriers removed	Clears or minimizes regulatory hurdles to H2 projects and trade	H2 emissions standards are emerging, with the EU finalizing its standards for "renewable H2"
6) Regulatory frameworks for H2 transport and storage emerge	Enables or reduces the costs of building a hydrogen economy	Some EU countries outlined support and a regulatory framework for H2 pipelines

Zero-carbon hydrogen remains economically uncompetitive compared to 'grey' H2. BloombergNEF has identified six policy signposts that will be required to change that.

The best policy mix will depend on deployment stage and market type, with support needed for multiple parts of the value chain.

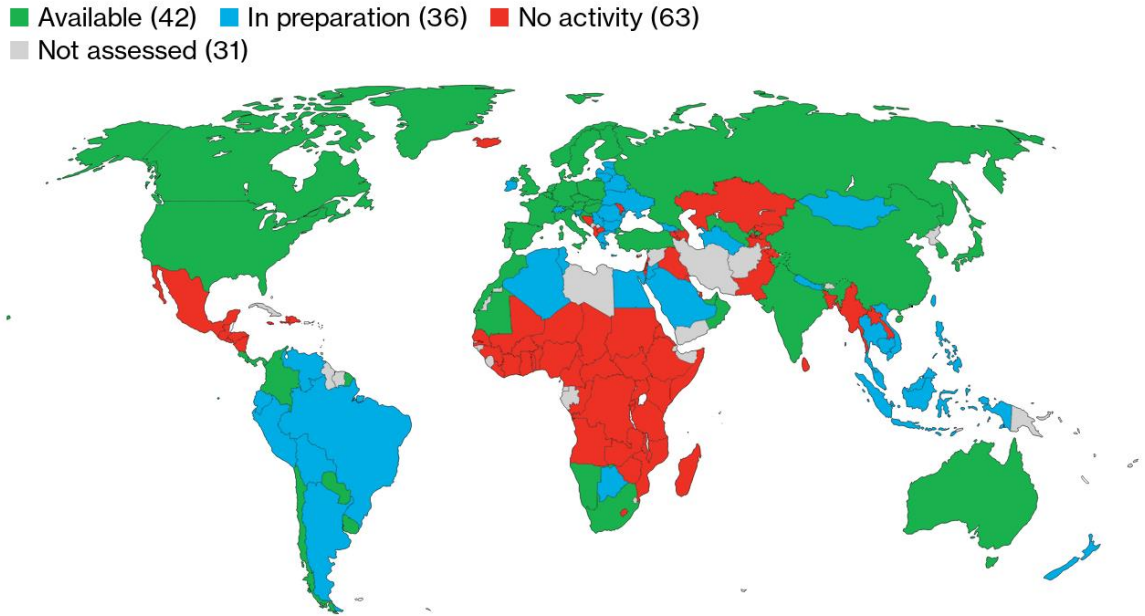
With net-zero targets covering almost 92% of global emissions, countries are focusing more on crafting specific policies to achieve their targets.

On hydrogen, there seems to be a preference for supply-side subsidies over demand-side incentives, for now.

Source: BloombergNEF. Note: Data updated as of August 15, 2022. Legend: More progress, some progress, less progress

42 economies now have hydrogen development strategies

Hydrogen strategies as of February 2023



Interest in hydrogen as a multi-purpose and potentially lower-CO2 fuel is rapidly growing.

As of February 3, 2023, 42 governments have written strategies to boost their hydrogen production and consumption. That's up from 26 economies at the end of 2021 and 13 at the end of 2020. Another 36 governments are preparing strategies as of February 2023.

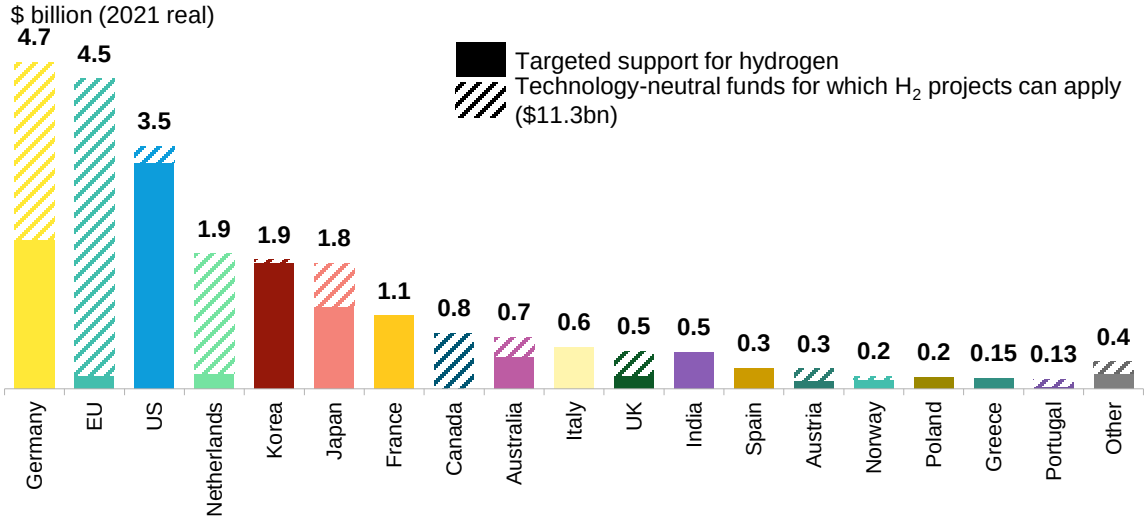
The US released its hydrogen strategy draft in September 2022, allocating $9.5 billion over the next four years to support hydrogen hubs and research programs.

