

BNEF Executive Factbook

Power, transport, buildings and industry,
commodities, food and agriculture, capital

Jon Moore, CEO

Nat Bullard, Chief Content Officer

March 2, 2021

BloombergNEF

Cover letter

This is BloombergNEF's Executive Factbook, our look at the most important developments in decarbonization, digital transformation, and the energy transition. We published our first Factbook in 2020, in part as a long-term response to the near-term uncertainties of the Covid-19 pandemic; response was so positive that we are now publishing annually. Content within is mostly, but not entirely, the work of BloombergNEF's analysis teams; we are happy to include, and credit, the work of other definitive institutions where they best tell the story of today.

2020 was an unusual world for the global economy, to say the least. Many of you reading this note spent it at home, sheltering from an ongoing pandemic. The systems underpinning that global economy responded in relatively expected ways, with slowdowns and shutdowns, and in some unexpected ways, such as a significant shift to remote working and remotely delivered services previously not thought possible at such scale or volume.

The systems of our global economy – power, transport, industry, buildings and digital, food and agriculture, and capital markets – are also part of the earth system. Human interaction with the earth system has never been more clear. 2020 was the second-warmest year on record, with atmospheric carbon dioxide levels not seen in 800,000 years. A pandemic may have dented annual emissions; it has not arrested their long-term trend.

At the same time, though, the ways in which many sector trends defied the pandemic allow us to consider how we might embark on much greater decarbonization. At the beginning of 2020, 34% of global emissions were covered by a net-zero target; by the end of the year, 54% were covered – an exceptional additional commitment despite the pandemic. BloombergNEF's 2020 New Energy Outlook finds that global primary energy demand peaked in 2019, though it will recover after dropping last year; meanwhile, emissions from both the global power sector and from coal combustion peaked in 2018. Investment in the energy transition reached an all-time high, of \$501 billion; sustainable debt an all-time high issuance, of \$732 billion; clean energy capital markets were at all-time highs, as were share issuances.

Wind and solar power are now the least-expensive option for bulk electricity for two-thirds of the global population, 71% of global GDP, and 85% of global power generation. Electric vehicle sales thoroughly defied the auto industry's overall dismal year, with sales rising 40% from 2019. Finally, infrastructure itself was resilient. The global Internet has allowed us to work from home, and remotely, at a previously unimagined scale, and the clean electricity infrastructure that increasingly powers the cloud was equally resilient.

The aim of this Executive Factbook is to set the many strategic solutions for decarbonization at scale in a global and interconnected context, relevant for anyone in a position of influence. We hope that you find it a useful and thought-provoking read, and look forward to hearing from you.

Kind regards,

Jon Moore and Nat Bullard

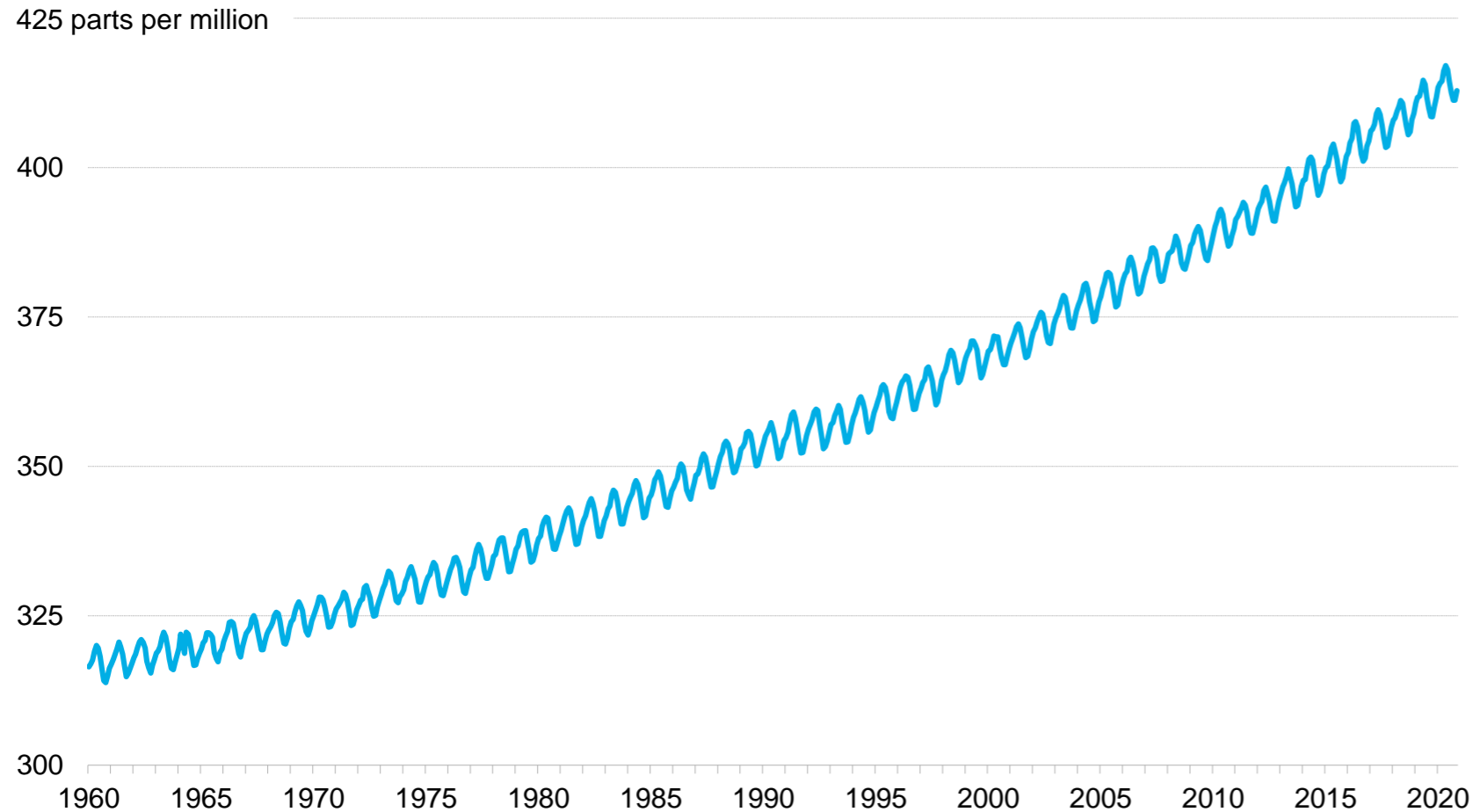
Table of contents

	Introduction: A Cleaner Future	3
	Power	23
	Transport	42
	Industry, Buildings, and Digital	52
	Commodities	68
	Food and Agriculture	82
	Capital	88
	About BNEF	97

Atmospheric carbon dioxide levels continue to rise



Atmospheric carbon dioxide concentration



Prior to the industrial revolution, atmospheric CO₂ never exceeded 300 parts per million in human history

In the 20th century, atmospheric CO₂ concentration passed 300 parts per million; in 2015, it passed 400 parts per million.

Despite a significant fall in global emissions during 2020, atmospheric concentration is rising unabated

The short-term impact of the pandemic is invisible in the longer-term atmospheric trend.

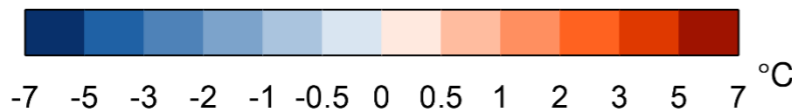
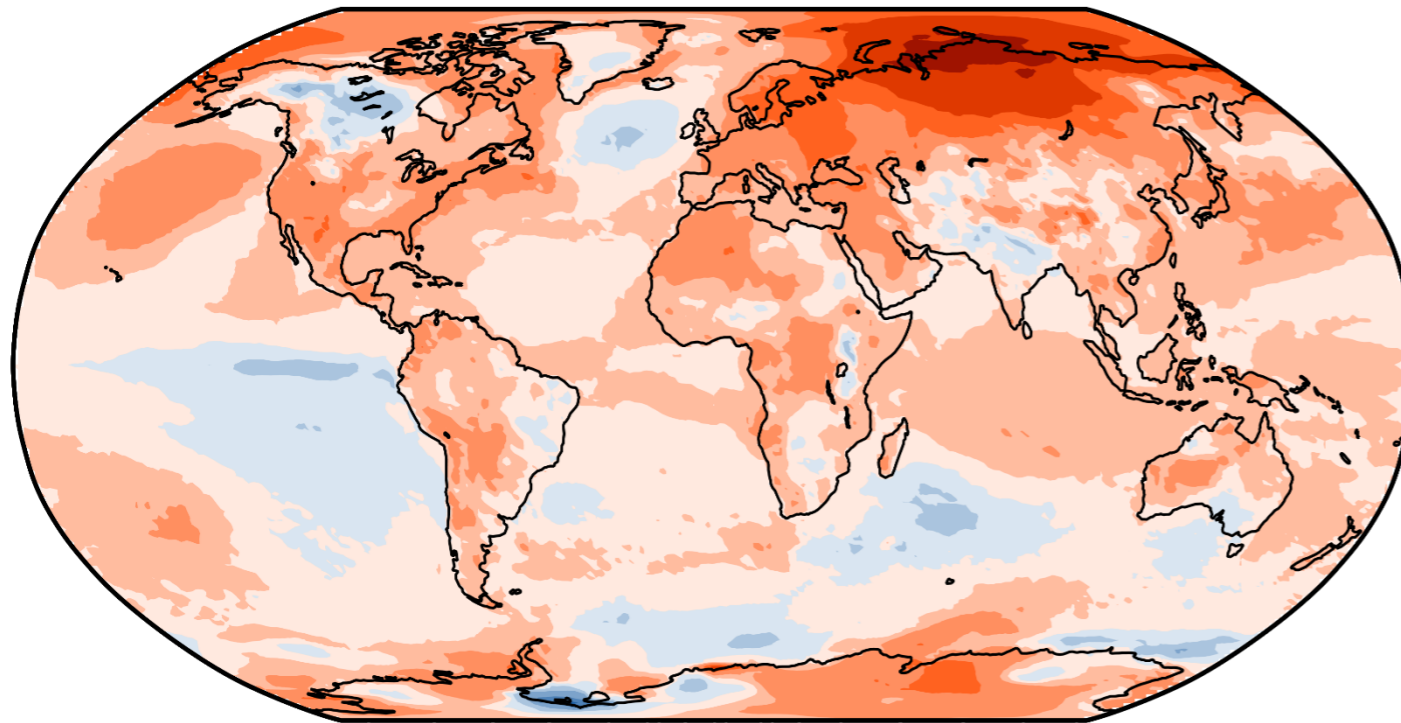
Global atmospheric concentrations of carbon dioxide are at their highest levels in 800,000 years

Source: [Earth Systems Research Laboratory link](#)

2020 was the warmest year on record for Europe; globally, 2020 tied with 2016 for warmest year recorded



Temperature difference 2020 and 1981-2010



Data source: ERA5



Europe saw its warmest year on record

Temperatures were 0.4°C warmer than 2019, which was previously the warmest year.

The largest temperature anomalies were in the far Northern Hemisphere

The largest annual temperature deviation from the 1981-2010 average was concentrated over the Arctic and northern Siberia, reaching to over 6°C above average.

The 2020 wildfire season in the Arctic and northern Siberia was also unusually active

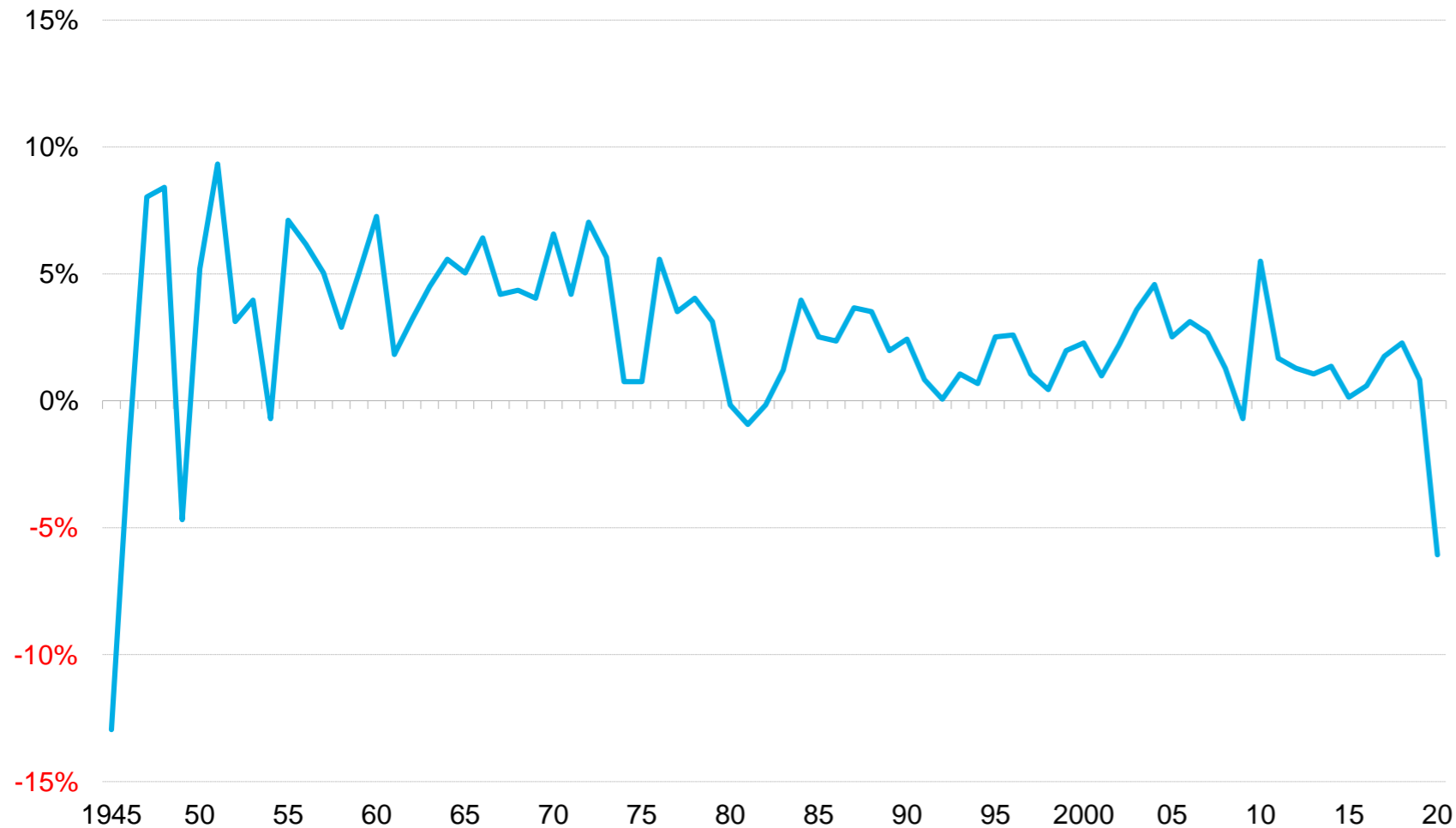
Fires were first detected in May, continued throughout summer, and persisted well into autumn. Fires poleward of the Arctic Circle released 244 million metric tons of CO₂ in 2020, a third more than the previous record year, 2019.

Source: [Copernicus Climate Change Service link](#)

In early 2020, global primary energy demand fell further than at any time since the end of World War II



Rate of change of global primary energy demand



The Covid-19 pandemic and ensuing drop in movement and economic activity drove energy demand down markedly

Energy demand was down 3.8% year-on-year in the first quarter of 2020.

Energy demand may have dropped almost 6% in 2020

That would be the most drastic decline in energy demand since the end of the Second World War.

Different fuels declined to differing degrees

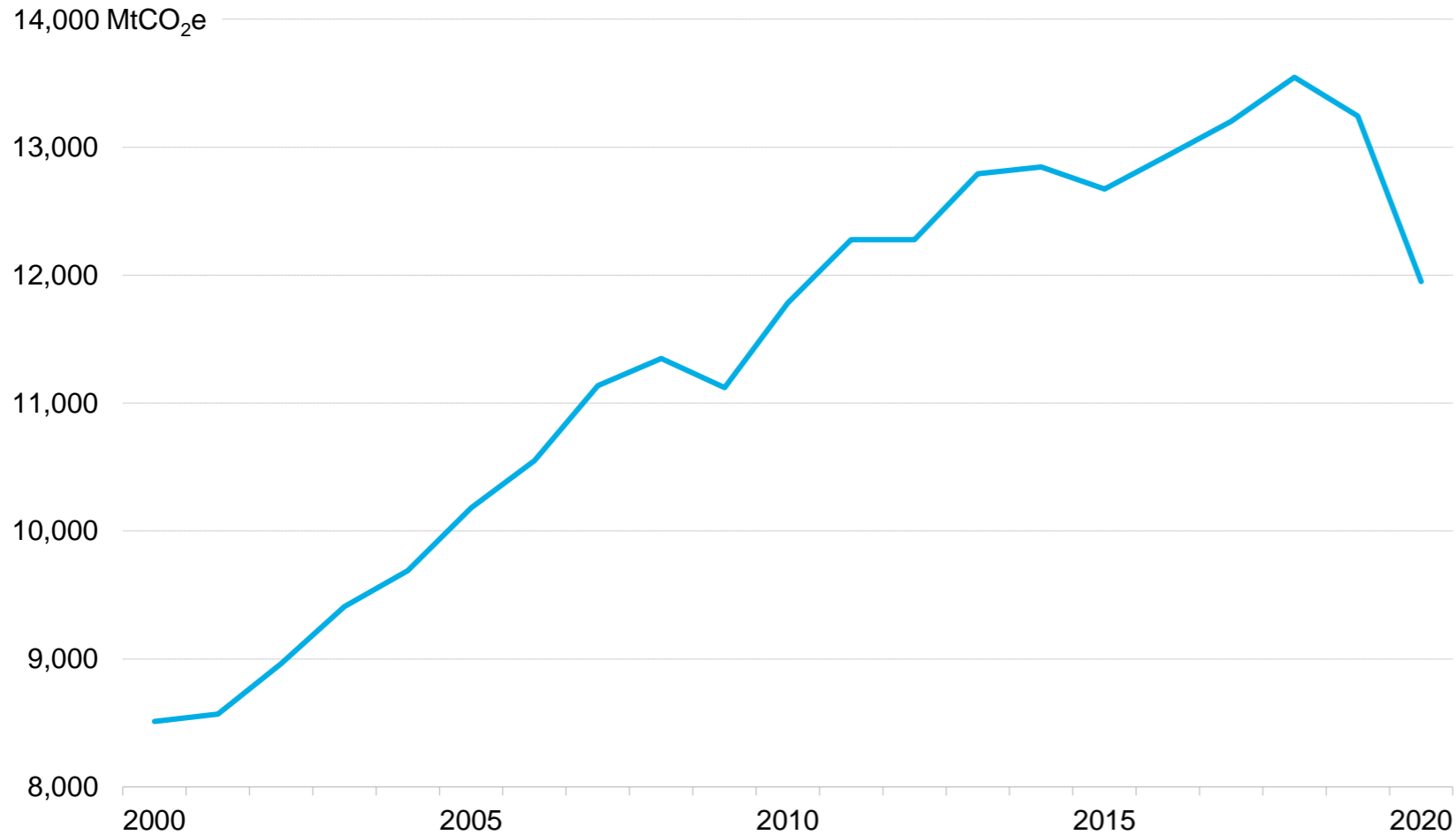
Coal demand fell almost 8%, while oil demand was down nearly 5% and natural gas demand down 2% year-on-year in the first quarter of 2020.

Source: [IEA link](#)

Global power sector emissions peaked in 2018



Total emissions from power generation



Power sector emissions peaked in 2018

Decarbonization of the world's power fleet, through renewables as well as a shift from coal to gas, means that emissions from power generation peaked in 2018.

Covid-19 accelerated power emissions' trend, but did not change it

Emissions fell sharply in 2020, but are expected to decline by 2% per year until 2050.

Power sector emissions will decline significantly as a percentage of total emissions.

Power emissions are the largest sector of emissions from fuel combustion, at 42% today. By 2050, they are likely to be 27% of total emissions from fuel combustion.

Source: BloombergNEF New Energy Outlook 2020

Oil prices went negative



West Texas Intermediate futures



In April, the U.S. crude oil benchmark priced below zero for the first time

On April 20, West Texas Intermediate futures plunged from \$17.85 a barrel to -\$37.63 a barrel.

With storage full or committed, traders paid others to take delivery

Traders were desperate to avoid taking delivery of physical product.

WTI is the world's most-traded financial oil contract

Each month, a futures contract nears expiry and traders roll positions to further-out contracts – or else take physical delivery, which was nearly impossible in April with storage in Cushing, Oklahoma nearly full.

The European oil benchmark traded normally

On the same day, Brent crude futures closed trading down sharply, but still above \$25 per barrel.

Source: Bloomberg

More than half of all global emissions are now covered by a form of net-zero target

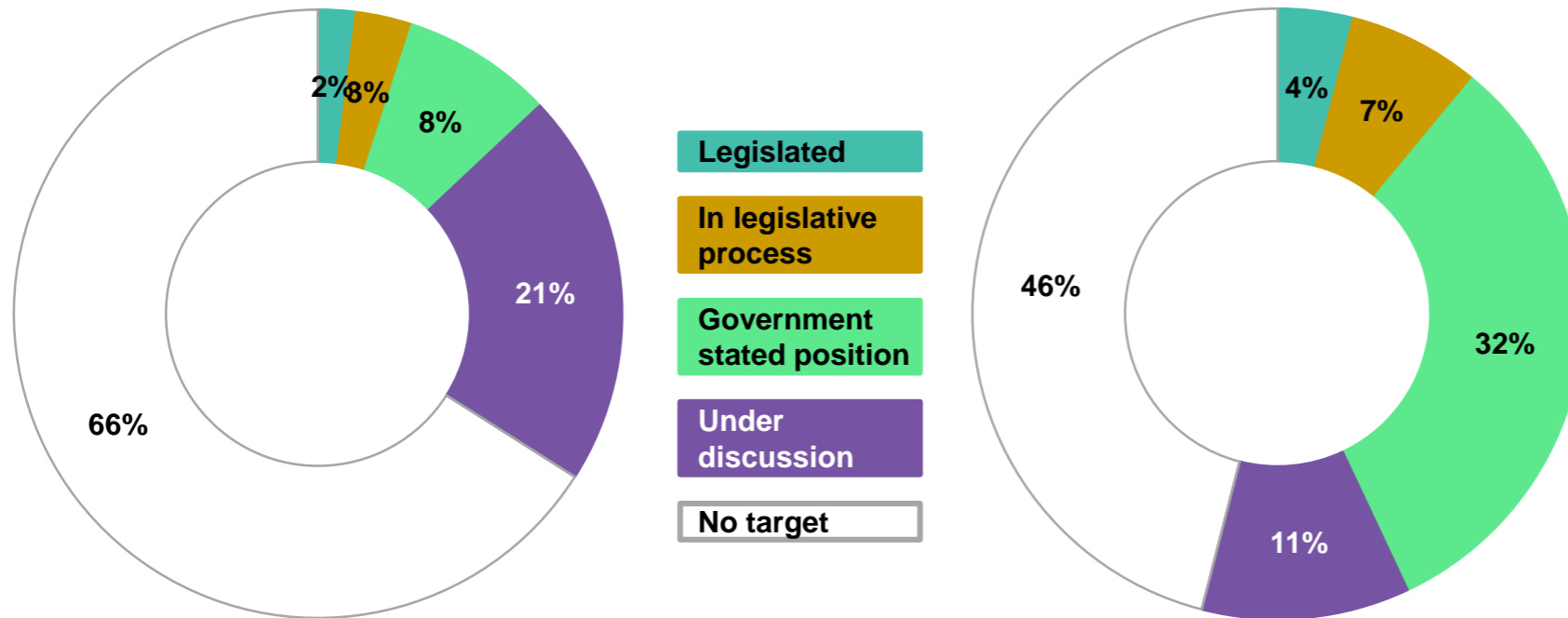


January 2020

34% with at least a net-zero discussion

December 2020

54% with at least a net-zero discussion



At the beginning of 2020, one-third of global emissions were covered by some form of net-zero target

Most of that total was only 'under discussion' – having been raised by governments as a policy target.

