Energy Transition Factbook

Prepared for the 13th Clean Energy Ministerial

Bloomberg Philanthropies

BloombergNEF

GLOBAL CLEAN ENERGY ACTION FORUM
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CLEAN ENERGY MINISTERIAL
Advancing Clean Energy Together

Cover letter

It is my pleasure to share with you this year's Energy Transition Factbook, which illustrates the critical progress the world is achieving in the transition to a net-zero economy.

As in the past, this year's factbook identifies key, measurable trends in the development and deployment of clean energy technologies. In 2021, wind and solar made record contributions to the global energy system, meeting over 10% of electricity demand for the first time. These technologies are also the fastest-growing new sources of power-generating capacity – largely because they are the lowest-cost options in countries where over two-thirds of the world's population lives.

The factbook also highlights the important policy efforts underway to support the energy transition. A few encouraging trends: 65 percent of the world's people reside in countries where national governments have promised or legislated net-zero CO2 targets. Last year's Glasgow climate talks prompted nations to strengthen their climate commitments. And this year in Washington, Congress passed the first major piece of climate legislation in US history. Nevertheless, the world's wealthiest nations have yet to follow through on their Paris Agreement commitment to ensure $100 billion flows annually to developing nations to help them tackle climate change and address its worst effects. Policy makers, philanthropists, development finance institutions and private investors must all do more to achieve this goal.

Finally, this factbook illustrates surging investor confidence in these technologies. A total of $920 billion in new capital went into the energy transition and climate tech in 2021, supporting the construction of thousands of clean power and power storage projects, funding the development of experimental technologies and underwriting the purchase of 6.5 million new electric vehicles.

While substantial obstacles to clean energy remain, the wind is now very much at our backs, as we push toward a 100-percent clean energy future. I hope this factbook provides policymakers and other leaders the critical information they need to accelerate the clean energy transition, and the health and economic benefits it will bring.

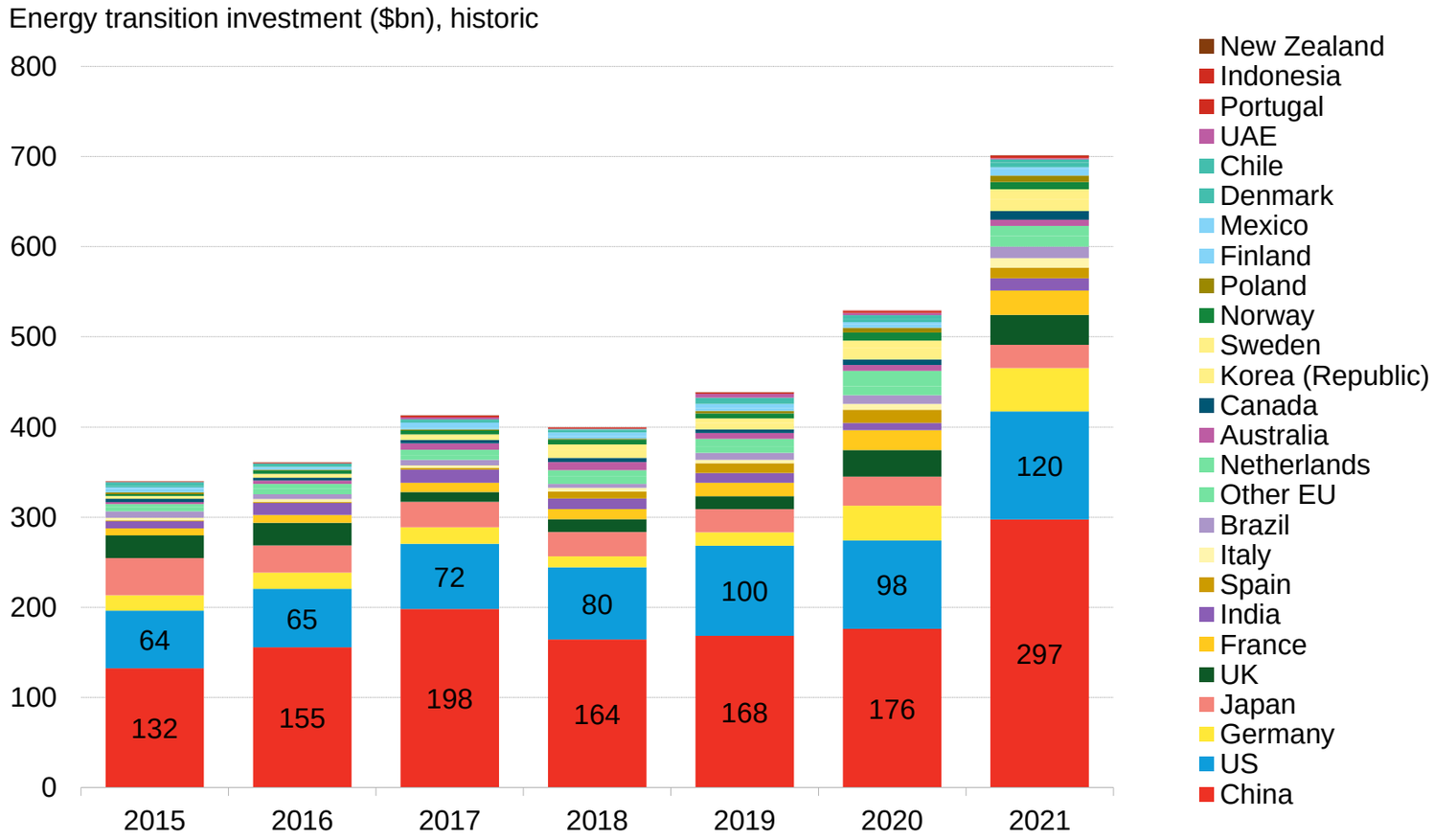
Thank you for your good work, and all the best.

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 a new high in 2021

CEM members' annual energy transition investment



Source: BloombergNEF. Note: "Other EU" refers to activity in EU nations other than Denmark, Finland, France, Germany, Italy, Netherlands, Poland, Portugal, Spain and Sweden.

Between them, the members of the Clean Energy Ministerial attracted $705 billion in investment for energy transition technologies in 2021 – a new record.

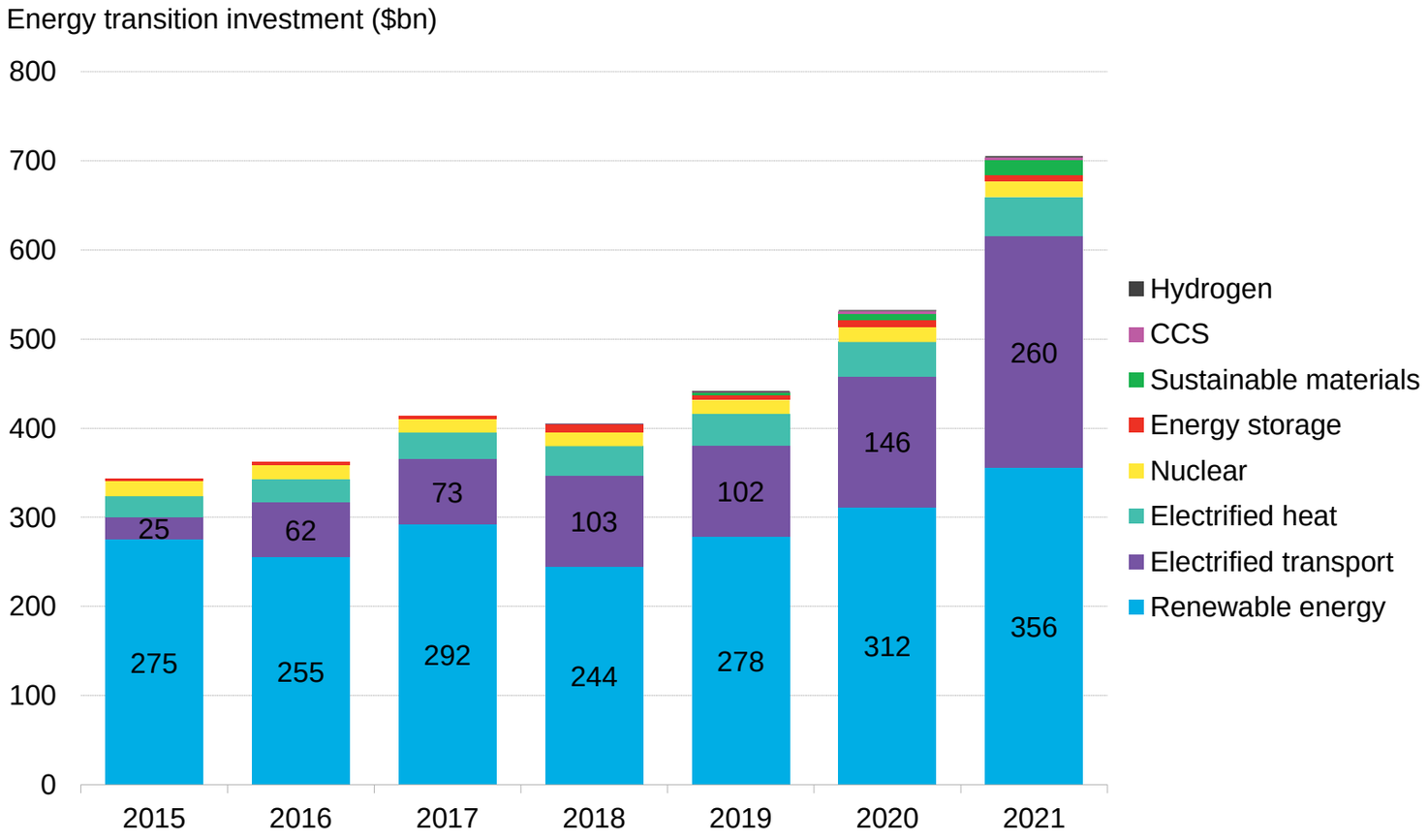
This marked a 32% jump from $533 billion invested in 2020, which had been the previous record, and included major investment in renewables, power storage and electric vehicles. Collectively, the members account for 90% of all energy transition investment worldwide.

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

Investment in China spiked 69% year-on-year to $297 billion. Investment also jumped in the US (22% to $120 billion) and Germany (25% to $48 billion).

Electrified transport's momentum is fueling overall investment, but other segments are also growing

CEM members' annual energy transition investment



Investment in electrified transport grew to $260 billion in 2021, but renewables remain the largest overall segment of energy transition investment among CEM members.

Surging investment in EV supply chains from investors and growing purchases of EVs from consumers allowed the electrified transport segment to post $114 billion year-on-year growth. However, renewables still accounted for over half of total 2021 investment at $356 billion, primarily due to continuing strong growth in solar deployment.

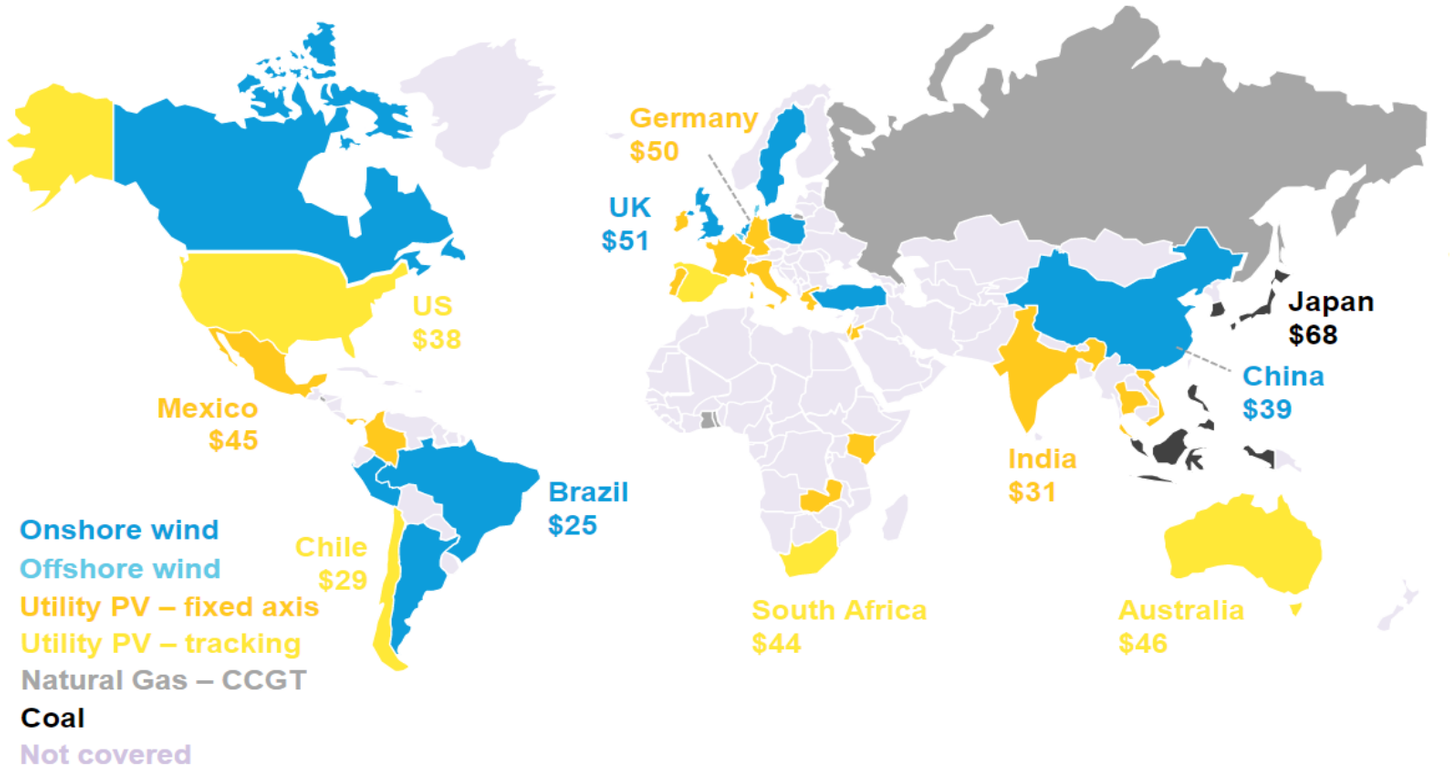
Other segments remain comparatively small but are growing.

Electrified heat, nuclear, energy storage, sustainable materials, CCUS, and hydrogen investment totaled $89 billion in 2021, or 12.7% of the global total. That was up from $74.6 billion in 2020 and $58.4 billion in 2018.

Source: BloombergNEF, Marklines. Note: EVs are electric vehicles, CCS refers to carbon capture and storage.

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

Cheapest source of bulk generation ($/megawatt-hour, levelized), 1H 2022



Two-thirds of the global population lives in a country where either onshore wind or utility-scale PV is the cheapest source of new bulk electricity generation.

This set of countries also accounts for three-quarters of global gross domestic product, worth $65 trillion, and 90% of world electricity generation.

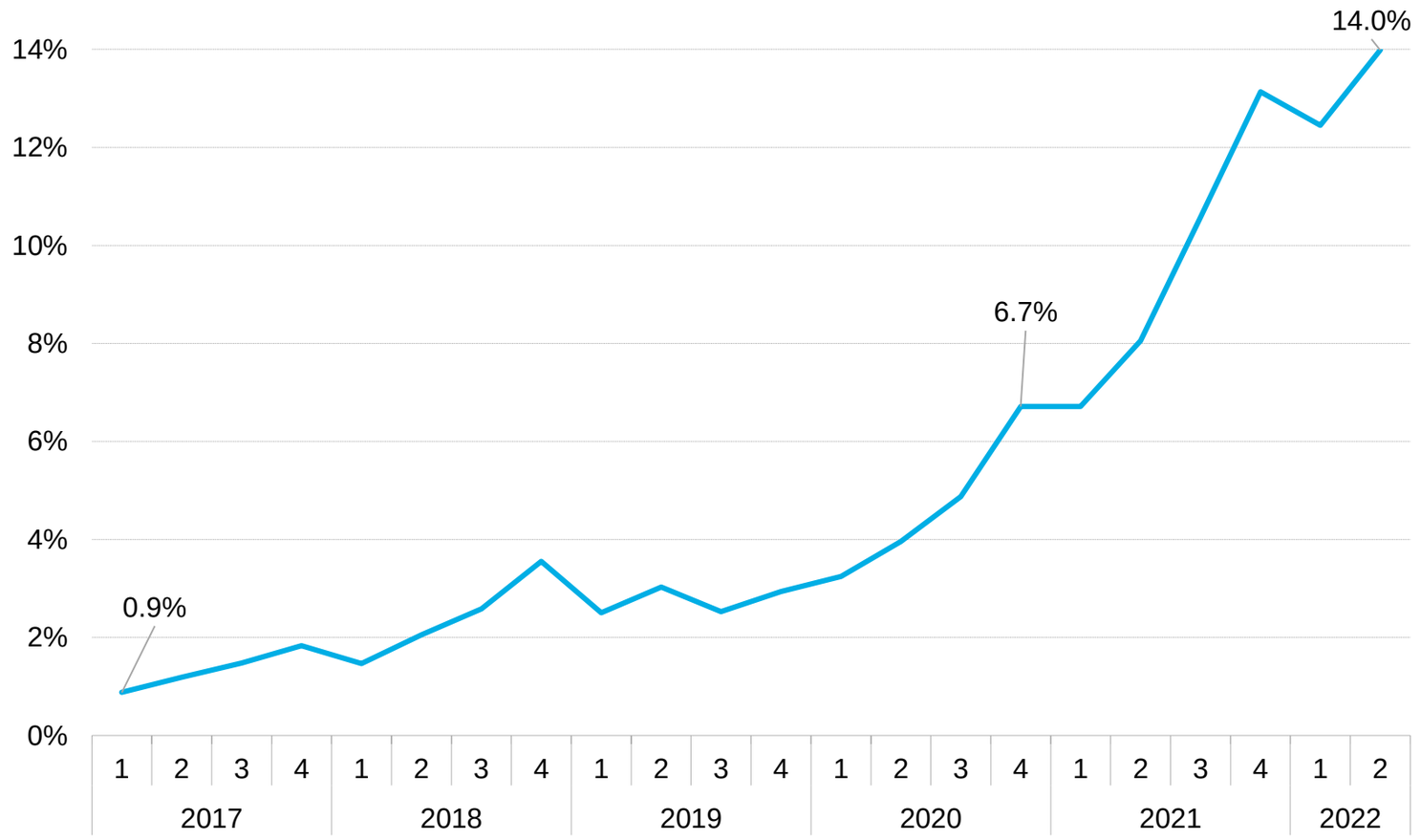
Rising gas and coal prices have made new wind and solar capacity cheaper than operating existing fossil fuel plants in a growing number of countries.

This is already the case in countries making up 58% of the world's population and two-thirds of electricity generation. Brazil, Argentina, Colombia, Chile, Peru, South Africa, Kenya, India, Thailand, Vietnam and Philippines are among the emerging markets that have reached this milestone.

Source: BloombergNEF. Note: The map shows the technology with the lowest levelized cost of energy (LCOE) for new-build plants in each country where BNEF has data. The dollar numbers denote the per-MWh benchmark levelized cost of the cheapest technology. All LCOEs are in nominal terms. Calculations exclude subsidies, tax-credits or grid connection costs. CCGT is combined-cycle gas turbine.

More than one in 10 cars sold today can plug into a wall

Global electric vehicle sales as a share of total car sales



Plug-in vehicles averaged 9.6% of total global car sales across the four quarters of 2021 and are trending higher in 2022.

A total of 6.5 million battery-electric (BEV) and plug-in hybrid cars (PHEV) were sold globally in 2021, more than double the 3.2 million sold in 2020.

Through the first six months of 2022, 4.3 million EVs were sold representing 13.2% of total car sales. One in seven cars sold had a plug.

In Europe, EV sales have now topped 20% of total car sales each quarter since the third quarter of 2021. The same has been true in China since the first quarter of 2022. Other countries and regions trail behind but have been gaining ground.

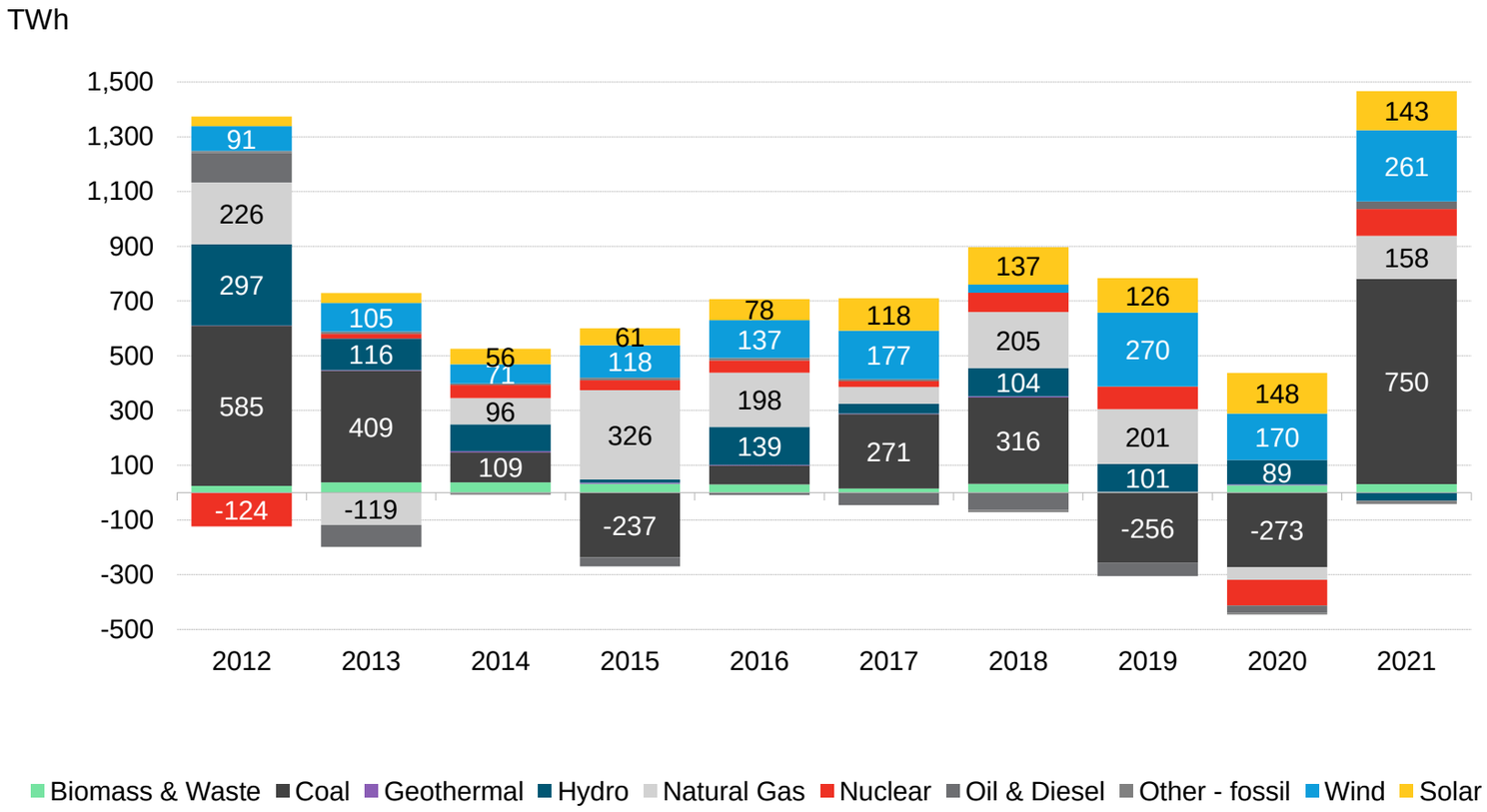
About 7 in 10 EVs sold each quarter are pure battery electric.