The strategy outlines goals to produce 10 million metric tons of hydrogen per year by 2030 to decarbonize existing hydrogen use in ammonia and oil refining, and 50 million tons per year by 2050 to address the broader economy.

Source: BloombergNEF. Mapped data shows data for distinct economies.

Long-term government support for hydrogen could top $146 billion

Average annual budget for national subsidies open to low-carbon hydrogen projects



Government funding for hydrogen (H2) continues to grow in key markets, with emerging economies such as India joining the global H2 subsidy race.

Global funding for H2 reached $146 billion to 2030, up by 46% from January 2022 and up 16% over the last six months.

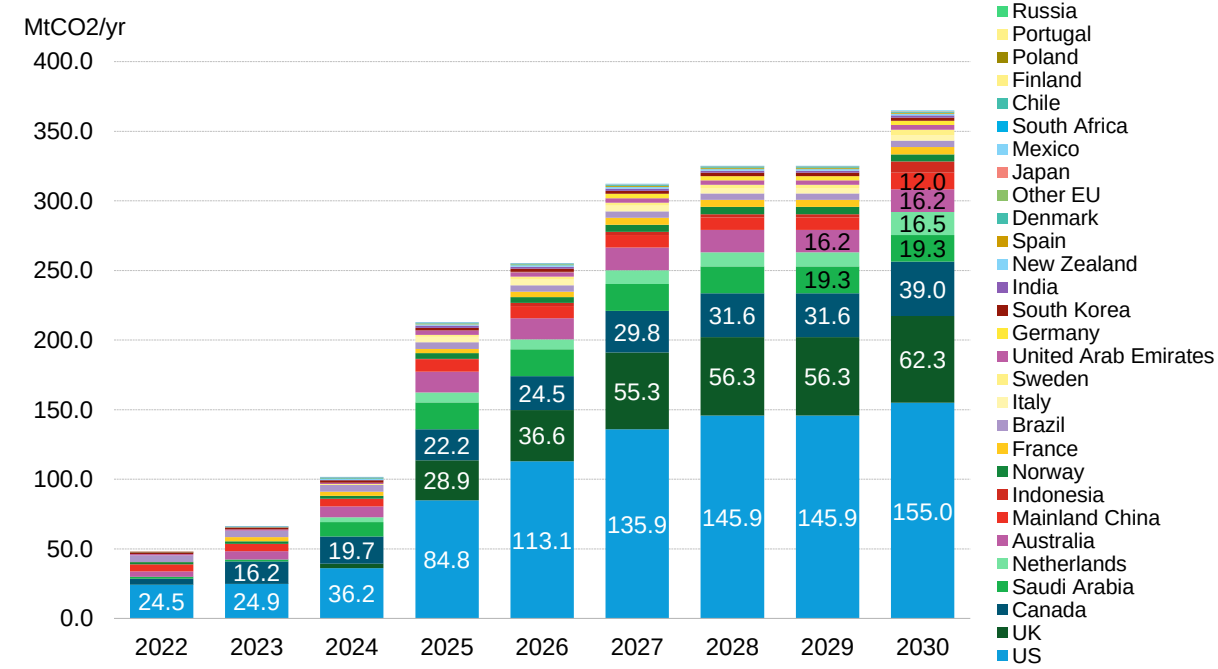
Funding worth around $24 billion per year is available in the European Union (EU) and 33 other markets.

This consists of $12.7 billion per year in support explicitly targeted at expanding hydrogen, plus another $11.3 billion per year from technology-neutral funds for which hydrogen projects can apply.

Source: Government agencies, BloombergNEF. Note: 'Other' includes Belgium, mainland China, Denmark, Estonia, Finland Romania and Uruguay. Includes subsidies announced and in force until 2030. Excludes sub-national funds and loan guarantees. Includes fuel cell funds. Funding amounts are annualized: for example, a $100 million fund delivered over 2021-30 is tracked as $10 million/year. Uses average 2018-22 FX rate for conversions to USD. H2 is assumed to access 15% of technology-neutral funds (such as the Netherlands' SDE++ scheme) and 40% of funds focused on industry decarbonization. Assumes 37% of EU funding from key programs is for clean energy projects, and that H2 is eligible for 15% of those funds.