By the end of 2020, more than half of global emissions were covered

The amount of emissions covered by a final, legislated target and in legislative process both doubled, while the amount covered by a stated government position increased four times.

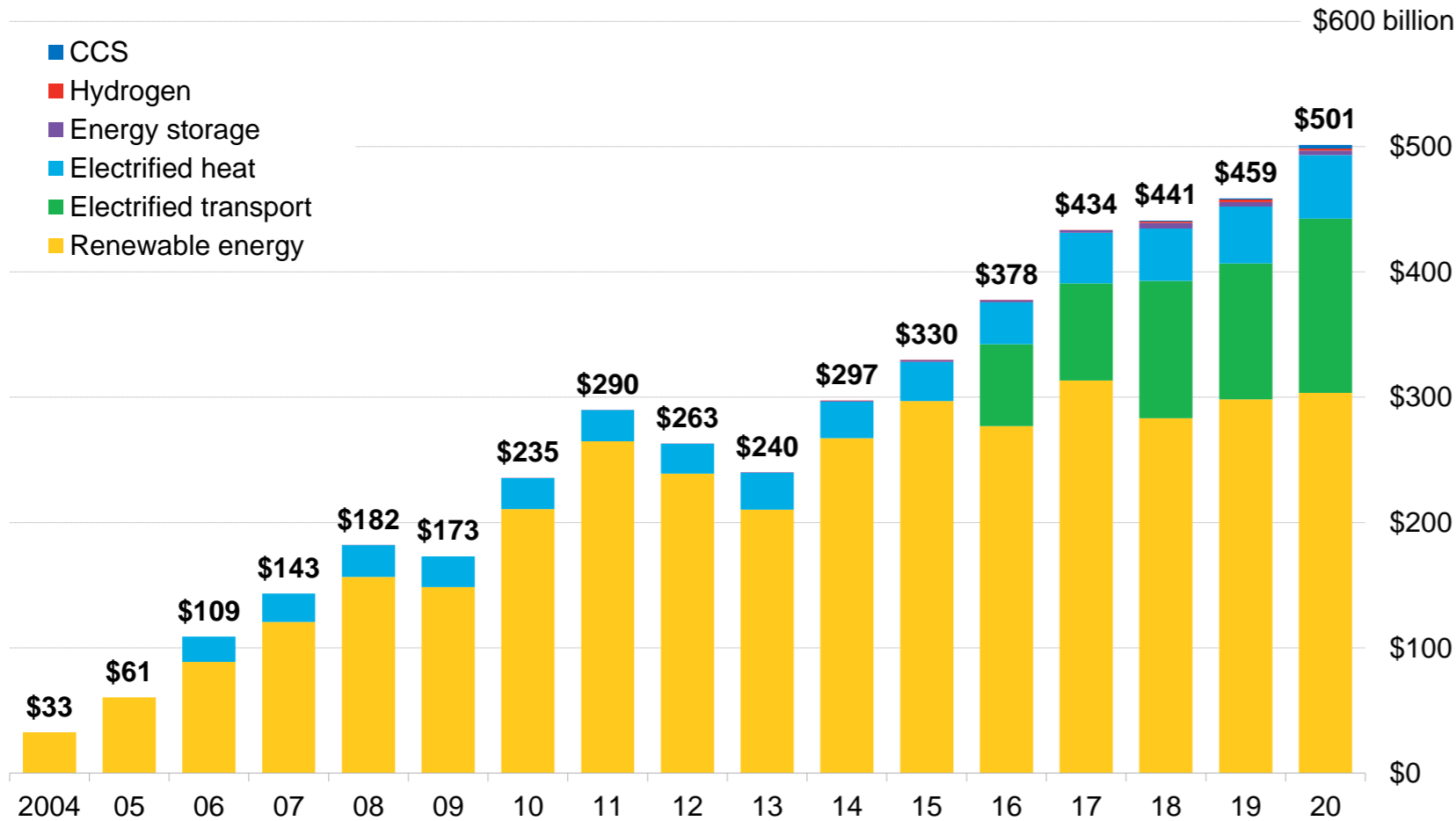
China, the EU, Japan and South Korea are all part of the 'net-zero club'

However, these bold ambitions are still lacking in policy specifics in many cases.

Energy transition investment reached a half a trillion dollars in 2020



Global energy transition investment



Global investment in the energy transition reached half a trillion dollars in 2020

Energy transition investment includes renewable energy, electrified transport, electrified heat, energy storage, hydrogen, and carbon capture and storage.

Renewable energy investment has been flat since 2015, at around \$300 billion per year

However, with equipment costs falling, the amount of capacity built has increased more than 13 times since 2004

Electrification of transport and heat received almost \$200 billion in 2020

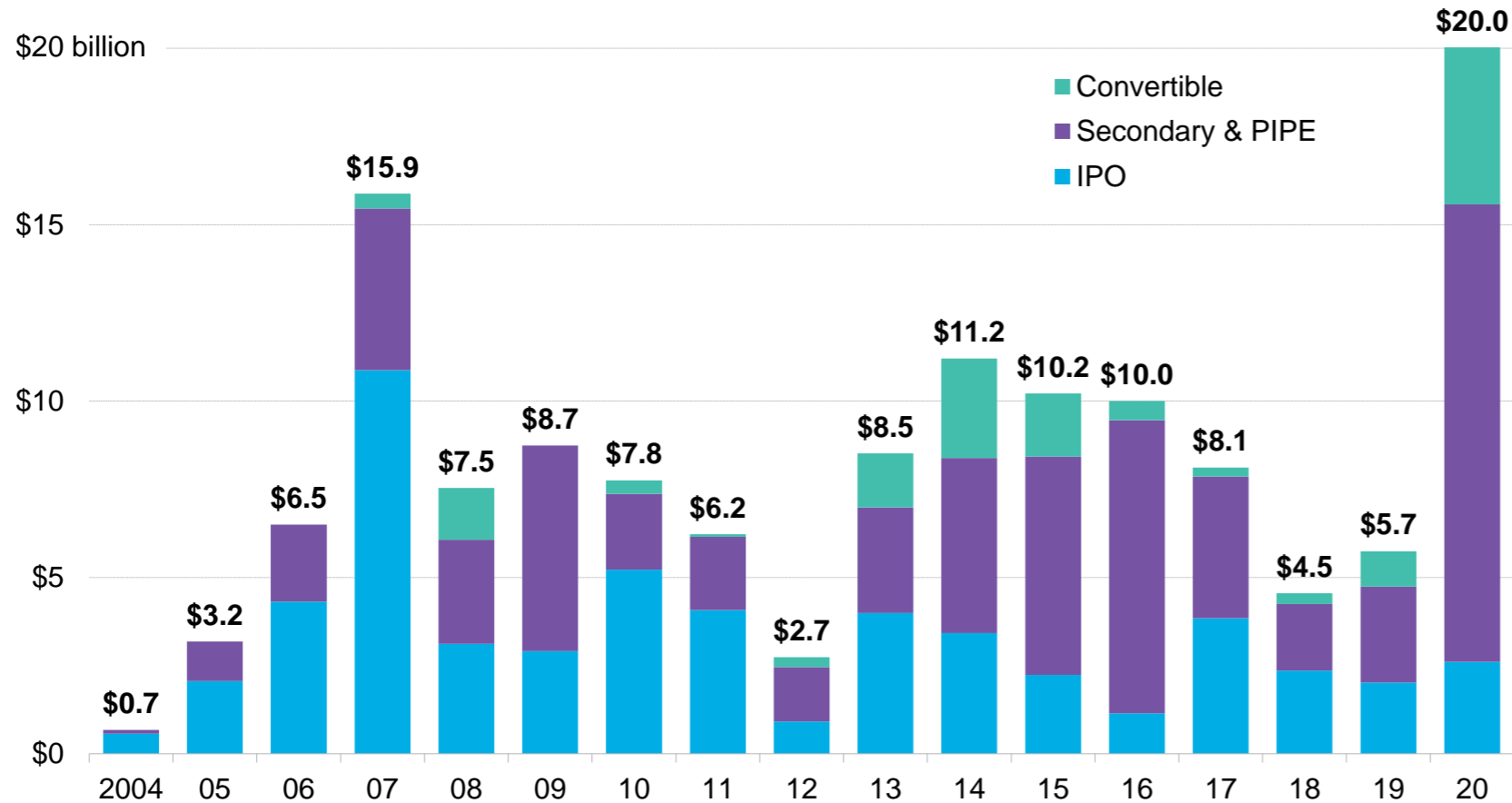
Electrified transport received \$139 billion in 2020, and electrified heat \$50 billion.

Source: BloombergNEF

Renewable energy and storage companies raised a record \$20 billion in public markets in 2020



Renewable energy and energy storage capital raising activity



2020 was a record year in public markets for renewable energy and storage companies

Companies raised \$20 billion via initial public offerings, secondary offerings, private placements, and convertible issuances.

IPOs were the least significant new source of funds; secondaries the most significant

Even without IPO funding, 2020's secondary and convertible funds raised would have made for a record year.

The biggest single deal was \$2.8 billion

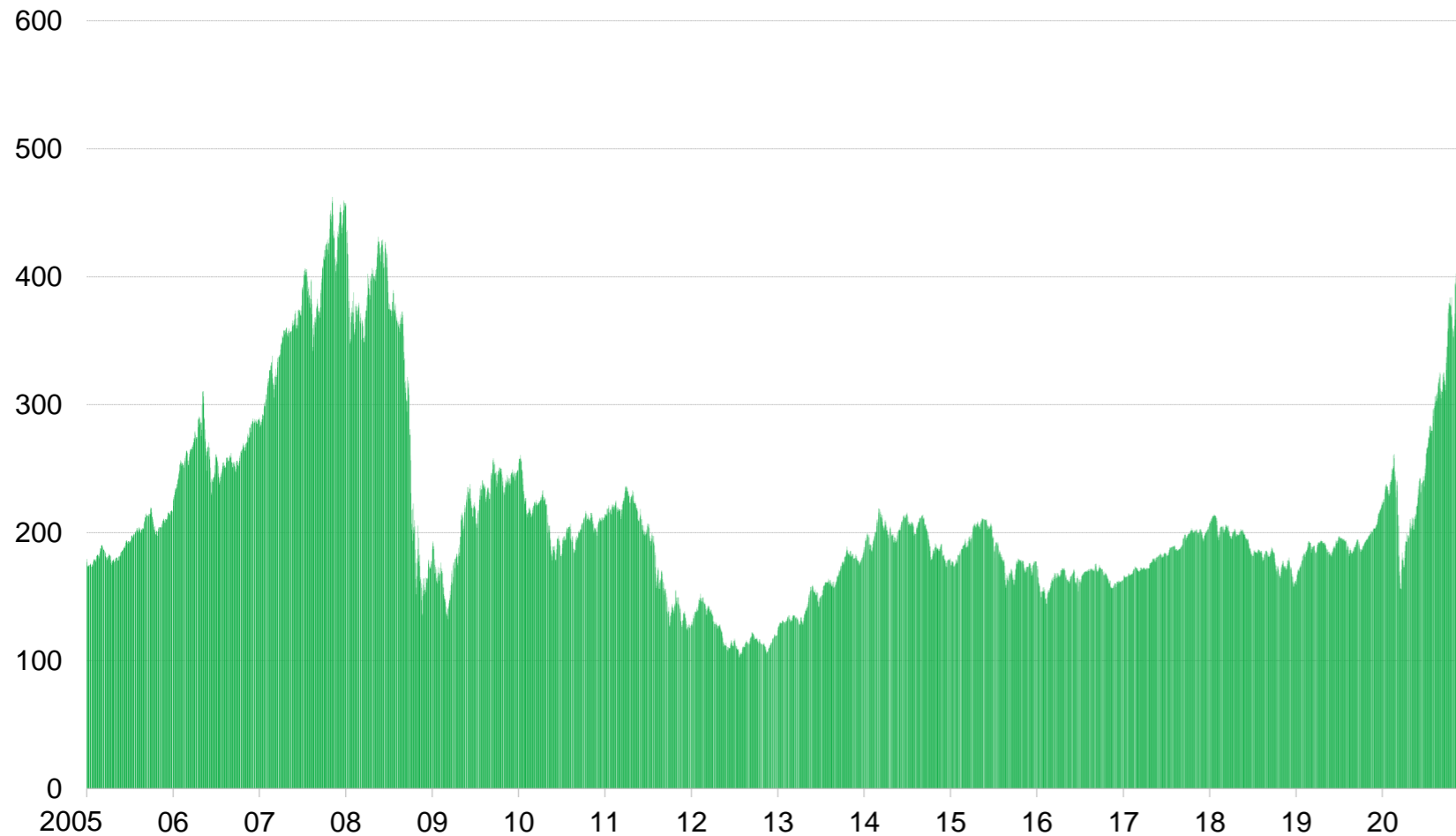
China's Contemporary Amperex Technology (CATL) raised \$2.8 billion. The next largest deals were Plug Power (\$846 million) and JA Solar (\$777 million).

Source: BloombergNEF

The NEX Index reached all-time highs, surpassing its 2007 levels



WilderHill New Energy Global Innovation Index



The WilderHill New Energy Global Innovation Index is a modified dollar-weighted index of publicly traded companies active in renewable and low-carbon energy

The majority of index members are quoted outside the U.S.

The WilderHill New Energy Global Innovation Index's low in 2020 was 179.50 and it ended 2020 at 535.65

The increase carried the index to an all-time high, surpassing its previous high in December 2007.

Solar, battery, and fuel cell companies are the largest index components by weight

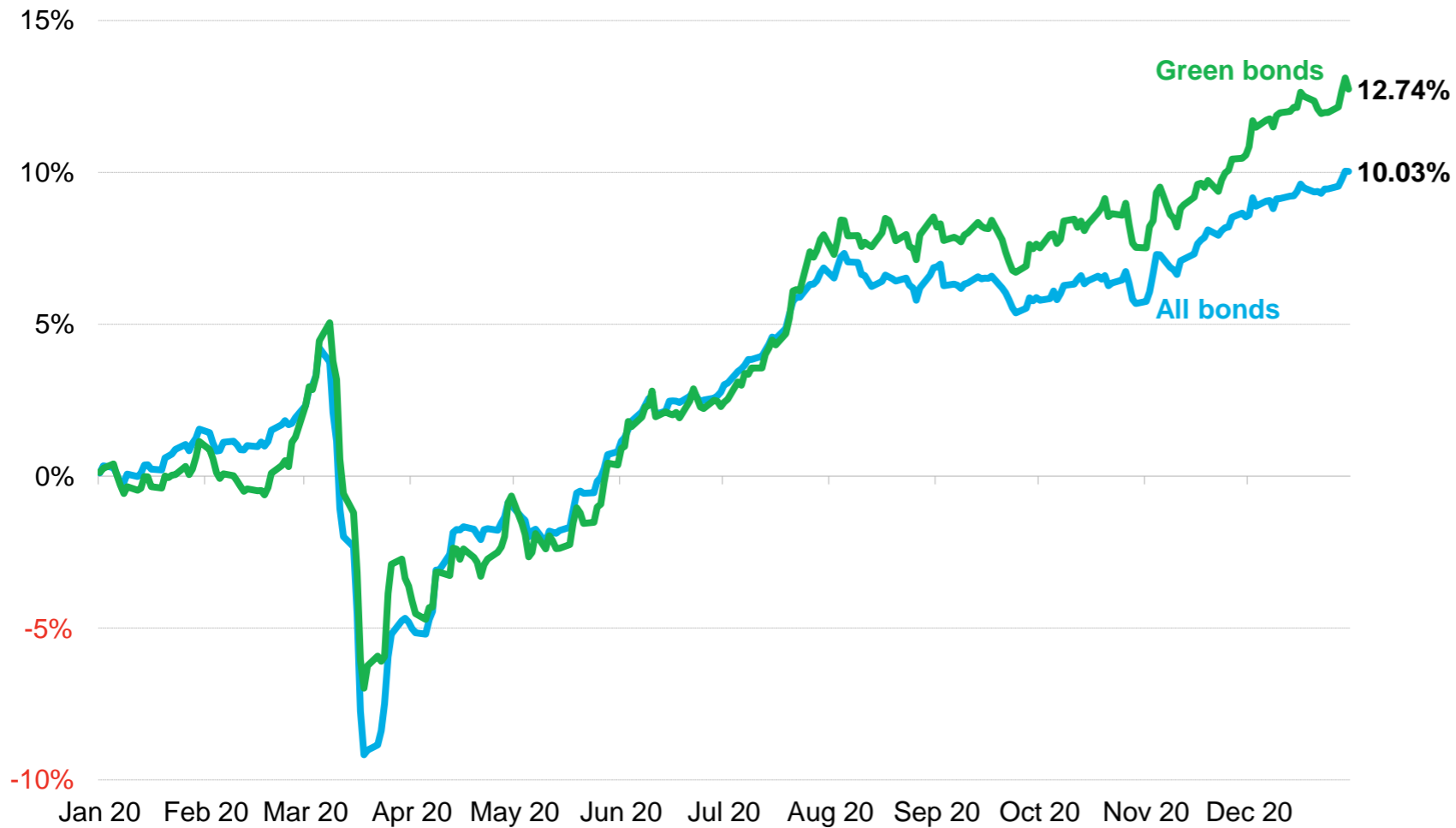
Renesola Ltd (2.1%), Plug Power Inc (1.9%), FuelCell Energy Inc (1.7%) and Lithium Americas Corp (1.5%) are the largest index components.

Source: BloombergNEF

Green bonds outperformed global bonds in 2020



Global green bond and all bond performance, 2020



Green bonds outperformed the broader global bond market in 2020

The Bloomberg Barclays MSCI Global Green Bond Index ended the year up 12.74%, while the Bloomberg Barclays Global Aggregate Credit Total Return Index ended the year up 10.03%.

Green bonds declined less in the early days of the Covid-19 pandemic than the broader bond market

Green bonds declined as steeply as the rest of the bond market, but not to the same degree.

Green bonds decoupled from the rest of the bond market in August 2020

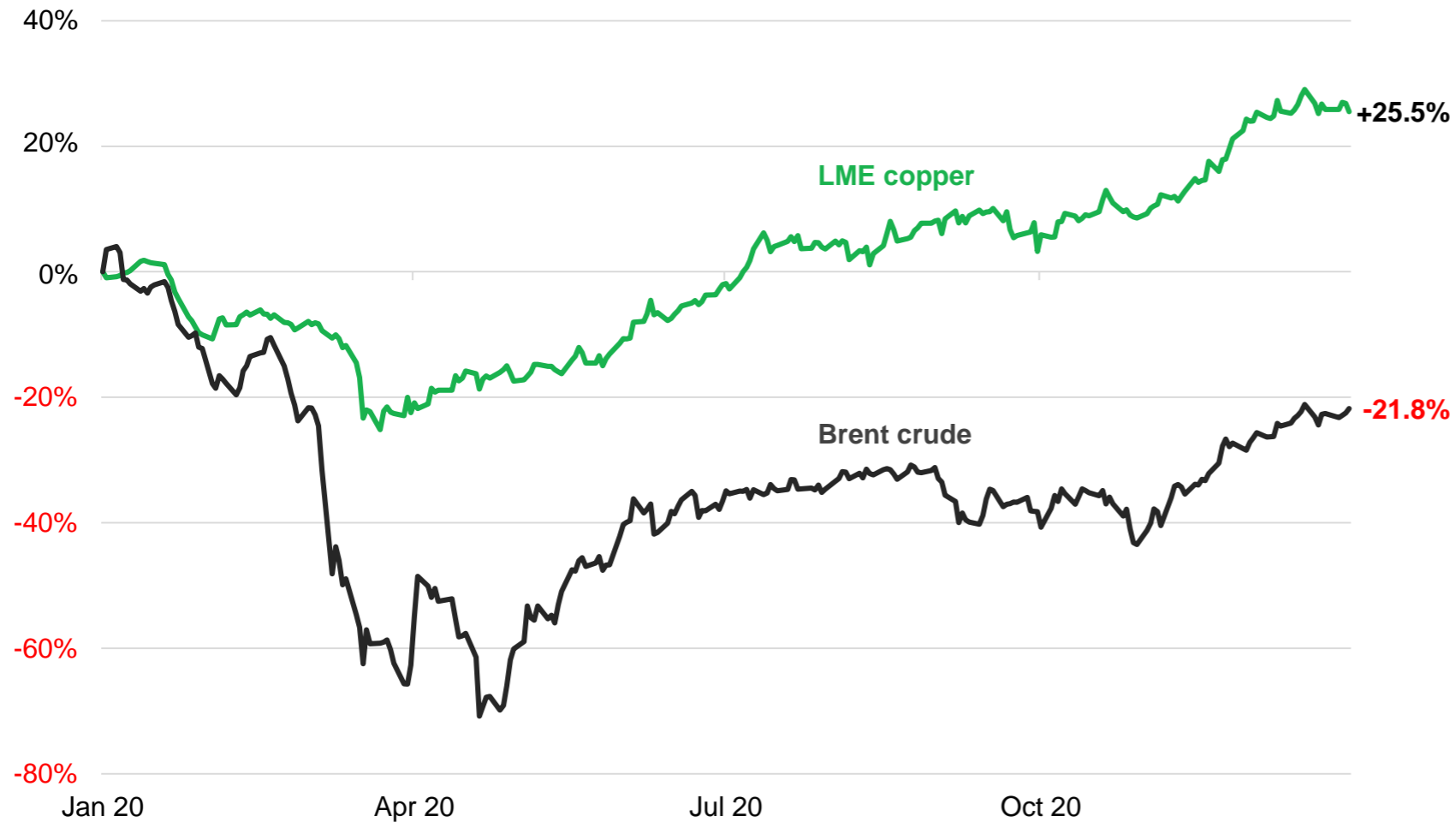
Annual performance was quite closely coupled in mid-summer, with green bonds then pulling away from the rest of the bond market.