The balance are plug-in hybrid electrics (PHEVs).

Source: BloombergNEF, Marklines.

After two years of decline, coal-fired power generation sharply rebounded in 2021

Global year-on-year generation change by technology (TWh)



Global coal-fired power generation surged 750TWh 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 China, the net change in coal-fired generation was +395TWh. But China was hardly alone as demand for coal-fired power also increased in India (+153TWh) and the US (+21.4TWh).

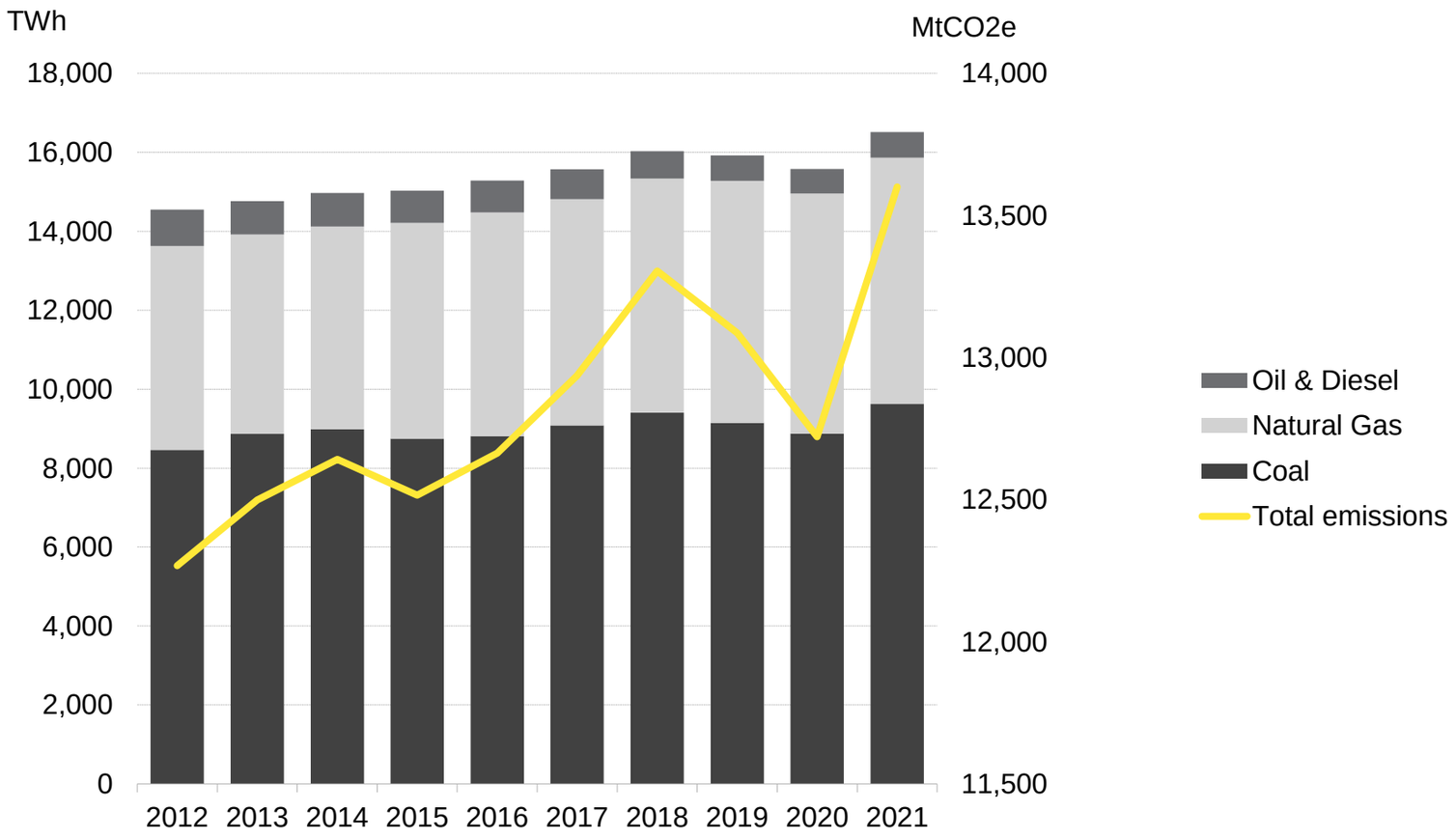
Wind and solar posted their biggest ever single year growth in contribution to new generation.

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. Its global contribution just crossed the 1,000TWh threshold for the first time to reach 3.7% of global generation.

Source: BloombergNEF Power Transition Trends report

Record demand and fossil fuel burn propelled power-sector CO2 emissions to an all-time high in 2021

Global fossil fuel power generation vs. global emissions



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 13,601MtCO2e.

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

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

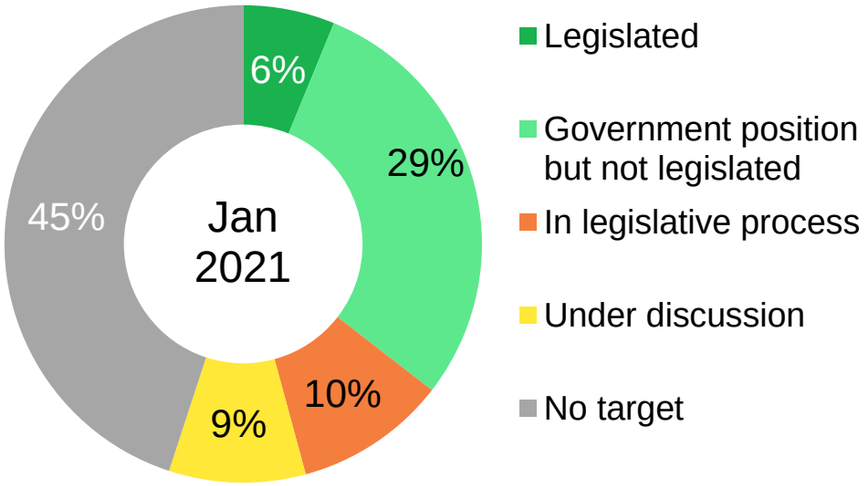
Coal-fired electricity generation totaled 9,622TWh, far exceeding the previous high of 9,401TWh set in 2018. Natural gas combustion also reached a record of 6,2423TWh in 2021, surpassing the previous peak of 6,131TWh set in 2019. Even oil combustion for electricity generation increased to 646TWh in 2021,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

Source: BloombergNEF Power Transition Trends report

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

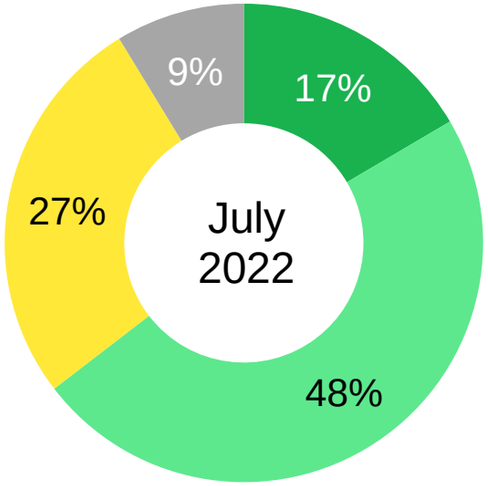
January 2021

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



July 2022

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.

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 takes 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.

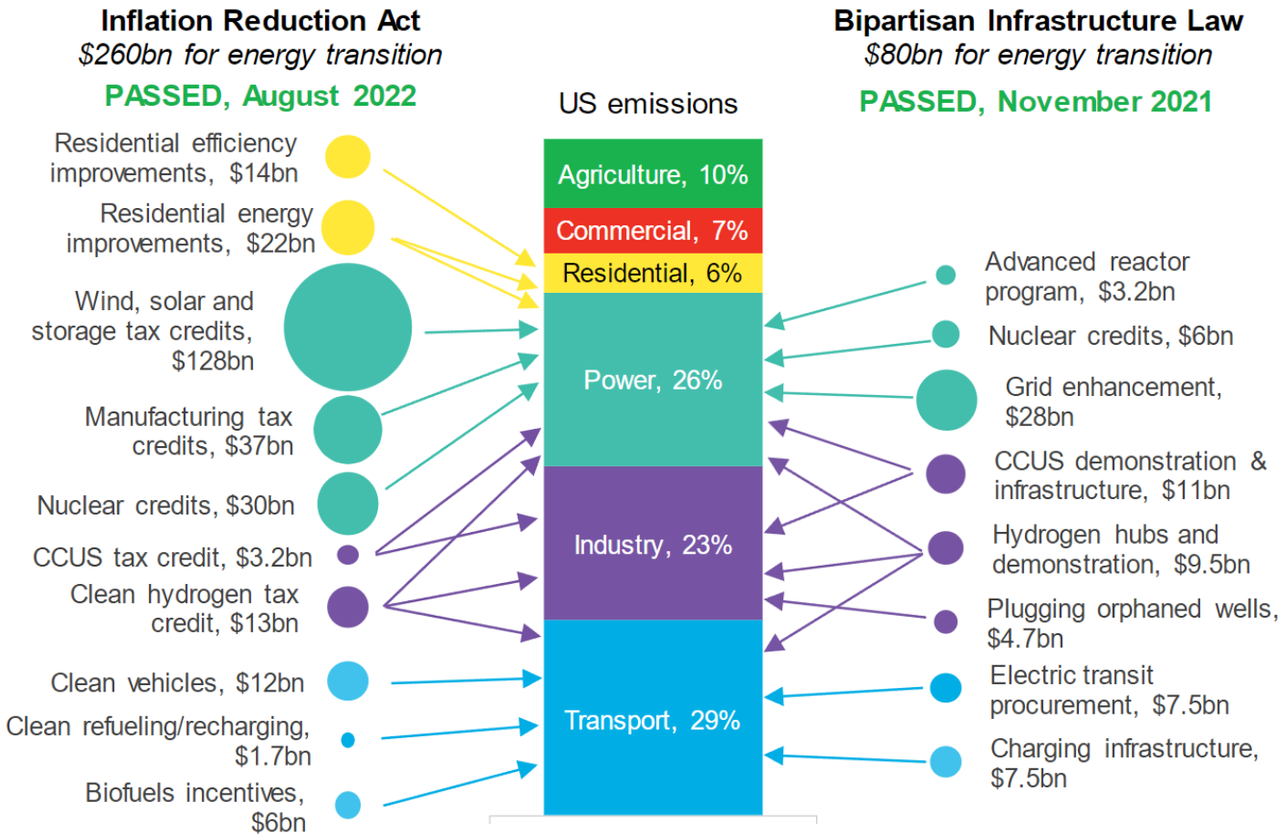
Commitments, as measured in greenhouse gas emissions covered, have nearly tripled in two and a half years.

In January 2020, 34% of global emissions were from nations either contemplating or enforcing net-zero targets. Only 2% was accounted for by countries with legally set targets. This 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.

The US has made an unprecedented commitment to energy-transition technologies with two new laws

2022-31 US federal support for energy transition technologies



The new climate law strengthens the US commitment to the energy transition.

With passage of the Inflation Reduction Act in August 2022, the US has committed $369 billion in new funding to combat climate change. This includes $260 billion specifically for lower-carbon technologies, including wind, solar and other renewables, along with nuclear power, electric vehicles, and others. It represents an unprecedented level of new commitment from the federal government.

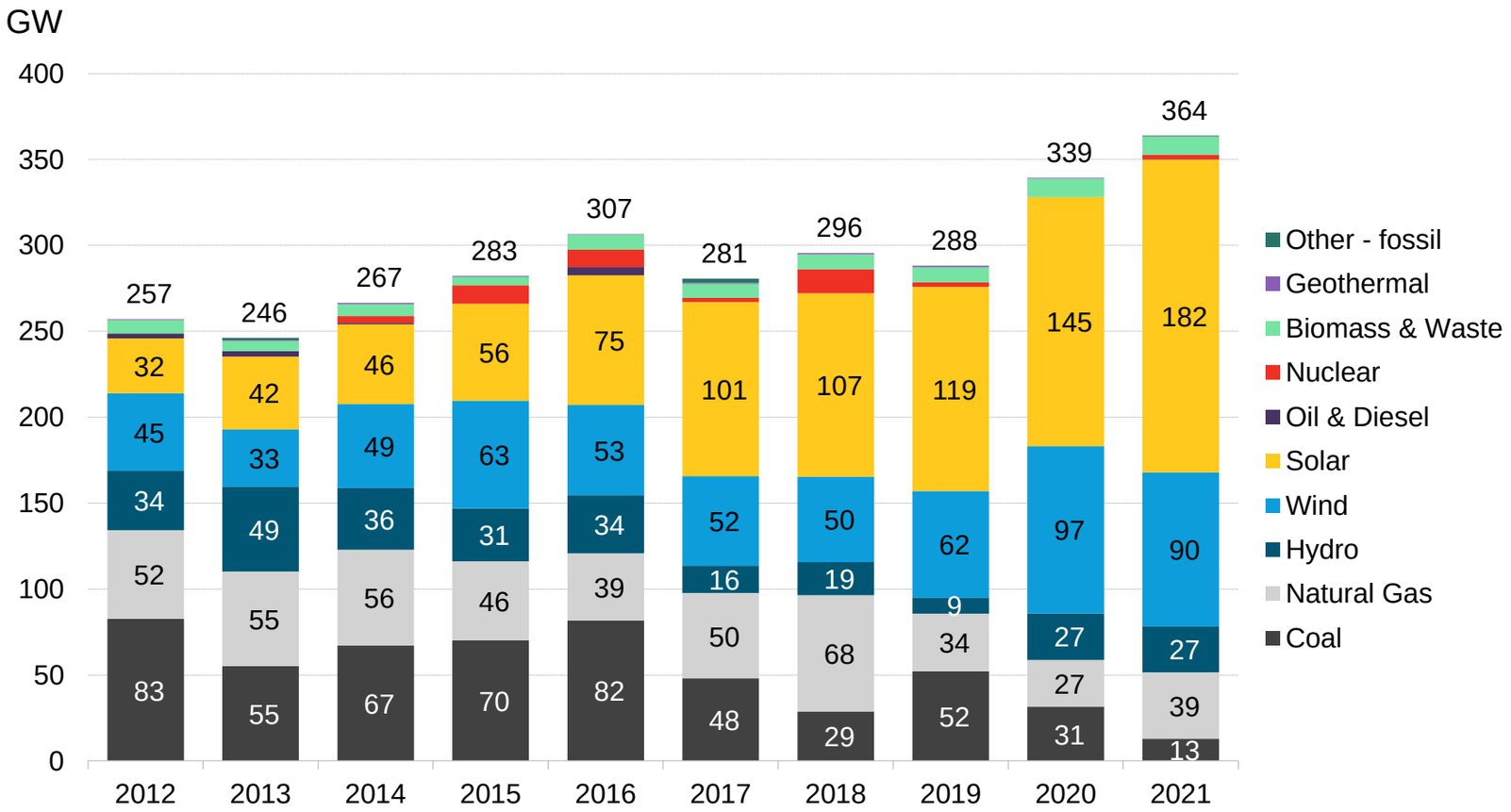
The US is now providing support for both the short- and long-term energy transition.

The Infrastructure Law, passed in November 2021, provides support for the technologies that could be required from 2030 onwards. This includes advanced nuclear reactors, hydrogen and carbon capture technologies.

Source: US Energy Information Administration, Environmental Protection Agency, Joint Committee on Taxation, BloombergNEF.
Note: Chart only captures tax credits and incentives, not grant programs or loans. Bn is billion. CCUS is carbon capture, utilization and storage.

Renewables set another record for new build in 2021 and now regularly dominate annual additions

Annual new power-generating capacity additions, global



2021 was another record year for the installation of zero-carbon power-generating technologies.

No less than 86 % of the world's new nominal capacity fed into the grids last 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 in 2021, up 26% from the 145-gigawatt record the year prior.

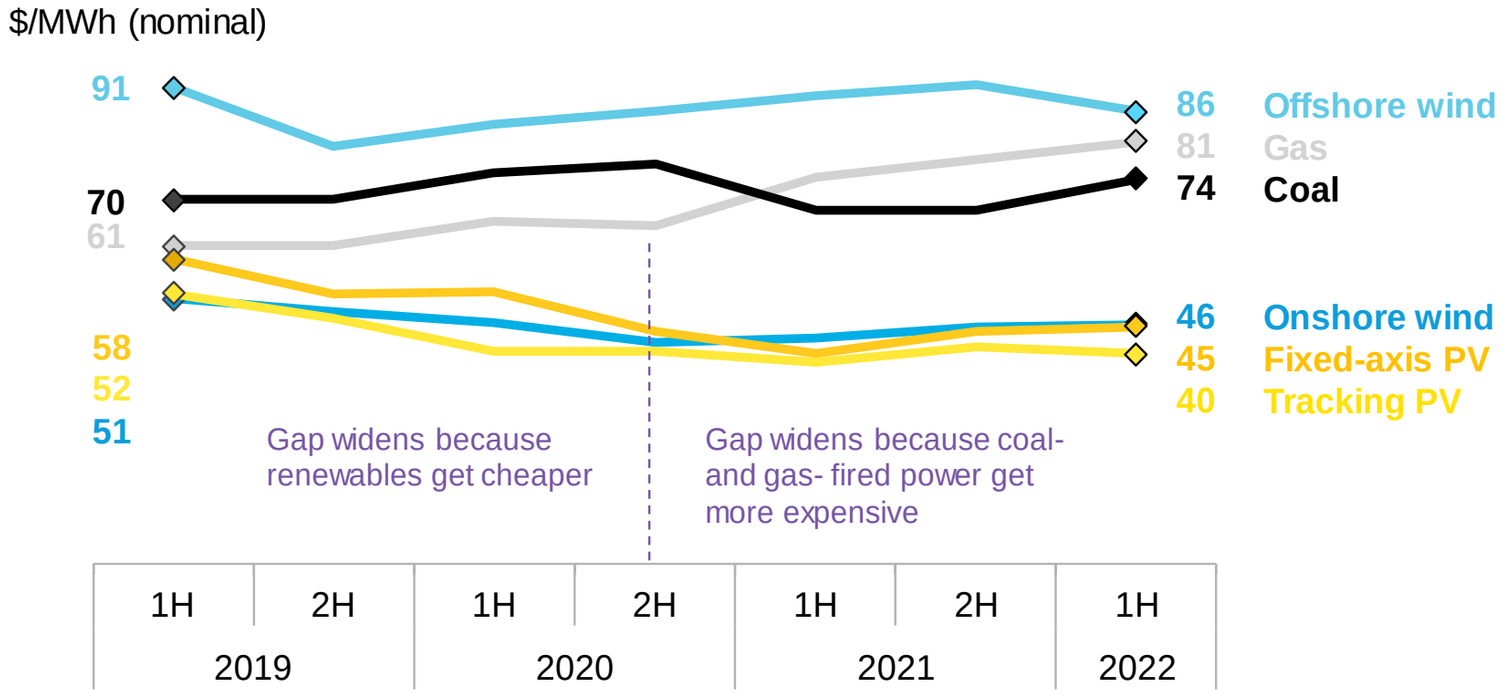
However, wind power capacity additions declined for the first time since 2017-2018.

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

Source: BloombergNEF. Note: GW is gigawatts.

Costs for both renewables and fossil-fueled power have risen but renewables retain the advantage

Global benchmark levelized costs of energy for bulk power, 2019-22



Onshore wind and solar have been the lowest-cost option since 2019 but their cost advantage has widened due to higher fossil fuel prices.

Supply-chain constraints and rising interest rates have arrested what had been a 10-year+ trend of declining levelized costs for renewables. However, those same constraints have sent fossil fuel prices through the roof in the last year. The net result: renewables are actually more cost-competitive with fossil sources of energy today.