Carbon capture utilization and storage development is poised to ramp up mid-decade

Expected CCUS capacity in CEM members, based on project announcements



Source: BloombergNEF

CCUS project developers are following the (public) money.

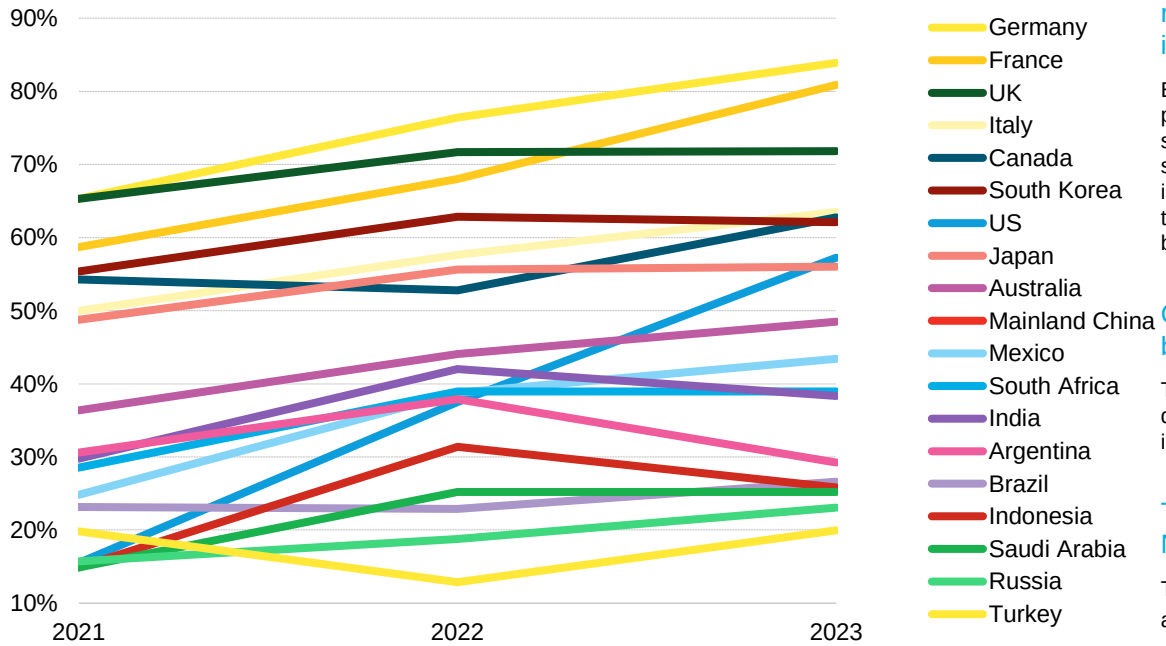
As policy is currently the largest driver of investment in the market, the US, Canada and the UK are likely to be leaders this decade. However, other regions are set to rapidly increase their capacity thanks to large financial commitments. Germany has announced it is devising a 'Carbon Management Strategy' to drive capture capacity to megaton scale by 2045. Japan updated its long-term CCUS roadmap again in 2022. The framework could position Japan as the fourth-largest market for CCUS as it is targeting 6-12 million tons per annum (Mtpa) of capture capacity by 2030.

By 2030, CO2 storage will surpass CO2 use.

Today, most of the CO2 captured is used for enhanced oil recovery. This is changing rapidly as CCUS becomes a route to decarbonization. By 2030, 66% of CO2 will be destined for storage, up from 25% in 2021.

Policy support for cutting industrial emissions has grown, but major work remains

BNEF industry policy scores, 2021-2023



Most G-20 economies are improving their policy regimes to support the decarbonization of industry.

Each year, BloombergNEF evaluates G-20 economies' policies to decarbonize the power, transport and industrial segments of their economies. From spring 2021 through spring 2023, most economies in the G-20 boosted their industrial decarbonization scores. But collectively, they scored just 48% for their efforts in this area – well below their scores for power and transport.

Germany, the UK and France have made the biggest commitments.

This is due primarily these economies' detailed decarbonization strategies and some incentives to ensure implementation, including carbon pricing.