Source: Bloomberg

Copper and oil were on different recovery paths in 2020



Copper and oil futures, January – December 2020



Two industrial commodities, copper and oil, painted a contrasting picture of global recovery in 2020.

In the past three recessions, both hit multi-year lows and then recovered as risk appetite returned.

In 2020, LME copper not only recovered, it gained significantly

Copper finished the year up more than 25%.

In 2020, Brent crude recovered from its April lows, but still ended the year down

Brent crude closed the year down more than 20%.

China, the world's largest copper market, recovered quickest

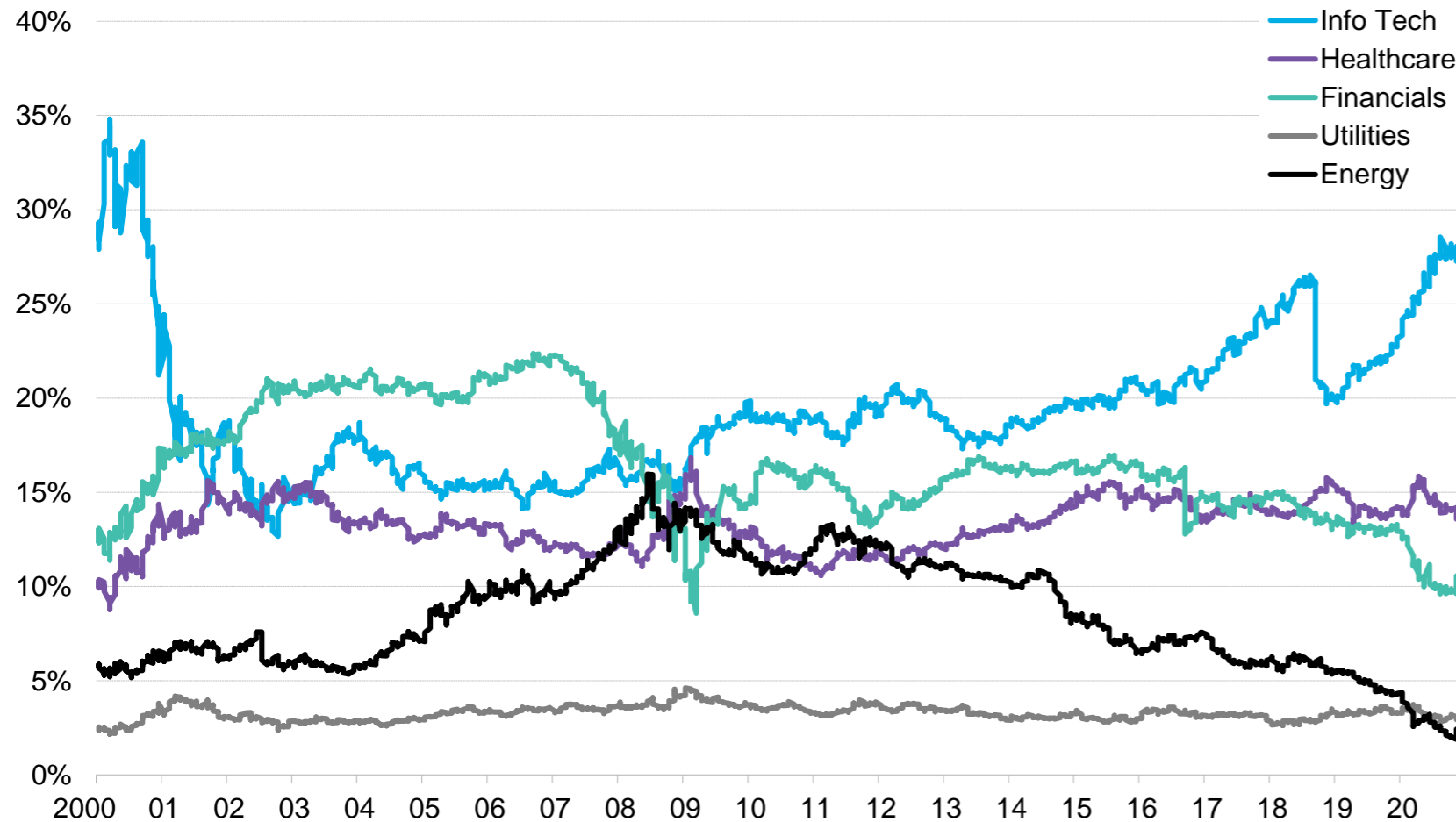
Alongside China's recovery, investors looked to copper to benefit from increased electrification, though in 2020 this was likely to be more sentiment than anything.

Source: Bloomberg

Energy companies became the smallest component of the S&P500



S&P500 member weightings by sector, % of total



In August 2020, energy became the smallest sector in the S&P500 index

Energy is one of 11 S&P500 sectors, comprised entirely of oil and gas and oilfield services companies. After falling past utilities, and then real estate, and finally materials, it became the index's smallest sector.

In 2008, energy was more than 16% of the S&P500

Record-high oil prices propelled the energy sector to its highest level this century, while low prices and uncertain demand depressed it in 2020.

Energy company molecules are now competing with bits and electrons

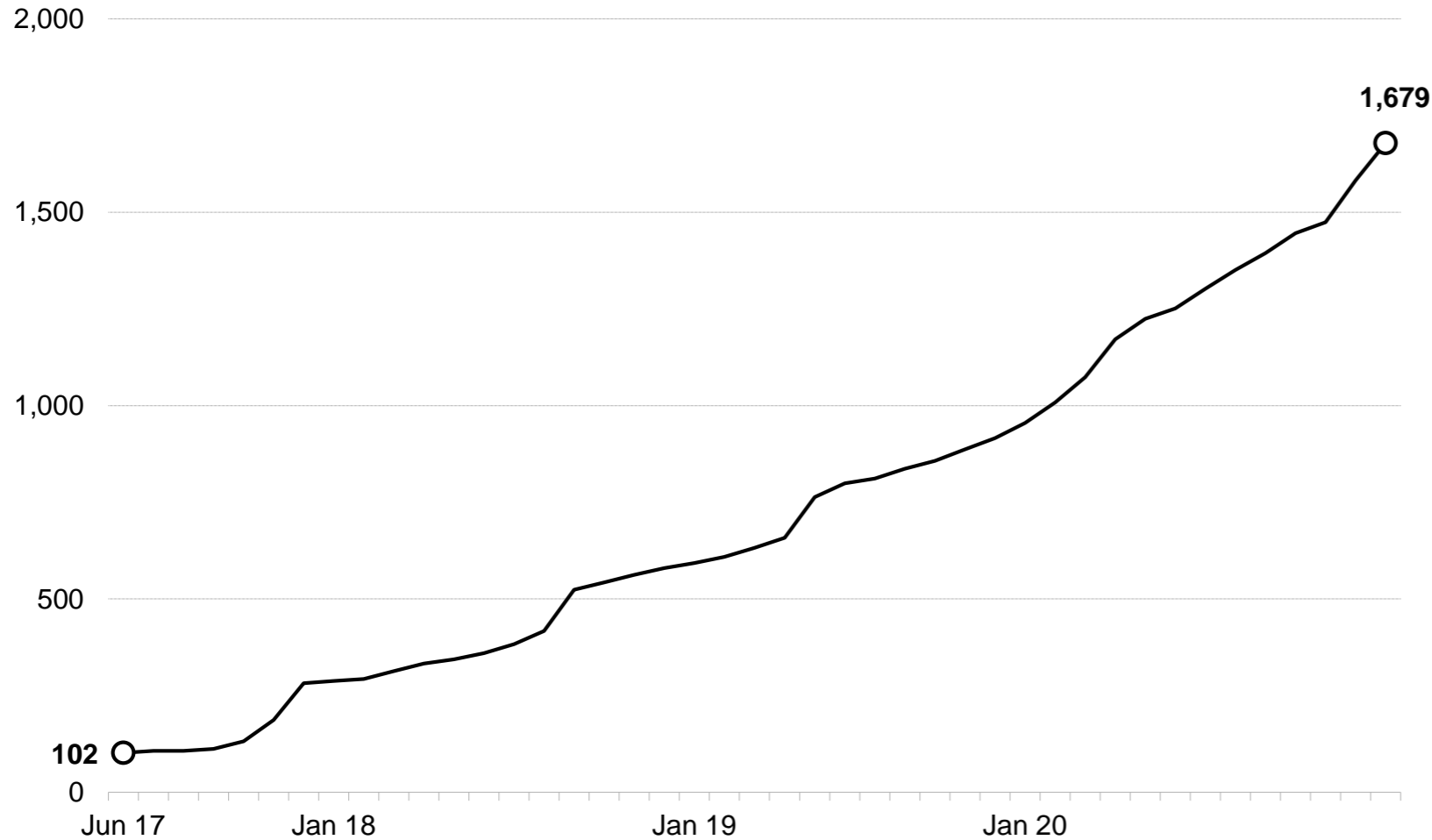
Electrification of more sectors of the global economy, as well as technology company ambitions to decarbonize their operations and processes, means competition has come to areas once the exclusive province of energy companies' molecules.

Source: [Bloomberg link](#)

Financial markets are making significant climate- and carbon-related commitments



Supporting companies



\$12.6 trillion

TCFD supporting company market cap

\$150 trillion

TCFD supporting financial institution assets under management



HM Treasury

The UK will become the first country in the world to make Task Force on Climate-related Financial Disclosures (TCFD) aligned disclosures fully mandatory across the economy by 2025, going beyond the 'comply or explain' approach.

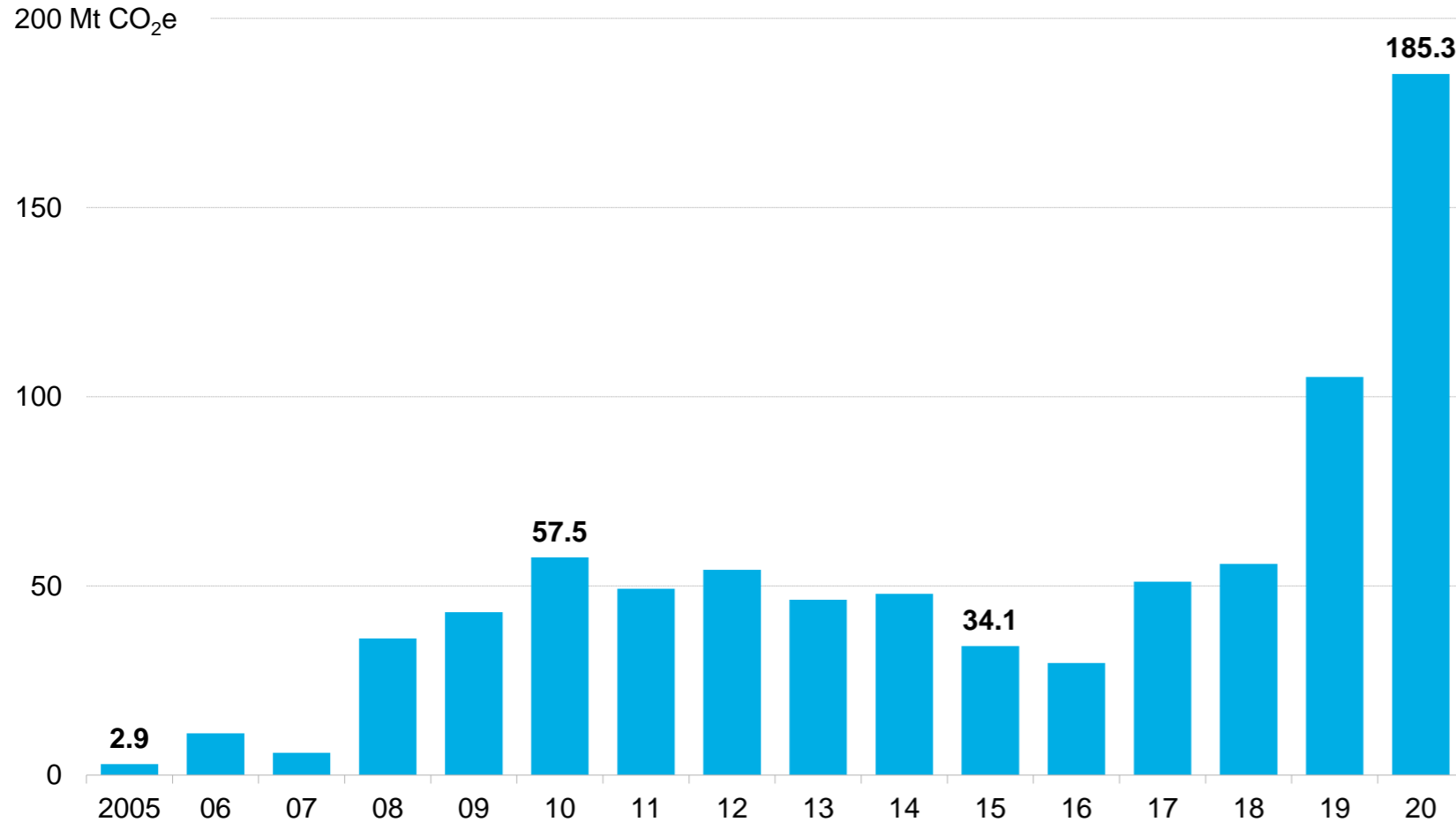
November 9, 2020

Source: TCFD

Voluntary carbon offsets will serve as an important low-carbon pathway, though they are often a sunk cost



Carbon offsets issued



Voluntary carbon offset issuance grew 76% in 2020

Demand for voluntary carbon offsets is surging, with companies in hard-to-abate sectors viewing it as an essential tool to hit their net-zero targets.

Offsite capacity is now at 774MtCO₂e

If all voluntary carbon offset projects were operating at their full capacity, they could issue offsets equivalent to the emissions of Germany.

Forestry projects are growing in popularity

Companies are increasingly seeking nature based solutions that *remove* carbon, rather than offset it. Projects focused on reforestation or prevention of deforestation, abbreviated as REDD+, have become more popular as a result. Over 60% of offsets issued in 2019 were from REDD+ projects.

Major corporations are purchasing offsets

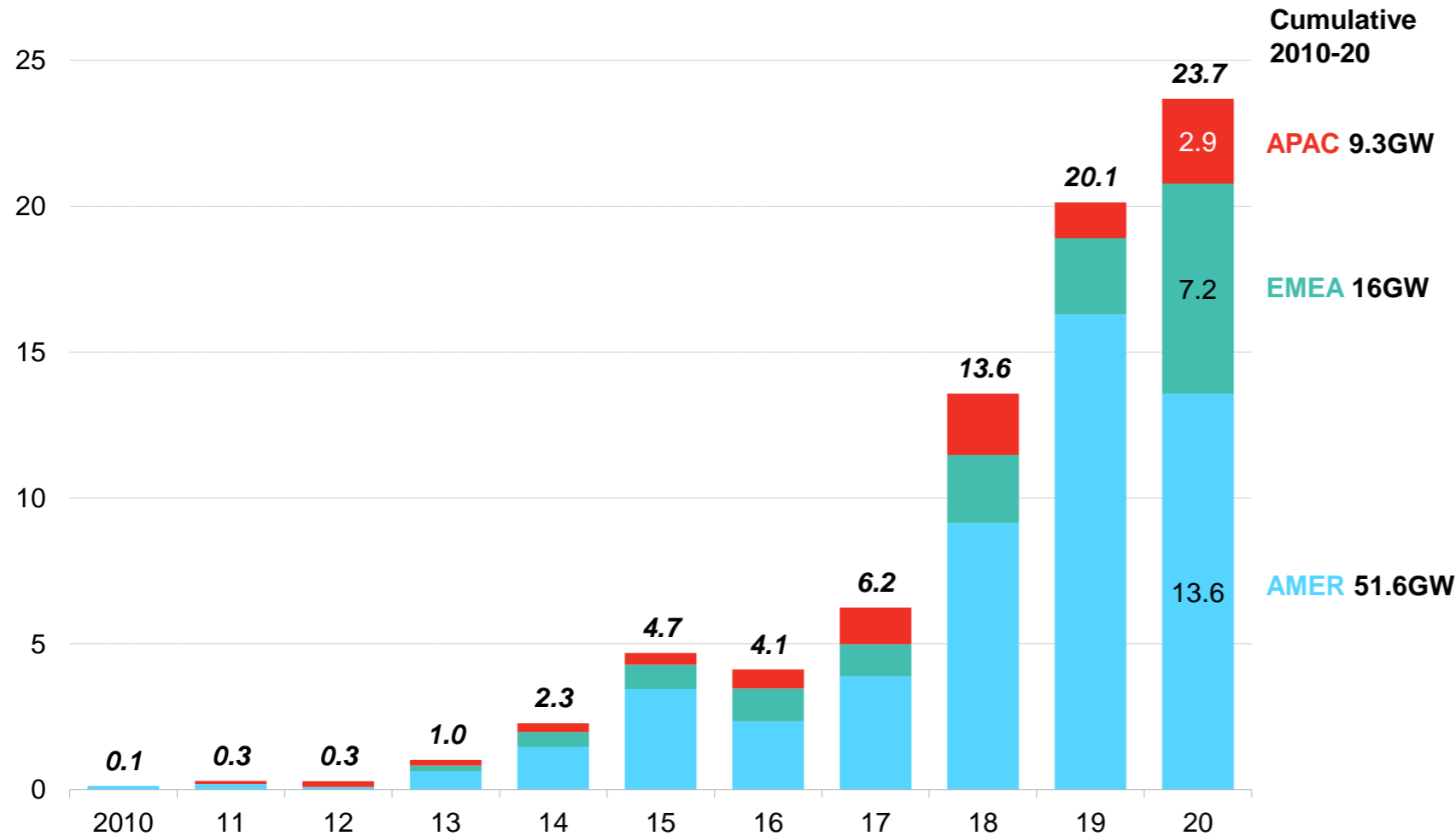
Blackrock, Delta Airlines, JPMorgan and Shell were just a few of the notable companies that publicly disclosed the purchase of carbon offsets in 2020.

Source: BloombergNEF, Verified Carbon Standard, Gold Standard, American Carbon Registry, Climate Action Reserve

Corporate renewable power purchase agreements grew 18% in 2020 despite the pandemic



Global corporate renewable power purchase agreements



Corporate renewable power purchases increased 18% in 2020

The growth comes despite Covid-19 interrupting corporate functions, and plummeting revenues in some sectors.

The U.S. was the largest market, though less dominant than in years past

U.S. companies announced 11.9 gigawatts of corporate PPAs, down from 14.1GW in 2019 and the first year-on-year decline since 2016.

The Asia Pacific region and Europe both set annual records for PPA volumes

Asian corporate PPA volumes more than doubled, and European volumes nearly tripled.

Amazon was the most active company

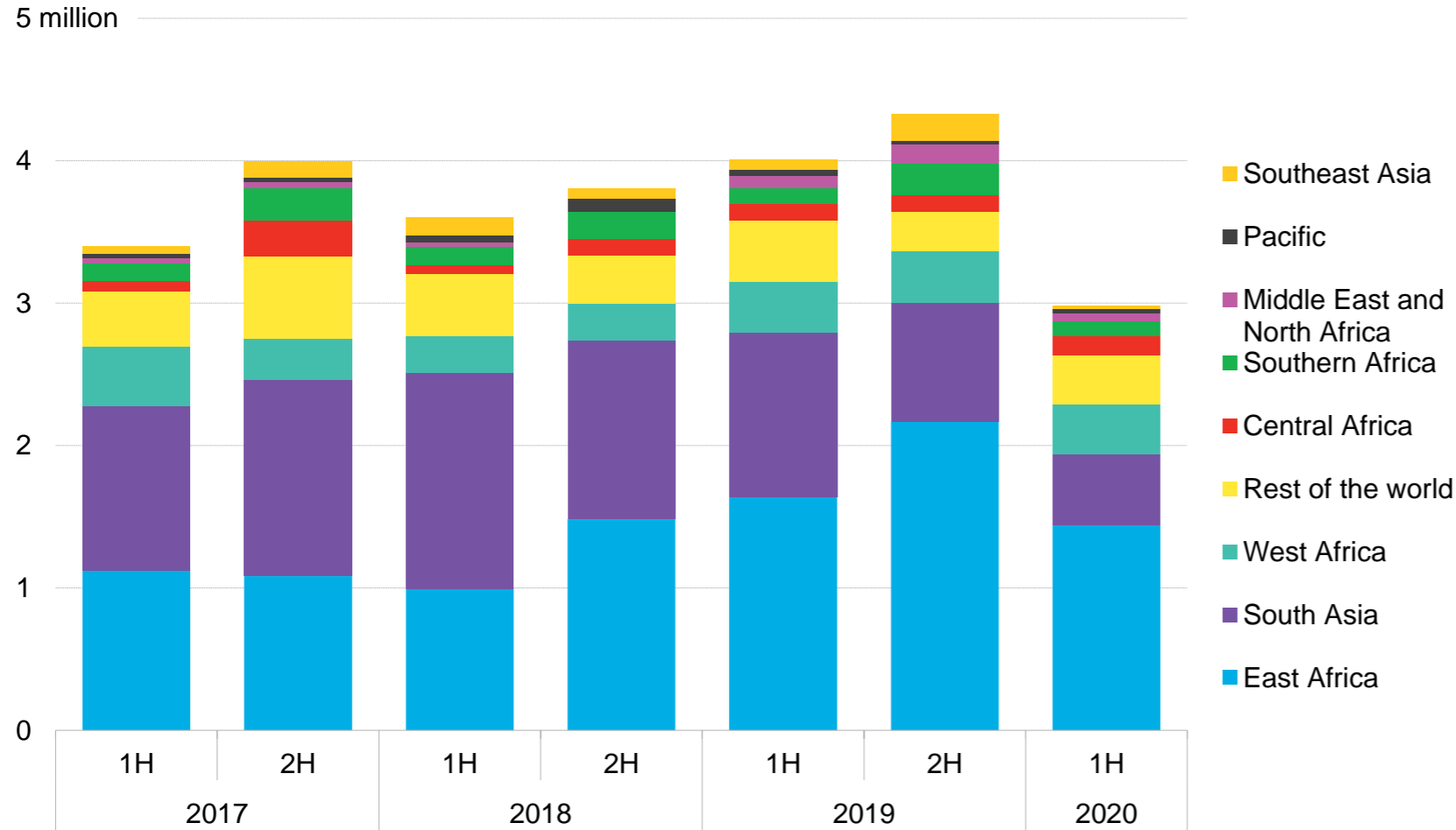
The company signed 35 PPAs totaling 5.1GW of capacity. Semiconductor manufacturer TSMC, oil supermajor Total SE, U.S. telecoms company Verizon, and Facebook rounded out the top five in capacity signed.