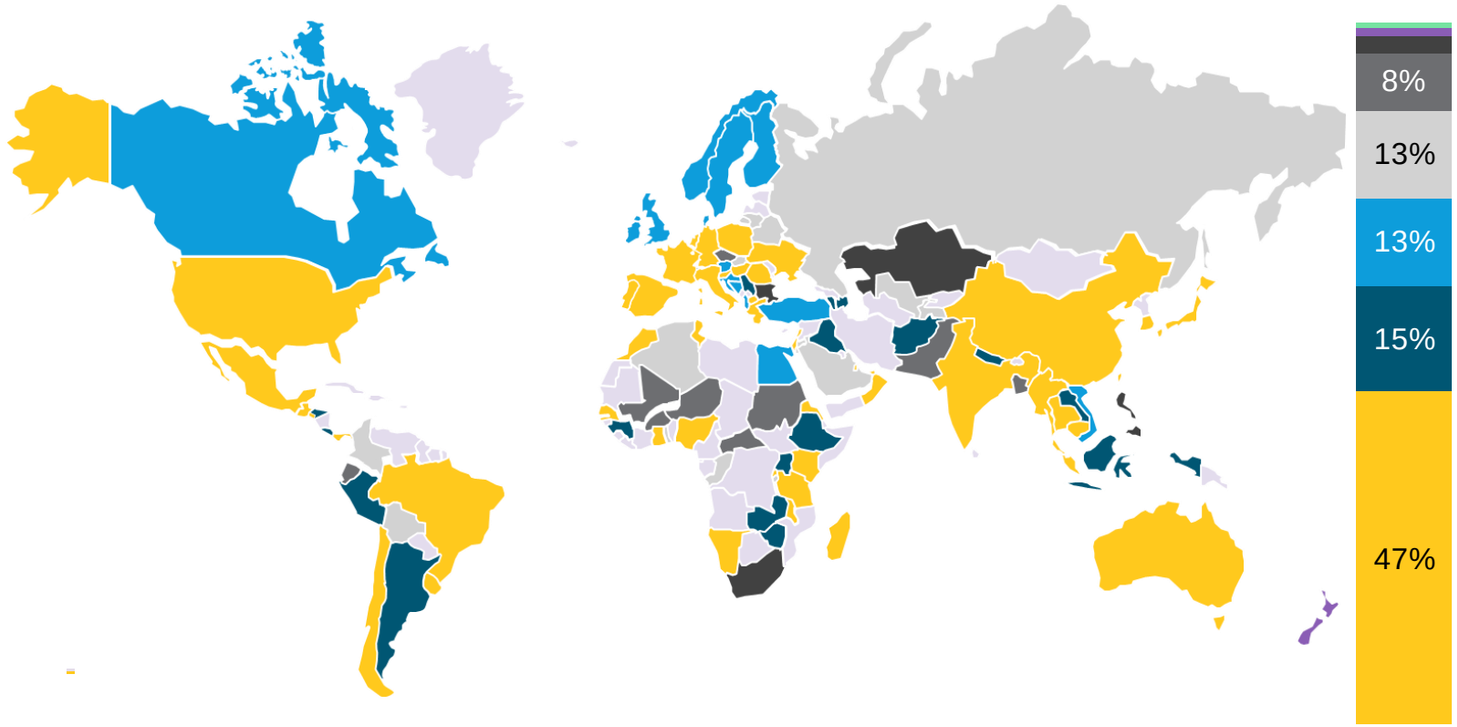
Offshore wind is increasingly competitive on an unsubsidized basis.

BloombergNEF's levelized cost of energy for offshore wind for 1H 2022 is $86 per megawatt-hour. That is now within striking distance of an $81 LCOE for natural gas. Offshore wind developers are also routinely signing power-delivery contracts for well below the estimated LCOE, often in anticipation of lower turbine costs in the future.

Source: BloombergNEF. Note: The global benchmarks are capacity-weighted averages using latest annual capacity additions and country LCOE benchmarks. Offshore wind includes offshore transmission costs. Coal and gas include a carbon price where policies exist. Gas depicted is combined cycle gas turbine. LCOEs exclude subsidies. LCOEs shown by financing date.

Renewables were the top choice for most countries in 2021

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



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

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

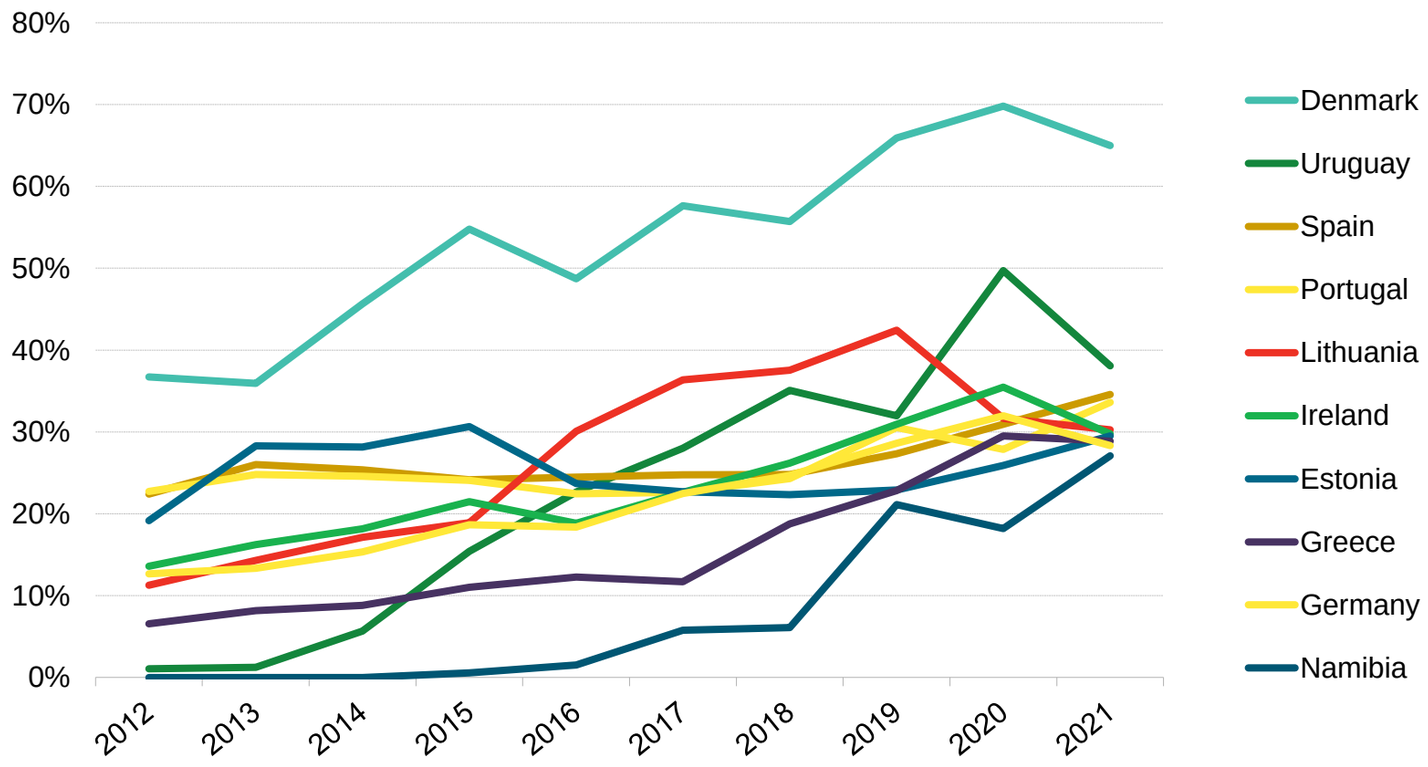
In 53 of the 112 nations where BloombergNEF could confirm new-build activity in 2021, solar was the top technology added, as measured in nameplate capacity. That is up from 14% of nations in 2012.

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.

Wind and solar continue to make unprecedented contributions to national grids

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



Source: BloombergNEF

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

In 2021, 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 percentage contributions in 2021 actually slipped compared to the prior year.

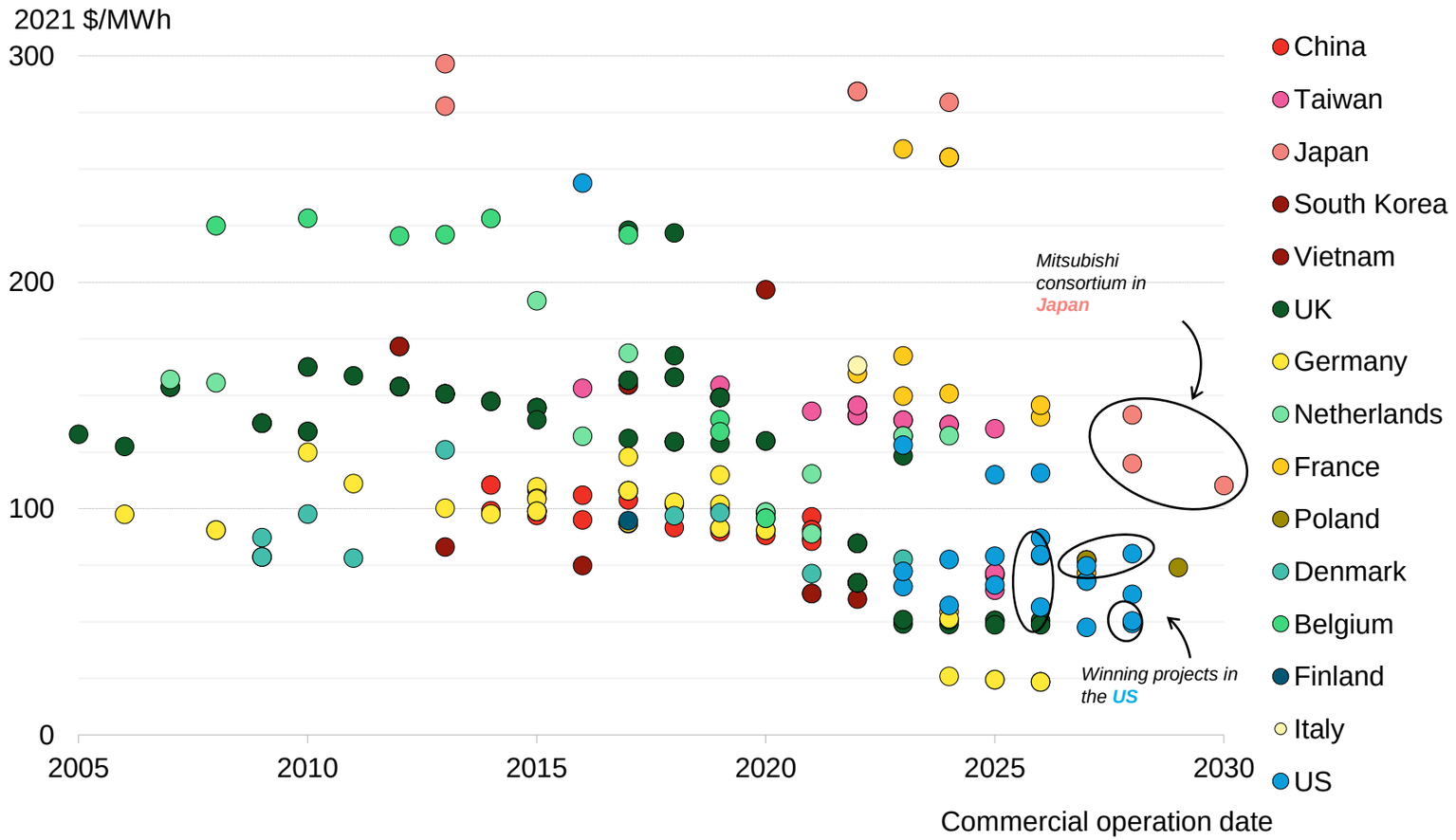
As economies recovered from Covid-19 lockdowns, top-line electricity demand jumped. As a result, renewables' share of total generation in these countries dipped somewhat, even in some cases where their absolute contributions as measured in megawatt-hours grew.

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.

Government-organized tenders are fueling an offshore wind capacity boom

Offshore wind power delivery contracts signed under tenders



Source: BloombergNEF

At 16.9 gigawatts, 2021 was a record year for new offshore wind capacity added with China accounting for over 80% of the total.

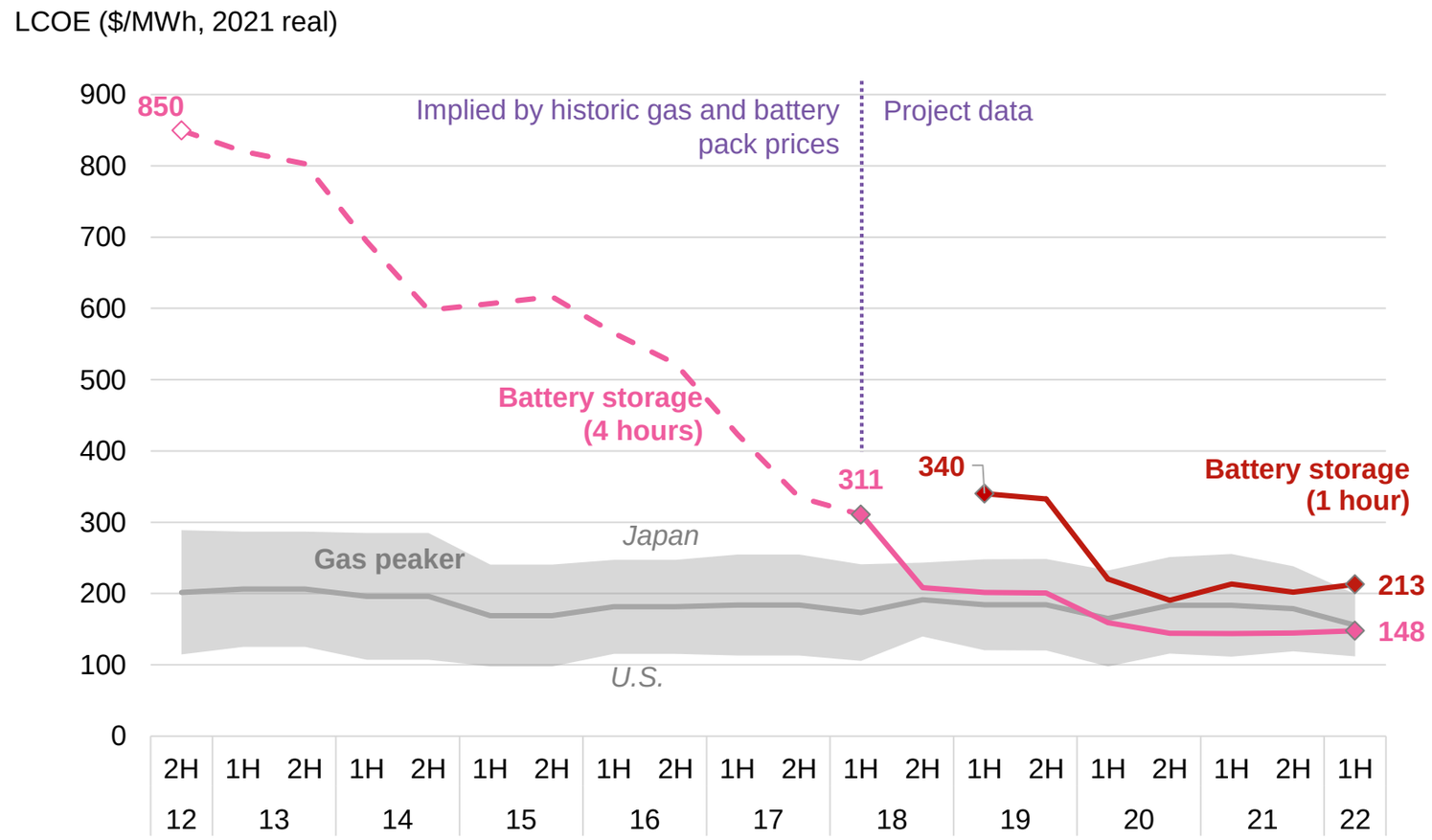
Activity should be somewhat slower in 2022 at 13.4 gigawatts but spread across more markets as projects in the UK, Taiwan and elsewhere come online.

Government-organized tenders promote growth and long-term confidence in markets.

In its first bottom-fixed offshore wind tenders, Japan awarded 1.7 gigawatts to three projects. In the US, Avangrid, Orsted, US Wind, and a partnership between Shell and Ocean Winds (an Engie and EDP Renewables joint venture) were awarded 3.3 gigawatts of contracts for wind farms sited off Massachusetts and Maryland. In January, New York finalized contracts for the 2.5GW awarded to Equinor and BP at the beginning of 2021. Around 36GW of projects are set to win auction contracts through the end of 2023. These offtake auctions will fuel the offshore wind pipeline in the latter half of the decade into the 2030s.

Power discharged from large storage systems can compete vs. gas-fired power despite rising battery prices

Global benchmark utility-scale battery storage and open-cycle gas turbine levelized costs



Utility-scale four-hour duration battery storage systems today can compete on cost with gas-fired peaking power plants in many markets, despite a recent rise in battery prices.

Storage is particularly cost competitive in markets where natural gas is imported, such as Japan or Europe. This is true despite a recent rise in battery costs due to supply-chain constraints.

The levelized cost for power discharged from battery storage systems was $148 per megawatt-hour in 1H 2022.

That includes the cost of charging batteries before discharging them. Battery costs fell sharply and steadily from 2012 to 2020. Prices then flattened and rose slightly due to supply-chain challenges.

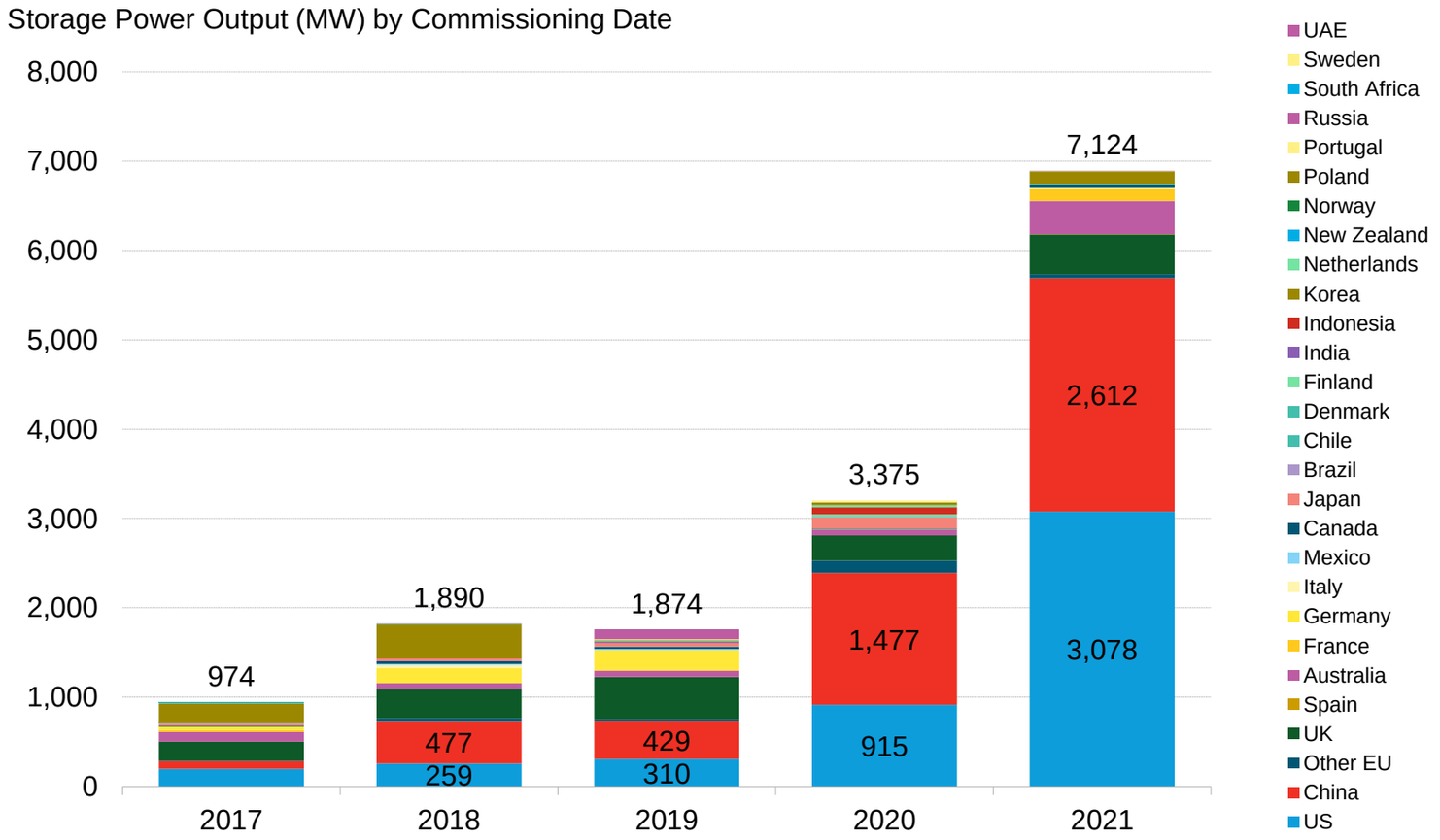
Upfront costs are the largest determinant of the levelized cost of storage.

System financing costs and charging systems costs are secondary.

Source: BloombergNEF. Note: LCOE is levelized cost of energy. $/MWh is dollars per megawatt hour..

Battery storage deployment doubled in CEM members in 2021 as more countries brought projects online

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



Over 7,100 megawatts of new battery storage capacity was added to grids in Clean Energy Ministerial member jurisdictions in 2021, up from 3,400 megawatts in 2020.

The rapid growth highlights the growing importance storage is playing on global grids, particularly as renewable energy penetration rates rise.

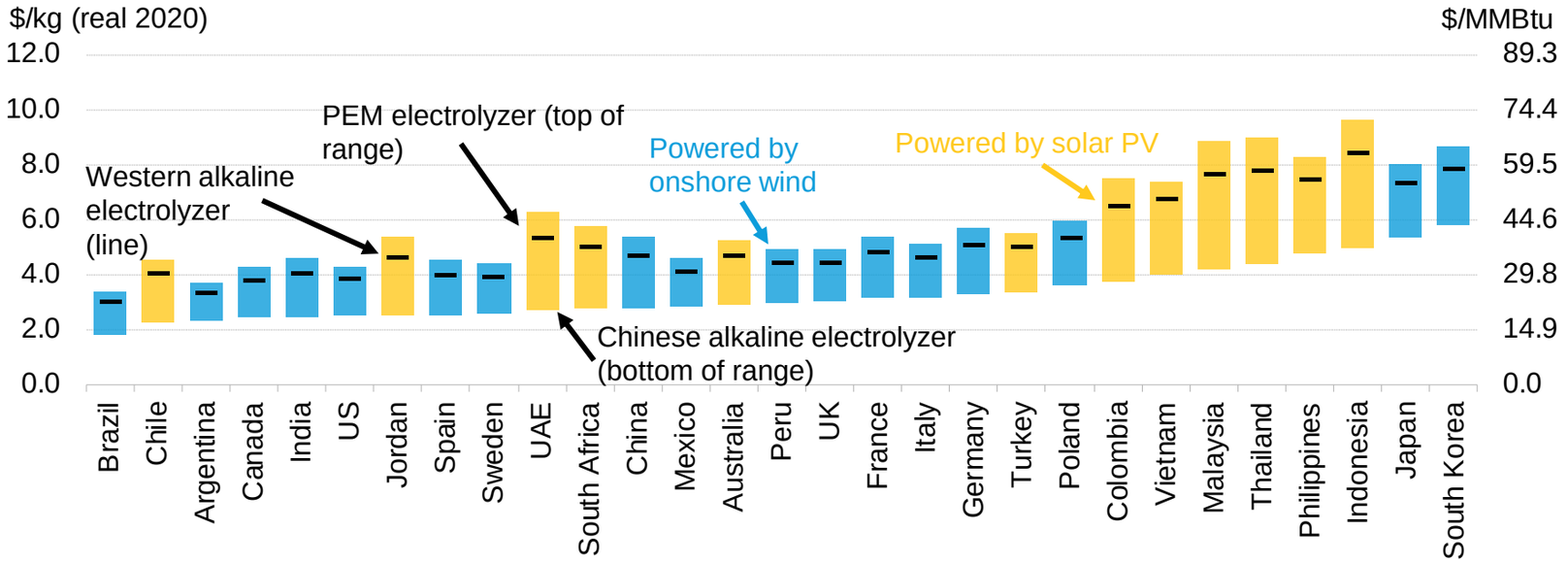
The US was the largest market for new installations in 2021, overtaking China for the first time since 2017.