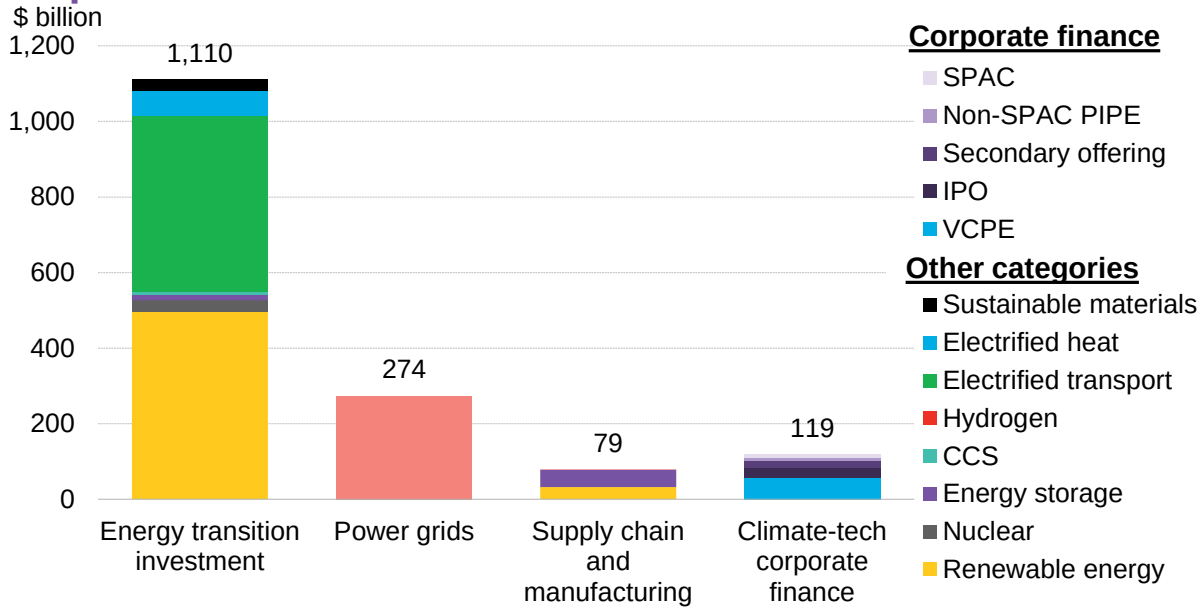
The biggest recent policy changes have been in North America.

The Inflation Reduction Act and Infrastructure Investment and Jobs Act have boosted US leadership in this area.

*Source: BloombergNEF. Note: Unweighted scores. For further details on BNEF's scoring methodology see the report (*https://tinyurl.com/bdd9dew4).

$1.6 trillion in investment flows to the low-carbon transition were tracked in 2022

2022 global energy transition investment and climate-tech corporate finance



Global energy transition investment, BNEF's measure of money spent to deploy low-carbon energy technologies, topped $1.1 trillion worldwide for the first time in 2022 and was up 31% from 2021.

This figure includes investment in projects, such as renewables, storage, charging infrastructure, hydrogen production, nuclear, recycling and CCS – as well as end-user purchases of low-carbon energy tech, such as small-scale solar, heat pumps and zero-emission vehicles.

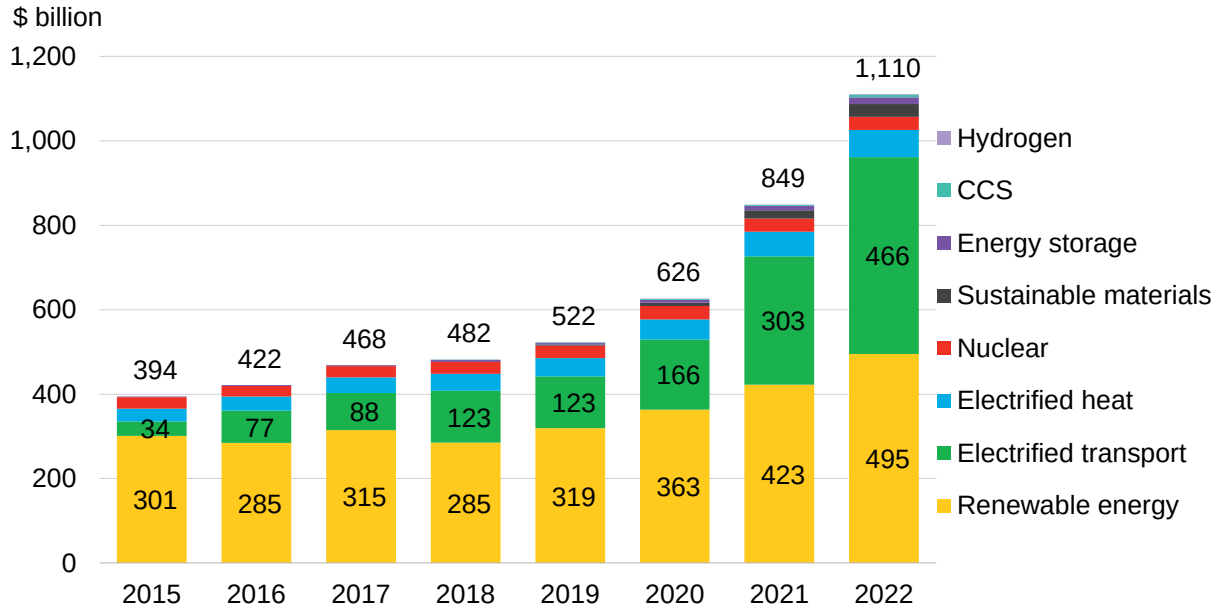
Climate-tech companies raised $119 billion in 2022, down 29% from 2021.