Source: BloombergNEF [link](#)

More than 25 million solar home systems have been installed since 2017



Off-grid solar home systems sales



Falling system prices are driving installation

Falling solar prices, coupled with energy-efficient appliances, led to more than 8 million off-grid solar home system sales in 2019.

Covid-19 impacted sales in 2020

Global sales in the first half of 2020 were down 26% from the first half of 2019.

Sales in South Asia fell furthest in 1H 2020

Sales in the region were down 60% compared to a year earlier.

Sales in Africa were much more stable

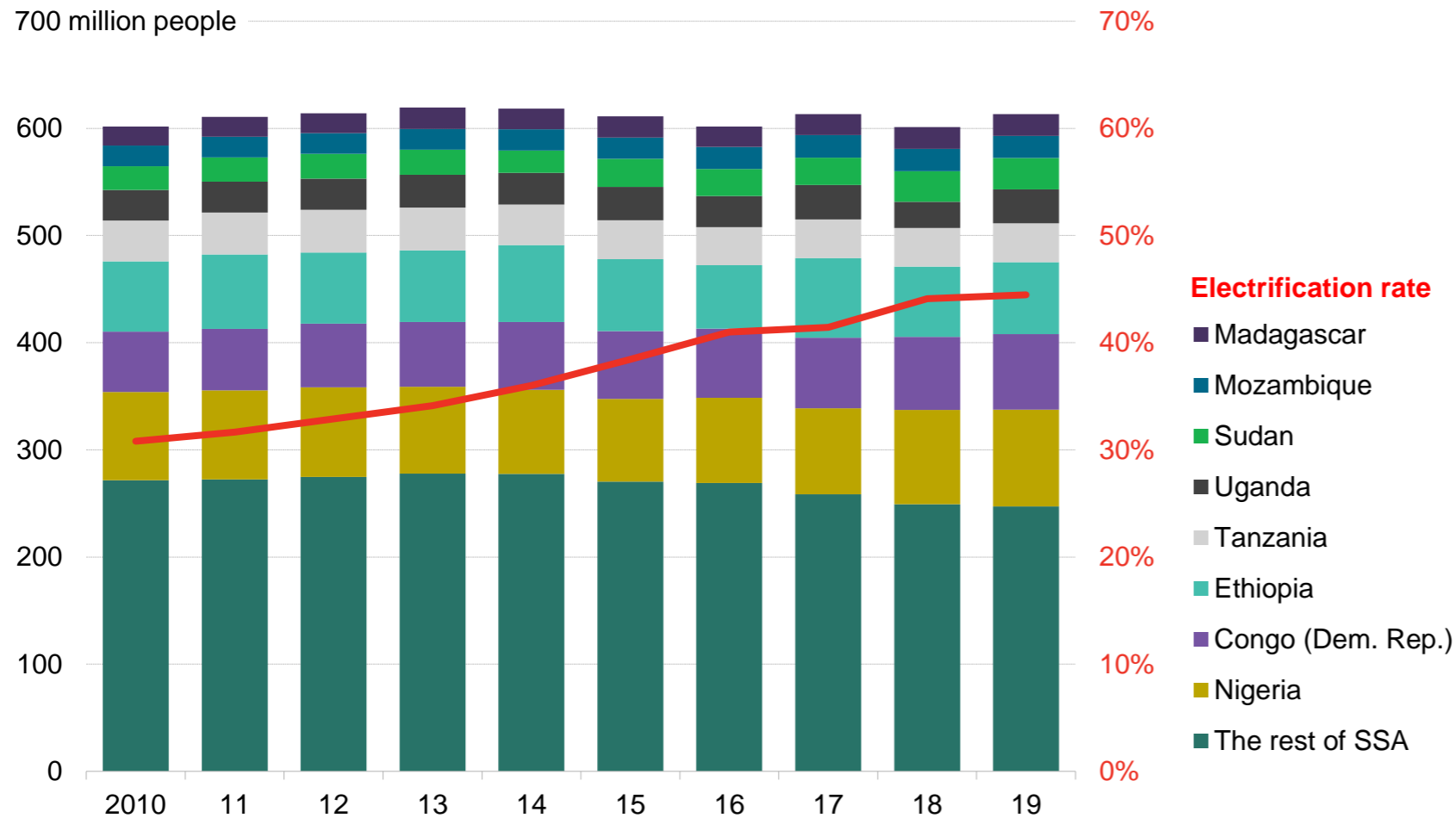
Sales in East Africa fell 11% year on year, while sales in West and Central Africa remained relatively stable.

Source: BloombergNEF, [GOGLA link](#)

Sub-Saharan Africa's electricity access rate is at its highest-ever level, but much more is needed



Electricity access in sub-Saharan Africa



Sub-Saharan Africa's electrification rate is at its highest-ever level

Sub-Saharan Africa's electrification rate reached 44% in 2019, up from 31% in 2010.

However, much more needs to be done

Given population growth, sub-Saharan Africa's population without reliable access to electricity is as large now as the total population in 2010.

Electrification has actually decreased in some countries

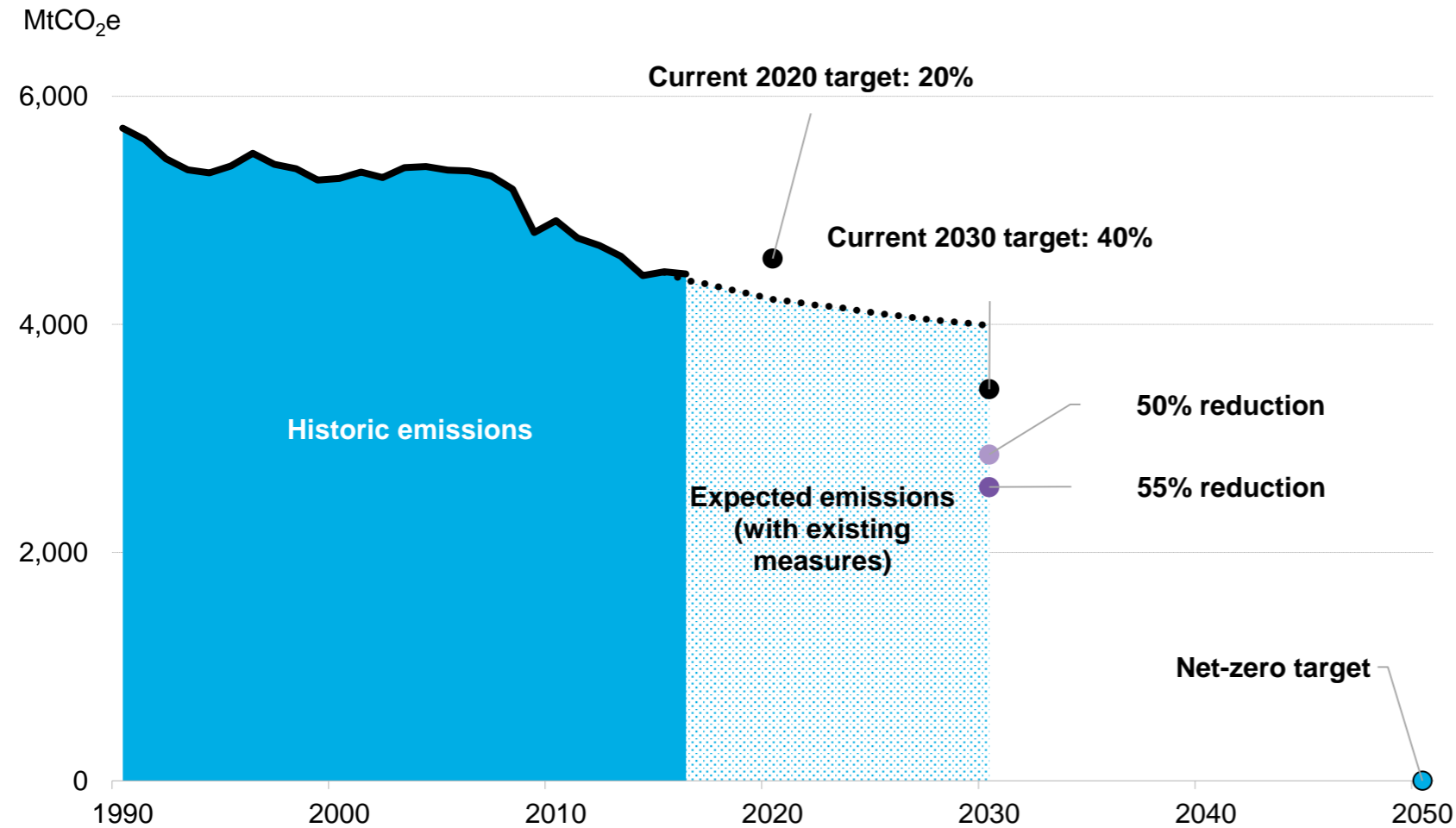
Tanzania's population with electricity access declined slightly during the decade. In smaller countries in Sub-Saharan Africa, the population with electricity access declined almost 10%, from 272 million to 247 million from 2010 to 2019.

Source: BloombergNEF

Europe has been at the forefront of policy innovation to decarbonize its economy



Annual EU emissions, current and proposed target reductions from 1990 baseline



Europe's carbon emissions have fallen substantially since 1990

Its current 2020 target is a 20% reduction from 1990 levels.

Six European countries have set legally-binding net-zero targets

As of November 2020, Denmark, Germany, France, Hungary, Sweden, and the U.K. all set targets for 2050 or earlier.

The European Commission launched the EU Green Deal in late 2019

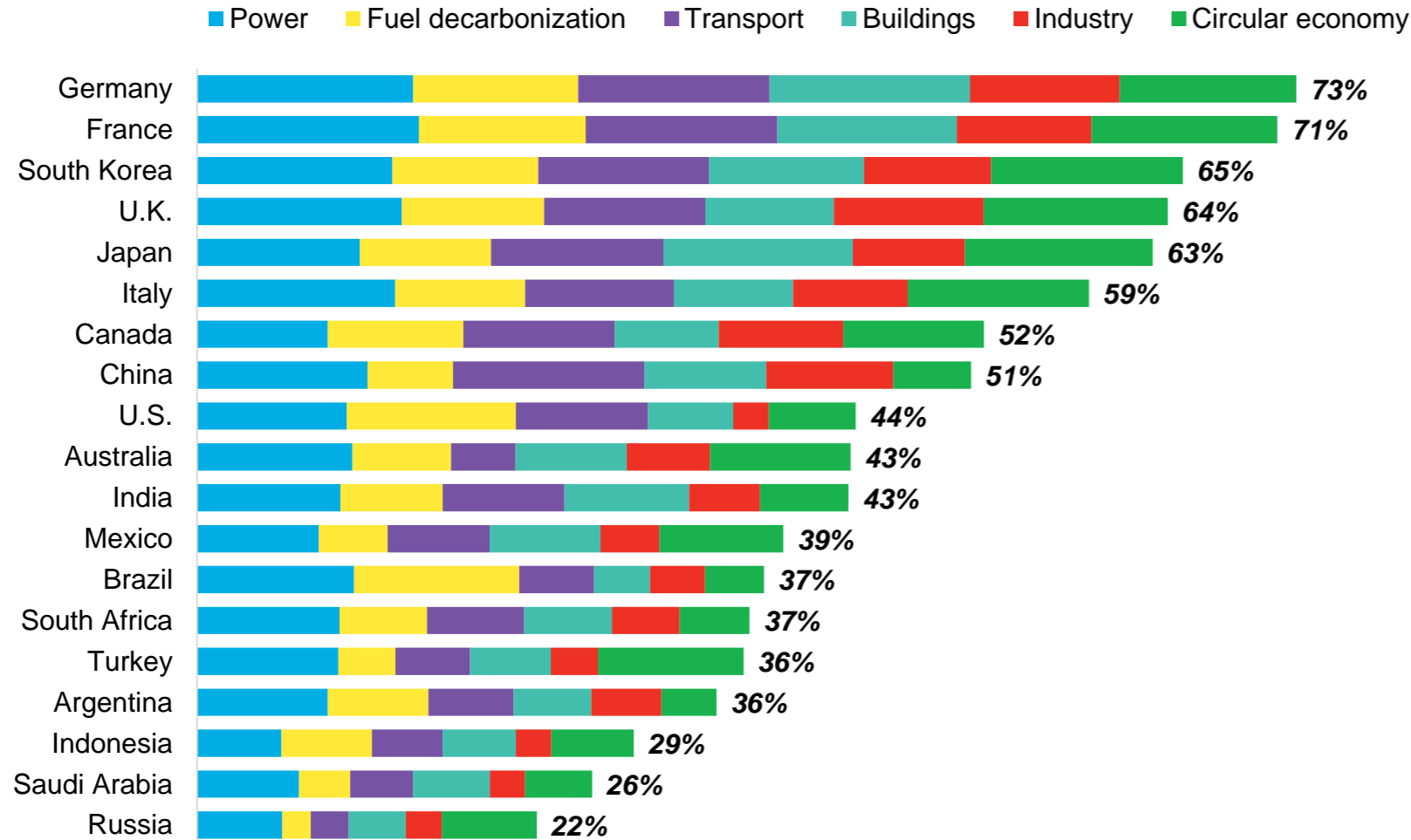
It aims to reduce emissions further than previously targeted, with a 55% reduction from 1990 levels by 2030.

Source: European Environment Agency, European Commission, BloombergNEF

G20 Countries' climate policies are not aligned with the pledges of the Paris Agreement



2021 G20 policy scoreboard – results by sector



The world's largest economies are far from the right policy plans to meet the Paris Agreement

BNEF's G20 Zero-Carbon Policy Scoreboard evaluates the G20 countries' decarbonization policies to measure which governments have implemented regimes to realize the goals of the Paris Agreement.

Much of the progress in cutting the rate of growth of CO₂ to date has come in the power sector

However, most countries have done little elsewhere in the economy – and even within the power sector, multiple pathways are needed.

The nations at the top have executed a higher number of robust, concrete measures

These countries have introduced policies to drive change on both the supply and demand side. Their policy-making processes are relatively transparent and predictable, and their initiatives are starting to have a measurable impact.

Source: BloombergNEF [link](#). Note: maximum score is 100%.

Table of contents

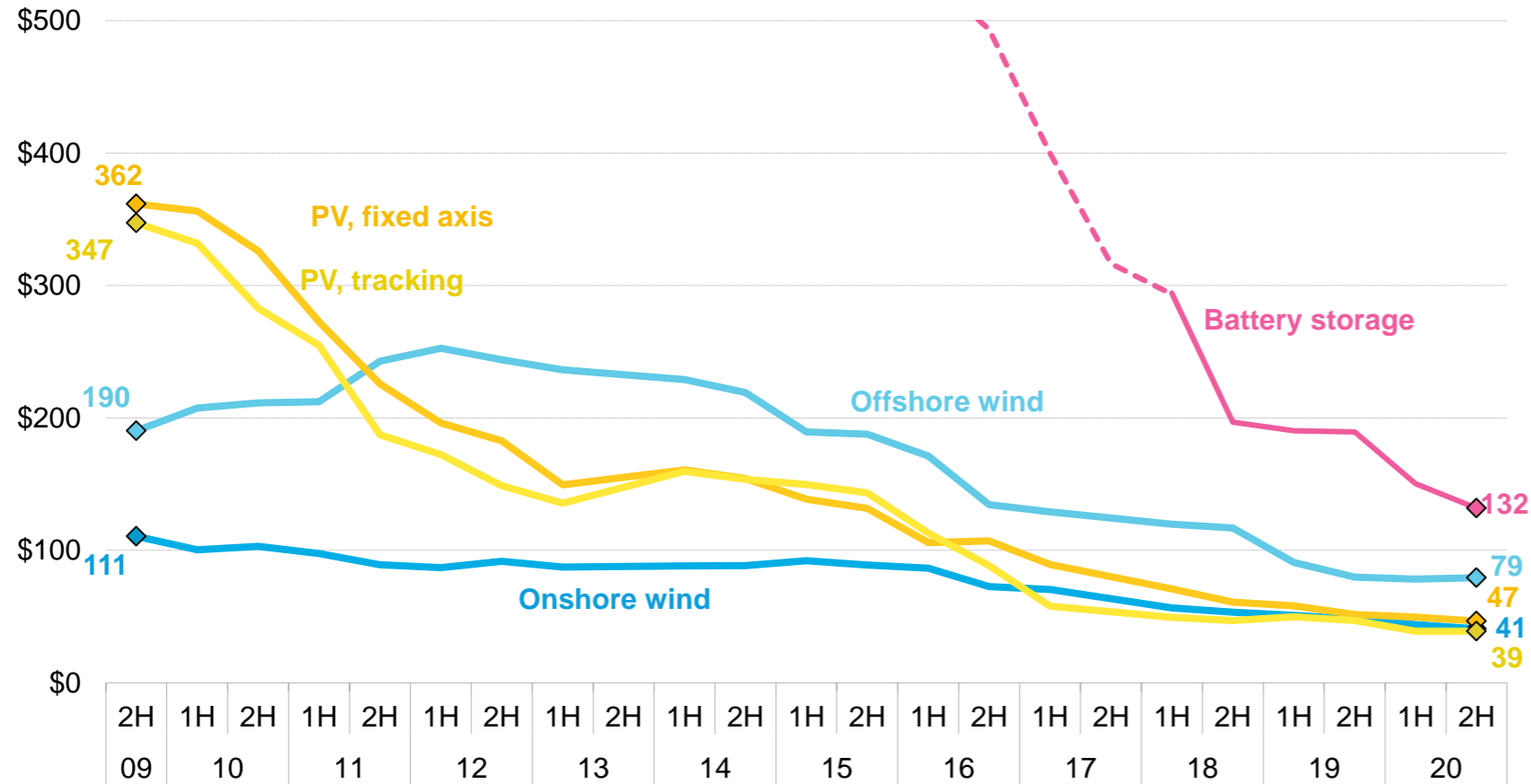
	Introduction: A Cleaner Future	3
	Power	23
	Transport	42
	Industry, Buildings, and Digital	52
	Commodities	68
	Food and Agriculture	82
	Capital	88
	About BNEF	97

Wind and solar generation costs have converged, and compete with (or outcompete) fossil fuel generation



Global levelized cost of energy benchmarks

LCOE (\$/MWh, 2019 real)



The benchmark cost of electricity generation from onshore wind and solar PV have converged

The cost for both is in the range of \$40 per megawatt-hour.

Offshore wind costs remain higher than onshore wind or PV, but offshore wind has operational advantages

Offshore wind has much higher capacity factor than either onshore wind or photovoltaic applications and is competitive with fossil fuel-fired power in many markets.

The cost of storage using lithium-ion batteries is on a steep downward trajectory

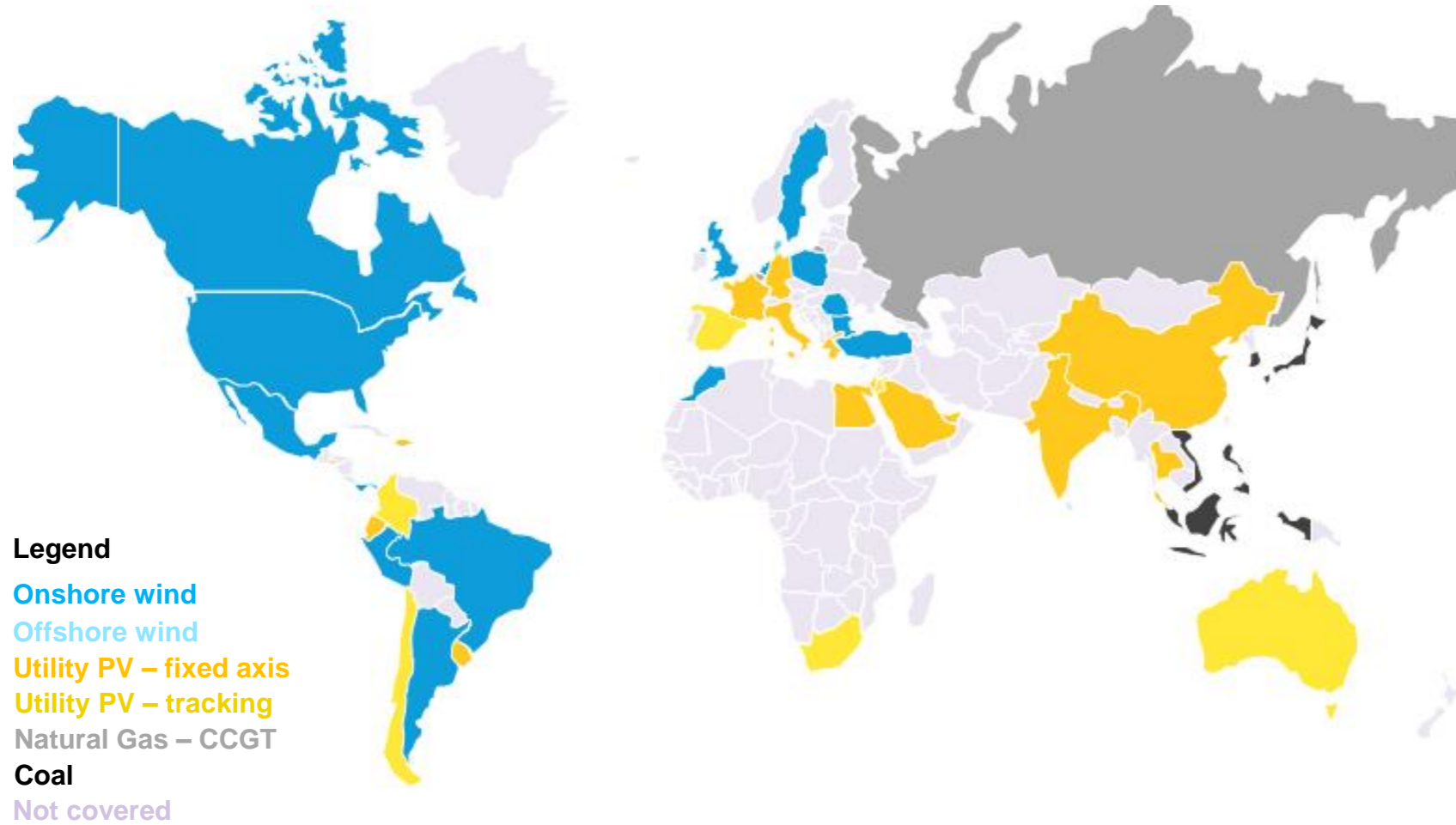
Current costs of \$132 per megawatt-hour mean that the levelized cost of energy from lithium-ion battery storage systems is competitive with many peak-demand generators.