Activity more than tripled in the US in 2021 from the year prior to hit 3,079 megawatts completed. China added 2,612 megawatts in 2021. Utility-scale solar power-generating projects accompanied by batteries are now commonplace in the US.

Source: BloombergNEF. Note: "Other EU" includes nations other than Portugal, Finland, Sweden, Spain, Netherlands, Italy, France and Germany.

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

Levelized cost of hydrogen production as of 1H 2022



Nations with exceptional natural resources have the potential to produce hydrogen with renewables at lowest cost.

Brazil operates onshore wind projects with some of the highest capacity factors in the world. Partly as a result, Brazil has the lowest potential levelized cost for zero-carbon hydrogen at $1.5-3.37/kg. Chile, thanks to its exceptionally sunny conditions in parts of the country, also has the potential to produce at relatively low cost ($2.24-$4.52/kg).

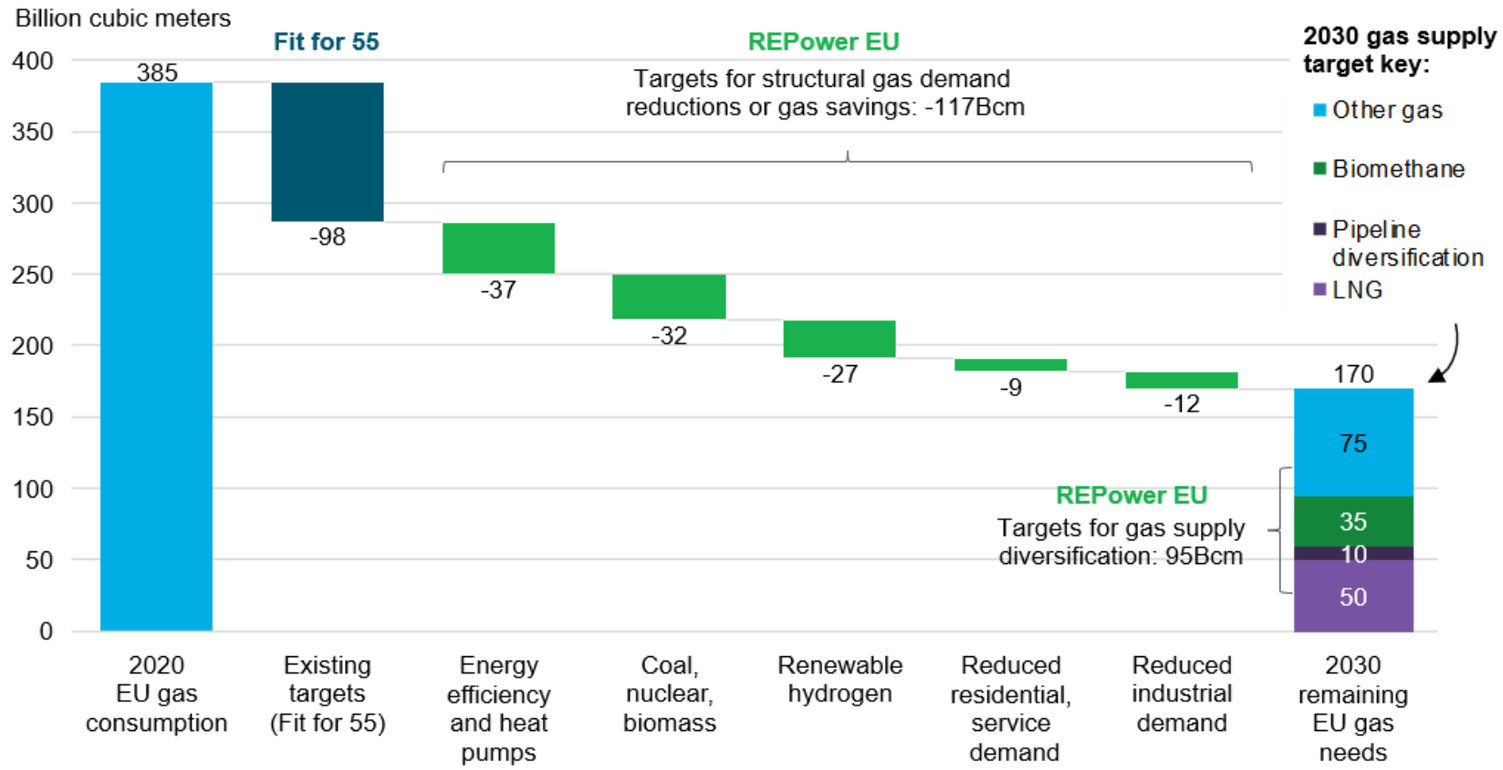
The cost of the equipment used to produce hydrogen – *electrolyzers* – is critical in the final levelized cost of producing the fuel.

Alkaline electrolyzers manufactured in China tend to be lowest cost while proton-exchange membrane (PEM) electrolyzers tend to be most expensive. Equipment costs are declining, however.

Source: BloombergNEF. Note: Countries colored by color (wind/blue, solar/yellow) based on which technology offers the lowest levelized cost in the country. Assumes a 1:1 capacity ratio of electrolyzer and power source. Assumes 2022 Chinese alkaline electrolyzer costs of $0.25/W, Western alkaline electrolyzer costs of $0.93/W and PEM electrolyzer costs of $1.11/W. By 2030, costs are assumed to converge to those listed in Hydrogen: The Economics of Production From Renewables (web | terminal). Electricity costs derived from BNEF's 2H 2021 LCOE Update (web | terminal), mid scenario.

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



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 use of energy efficiency and heat pumps, and to up 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.

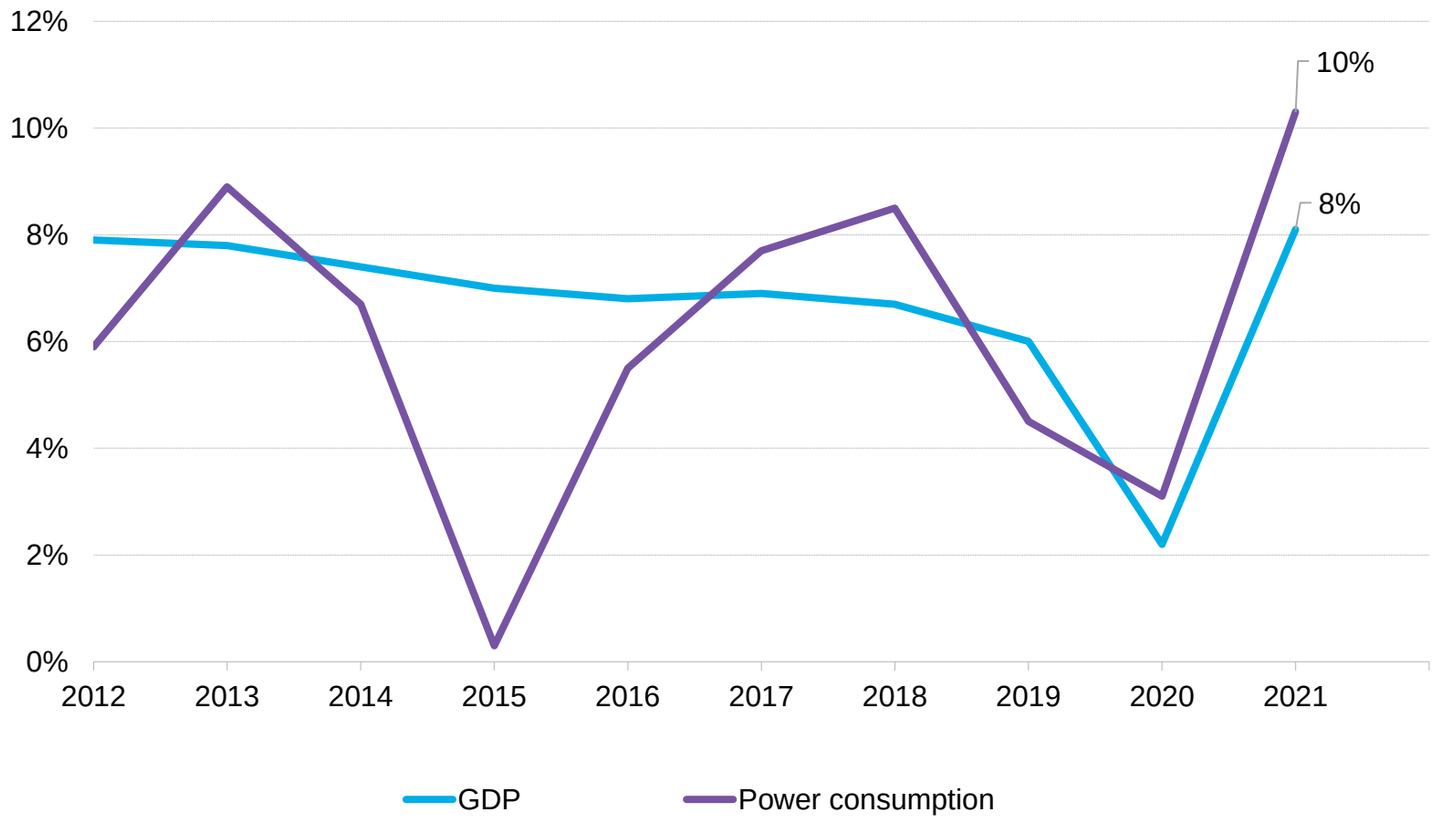
Clean energy isn't the only sector getting a boost.

REPowerEU also 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 LNG.

Source: European Commission, Eurostat

China’s resurgent economy boosted global power demand and coal burn

China year-on-year change in GDP and power consumption



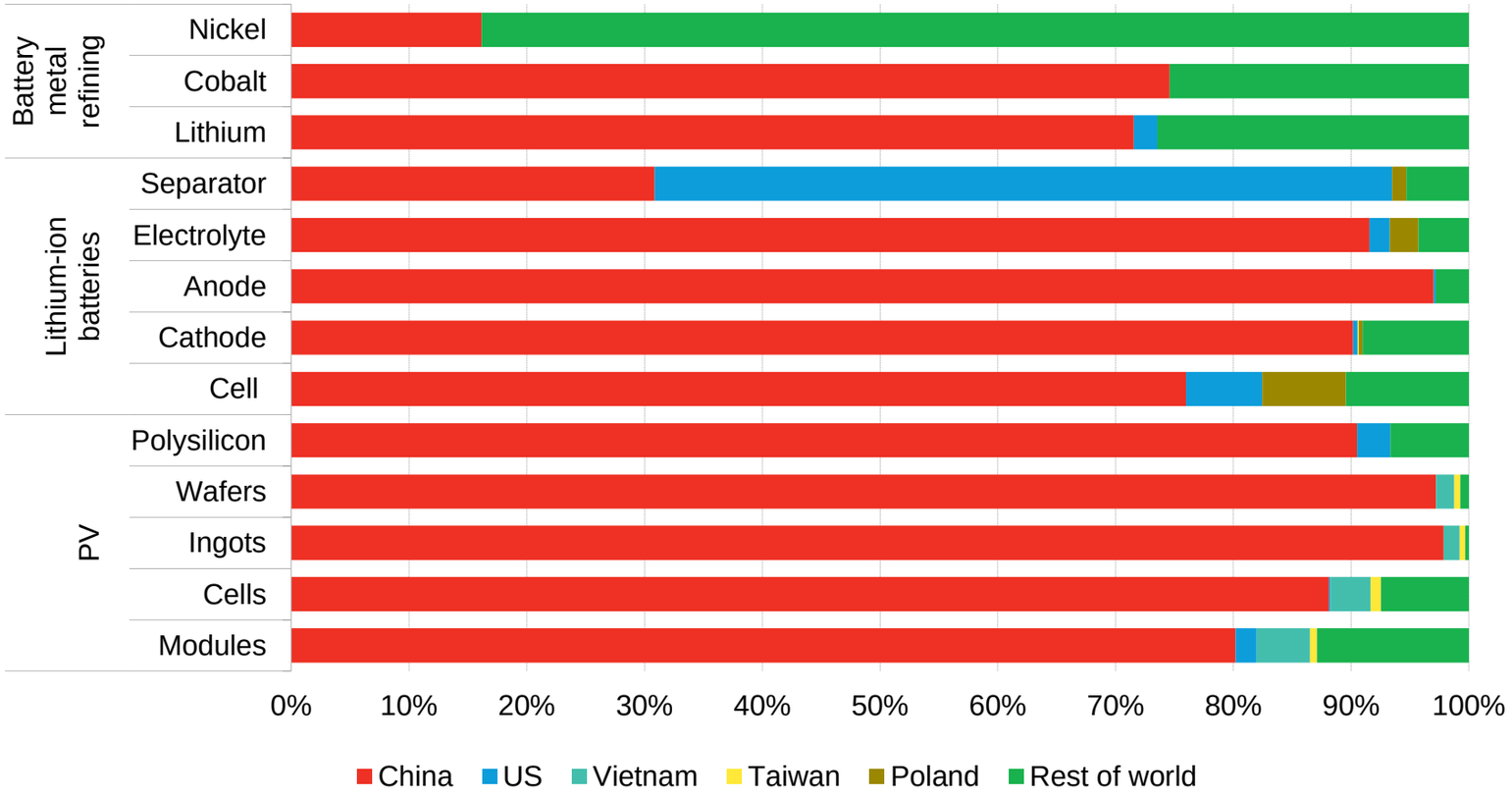
As the Chinese economy rebounded from the worst effects of Covid-19 in 2021, electricity demand surged 10.3% from the prior year, according to government statistics.

The jump contributed to higher electricity usage worldwide and greater consumption of coal. China has the world’s largest fleet of coal-fired power plants with 1,109GW, including 13GW added in 2021. It consumed over 5,000TWh of coal-fired power in 2021.

Source: National Bureau of Statistics, National Energy Administration, BloombergNEF

Battery and solar commodities production remains highly geographically concentrated

Current production capacity by location



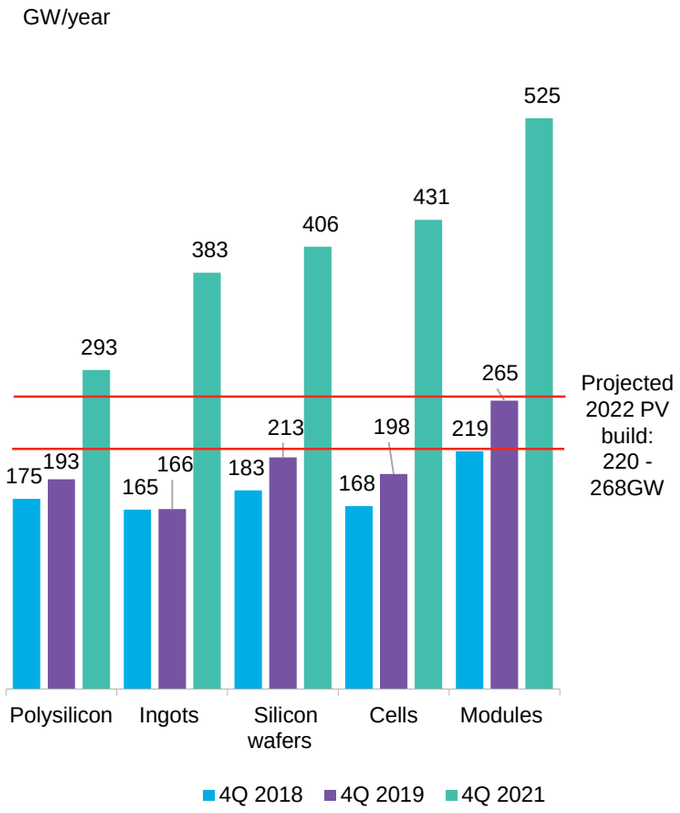
Source: BNEF. Note: PV components expressed in MW; separators in m2; battery metals and other battery components in tons. Data for August 2022 except metal refining which is 2021. Oversupply in the solar sector is such that nameplate capacity for most segments of the PV value chain far exceeds yearly output. Nickel is the battery-grade class 1 variety.

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

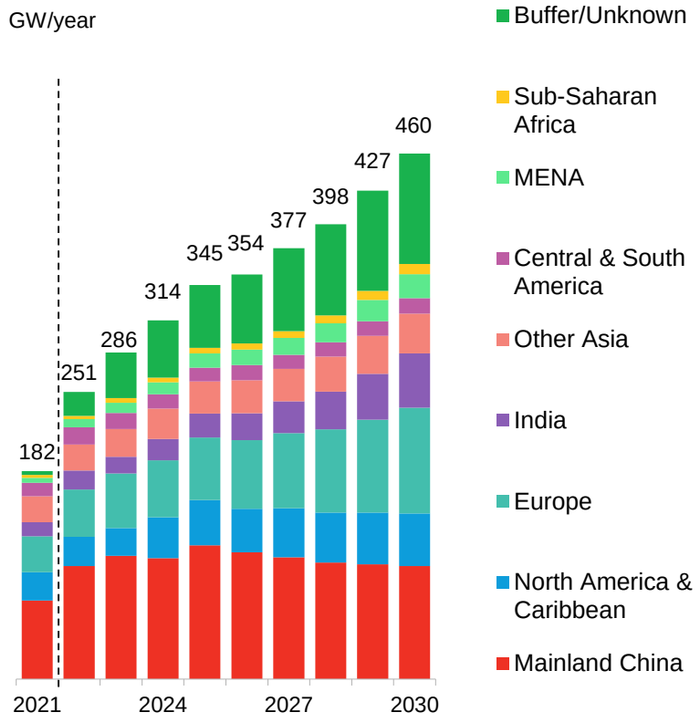
This includes the refining of cobalt and lithium, metals used in batteries. It also includes production of battery components electrolytes, anodes, cathodes, and cells. Finally, it includes PV components polysilicon, wafers, ingots, cells and modules.

A tight market for solar equipment has begun to loosen but questions remain about the longer term

Recent global PV supply/demand



Long-term global PV demand



Global supply chain bottlenecks and high demand for solar have paused the long-term decline in PV costs.

High prices for most solar components, materials and projects have continued in 2022, driven by strong demand as much as by high costs. BloombergNEF expects 2022 to be yet another year of record build, especially in Europe and China but also in new markets where high energy prices are hitting hard. Polysilicon has been the component most responsible for elevated prices, but production is ramping quickly. BNEF tracks over 900GW of polysilicon capacity announced or under construction, more than twice our 2030 build forecast.

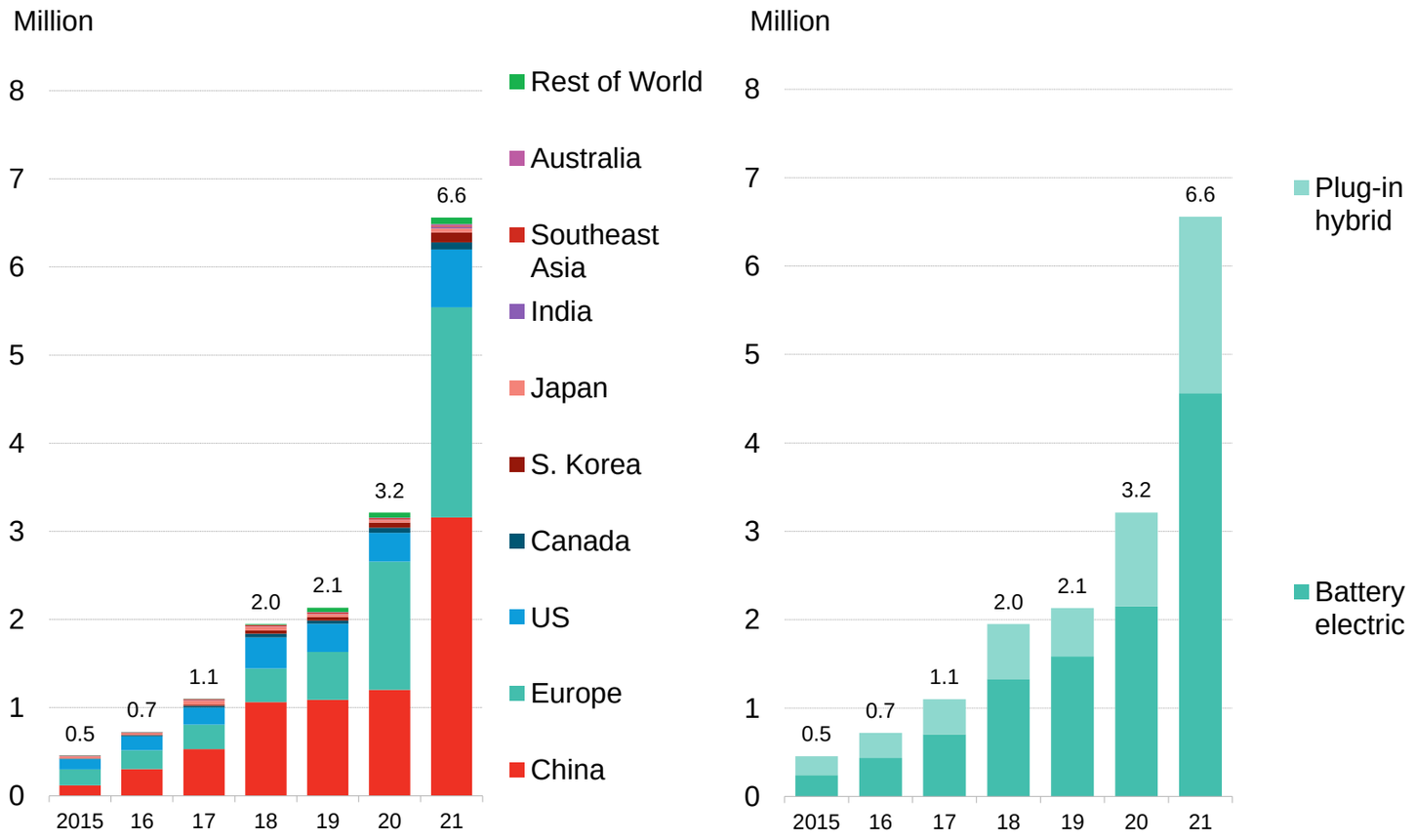
BNEF expects annual PV demand to surge more than 150% by 2030.