However, investment in clean-technology factories jumped 44% from 2021 to $78.7 billion in 2022. Power grid investment hit $274 billion globally. Transmission and distribution are critical enablers of the energy transition, even though power lines do not themselves displace greenhouse gas emissions.

Source: BloombergNEF. Note: SPACs are special purpose acquisition companies. PIPEs are private investment in public equity transactions. IPOs are initial public offerings on stock exchanges. VCPE is venture capital and private equity.

Energy transition investment surged past $1 trillion in 2022

Global investment in the energy transition by sector



Source: BloombergNEF

New capital invested in support of deploying energy transition technologies hit a record $1.11 trillion globally in 2022.

Renewables, which include wind, solar, biofuels and other sources of power, narrowly retained its position as the largest sector, with a record $495 billion in new project investments.

Electrified transport, which includes spending on EVs and charging infrastructure, is now a very close second.

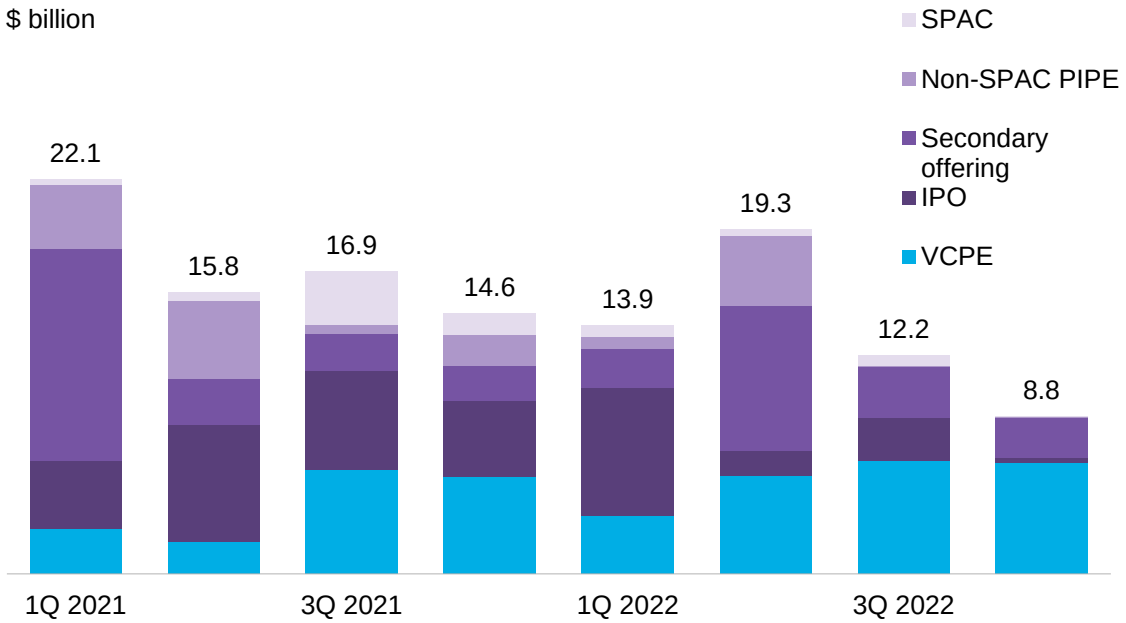
The sector grew to $466 billion (up 54%) as the EV market continued to accelerate globally.

With the exception of nuclear power, which has been flat in recent years, all other sectors also saw record levels of investment.

Together, electrified heat, sustainable materials, energy storage, carbon capture (CCS), energy storage and hydrogen added another $149 billion in 2022.

Climate-tech company fund-raising slipped in 2022

Corporate financing in low-carbon energy by subsector, 2022



Source: BloombergNEF. Note: SPACs are special purpose acquisition companies. PIPEs are private investment in public equity transactions. IPOs are initial public offerings on stock exchanges. VCPE is venture capital and private equity.

Climate-tech dealmaking was down in each quarter of 2022 compared to the year prior, but the story varied between the public and private markets.