Source: BloombergNEF

Wind and solar power are the lowest-cost new source of power for 2/3 of the global population



Lowest-cost source of new bulk power generation by technology, 2H 2020



Two-thirds of the global population lives where renewables are the cheapest new power generation option

BloombergNEF estimates that two-thirds of the global population lives in a country where either onshore wind or utility-scale PV, if not both, is the cheapest option for new bulk generation.

Renewables are the cheapest power option for 71% of global GDP and 85% of global power generation

It is now cheaper to build a new solar or wind farm to meet rising electricity demand or replace a retiring generator, than it is to build a new fossil fuel-fired power plant.

Power plant developers can make a clear economic choice for renewables

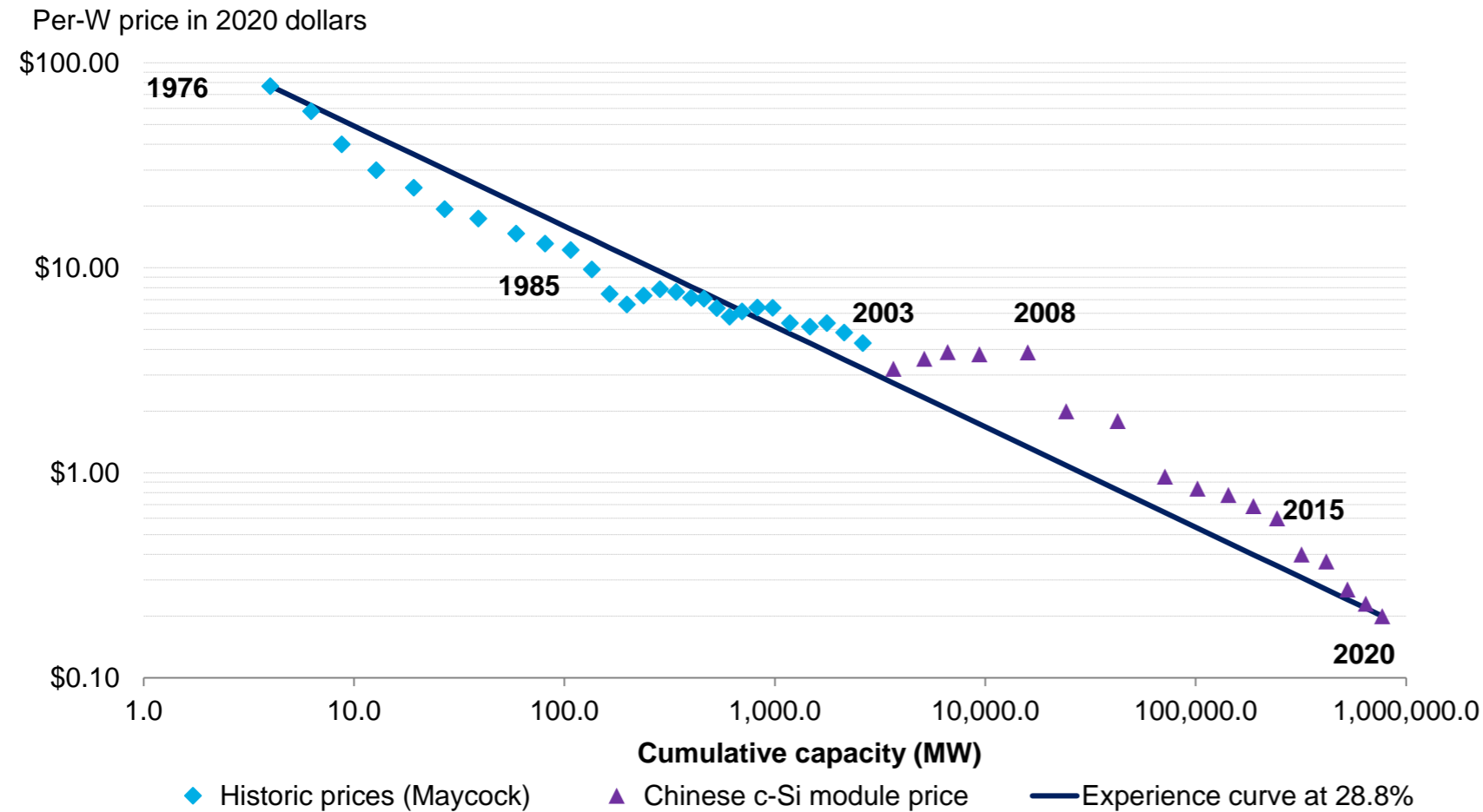
On a cost basis, wind and solar is the best economic choice in markets where firm generation resources exist and demand is growing.

Source: BloombergNEF

The photovoltaic experience curve is 28.8%



PV module experience curve (2020\$/W, MW)



Photovoltaic modules have a 28% learning rate

For every doubling of cumulative manufactured capacity, the cost of PV modules declines by 28%.

PV prices have deviated from the experience curve, both above it and below

From 2003 to 2008, PV module prices rose above the fundamental experience curve value, with industry materials, particularly polysilicon, in short supply.

In 2020, prices and costs are aligned

The current price of Chinese-made crystalline silicon modules coincides almost exactly with the fundamental cost suggested by the experience curve.

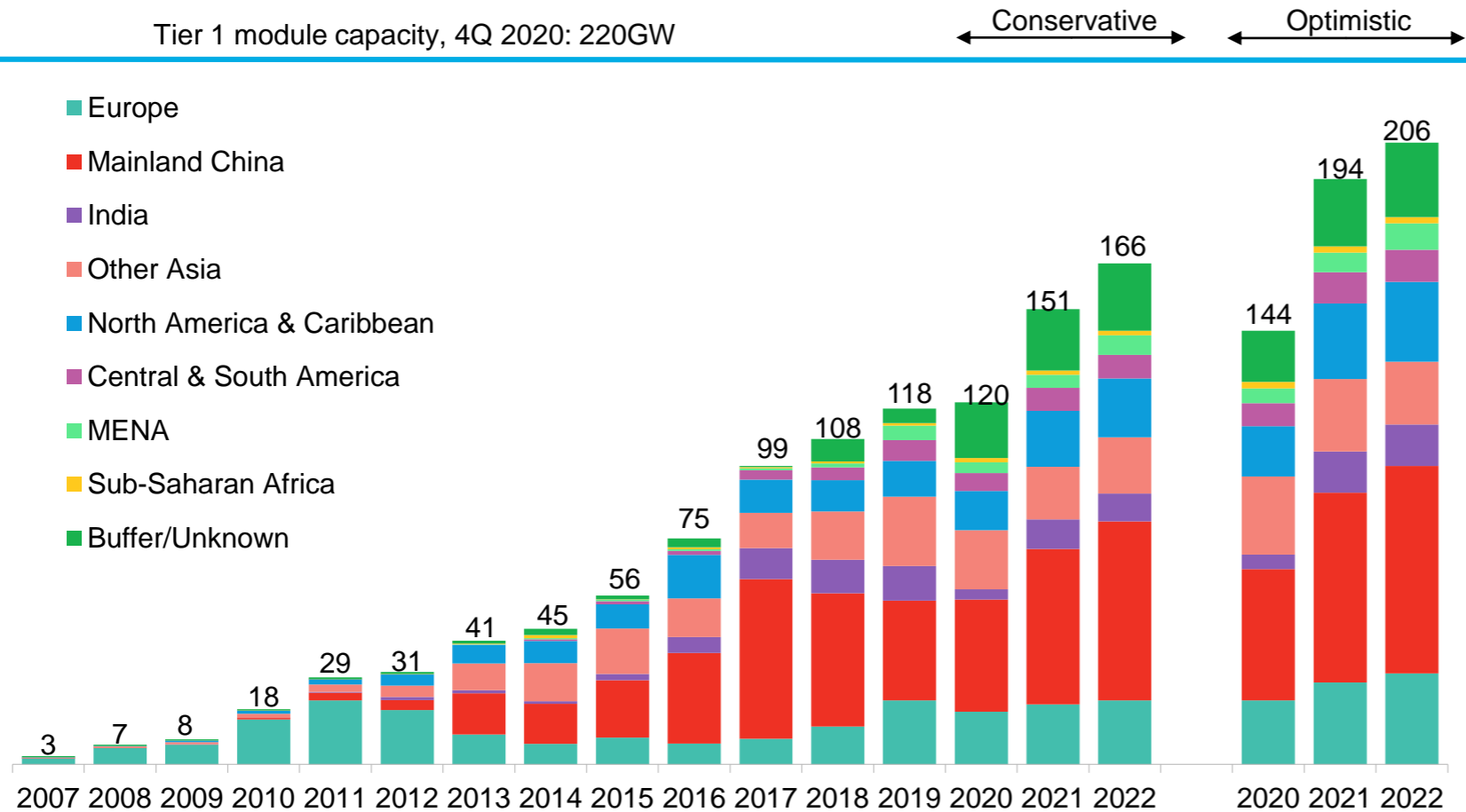
Source: Paul Maycock, BloombergNEF

The global PV market expanded more than four-fold from 2011 to 2020



Global PV new build, 2007-2019, and forecast to 2022

GW/year



The global PV market expanded from 29 gigawatts in 2011, to 120-144 gigawatts in 2020

PV installations have never experienced a down year, even during the global financial crisis or last year, Covid-19.

The bulk of installations are now outside of Europe and North America

China is the largest single PV market, but there are numerous others of significant scale, including Vietnam, in 2020.

Installations could hit 200 gigawatts a year by 2022

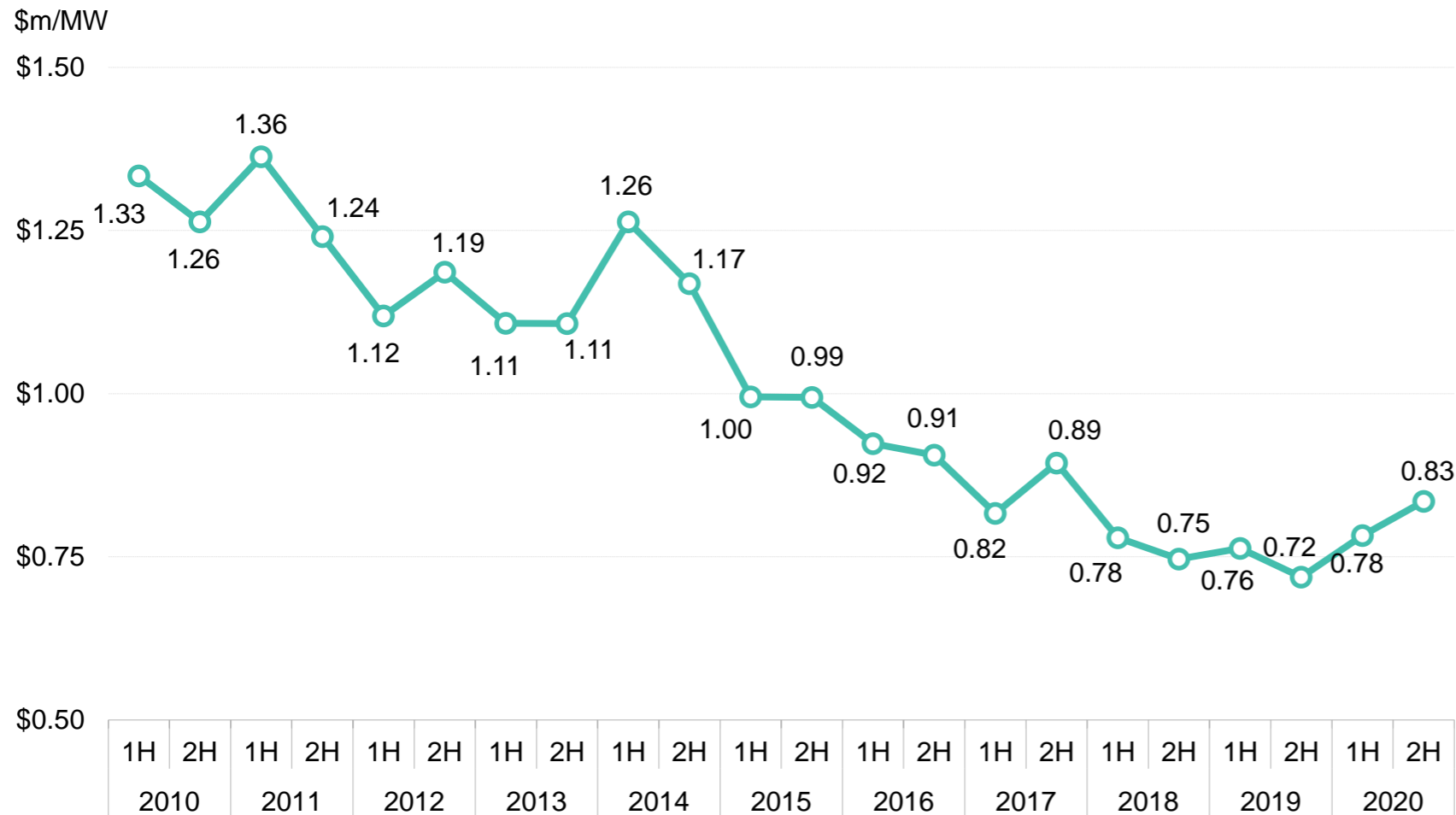
BloombergNEF's optimistic forecast sees 206 gigawatts of PV installed next year.

Source: BloombergNEF

Wind turbine prices have fallen 40% since 2010



Wind turbine prices by signing date



Wind turbine prices have fallen almost 40% in the past decade

In 2011, prices were above \$1.3 million per megawatt; last year, prices were \$830,000 per megawatt.

The price per megawatt-hour of wind power has fallen 60% in the past decade

New turbines generate more megawatt-hours per megawatt of nameplate capacity than those designed and built a decade ago.

Index prices ticked up in 2020

The majority of contracts in BNEF's 2H 2020 update were in Western Europe, where turbines are generally of lower-rated capacity and more expensive than elsewhere.

Onshore wind has a learning rate of 13.6%

Turbine prices decline at a steady rate for every doubling of cumulative turbine capacity manufactured.

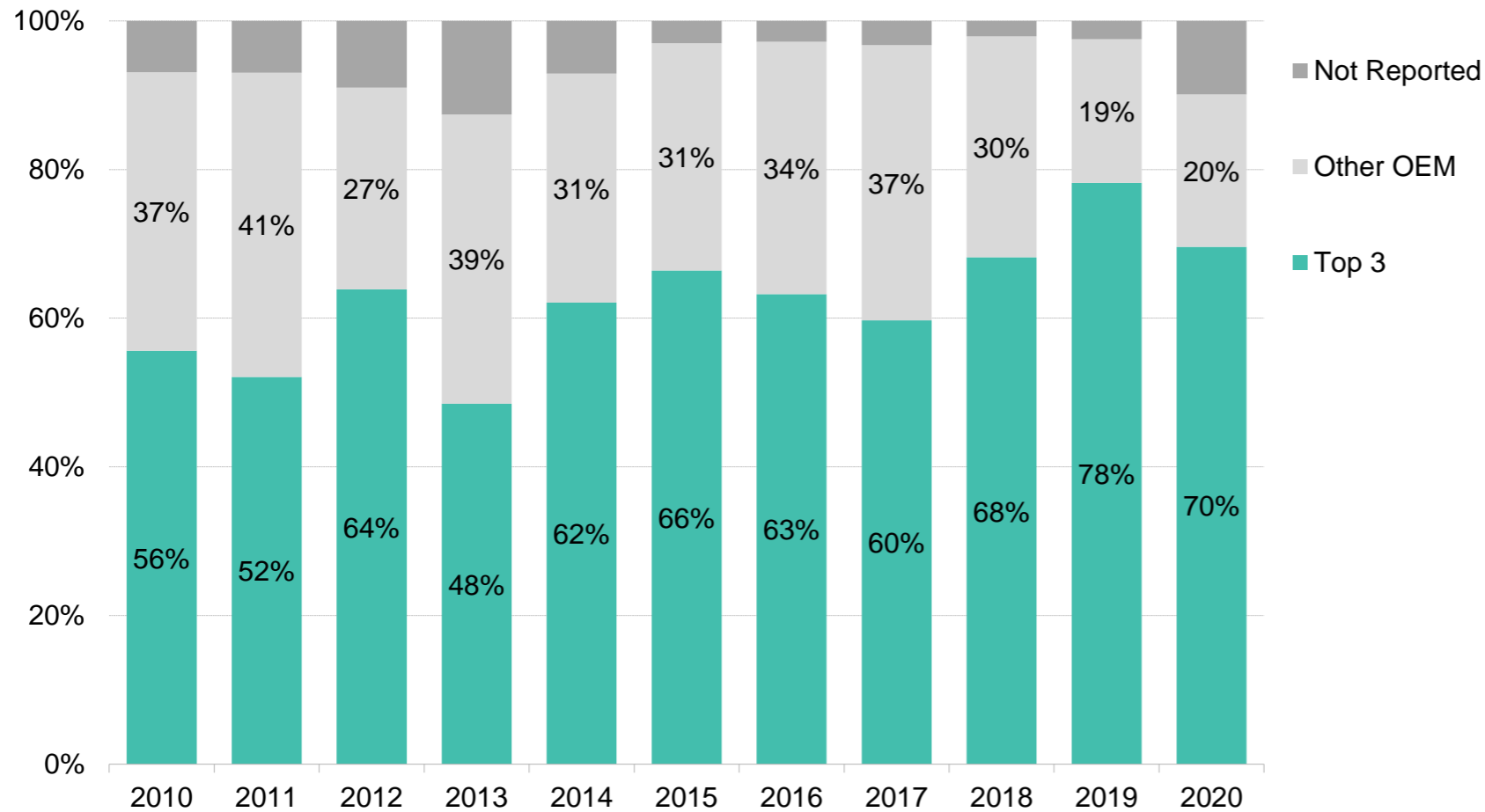
Source: BloombergNEF

The wind turbine market has consolidated since 2010



Turbine maker market shares, onshore market excluding China

Share of new onshore capacity installations, ex-China (%)



Three turbine makers captured more than two-thirds of the global market, ex-China, last year

Vestas, Siemens Gamesa, and GE combined hit an all-time high of 78% market share in 2019, before declining slightly.

This growth continues even as the market itself expands

Onshore wind installations ex-China grew 28% in 2020, but the market share of the top three only declined 8%.

Market pressure still applies even to a highly consolidated market

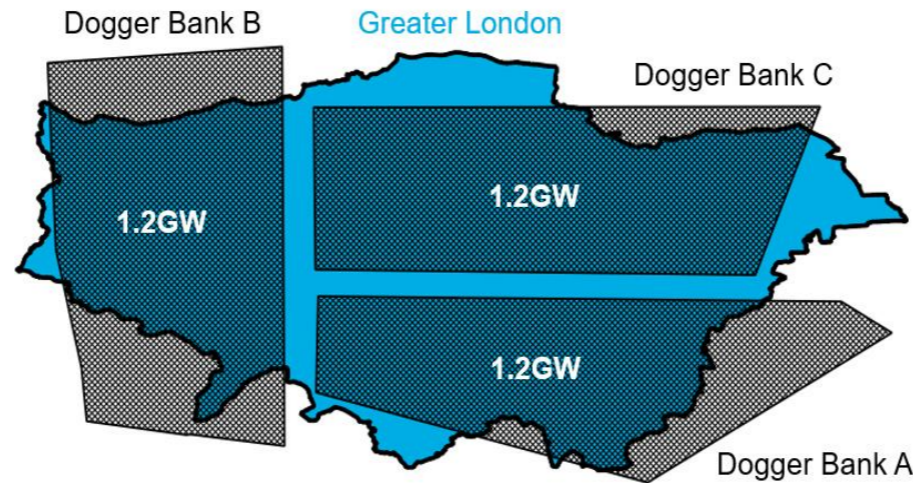
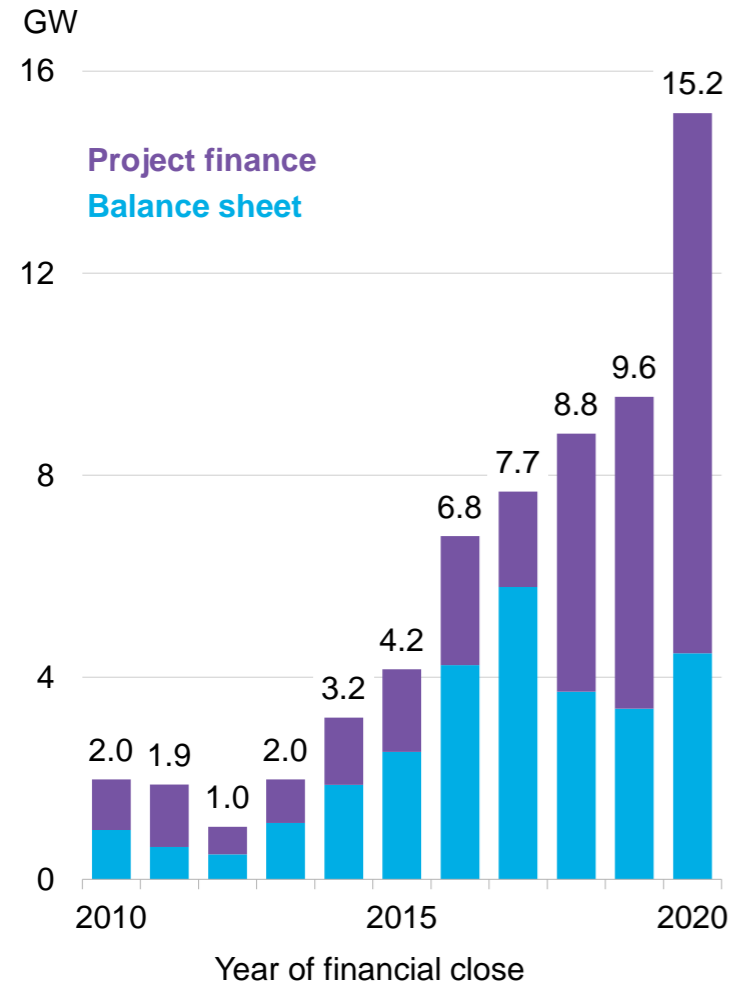
Legacy subsidies are being phased out, in favor of auctions and subsidy-free projects, meaning that manufacturers feel pressure to compete on price.

Source: BloombergNEF

2020 was a record year for offshore wind financings



Offshore wind capacity financed by year



2020 was a record year for offshore wind capacity financed

More than 15 gigawatts was financed, up more than 50% from 2019, the previous record, and 15 times the volume in 2012.