More heterogenous demand from a wider variety of countries, as well as generous manufacturing subsidies and import restrictions in places like the US and India, will potentially require a supply chain encompassing a greater number of nations.

Source: BloombergNEF.

Global EV sales topped 6.6 million in 2021

New EV sales by major country/region, drive train



Sales of four-wheeled passenger EVs doubled from 2020 to 2021.

Higher gasoline prices, the availability of subsidies, fuel economy standards and other factors made EVs more compelling than ever to consumers. Sales of these vehicles for 2021 totaled 6,559,000.

China was top of the table in total EV sales.

Compared to other individual nations, China has been the top market for EV sales for six years in a row. In 2021, China topped Europe for most EVs sold. China bought 3.2 million EVs in 2021 compared to 2.4 million in Europe.

The US is coming on strong.

EV sales in the US more than doubled in 2021 to 657,000 from 325,000 the year prior.

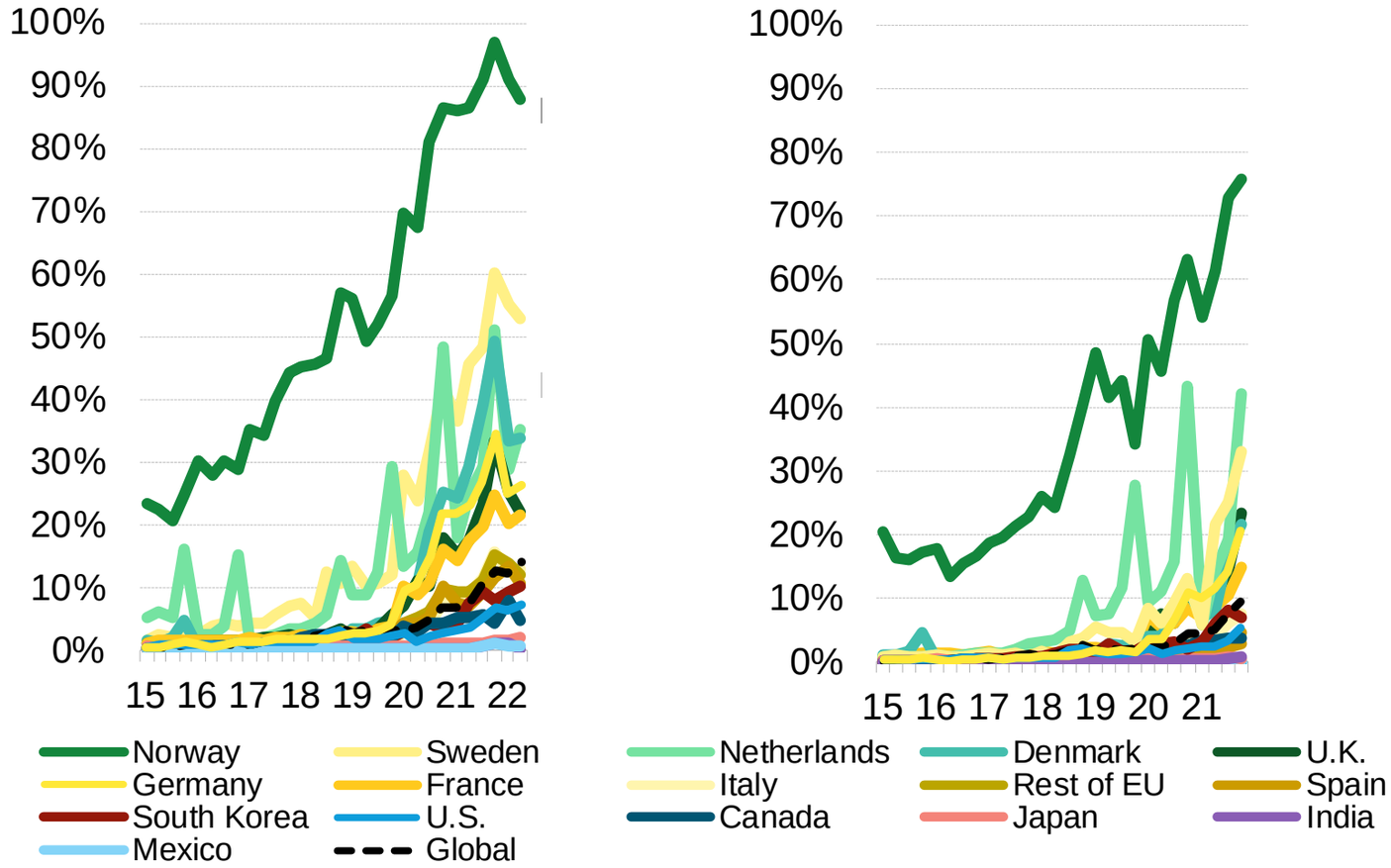
Battery electric vehicles remain most popular though sales of plug-in hybrid electric vehicles are also growing.

BEVs were 70% of total EV sales in 2021, totaling 4.6 million. But PHEV sales grew by 88% year-on-year to reach just under 2 million in 2021.

Source: BloombergNEF, Marklines

Some countries have already achieved mass-market adoption of EVs

EV share of passenger vehicle sales



ZEV share of passenger vehicle sales (excludes PHEVs)

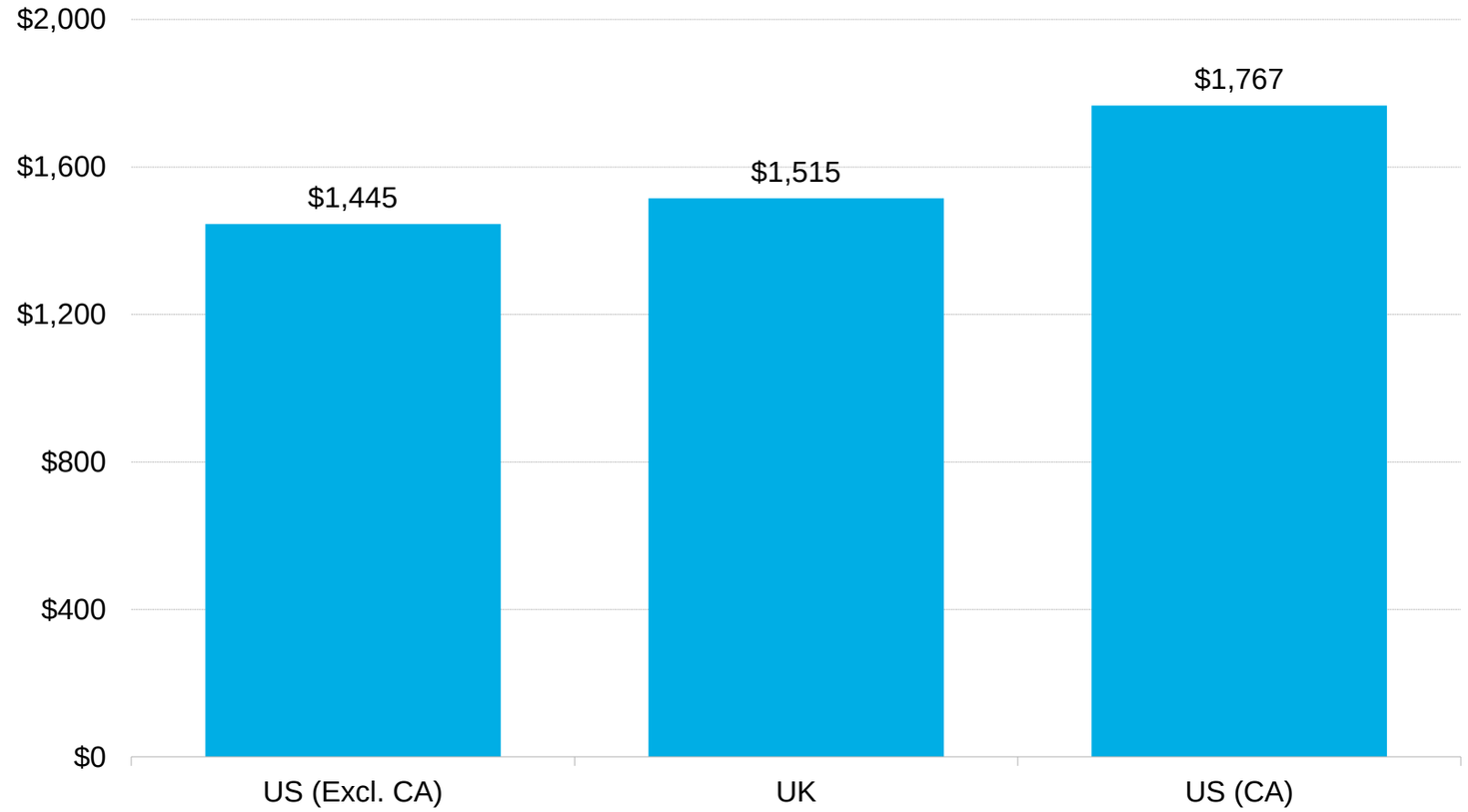
EVs accounted for 13% of global passenger vehicle sales in 1H 2022, or 9% when excluding PHEVs. This is the same as in the last quarter of 2021.

If plug-in hybrids are included, countries like Norway (89%), Sweden (54%), Denmark (44%) and Netherlands (32%) were the leading markets for the first half of the year. These are the same leaders as in 2021, but the wider European market's EV share of sales has dropped compared to last year overall and 4Q 2021. This is partly due to market seasonality, but also continued automotive supply chain issues and the prolonged 'cost of living crisis'.

Source: BloombergNEF. Note: Includes battery electric vehicles (BEVs), plug-in hybrid electric vehicles (PHEVs) and fuel cell vehicles (FCVs). ZEV is zero-emission vehicles.

Higher gasoline prices make electric vehicles more economically competitive than ever

Estimated annual fuel cost savings for off-peak EV charging compared to internal combustion energy car ownership in the US and UK



Source:BNEF. Gasoline prices based on May 2022 data. Assumes off peak charging rates of $0.18/kWh in California, $0.07/kWh in other parts of the US, and $0.09/kWh in the UK.

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

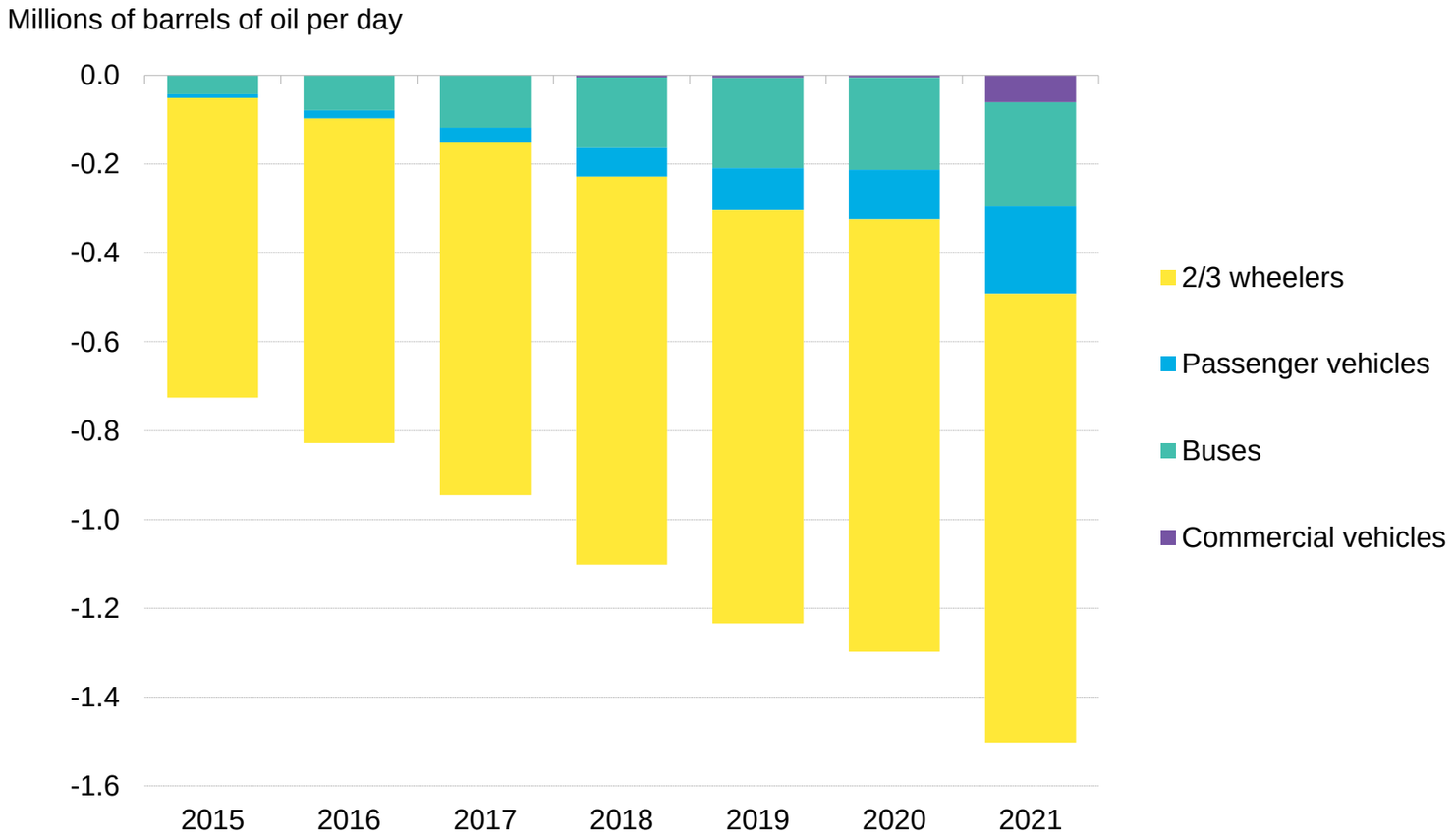
"Sticker price parity" (the point at which an EV is lower-priced in the showroom than its ICE rival) is probably still the most important determinant of EV adoption. Yet total cost of ownership (TCO) matters too. While the sticker price of EVs is set to rise in the immediate term due to higher battery prices, their TCO advantage over internal combustion vehicles is becoming larger as well thanks to higher oil and gasoline costs.

EV owners in California, elsewhere in the US and the UK could save $1,445-1,767 per year on fuel as of May 2022.

The same macroeconomic factors that have resulted in higher prices for EVs in the short term are also serving to inflate fuel costs. The savings shown at left were possible for consumers who charged their vehicles during off-peak (lower-priced) hours.

The shift to electrified transport has begun to take a (small) bite out of global oil demand

Oil demand avoided by electric vehicles and fuel cell vehicles



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

The adoption of electric vehicles and fuel cell vehicles avoided almost 1.5 millions of barrels of oil per day in 2021 – about 3.3% of total demand from the road transport sector. The displaced demand in 2021 is roughly equivalent to one-fifth of Russia's total oil product exports prior to the war, and roughly double Germany's imports of Russian oil and products at the end of 2021.

Two- and three-wheeled EVs accounted for 67% of the oil demand avoided in 2021

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

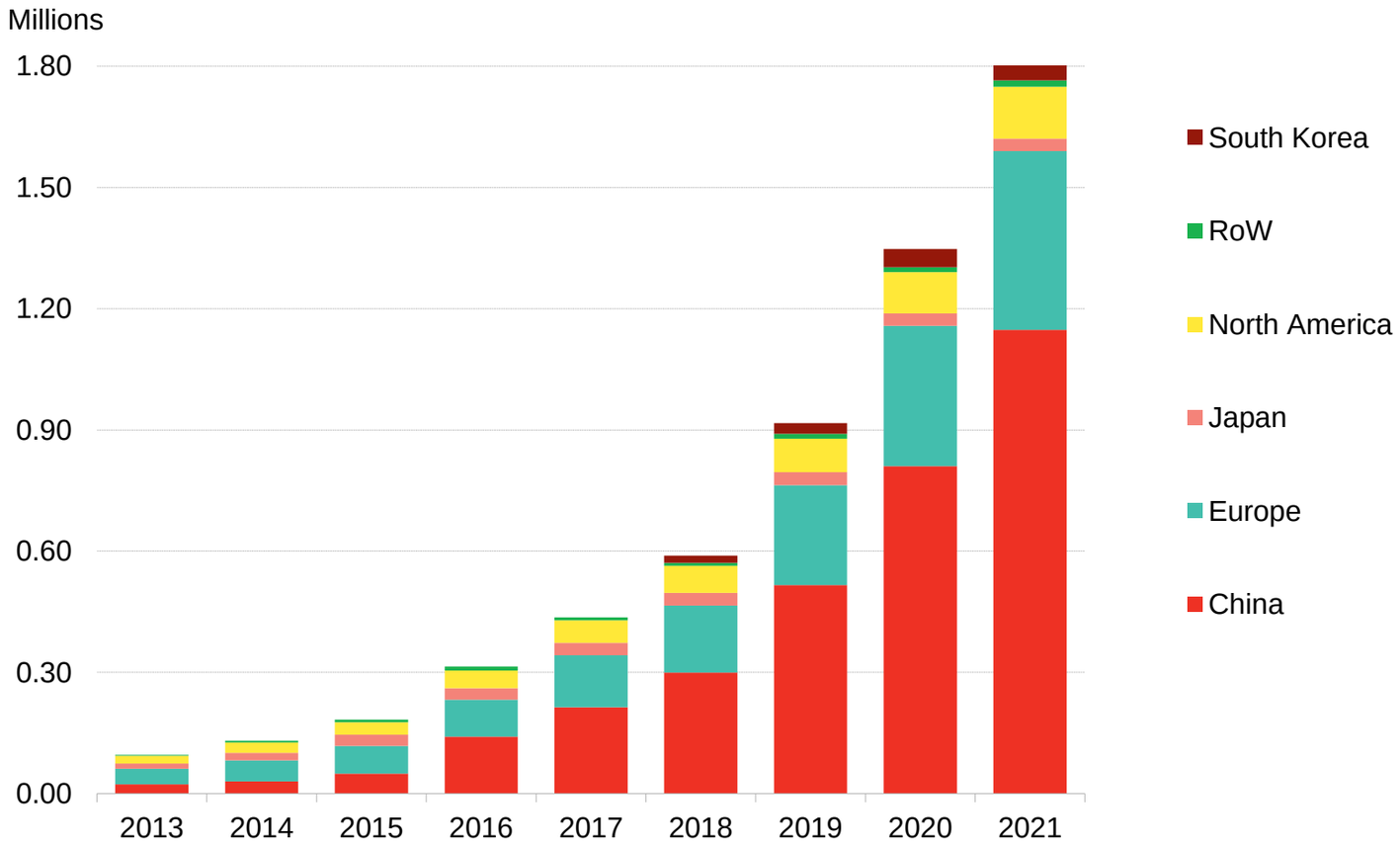
Passenger vehicles was the fastest growing segment, accounting for 13% of the reduced oil demand in 2021.

Commercial vehicles accounted for 4% of total oil demand avoided in 2021, largely from light commercial EVs.

Source: BNEF, IEA

There are more than 1.8 million public electric vehicle charging connectors worldwide

Total number of public EV charging connectors installed



A total of 1.82 million charging points had been installed worldwide as of year-end 2021.

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 mean that the market has yet to consolidate, and is likely to remain fragmented for at least the next several years.

Viable business models are emerging.

However, there are a number of critical questions outstanding for network operators, such as the optimal speed for charging, ideal location of public chargers, and the approach to billing customers.

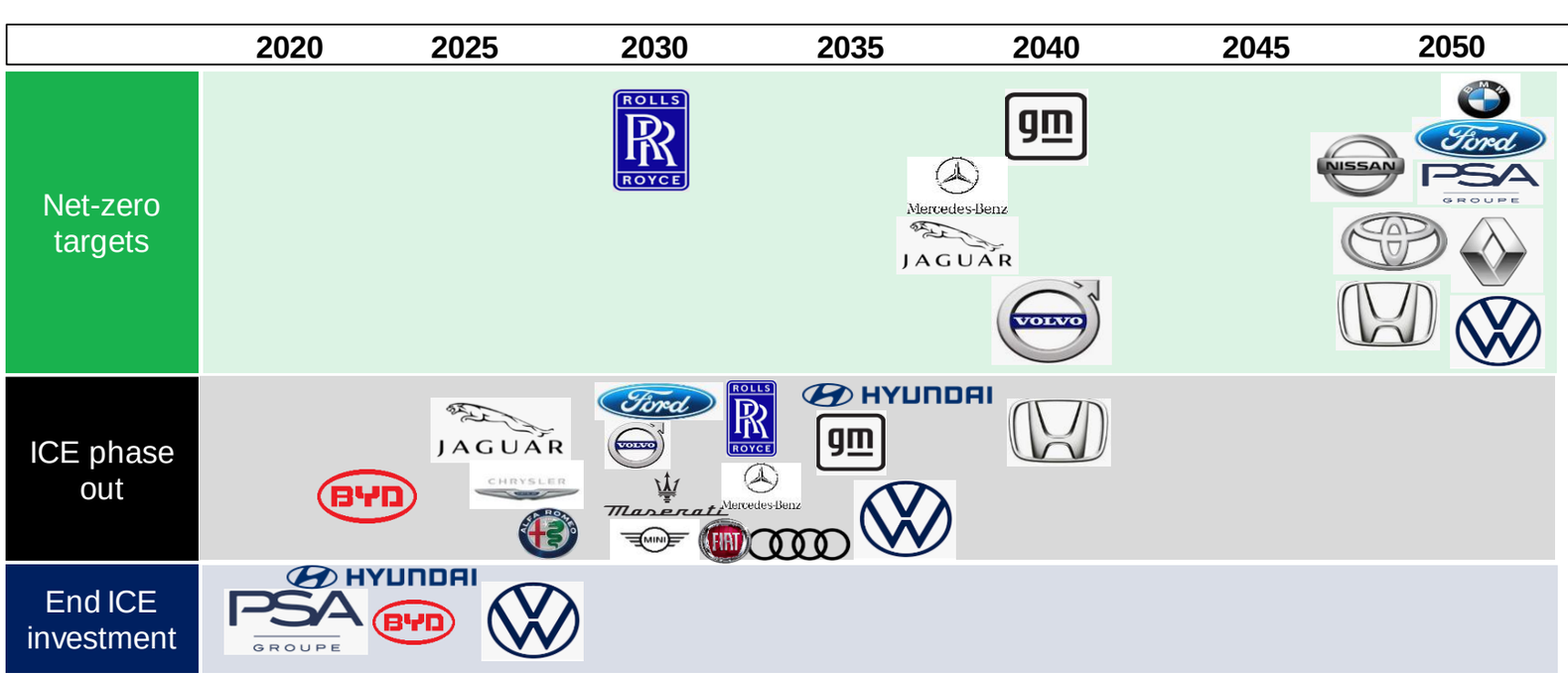
China and Europe lead in terms of absolute connectors available.