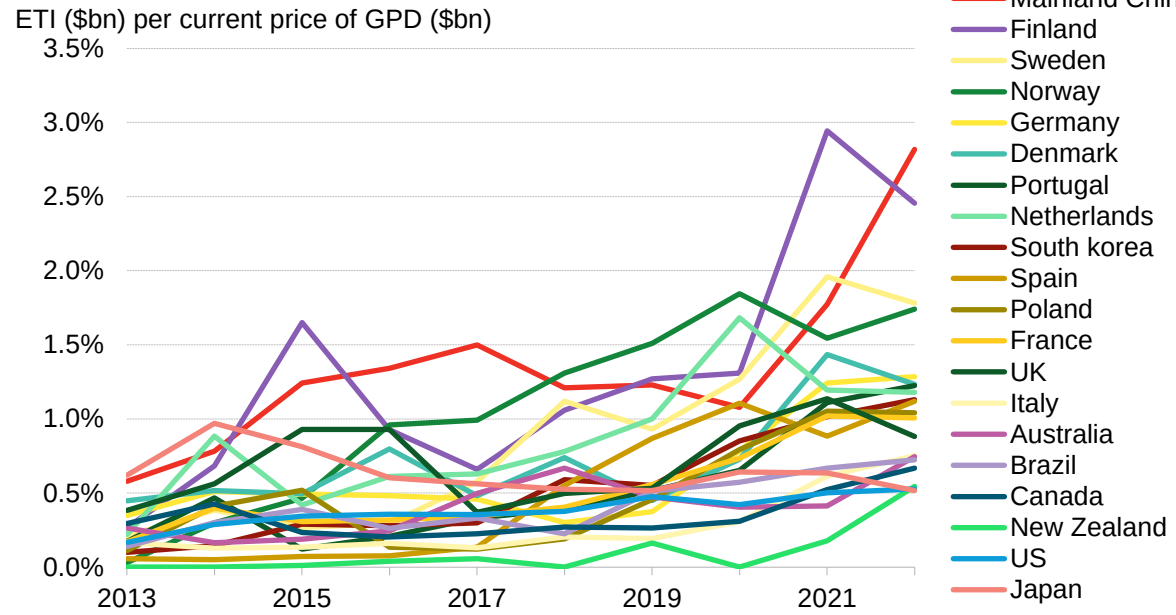
Public market fundings via primarily stock offerings fell 45% in 2022 compared with 2021. Meanwhile, venture capital and private equity (VCPE) stayed roughly level. Overall public market conditions in 2022 were not conducive to new fund raising. In addition, later-stage climate tech firms found opportunities to raise capital from private equity funds thanks to the large volumes those funds have raised in recent years.

On average, VCPE deals skewed larger in 2022 with over $21.2 billion raised.

On average, VCPE deals in 2022 were disproportionately larger, with more than $21.2 billion raised. This trend was particularly evident at the upper end of the deal distribution. The amount raised in nine-digit VCPE deals increased by 37% in 2022. Companies in the energy and transportation sectors tended to raise the largest amounts.

Global expenditure in energy transitions is growing

Energy transition investment per GDP in top 20 CEM members



A total of 1.3% of world gross domestic product went to energy transition investment in 2022.

That was up from 1% in 2021 and 0.8% in 2020. From 2021 to 2022 such investment's share of GDP jumped by close to a third.

Investment in mainland China and Finland as a share of GDP reached 2.8% and 2.5% in 2022, respectively.

Sweden came in third, with 1.8% of GDP. At 1.7%, Norway was a close fourth. The top 10 spending countries on an investment-to-GDP basis were located in Asia and Europe.

On average, CEM members invested 0.91% of their GDP in the energy transition.

Australia, Mainland China, Canada, Spain and Italy rose significantly compared to last year. Over half of CEM members increased ETI spending per GDP in 2022.

Source: BloombergNEF and IMF.

Sustainable lending is being used to achieve many goals

Sustainable lending labels and characteristics

Lendinb Type	Lending style	Purpose	Market size ($ billion)	Proportion of sustainable lending market	Growth rate 2021-2022
Green Bond	**Activity-based**	Environmental projects	2,422	42%	-10%
Sustainability-linked loan	**Behavior-based**	Institutional ESG targets	1,243	21%	-16%
Green loan	**Activity-based**	Environmental projects	735	13%	26%
Sustainability bond	**Activity-based**	Environmental and social projects	615	11%	-23%
Social bond	**Activity-based**	Social projects	548	9%	-39%
Sustainability-linked bond	**Behavior-based**	Institutional ESG targets	210	4%	-21%

Source: BloombergNEF, Bloomberg Terminal. Note: Instruments included are from 1996 to 1H 2022. Colors depict growth rate/size from green (most/greatest) to red (least/lowest).