Most new capacity was project financed

More than 10 gigawatts of capacity was project financed. From 2013 through 2017, most capacity was financed on corporate balance sheets.

A single financing, the 2.4 gigawatt Dogger Bank development zone, dominated the second half of 2020

The 2.4 gigawatt project is the largest offshore wind project in the world, and the largest financing to date for the sector, at \$8 billion.

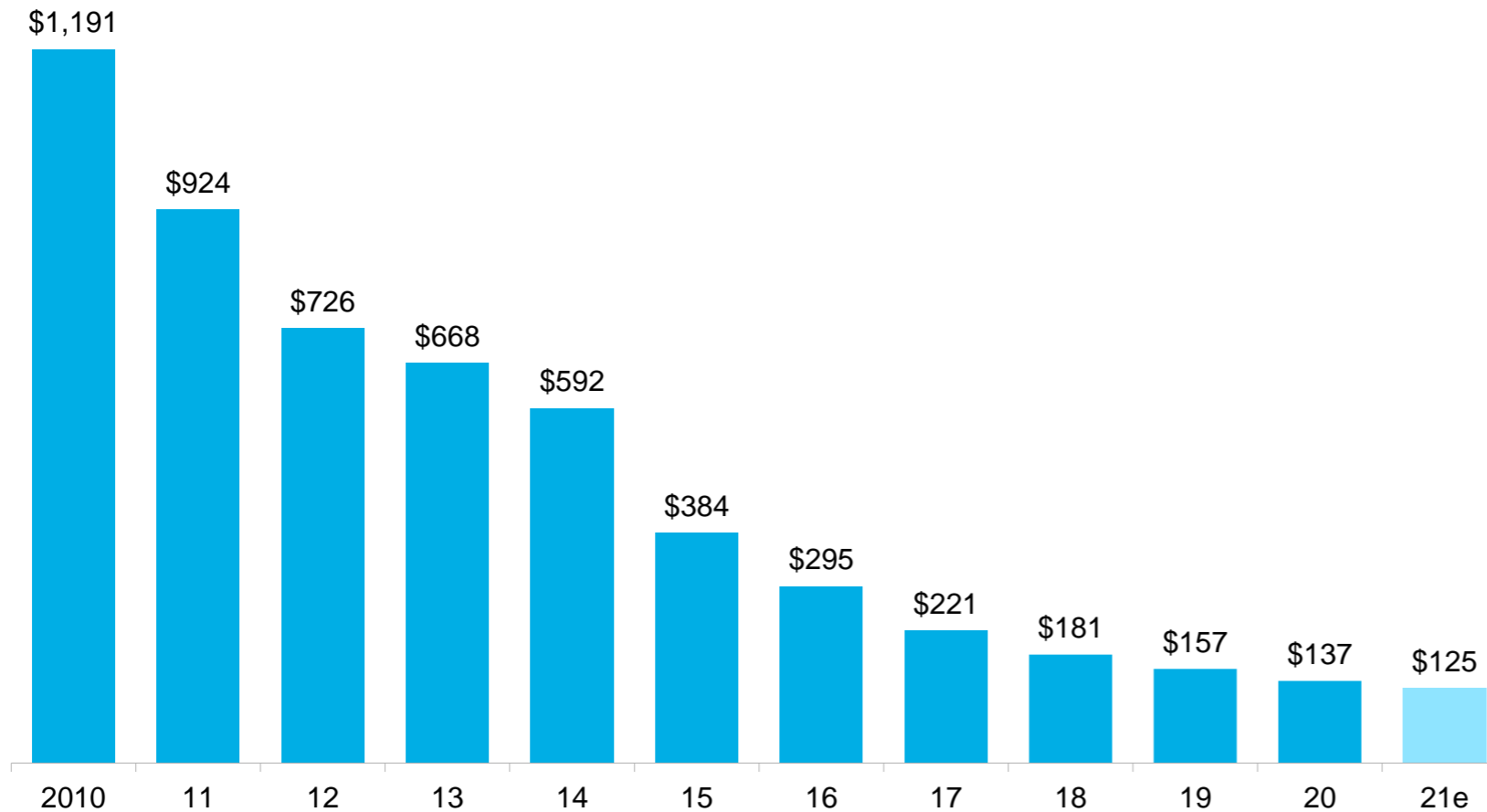
Source: BloombergNEF

Lithium-ion battery costs fell 89% from 2010 to 2020



Lithium-ion battery price survey results (volume-weighted average)

Battery pack price (real 2020 \$/kWh)



Lithium-ion battery pack prices fell 89% from 2010 to 2020

BloombergNEF surveys battery buyers and sellers to determine the volume-weighted average price for lithium-ion battery packs, modules, and cells.

The lithium-ion battery learning rate is 18%

For every doubling of cumulative production, the fundamental cost of manufacturing lithium-ion storage batteries declines by 18%.

BloombergNEF expects lithium-ion storage battery costs to continue to fall

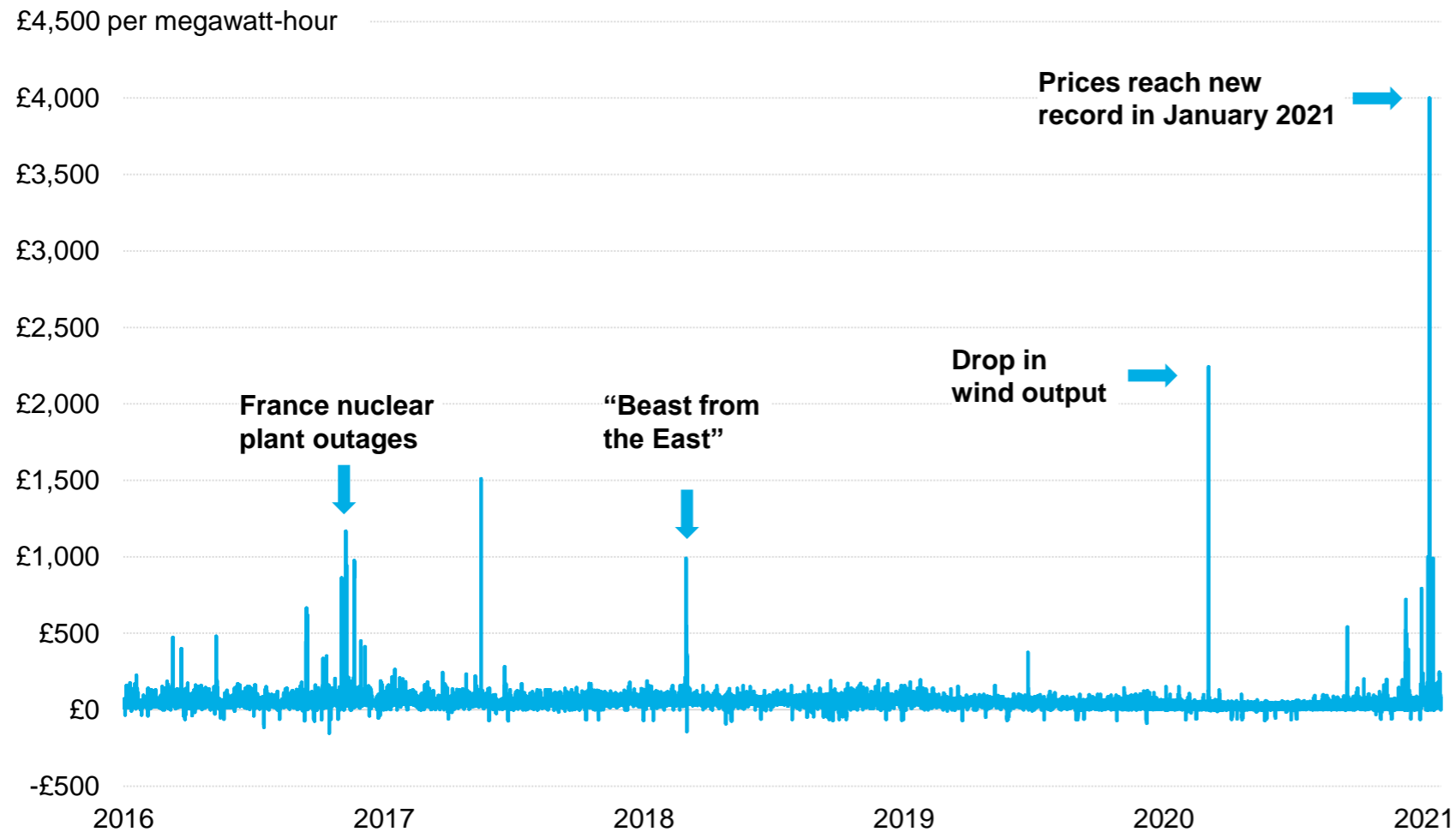
Changes to cell chemistry have been important drivers of price declines, new manufacturing techniques will become more important to maintain downward pressure on prices. We expect prices to be close to \$100/kWh by 2023.

Source: BloombergNEF

UK power prices spiked to record levels in early 2021, as plant outages, cold, and commodity prices hit



Half-hourly British imbalance price



European power markets are experiencing a period of unusually high volatility

Power prices have swung from record lows in March-June 2020, to record high prices in January 2021. Daily price volatility has increased as well.

Commodity prices play a role

The simultaneous increase in gas, coal and carbon prices should lead to a proportional increase in power prices. However, power prices have at times exceeded what could normally be explained by the swing in commodity prices.

Unseasonably high outages are the main reason for the U.K.'s record prices.

An unexpected outage in the interconnector to The Netherlands removed one gigawatt of capacity until at least early February.

Covid-19 contributed to outages

Maintenance has been challenging, due to reduced staffing and social distancing.

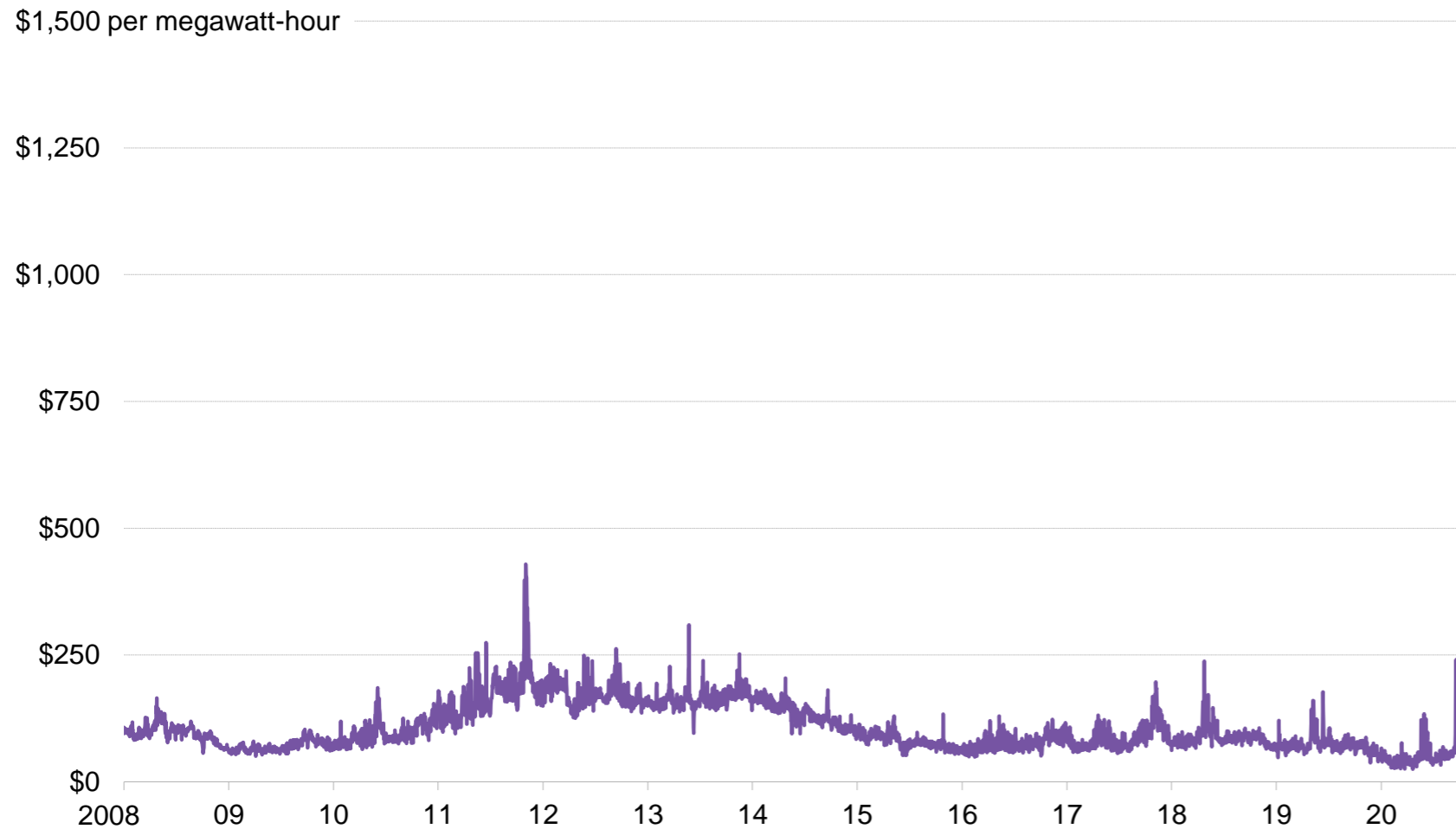
Source: Elexon, BloombergNEF.

Note: The 'Beast from the East' was a spell of cold weather in February-March 2018, when European gas markets were very tight.

Japan's power price reached an all-time high in January 2021



Japan system power prices



Japan's wholesale power price hit an all-time high in January 2021

Prices spiked to nearly \$1,500 per megawatt-hour, more than three times the previous record price in 2011.

A shortage of LNG led to the price spike

Spot liquefied natural gas prices also hit a record high price in January 2021 with demand in North Asia very high due to cold weather and in Japan, lower availability of nuclear power.

The price spike highlights Japan's dependence on imported fuels

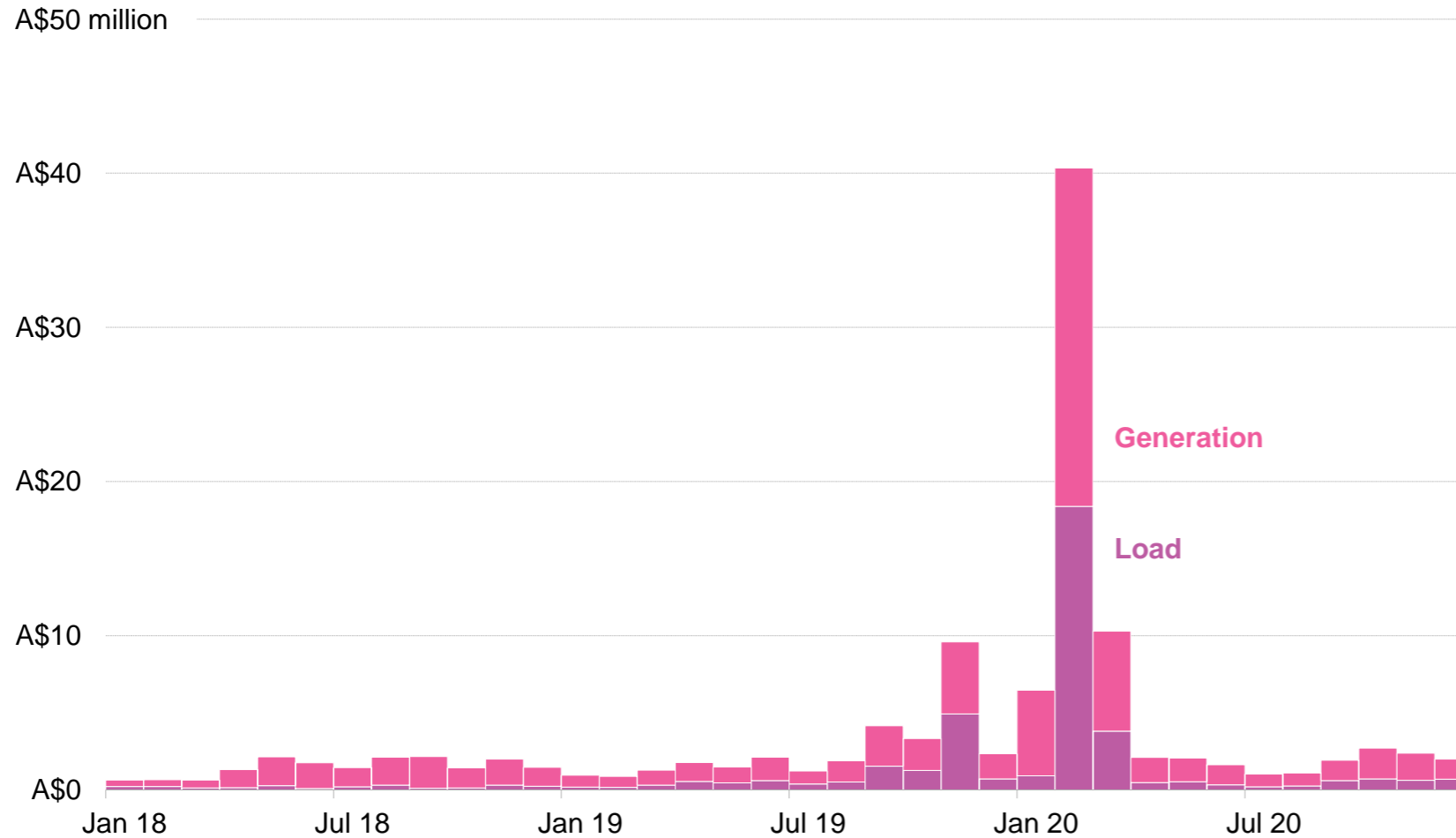
Japan's power generators and fuels importers are likely to ramp up spot LNG purchases when prices have declined.

Source: Japan Electric Power Exchange

Keeping the lights on is a lucrative business for Australia battery systems



Australia battery revenue from frequency control and ancillary services



Australia battery operators doubled their annual revenue in 2020

Operators had A\$83 million in revenue from frequency control and ancillary services in 2020.

Climate change has increased the risk of disruptive weather events

Risk of disruption has increased the value of grid balancing via the services which batteries provide.

Half of 2020's revenue came during one windfall month

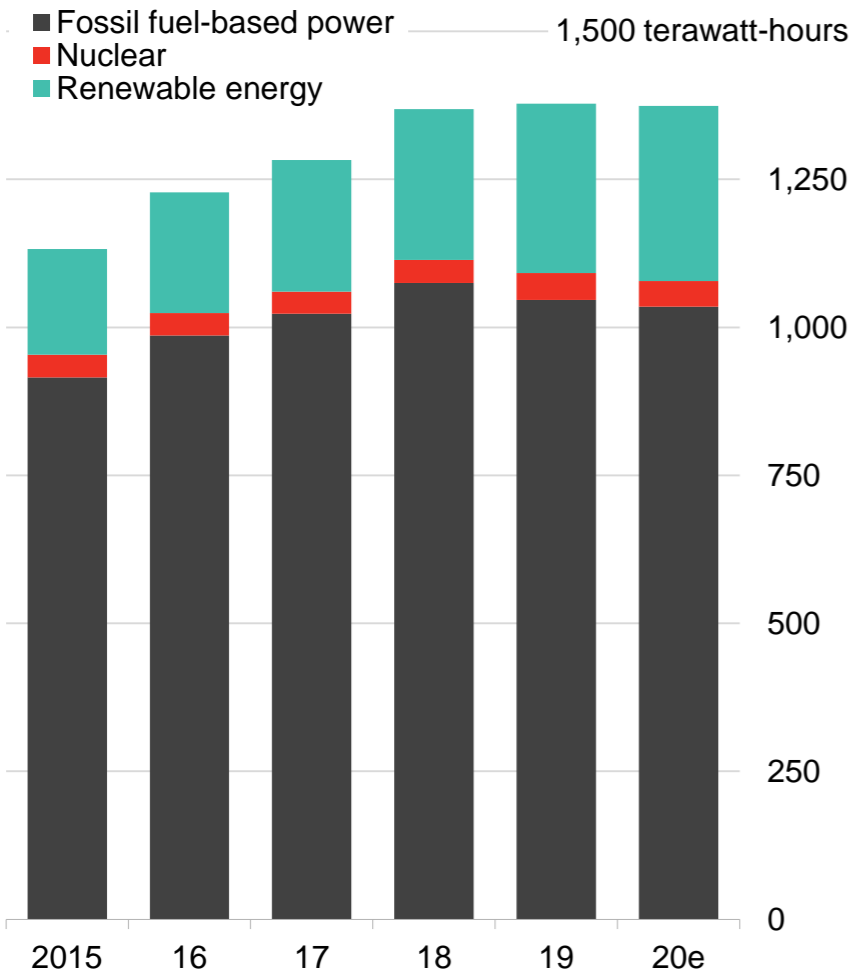
In February, the South Australia temporarily separated from the rest of the country's grid, meaning that demand for grid balancing skyrocketed. Revenue for the state's three large batteries equaled 17-33% of their initial capital costs.

Source: BloombergNEF

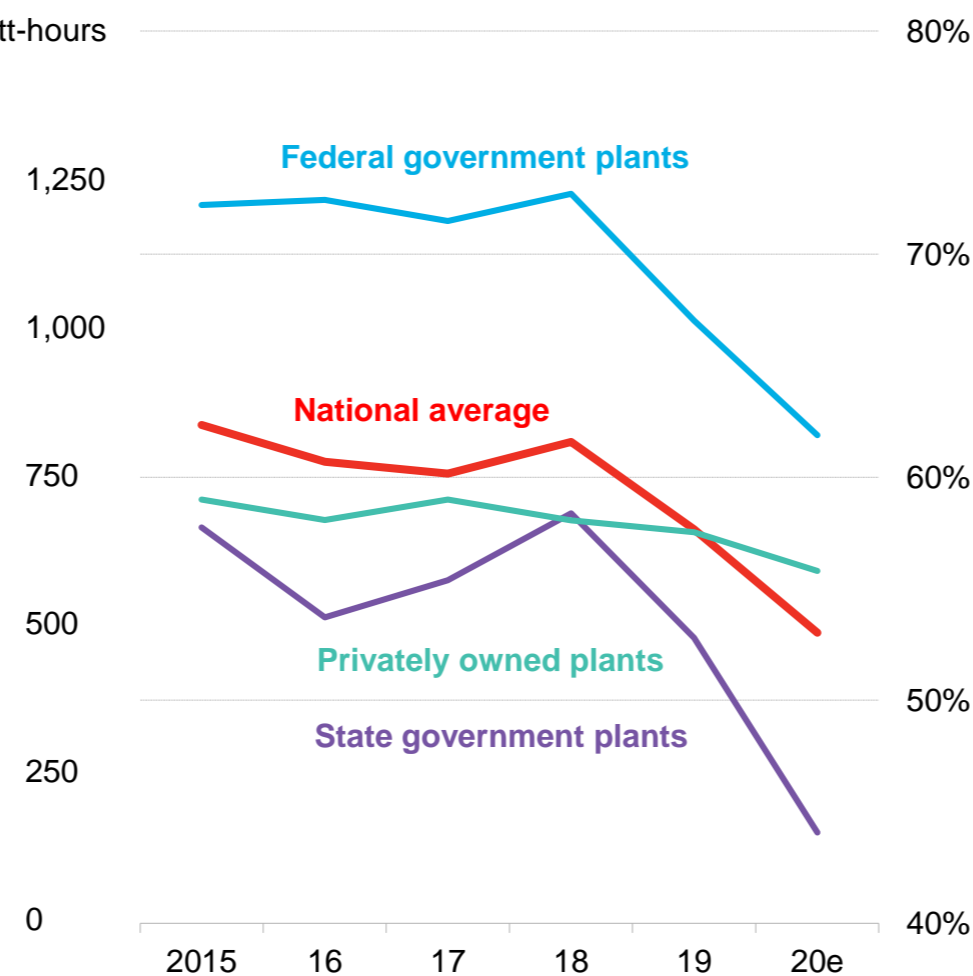
As India's renewable power generation expands, coal plant utilization falls



India power generation



India coal plant utilization



Renewable power has been almost all of India's power generation growth since 2018

Fossil fuel-fired power generation peaked in 2018, and in 2020 has fallen back to about the same level as in 2017.