China had 1.15 million chargers as of year-end 2021 while Europe had 442,000.

Source: BloombergNEF

More automakers are committing to phasing out sales of internal combustion engine vehicles

Automakers' development targets as of May 2022



In 2021, 12 automakers committed to phasing out their sales of internal combustion engine (ICE) vehicles by some future date.

Four automakers made ICE phase-out announcements in early 2021: Jaguar, Volvo, GM and Ford. Over the course of the year, Mini, Fiat, Audi, Honda, VW, Mercedes-Benz, Hyundai and Rolls-Royce also announced targets.

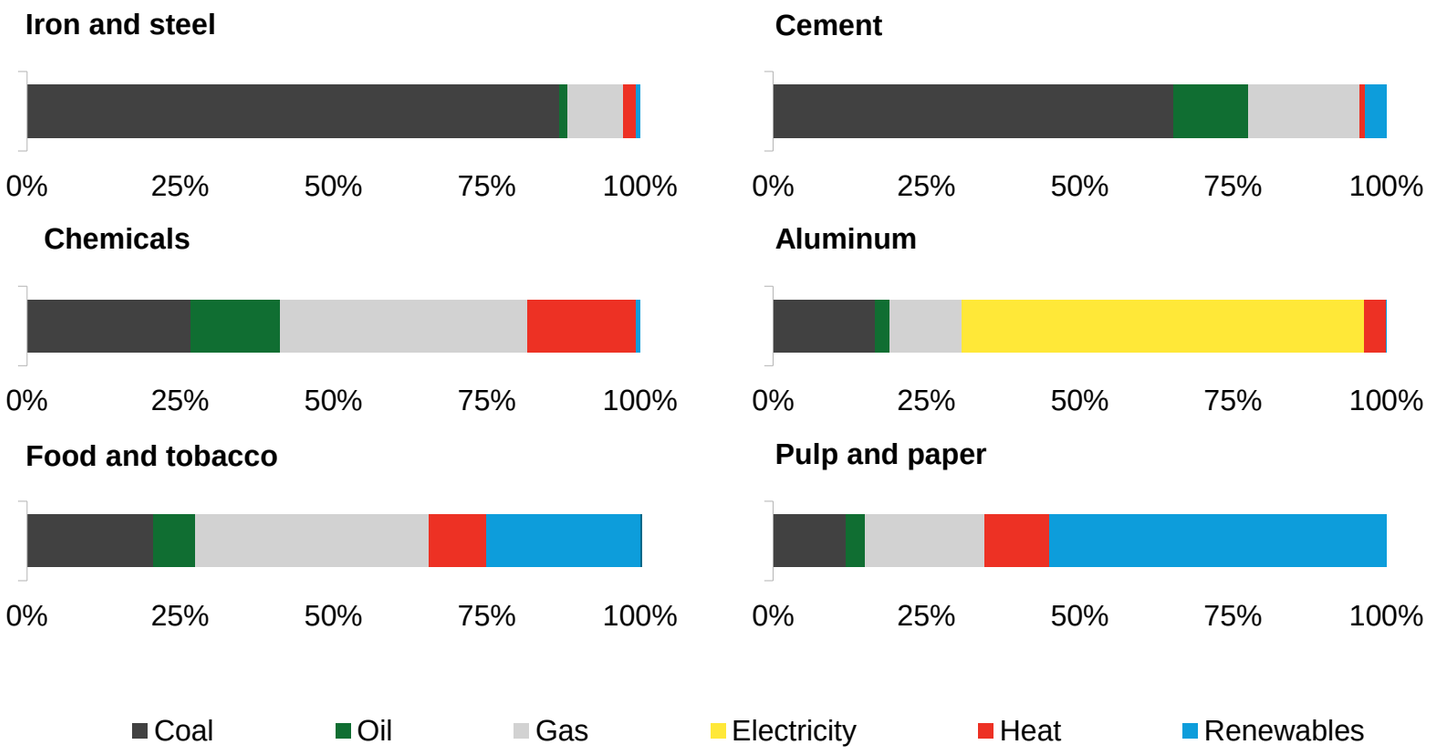
Early 2022 brought more announcements

Chrysler set an all-electric target for 2028, followed by an announcement by BYD that it had ceased sales of conventional ICE vehicles already in early 2022. Moving forward, BYD will only sell battery electric and plug-in hybrid vehicles.

Source: BloombergNEF. Note: Ford, Hyundai 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 towards an ICE phase-out globally by 2040 and in leading markets by 2035.Excludes interim targets.

Heat is essential for many industrial processes, and industries meet their demand in many different ways

Share of energy supply for industrial process heat, 2018



Six sectors have significant demand for process heat

Iron and steel, cement, chemicals, aluminum and non-ferrous metals, food and tobacco, and pulp and paper all require heat for essential industrial processes.

Some industries already use significant amounts of renewable energy for heat

Food and tobacco, and pulp and paper, already use a relatively high proportion of renewable heat sources such as biomass and biogas thanks to the ready availability of organic waste at their sites.

Other industries use mostly fossil fuels

Chemicals, cement and iron and steel use a higher proportion of fossil fuels. These industries have high heat requirements and use fossil fuels as feedstocks as well.

Source: BloombergNEF, IEA

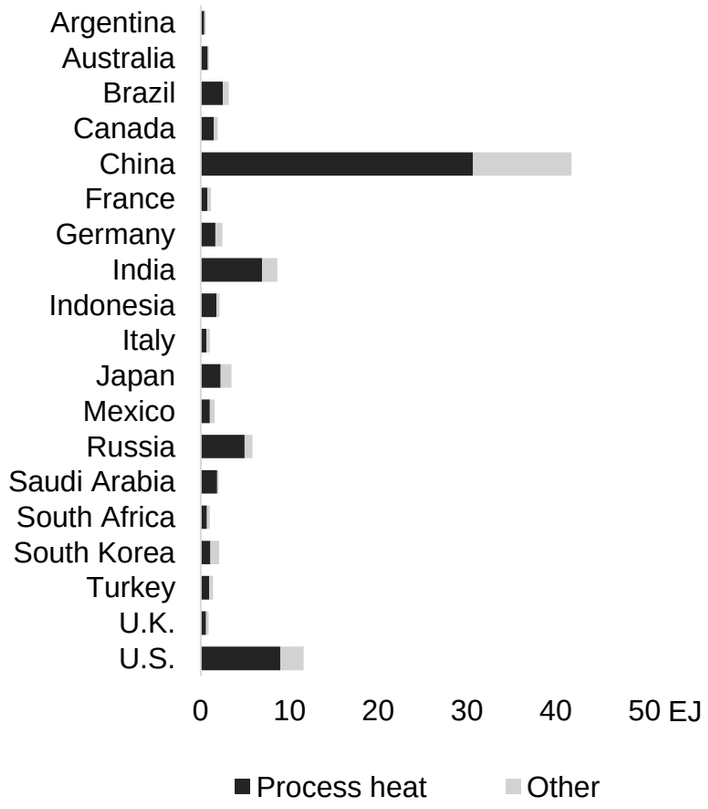
The potential for decarbonizing heat varies widely but can bring major benefits to large sectors

	Sector	Status as of 2016		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

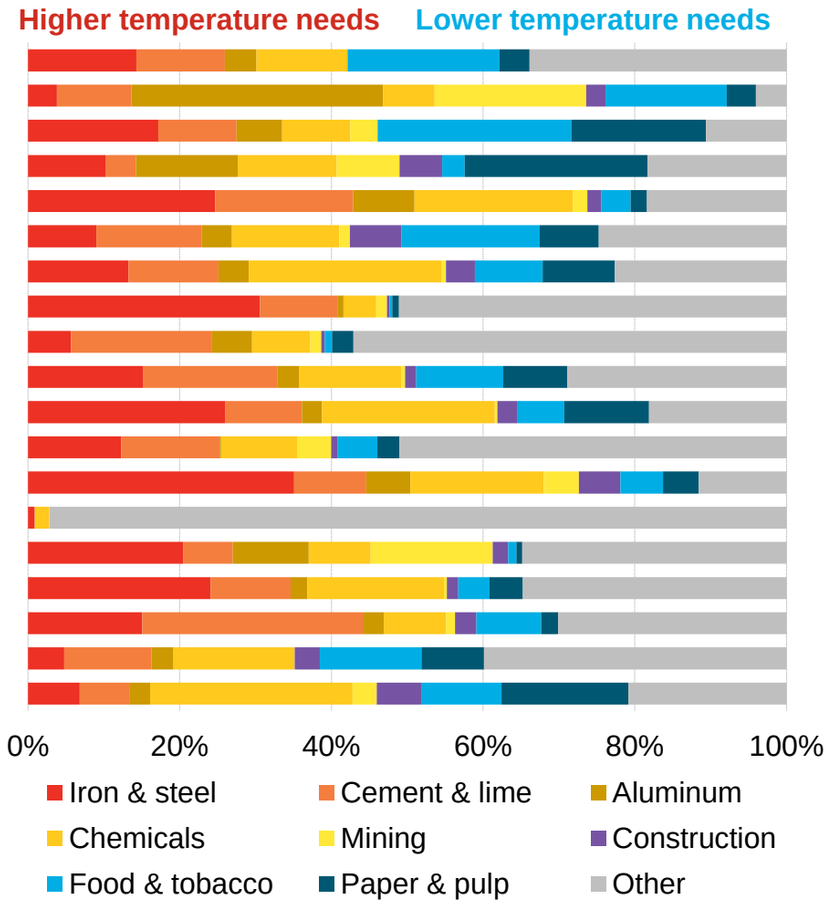
Source: BloombergNEF, IEA

Industry has a number of specific decarbonization challenges

Industrial energy consumption, type



Industrial energy consumption, sector



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

Industry is 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.

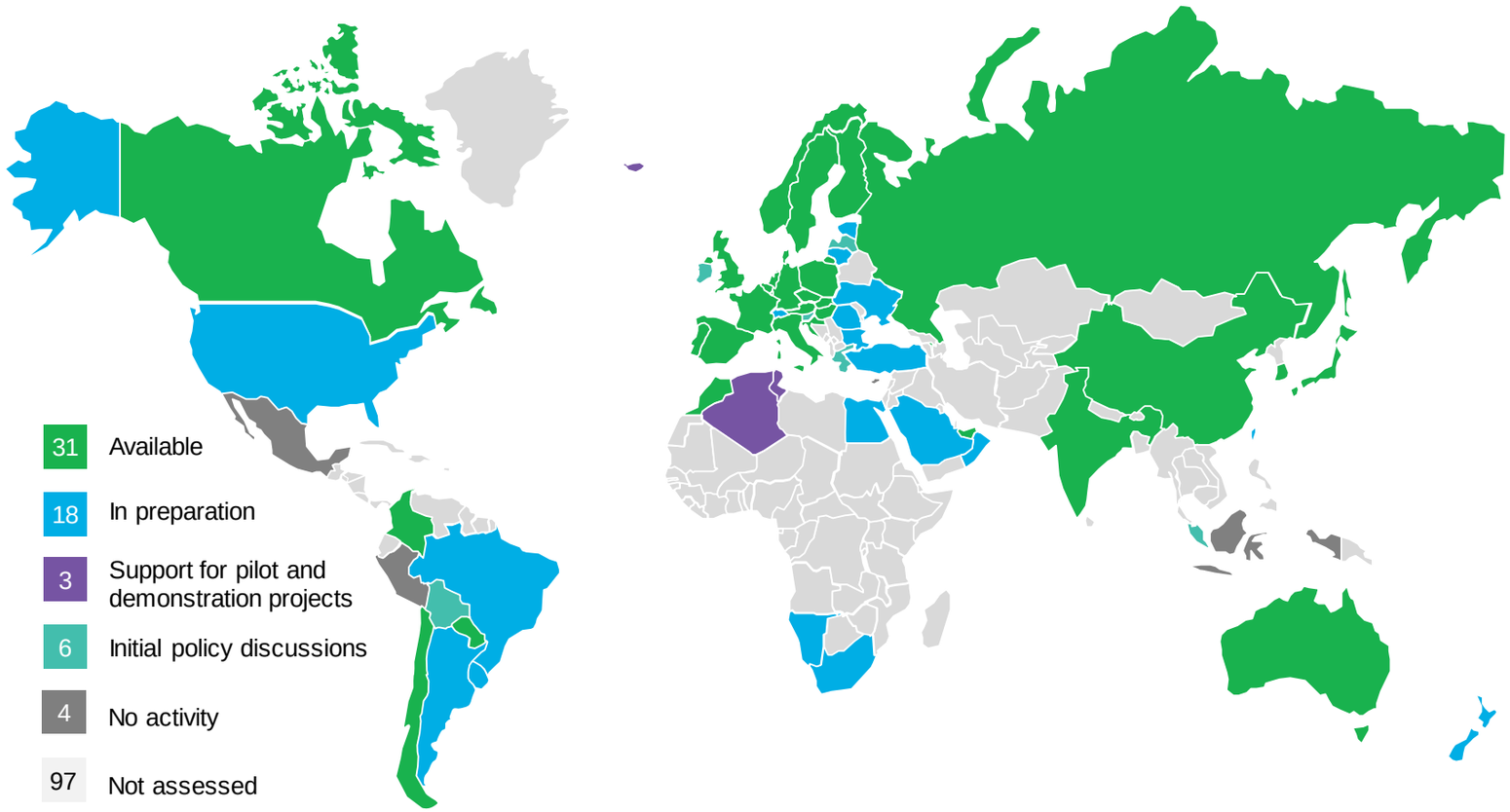
Countries face different challenges in decarbonizing industry

Those challenges range from scale (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

31 countries now have hydrogen development strategies

National hydrogen strategies as of June 2022



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

Through June 2022, 31 national governments have written strategies to boost their hydrogen production and consumption. That's up from 26 countries at the end of 2021 and 13 at the end of 2020.

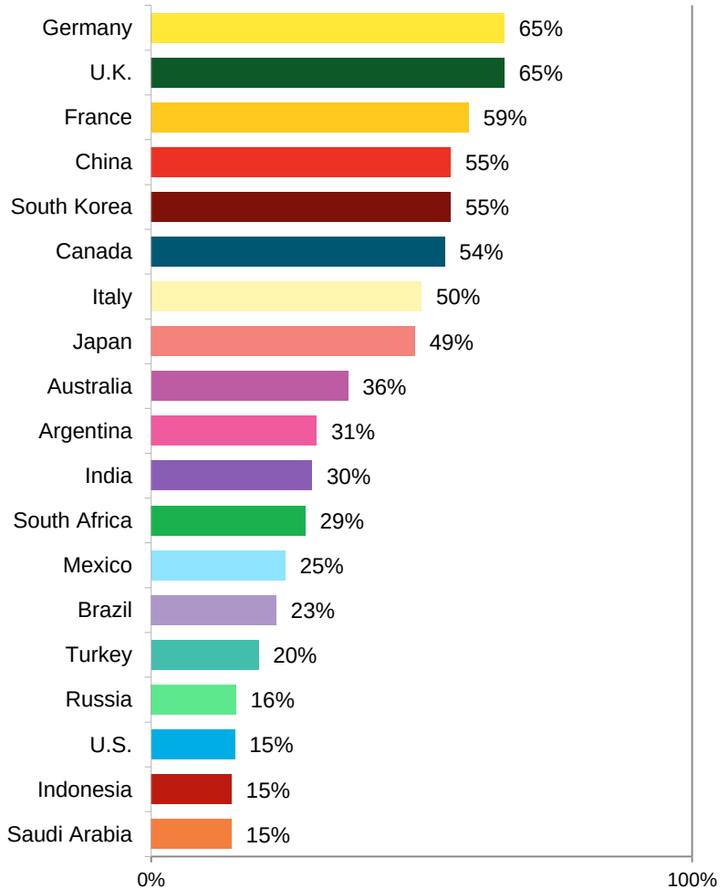
Another 18 countries are preparing strategies with three offering support to pilot and demonstration projects.

More than two-thirds of the plans issued to date have come in European countries. More than half of Latin American countries have either released a plan or are drafting one. This includes Brazil and Chile, the two nations with the potential to produce hydrogen at lowest cost globally, BloombergNEF estimates.

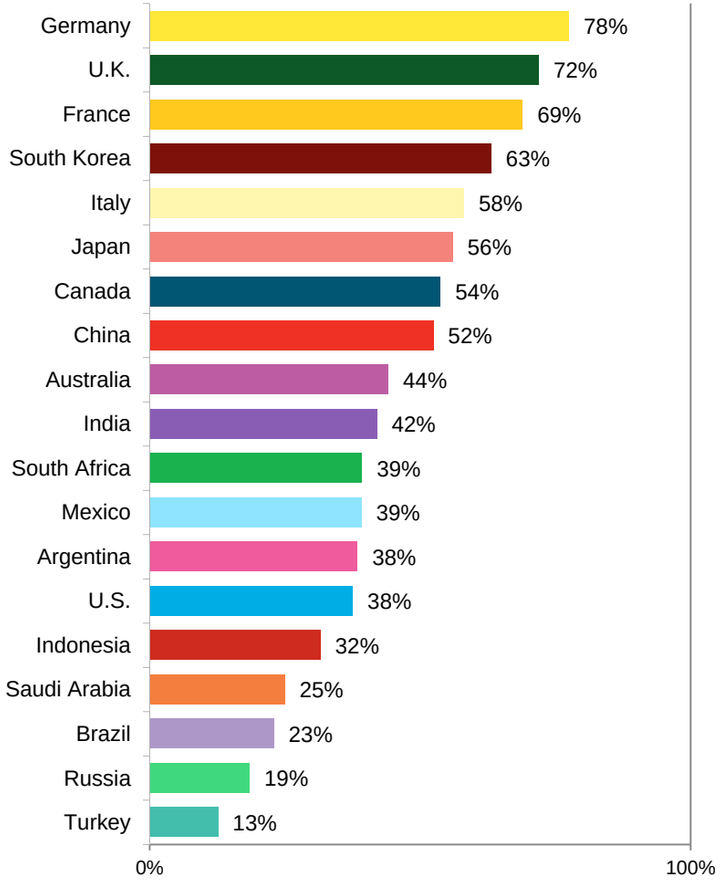
Source: BloombergNEF

Policy support for cutting industrial emissions is growing, but substantial work remains

2021 BNEF industry policy scores



2022 BNEF industry policy scores



Source: BloombergNEF 2022 G-20 Zero-Carbon Policy Scoreboard published in April 2022. Note: Does not take into account policies approved after March 2022.

Most G-20 nations have made improvements in the last year.

Each year, BloombergNEF evaluates G-20 countries' policies to decarbonize the power, transport and industrial segments of their economies. From Spring 2021 through Spring 2022, most in the G-20 boosted their industrial decarbonization scores. But collectively, the countries scored just 45% for their efforts in this area – below their 52% score for transport and 60% for power. Significant additional policy efforts will be need to cut industrial emissions in line with net zero.

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

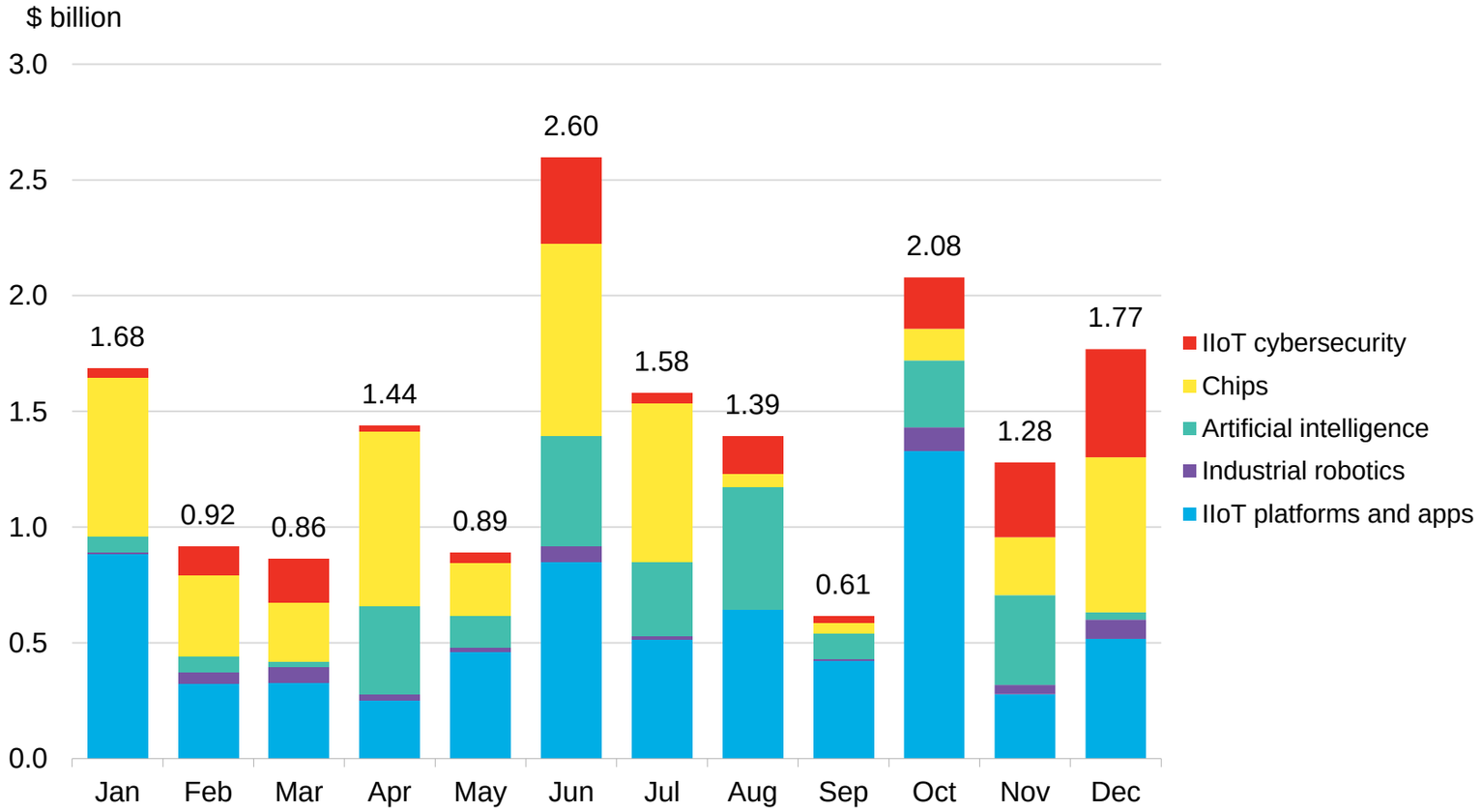
This is due primarily these countries' detailed decarbonization strategies and some incentives to ensure implementation, including carbon pricing.