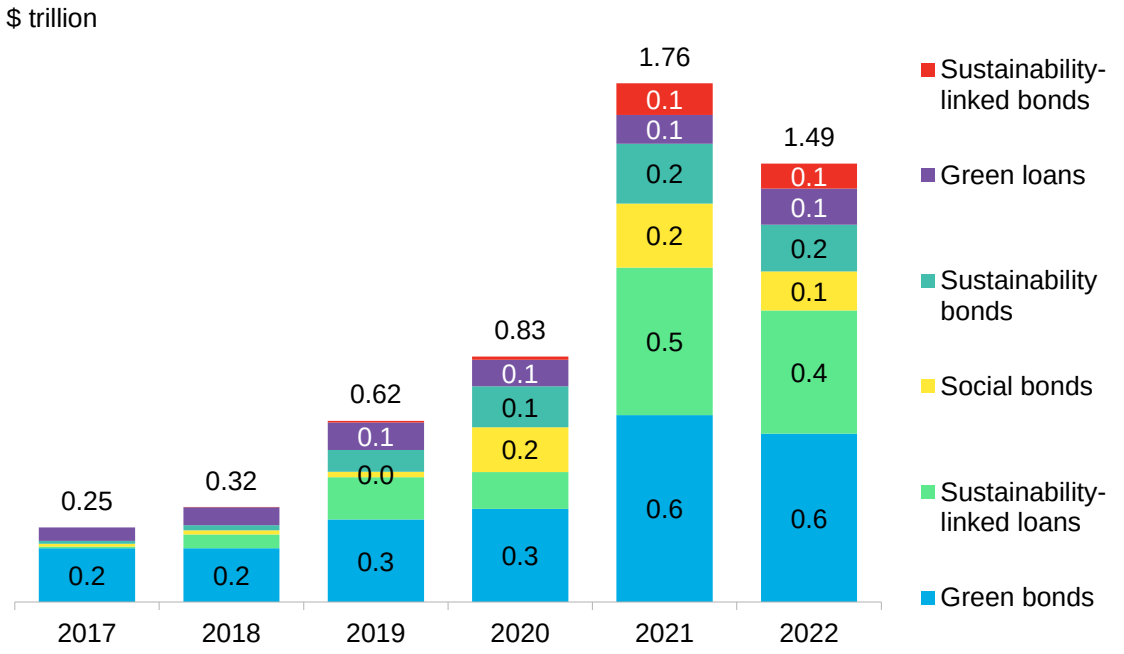
Companies, financial institutions and others have increasingly turned to the public markets to raise lending to promote environmental or social improvement.

Activity-based lending encompasses *green bonds*, *social bonds*, *sustainability bonds* and *green loans*. These are used to raise money to finance new, or refinance existing, green projects or activities. The money raised must be used for these activities, which can be for environmental benefit, social benefit, or both.

Behavior-based lending encompasses *sustainability-linked loans* and *sustainability-linked bonds* used to raise money for general purposes. The activities performed with the raised money are not what earns behavior-based debt types their 'sustainability' label. Behavior-based debt is dubbed 'sustainable' when it is tied to a sustainability target for the issuer, requiring them to modify their behavior. This could be a greenhouse gas emission reduction goal, a quota for diversity in the workforce or many other types of behavior.

Sustainable debt activity slowed as markets tightened, ESG scrutiny widened

Sustainable debt issued by instrument type



Source: BloombergNEF.

Sustainable debt issuance, which describes borrowing for environmental or social purposes and debt for which the repayment is tied to sustainability metrics, totaled $1.5 trillion in 2022.

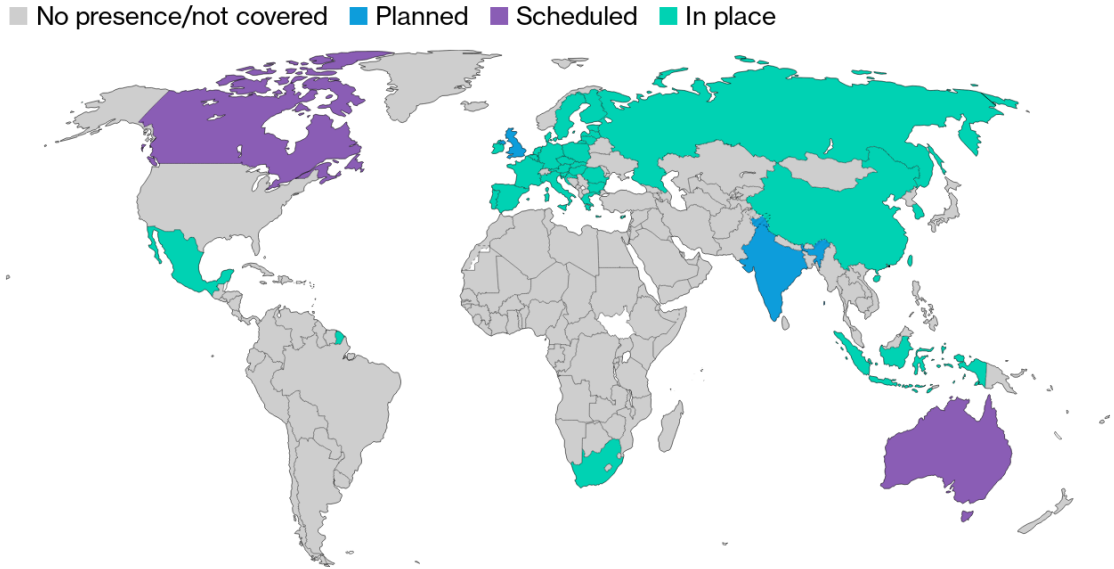
This was 16% below the 2021 record and the first-ever year-on-year decline. Activity slowed across broader fixed income markets. Inflation and higher interest rates constrained issuances. This was compounded by increased scrutiny of 'greenwashing' and general backlash against environmental, social and governance (ESG) investing.