The rise of renewables, and to a lesser extent nuclear, has impacted coal plant utilization

Coal plant utilization has fallen across the board, with the national average now only 53%.

Declines in coal plant utilization hit different owners in different ways

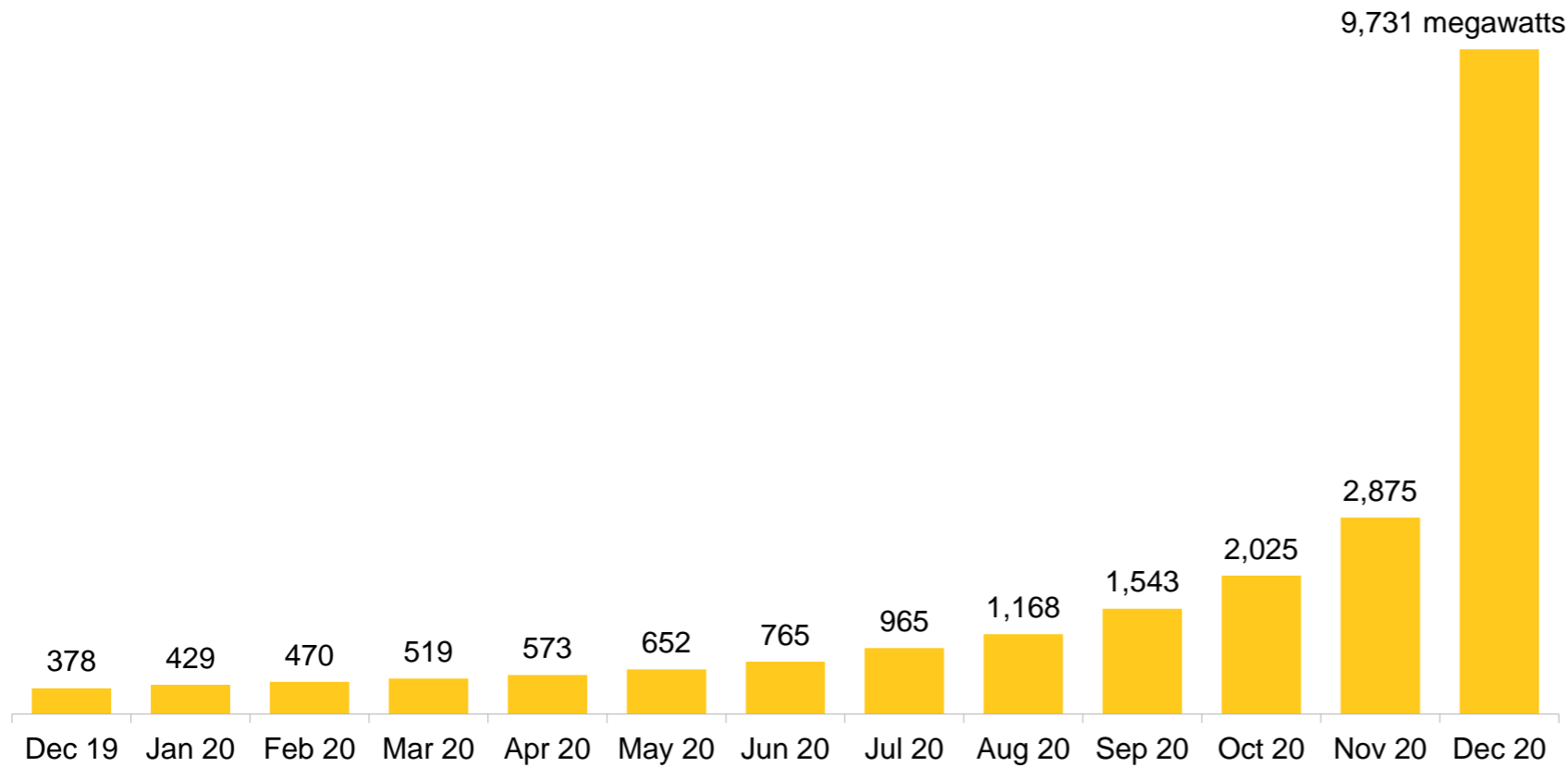
State government plants now have a utilization rate below 50%, while federal government plants are still above 60% utilization.

Source: BloombergNEF

Vietnam installed six gigawatts of rooftop solar in December, making it the third largest market in 2020



Vietnam cumulative installed rooftop PV installations



Vietnam's rooftop solar companies delivered a last-minute boom in installations in 2020

Capacity increased 25-fold for the year, from only 378 megawatts in December 2019.

Companies installed more than six gigawatts of PV in December alone

Of that amount, 4.6GW was commissioned just in the last week of the year.

The market is almost certain to slow in 2021

The future of Vietnam's feed-in tariff is uncertain, and the national utility has said that it will not sign any more power purchase agreements before the new support mechanism is announced.

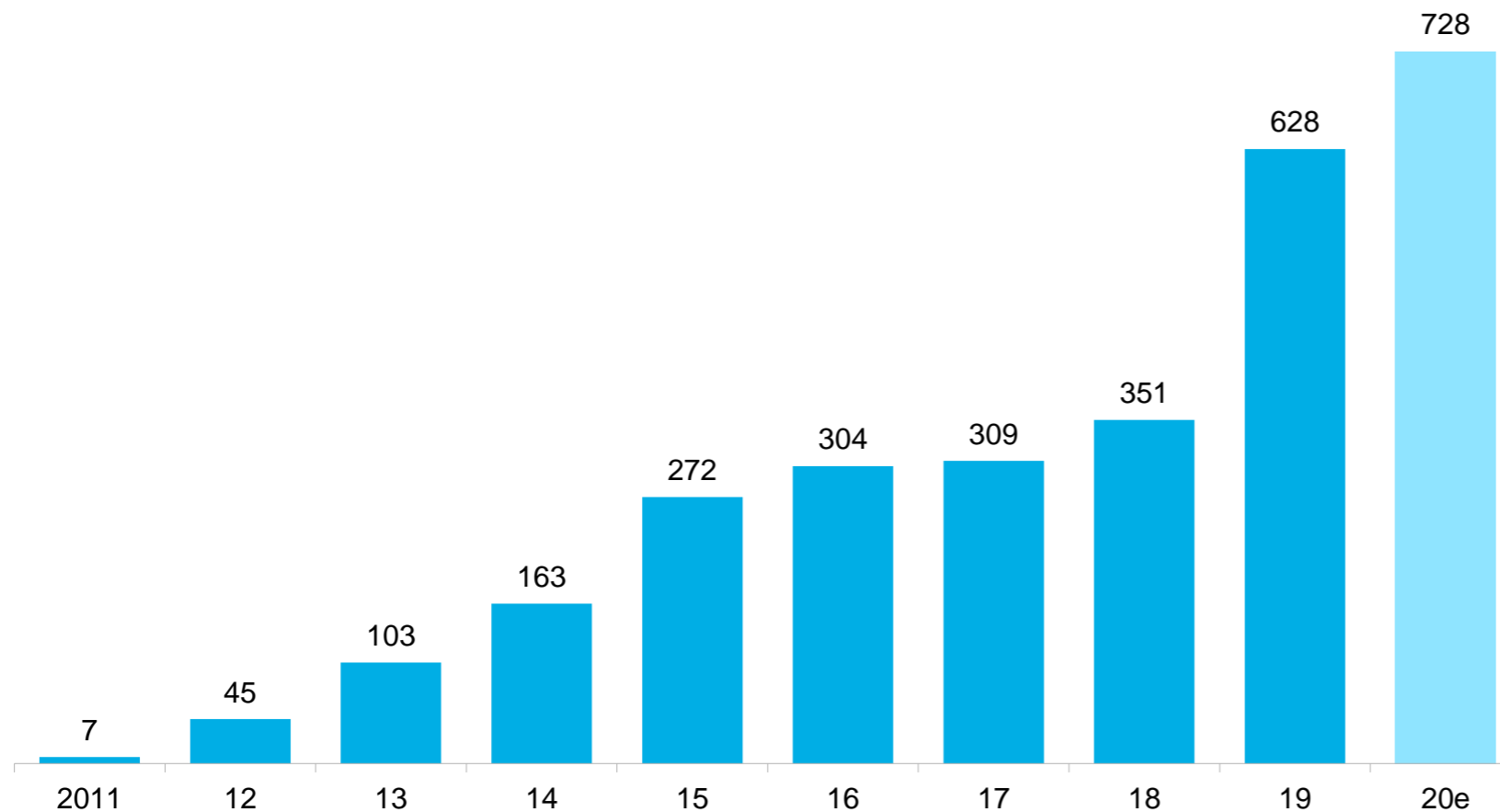
Source: Vietnam Electricity Group

Japan's residential energy storage installations doubled in two years



Japan behind-the-meter residential energy storage installations

Megawatt-hours



Japan's annual installations of residential energy storage systems doubled from 2018 to 2020

Installations rose quickly from 2011 to 2015, before growing at a much slower rate before a jump in 2019.

Average system sizes almost doubled from 2011 to 2016, before decreasing

In 2011, the average system size was 4.5 kilowatt-hours, growing to 8.5kWh by 2016. Sizes then dropped back to 6.6kWh and are slowly expanding again.

Covid-19 impacted residential battery installations

BloombergNEF's pre-pandemic expectation was for 866 megawatt-hours in 2020.

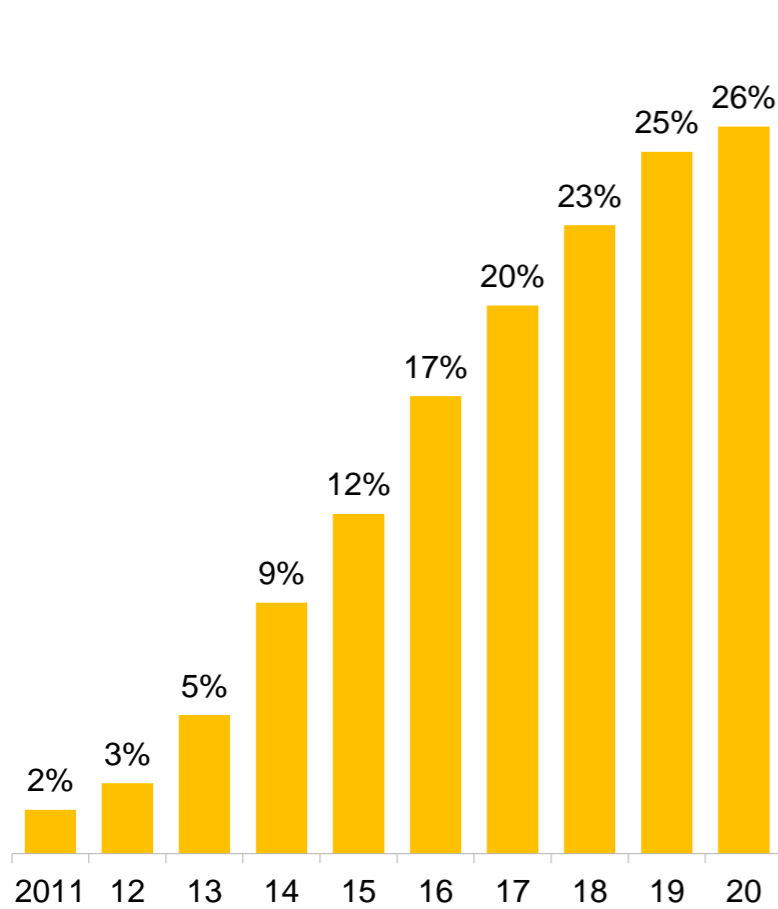
Source: BloombergNEF

Solar is a victim of its own success, as more deployment results in lower realized prices

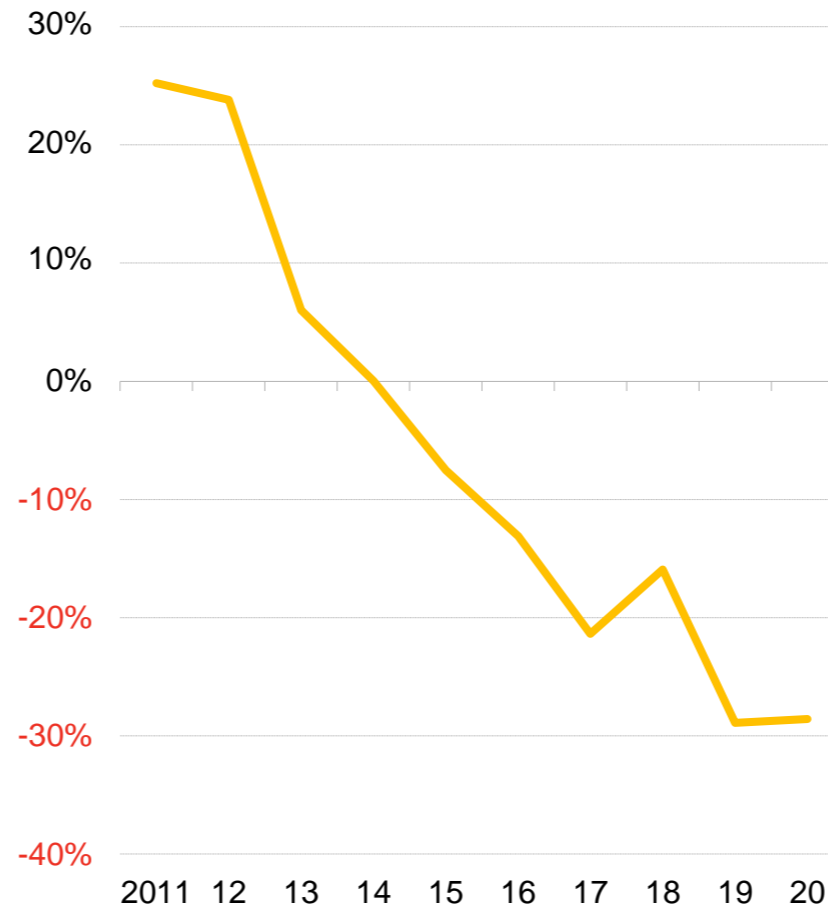


California solar penetration, difference to around-the-clock prices, and solar realized power price

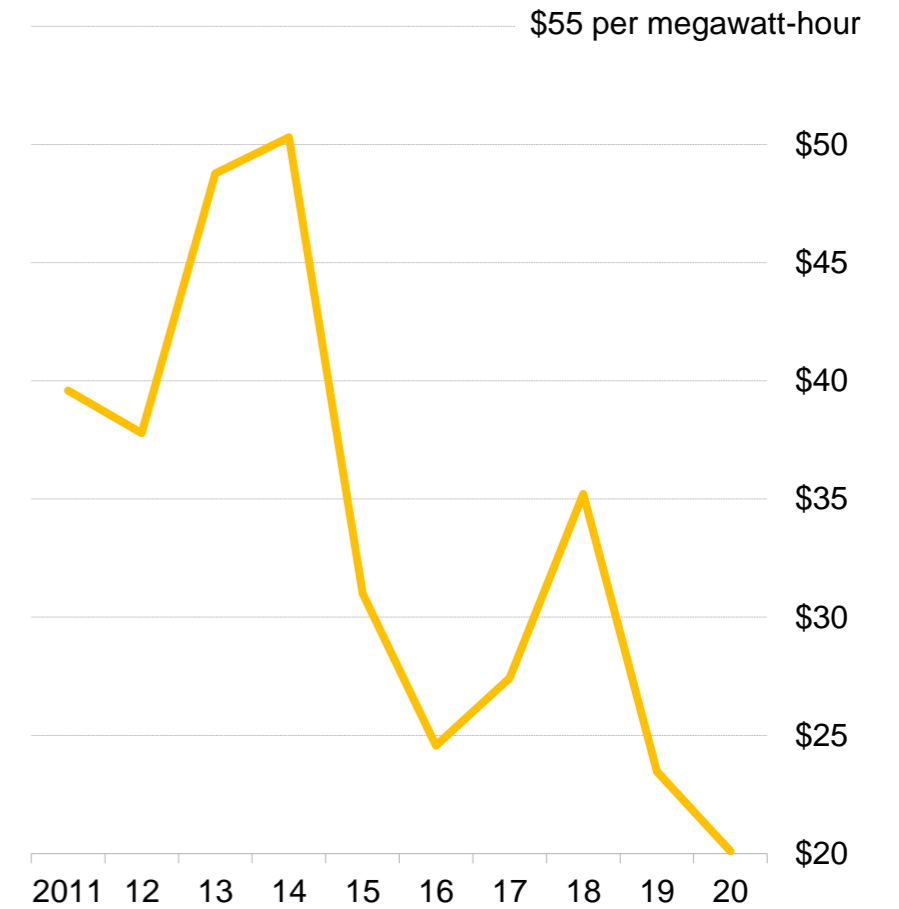
Solar % of power generation



Solar difference to around-the-clock price



Solar realized power price

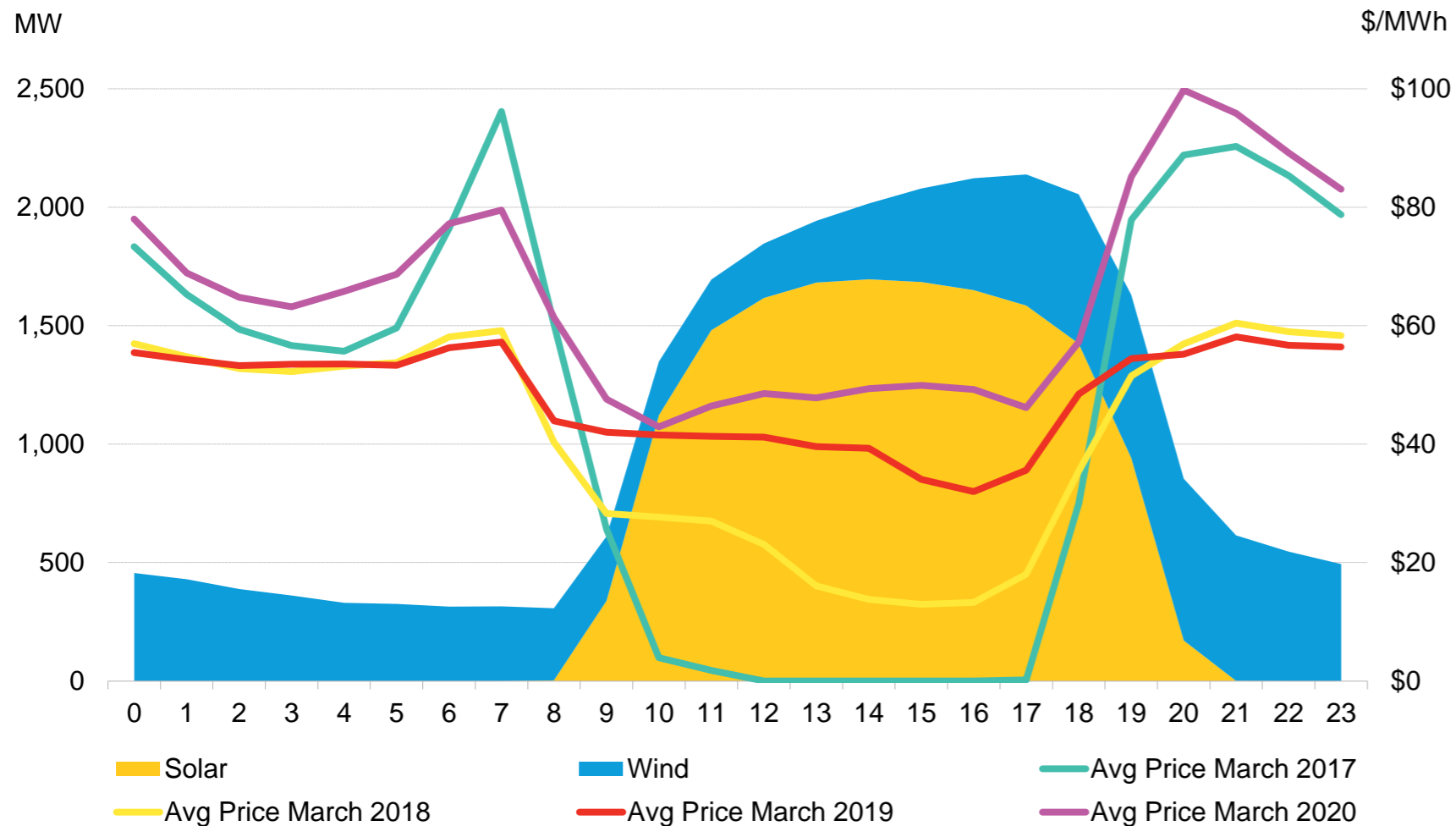


Source: BloombergNEF U.S. Plant Stack, Bloomberg Terminal, CAISO

Integrating renewable energy is an ongoing concern in high-penetration markets like Chile



Average wind and solar hourly generation and daily average power price, Diego de Almagro



Wind and solar generation has grown from near-zero in 2013 to meeting 15% of Chile's power demand in 2020

Chile's wind and solar fleet generated well over one terawatt-hour of power in 2020.

Infrastructure upgrades have been essential to integrating renewables

Chile has completed a number of major transmission upgrades, integrated its two main power grids, and introduced a flexibility strategy as well.