The US significantly boosted its score due to new funding for industrial clusters using hydrogen and CCUS.

However, the recently-passed Inflation Reduction Act did not figure in the country's scoring as it was signed into law in August 2022.

Private industrial IoT, AI, analytics, and robotics companies raised more than $17 billion in 2021

2021 venture capital and private equity fundraising by startups selling industrial IoT, AI, analytics, robotics products



Activity topped 2020's total of $13 billion

Thousands of startups are building software, sensors, chips, and drones for industrial digitalization. However, most are very small, raising seed or Series A financings. In 2021, industrial Internet of things (IoT) and artificial intelligence (AI) chip companies were the biggest fundraisers, raising $6.79 billion and $4.95 billion respectively, almost triple the amount of 2020.

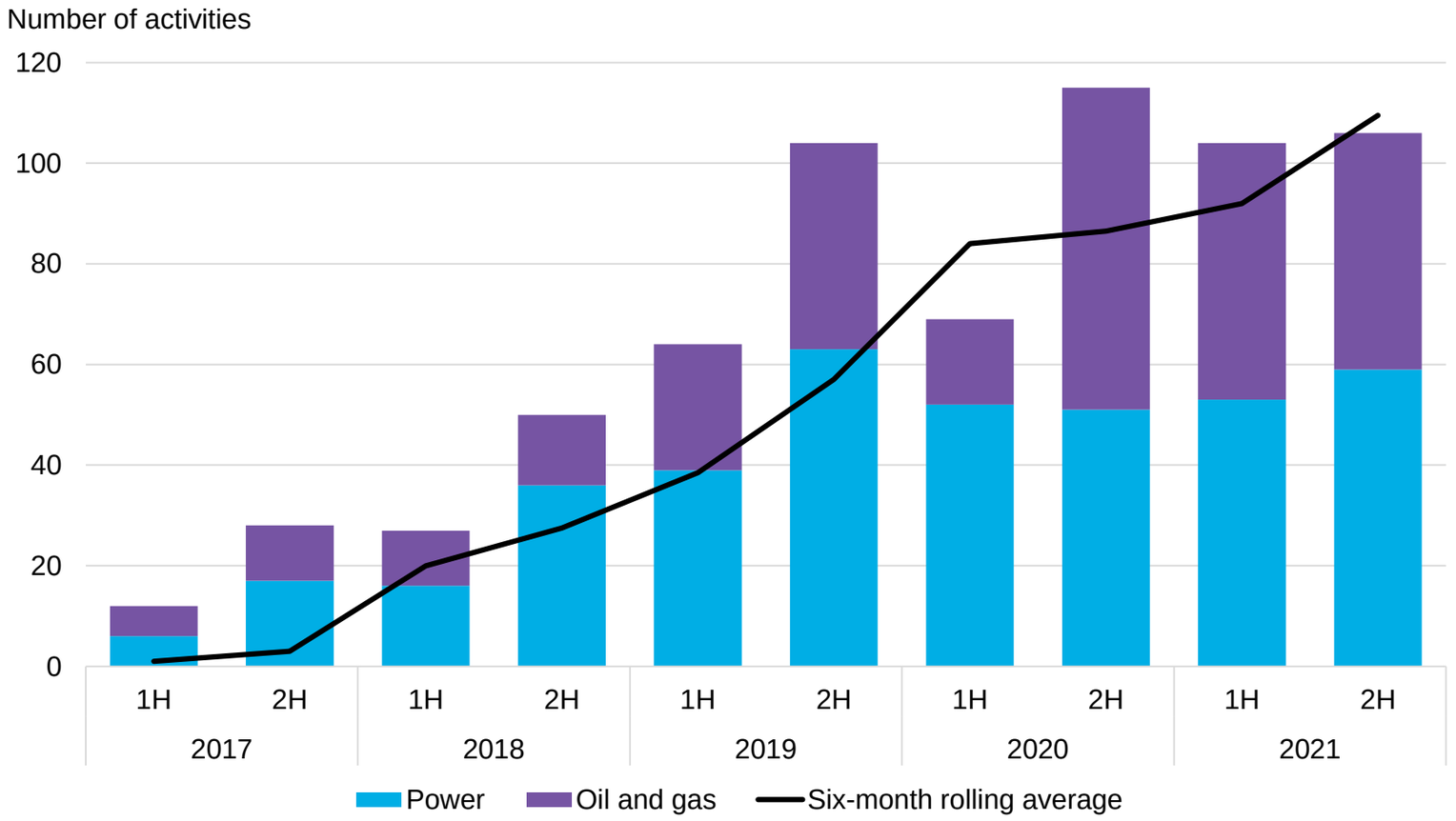
Industrial IoT and AI venture funding is a small part of the global funding landscape

Much more money is being spent by large corporations in R&D, like by GE or Siemens or Schlumberger, than is being spent on startups.

Source: BloombergNEF. Note: IoT is Internet of Things, AI is artificial intelligence.

Power, oil and gas firms are integrating digitalization into their operations and forging more partnerships

Projects and partnerships in the power, oil and gas sectors



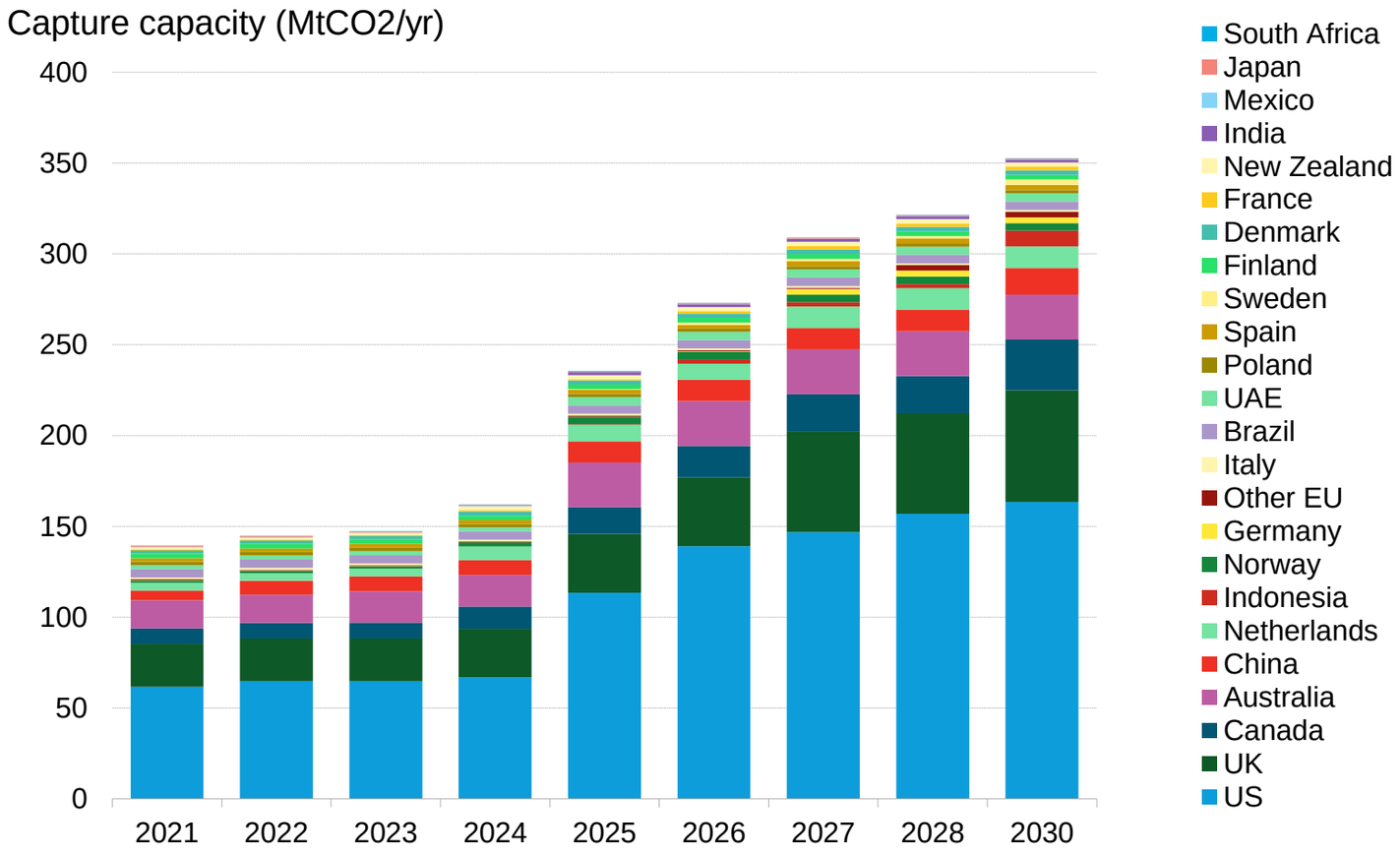
BloombergNEF tracked 210 new activities started and partnerships formed by utilities, oil, gas and other energy companies in 2021.

Companies are often employing Internet of Things sensors and software to optimize assets and track emissions. In the second half of 2021, analytics software accounted for the largest share of digital activity in both the oil and gas and power sectors, at 50% and 36% respectively. This includes technologies such as artificial intelligence (AI) and digital twins. For power, a significant share of partnerships also focused on IoT connectivity, accounting for 31% of activity in 2H. BNEF has tracked 679 such activities launched and partnerships established since 2017.

Source: BloombergNEF. Initiatives include analytics software, automation, cloud/data, communications, connectivity, and IoT software.

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

Expected CCUS capacity in CEM members, based on project announcements



CCUS project developers are following the (public) money.

While the US will remain the largest market for CCUS, several other regions are set to rapidly increase their capacity thanks to large financial commitments. The UK has pledged $1.3 billion for CCUS hubs, Australia allocated more than $200 million to grow its capture industry, and Canada recently passed a capture, transport and storage subsidy that should spur development in the 2020s and 30s.

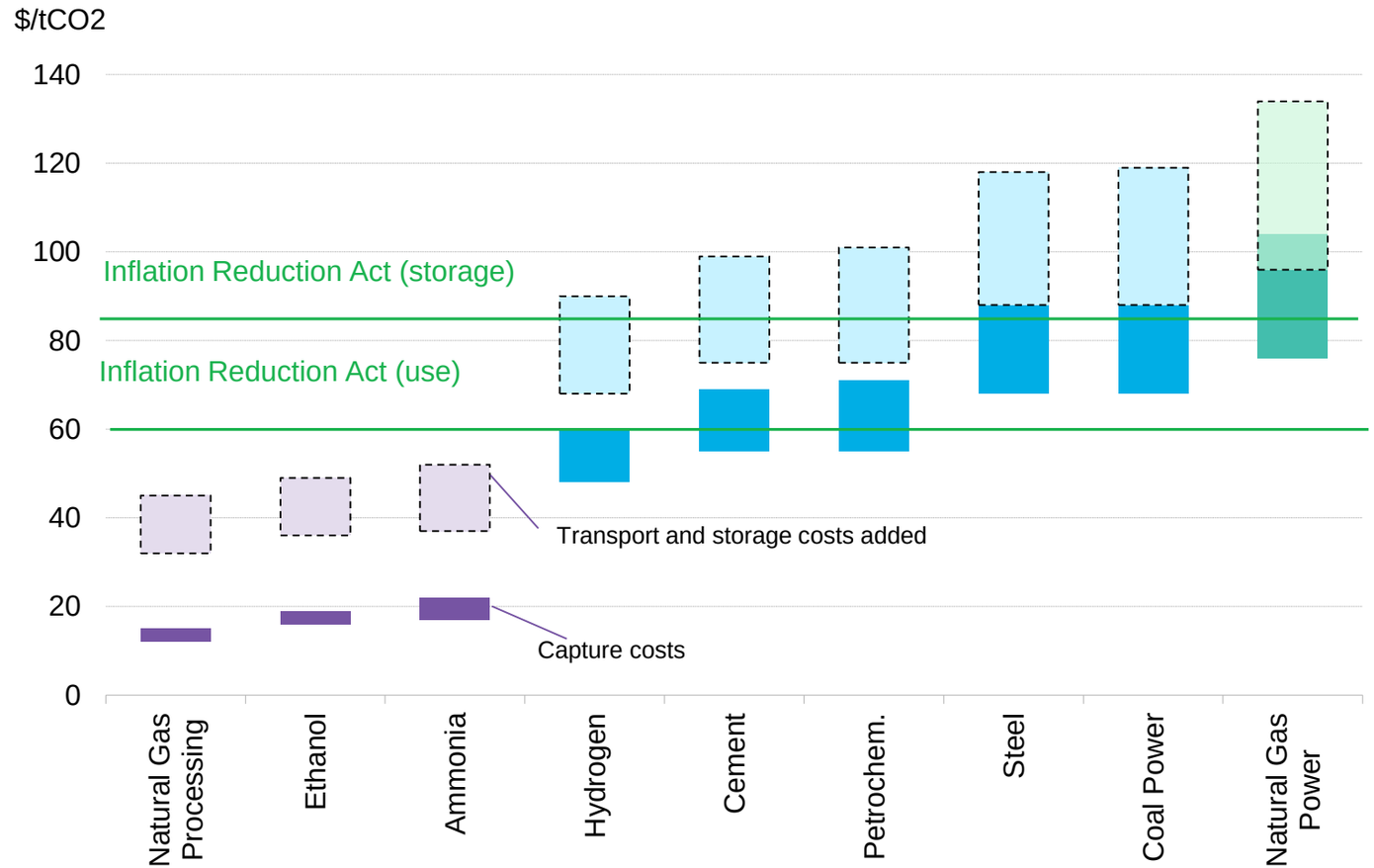
By 2030, CO2 storage will surpass CO2 use.

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% today.

Source: Global CCS Institute, BloombergNEF

The new US climate law has the potential to bring CCUS to hard-to-abate sectors

Cost of abatement with new 45Q credits, by sector



Source: BloombergNEF, Great Plains Institute

Higher 45Q credit levels make CCUS a viable decarbonization route for industry.

Prior to the Inflation Reduction Act, the credit offered for carbon capture was set at $35/tCO2 for projects that used CO2 (mostly for enhanced oil recovery) and $50/tCO2 for projects that stored it. The new law raises the credit in both cases, makes it “direct pay” for five years, and lowers the plant size thresholds. This could cement the US’ place as the carbon capture leader and should provide the economies of scale and learnings to lower CCUS costs globally.

Combined with a carbon price, CCUS can be used to provide 24/7 clean power.

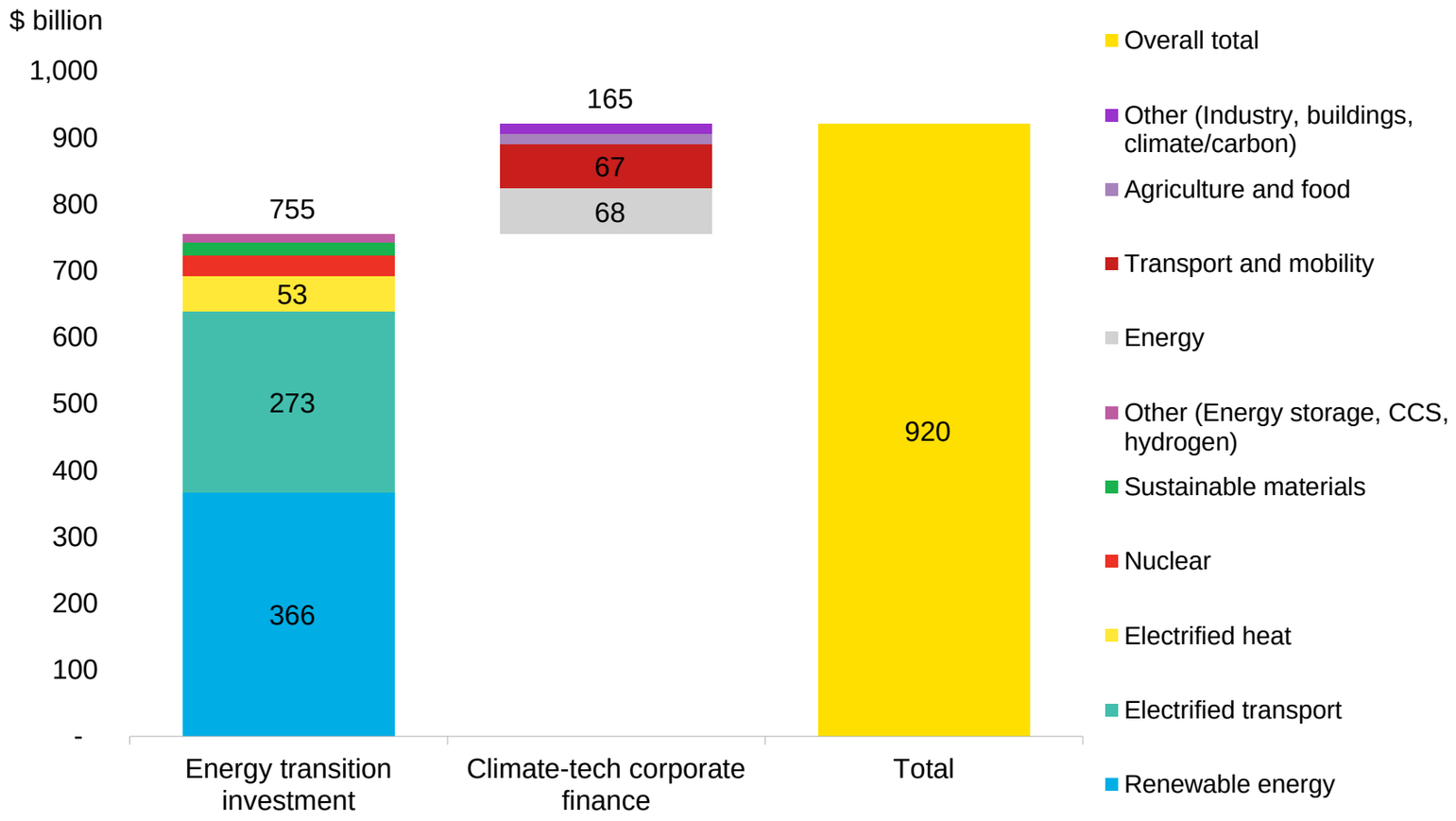
Even the higher credits are not enough to offset the costs of CCUS in the power sector. However, when combined with a carbon price, such as in California, most of the capture and storage costs could be offset.

Combined with a green premium, low-carbon steel, cement and plastics can be competitive.

Similar to power, with a green premium on top of the 45Q credits, low-carbon materials could be cost competitive. Premiums for steel are typically around 25%. However, industrial sites will need to organize themselves into clusters to make use of shared transport and storage infrastructure.

Global energy transition + Climate tech investment = $920 billion in 2021

2021 energy transition investment and climate-tech corporate finance



New capital to support the deployment of energy transition technologies jumped 27%.

This $755 billion figure includes investment in projects such as renewables, storage, charging infrastructure, hydrogen production, nuclear, recycling and CCUS projects – as well as end-user purchases of low-carbon energy devices, such as small-scale solar systems, heat pumps and zero-emission vehicles.