Green bonds remained the most popular sustainable debt instrument, with $572 billion issued, although this figure was down from $635 billion in 2021.

Sustainability-linked loans, which tie interest repayment to an issuer's sustainability performance, were the second most popular, at $419 billion – down from $502 billion in 2021. Social bonds saw issuance drop 39% in 2022, from $218 billion to $133 billion.

'Green taxonomies' to define environmentally sustainable activities continue to proliferate

Green taxonomies around the globe



Source: BloombergNEF, various policy documents. Note: Planned policies refer to those that have been announced or are under development. Scheduled policies have a set time frame for their introduction. Data as of March 2023. Both mainland China and Taiwan have green taxonomies in place.

Governments are moving to better define what are (and are not) 'green' investments.

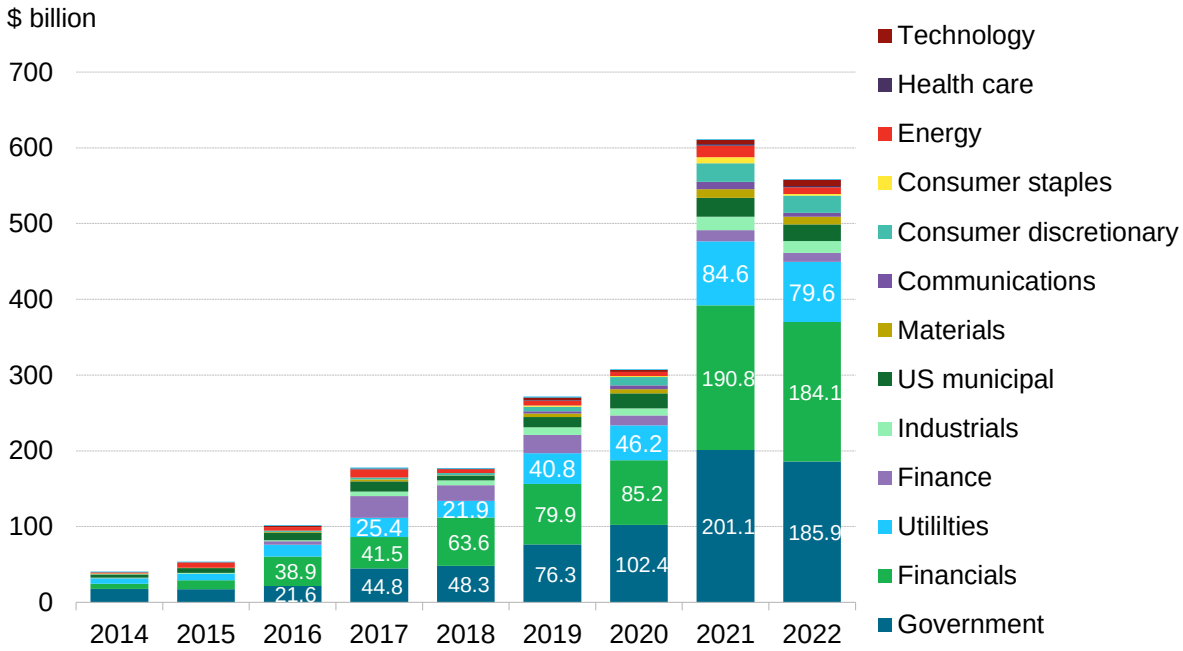
Taxonomies are classifications that set out the conditions under which an economic activity can claim to be environmentally or socially sustainable. Classification helps prevent 'greenwashing', or misrepresenting the sustainability credentials of a financial product or a corporate activity.

The EU has introduced complementary policies, like mandating the disclosure of company revenue shares aligned with its taxonomy. It has additional checks on whether activities aligned with the taxonomy 'do no significant harm' to other environmental objectives such as biodiversity and waste disposal.

Green taxonomies have been passed in mainland China, Russia and South Africa. An additional 31 countries have taxonomies in place. Another six have taxonomies either planned or scheduled.

Governments, financials and utilities are the biggest issuers of green bonds

Green bond issuance by sector



Source: BloombergNEF. Bloomberg Terminal

Green bonds remain top-heavy in terms of issuer sectors.

Governments ($186 billion) and financial entities ($184 billion) each accounted for 32% of the market in 2022. Utilities, at $80 billion, were the third largest sector, accounting for 14% of the market. Other sectors' issuance volume was much smaller, totaling $122 billion in 2022.

Technology was the only sector that issued more green bonds in 2022 than in 2021, rising by nearly 50% to $8 billion.

Intel Corp., Lenovo Group and ASML Holding, among others, debuted in the green bond market in 2022 and supported growth. All other sectors saw issuance decline, with consumer staples, communications and energy all dropping by over 40%

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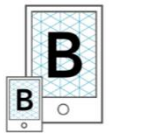

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