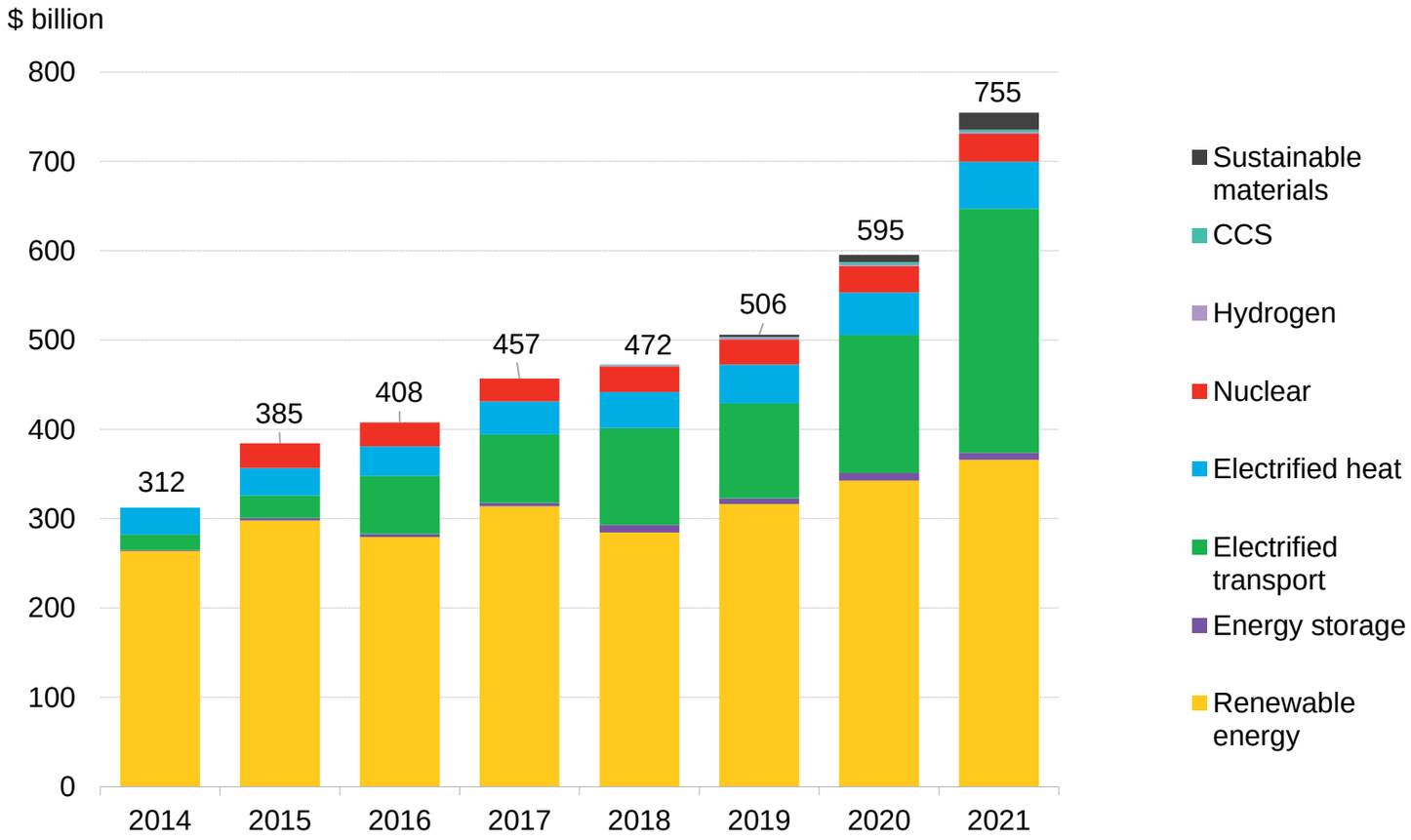
An additional $165 billion was raised in equity financing over public markets and from private investors for climate tech investments.

This was private funding primarily to support the development of new technologies and business models that have yet to achieve major scale. The scope included technologies and business models to decarbonize the energy, transport, buildings & infrastructure, industry and agriculture sectors, or help better understand our planet and environment, assist in tracking greenhouse gas emissions, and mobilize financial (and consumer) markets toward greener investments.

Source: BloombergNEF

Global energy transition investment set a new record in 2021

Global investment in the energy transition by sector



New capital invested in support of deploying energy transition technologies hit $755 billion globally.

Renewables accounted for the largest share. Wind, solar, and other technologies attracted $366 billion for new projects and small-scale systems.

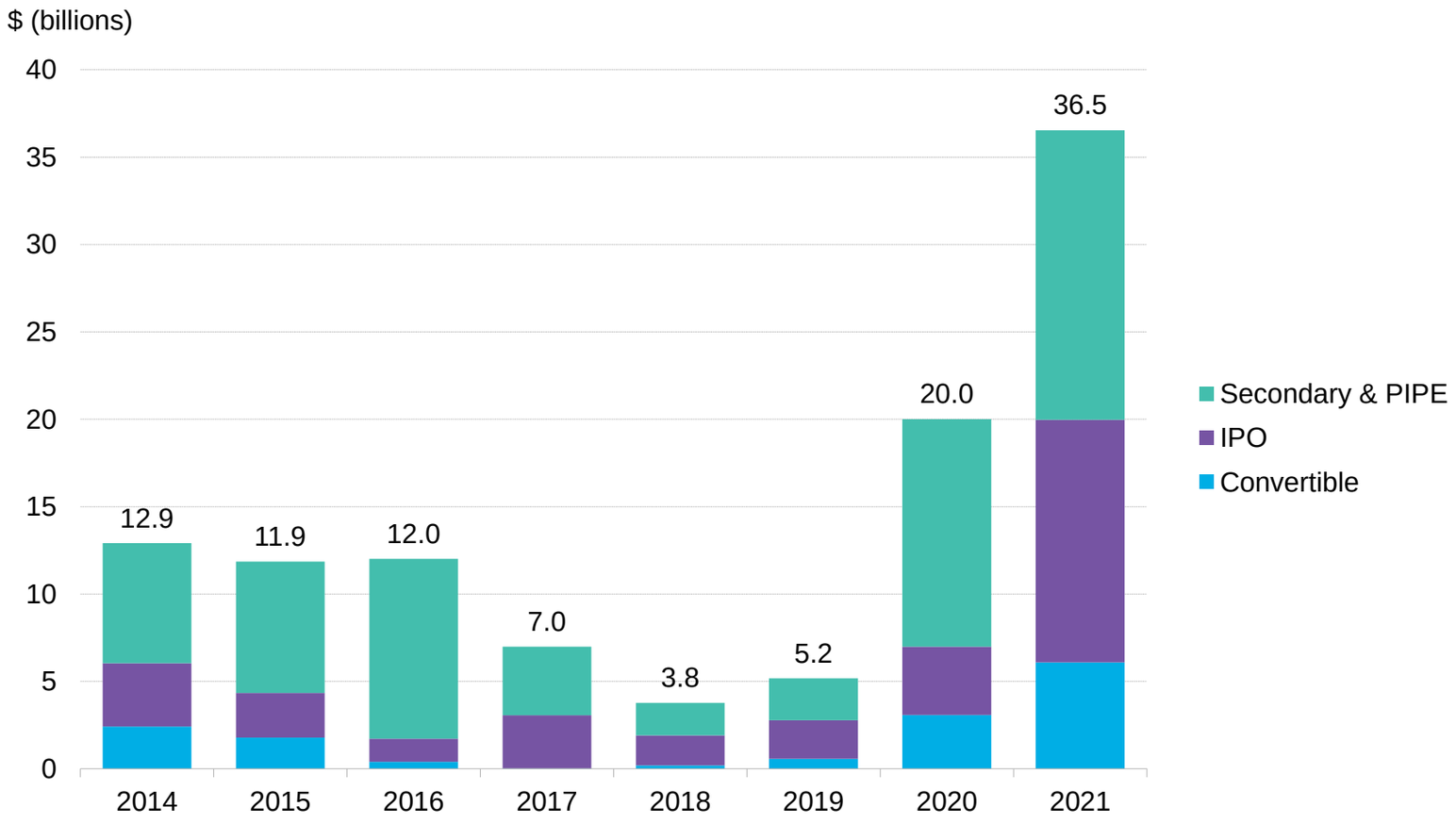
The electrified transport sector grew fastest.

New investment in EVs hit $273 billion (up 77%). The next largest sectors of spending were electrified heat, at $53 billion and nuclear energy, at $31 billion.

Source: BloombergNEF

Renewables and energy storage companies had another blockbuster year of fund raising on the public exchanges

Renewable energy and energy storage capital raising activity



Source: BloombergNEF. Note: PIPE is private investment in public equity.

2021 was another record for fundraising over public stock exchanges for renewable energy and storage companies.

Companies raised $36.5 billion, up 83% from the prior year's record $20 billion. This growth capital typically allows companies to invest in new technologies or projects, expand marketing efforts and hire staff.

$13.9 billion of the total was raised through initial public offerings (IPOs) from companies.

Four energy IPOs raised over $1 billion, with all companies focused on solar or wind energy generation or equipment. These were: China Three Gorges Renewables ($3.6 billion), Shoals Technologies ($1.9 billion), Acciona Energia ($1.8 billion) and Raizen ($1.3 billion).

Another $16.6 billion came via secondary and private investment in public equity (PIPE) transactions.

The largest private fundings included $2.8 billion for Northvolt (batteries) and $1.7 billion for SVOLT (also batteries).

Sustainable debt is being used to achieve many goals

Sustainable debt labels and characteristics

Debt Type	Debt style	Purpose	Market size ($bn)	Proportion of sustainable debt market	Growth rate 2020-2021
Green bond	**Activity-based**	Environmental projects	1779	44%	101%
Sustainability-linked loan	**Behavior-based**	Institutional ESG targets	811	20%	297%
Green loan	**Activity-based**	Environmental projects	473	12%	4%
Social bond	**Activity-based**	Social projects	410	10%	42%
Sustainability bond	**Activity-based**	Environmental & social projects	446	11%	51%
Sustainability-linked bond	**Behavior-based**	Institutional ESG targets	125	3%	856%

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

These changes have generally taken two forms:

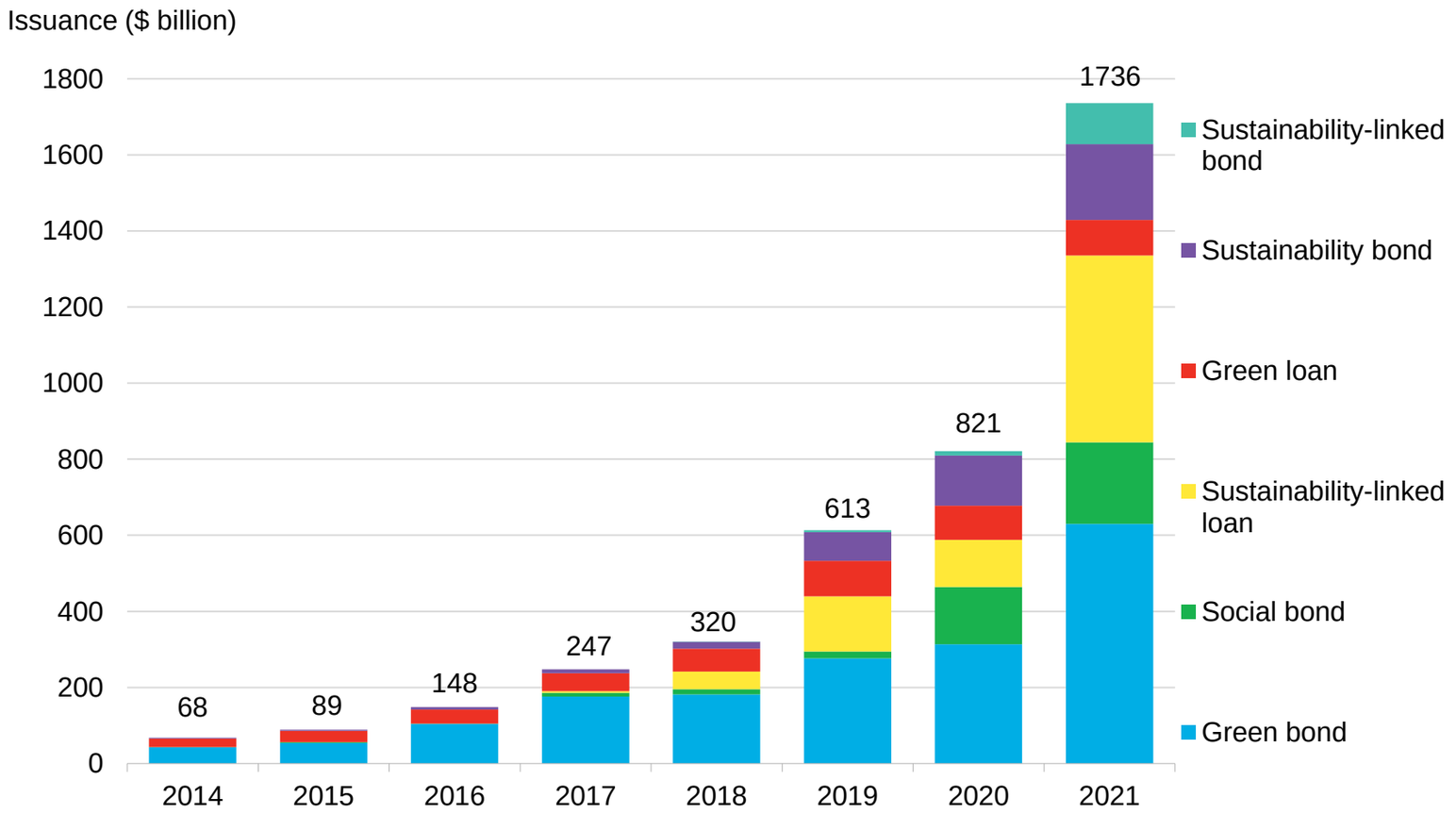
Activity-based debt, encompassing *green bonds*, *social bonds*, *sustainability bonds* and *green loans*. These are used to raise money to finance new, or refinance existing, green projects or activities. The money raised must be used for these activities, which can be for environmental benefit, social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

Behavior-based debt, encompassing *sustainability-linked loans* and *sustainability-linked bonds*, are 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.

Source: BloombergNEF. Bloomberg Terminal. Note: Instruments included are from 2014-2021. Colors depict growth rate/size from green (most/greatest) to red (least/lowest).

Companies and institutions raised more than $1.7 trillion in sustainable debt in 2021

Sustainable debt issued by instrument type



Sustainable debt raised by companies and institutions more than doubled in 2020 from the year prior.

Borrowing totaled $1.736 trillion as a wide variety of companies raised funds. Total debt issuance jumped from $821 billion from the prior year.

Sustainable debt includes activity- and behavior-based instruments

Behavior-based debt includes goals such as reduction in emissions intensity, reducing waste from operations, and improving workforce diversity and safety.

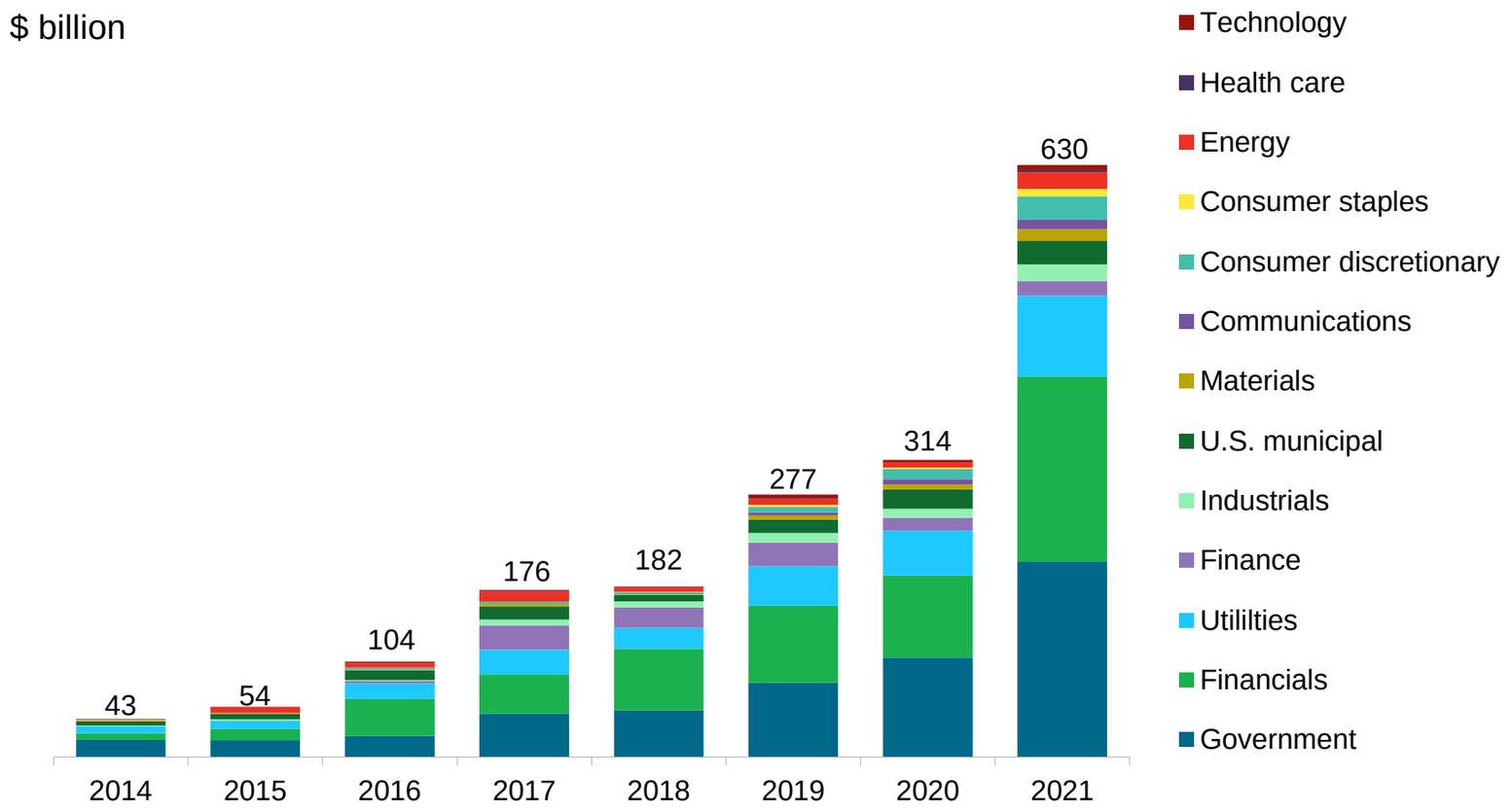
The market's scope continues to expand dramatically.

At $630 billion, green bonds accounted for the largest share raised at 36%. But the popularity of other debt vehicles grew as well. Investment in sustainability-linked loans nearly quadrupled to $491 billion in 2021 from $124 billion in 2020. And sustainability-linked bonds, which attracted $11 billion in 2020, pulled in $108 billion in 2021. Every segment of sustainable debt enjoyed a record year for new investment in 2021.

Source: BloombergNEF. Note: Figures current as of July 2022.

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

Green bond issuance by sector



Governments and financial institutions each accounted for just under a third of total green bond issuances in 2021.

The green bond label made its debut in 2007 as a way of denoting environmental borrowing activities. Proceeds of green bonds go toward financing or refinancing eligible environmental actions.

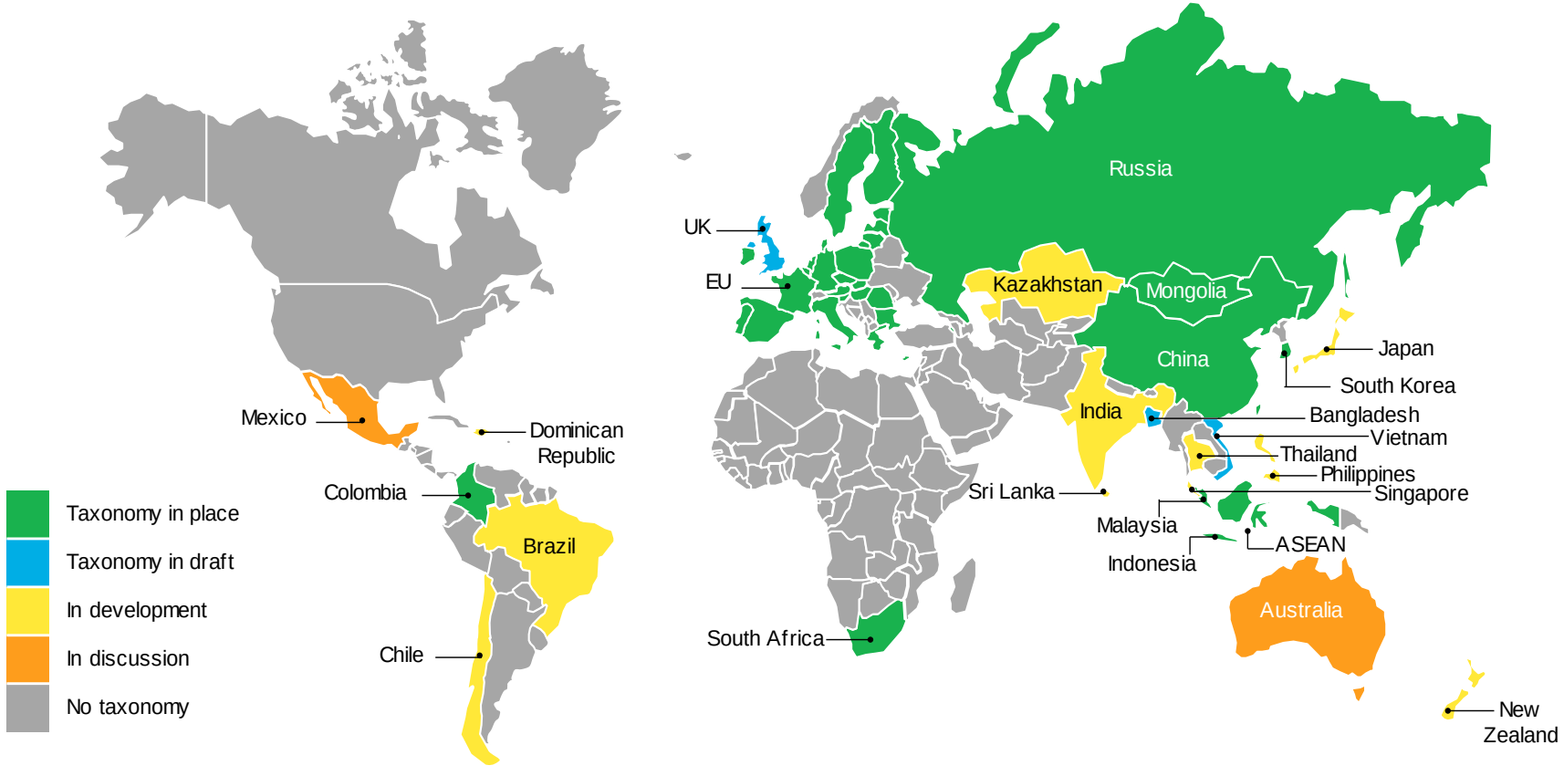
In 2021, governments issued $201 billion in green bonds divided into three groups: government agencies, sovereigns and supranationals. The most substantial parent issuers of government green bonds were the Federal Republic of Germany, the French Republic and the United Kingdom of Great Britain and Northern Ireland.

Financial institutions issued $190 billion in 2021.This included banks, insurance and real estate companies such as ING Groep, CaixaBank, and Landesbank Baden-Wuerttemberg.

Source: BloombergNEF. Bloomberg Terminal

“Green taxonomies” to define environmentally sustainable activities are growing in popularity

Green taxonomies around the globe



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

Green taxonomies are reference frameworks that define what can be considered an environmentally sustainable economic activity in different regions. While the EU taxonomy is the most well known because it was the first to be enforced as a regulation, it is not the only one around the globe. Green taxonomies have been passed in China, Colombia, Russia and most recently, in South Africa. An additional 12 countries either have a taxonomy in draft, in development or under discussion.

Source: BloombergNEF, Climate Bonds Initiative.

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21 – 23 September, 2022

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