These upgrades have dramatically reduced curtailment, and kept power prices from falling to zero

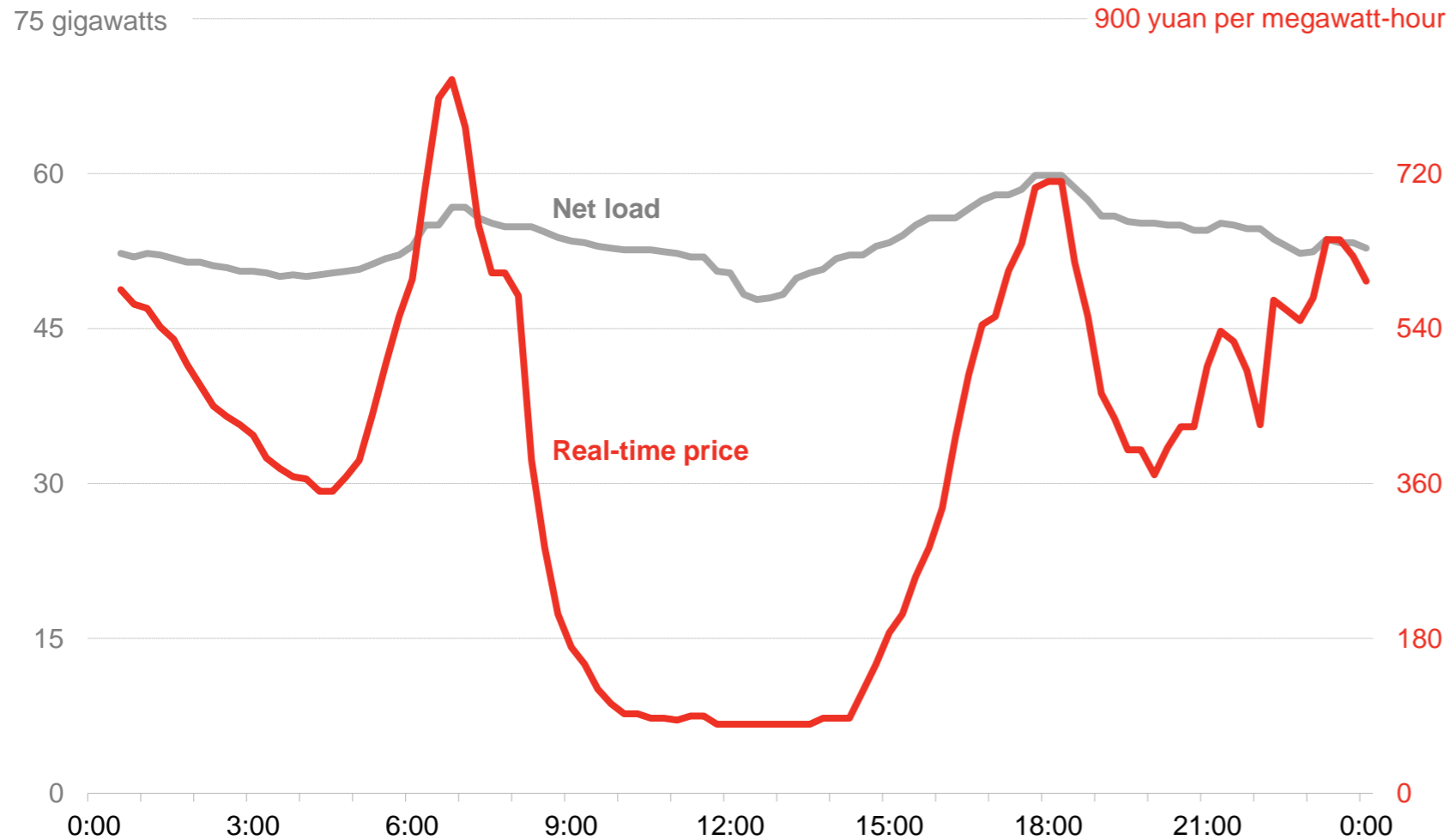
Average curtailment in 2020 stayed below 2%, and power prices stayed about \$40 per megawatt-hour even during peak generation.

Source: CNE, Coordinador Electrico Nacional, BloombergNEF. Note: Node is Diego de Almagro.

China's electricity spot market trial is leading to depressed midday power prices



Shandong province net load and real-time prices, Oct. 22, 2020



The electricity spot market in China's biggest solar province has depressed midday prices

Shandong province is trialing a spot market, which has resulted in morning and evening shoulder prices which are seven times higher than midday, when solar generation peaks.

Officials have changed the regulated time-of-use tariff as a result

Shandong has used small-scale spot trials to inform tariff changes. Prices have been lowered around noon, and increased after 2:30pm, benefiting a large group of commercial and industrial consumers.

Liberalization is impacting China's market in various ways

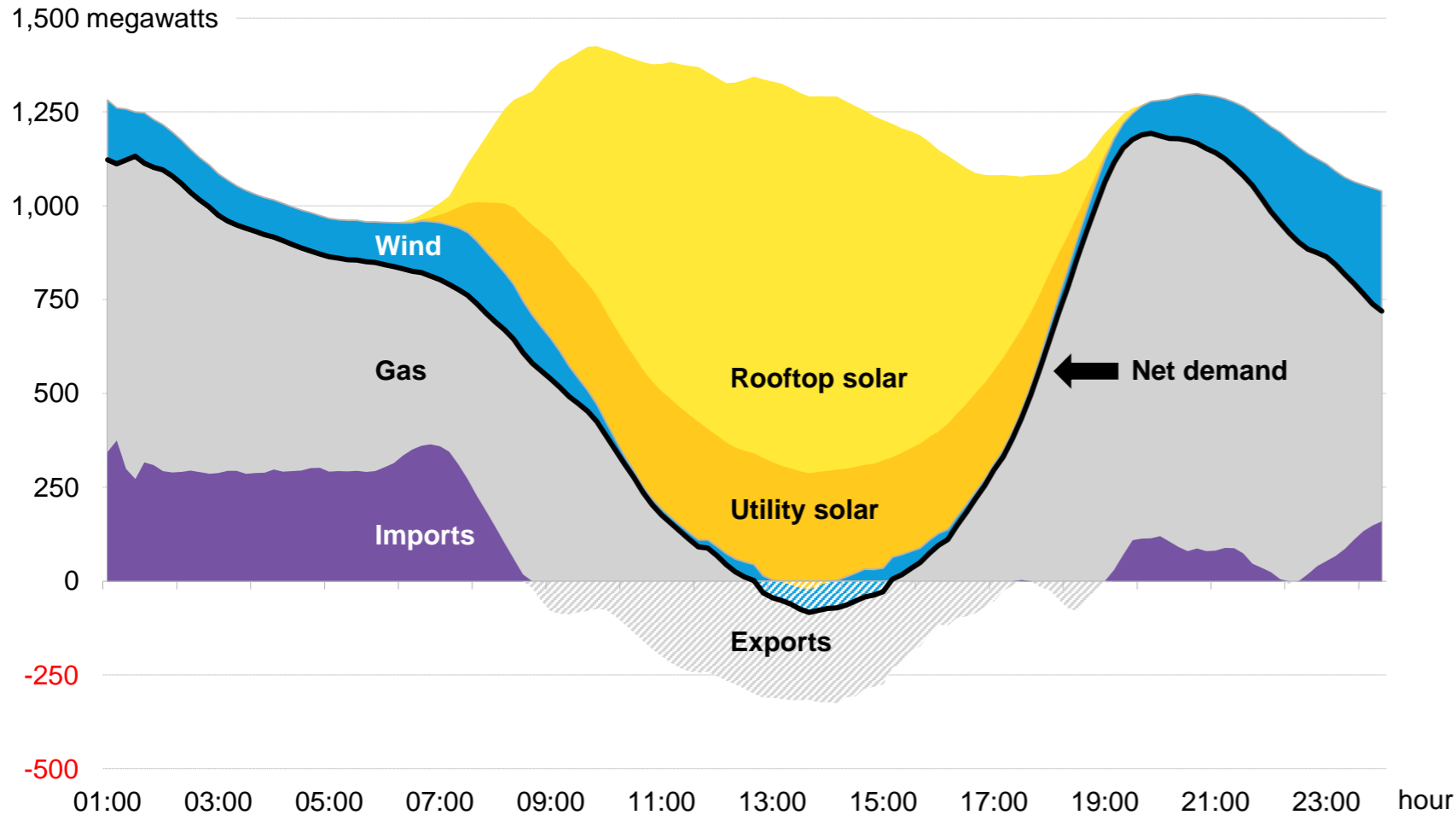
Prices for 39% of China's power demand in 2019 were determined by various markets, rather than government planning, with lower prices usually the result. A majority of price deregulation is in coal power, but renewables are also seeing market exposure in at least 20 of 31 provinces.

Source: Shandong power exchange, news media

Solar supplied 100% of South Australia's power demand in October 2020



South Australia power generation and net demand, October 11, 2020



Solar supplied 100% of South Australia's midday power demand on October 11, 2020

The state became one of the first gigawatt-scale grids to meet all of its demand with solar energy.

288,000 rooftop systems supplied three-quarters of demand

Utility-scale solar supplied the remaining power. Neither contributed to grid stability.

Gas power plants still operated throughout the day


Gas plants provided grid stability, including by exporting power to the neighboring state of Victoria.

South Australia's grid stability will require technology deployment

Energy storage and improved inverters will be necessary to ensure that the grid is stable as solar generation continues to increase.

Source: Source: BloombergNEF, AEMO Note: Net demand, defined as demand minus renewable generation, turned negative midday on Oct. 11 in South Australia. Between noon and 1:00 p.m., solar power provided 100% of the grid's energy needs, 73% of which came from rooftop solar systems.

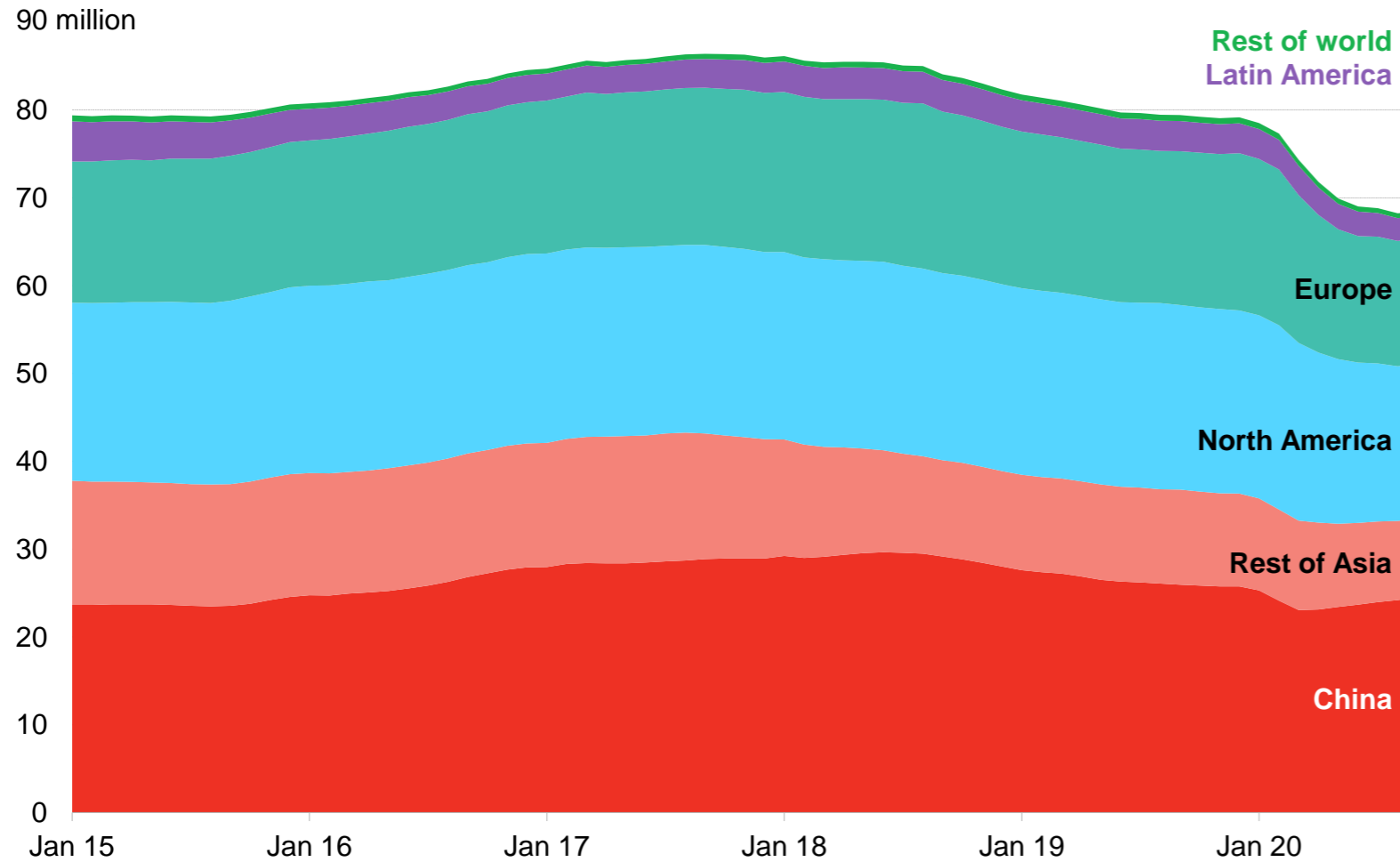
Table of contents

	Introduction: A Cleaner Future	3
	Power	23
	Transport	42
	Industry, Buildings, and Digital	52
	Commodities	68
	Food and Agriculture	82
	Capital	88
	About BNEF	97

Passenger vehicle sales peaked in 2017, and have since declined by almost 14%



Global passenger vehicle sales, trailing 12 months



Global passenger vehicle sales fell dramatically in 2020

Covid-19 impacted buying behavior in almost every major auto market.

Sales in North America remained relatively robust

Sales were down more than 10% in the U.S., but still rebounded sharply from lows early in the pandemic.

Passenger vehicle sales peaked well before Covid-19

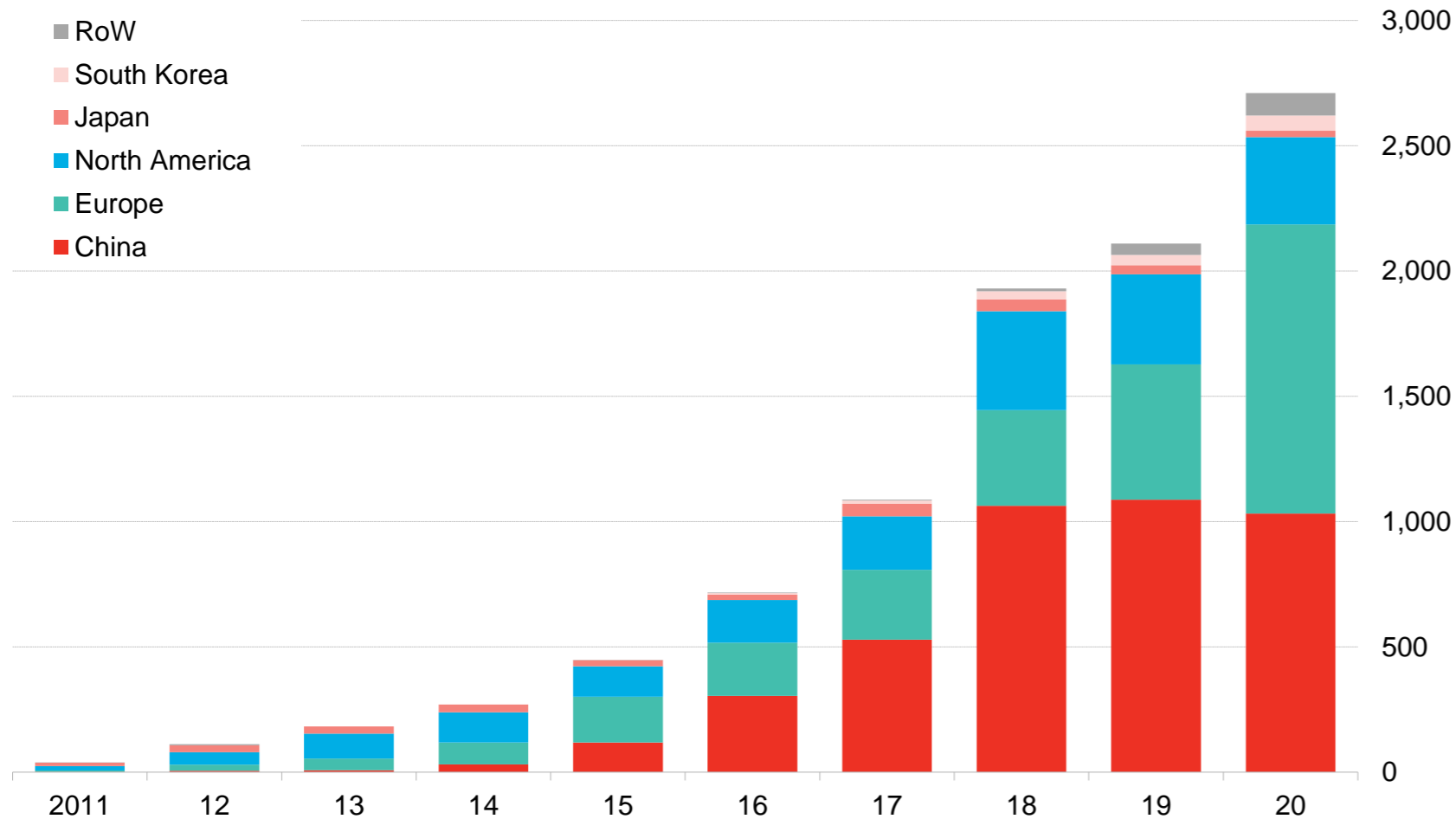
Sales peaked in 2017, and have since declined by almost 14%.

Source: Bloomberg Intelligence

Passenger electric vehicle sales increased 28% in 2020



Global passenger electric vehicles by market or region



Global passenger electric vehicle sales defied Covid-19, and auto industry trend, in 2020

Sales increased more than 28%, even as EV sales in China, the largest market in 2019, fell slightly.

European sales more than doubled year on year, with emissions policy the main driver

Europe sales topped 1.1 million, more than 100,000 ahead of China in 2020.

North America sales fell slightly

U.S. sales declined from 360,000 to 348,000.

Sales elsewhere rose more than 40%

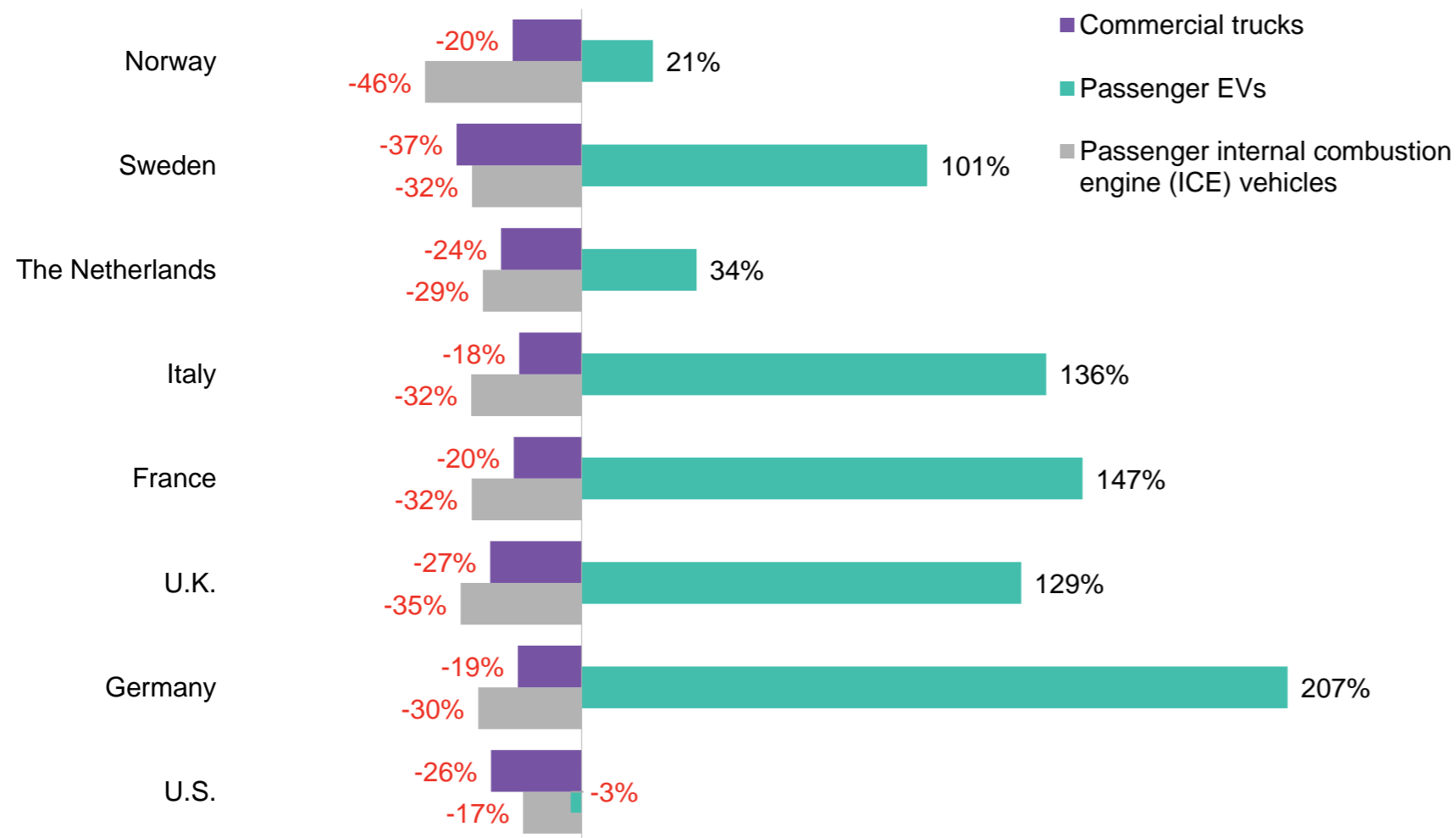
Sales in Japan, South Korea, and the rest of the world reached 176,000 vehicles.

Source: BloombergNEF

Electric and internal combustion engine passenger vehicle sales diverged almost everywhere



Change in passenger vehicle, EV and truck sales, 2019 to 2020 (January to October)



Every major European auto market saw growing sales of passenger EVs in 2020

At the same time, sales of internal combustion engine passenger vehicles, and commercial trucks, declined substantially everywhere.

Sales in some markets increased three-fold

German sales increased 207%, French sales increased 147%, and Italian sales increased 136%.

EV sales in the U.S. fell, however

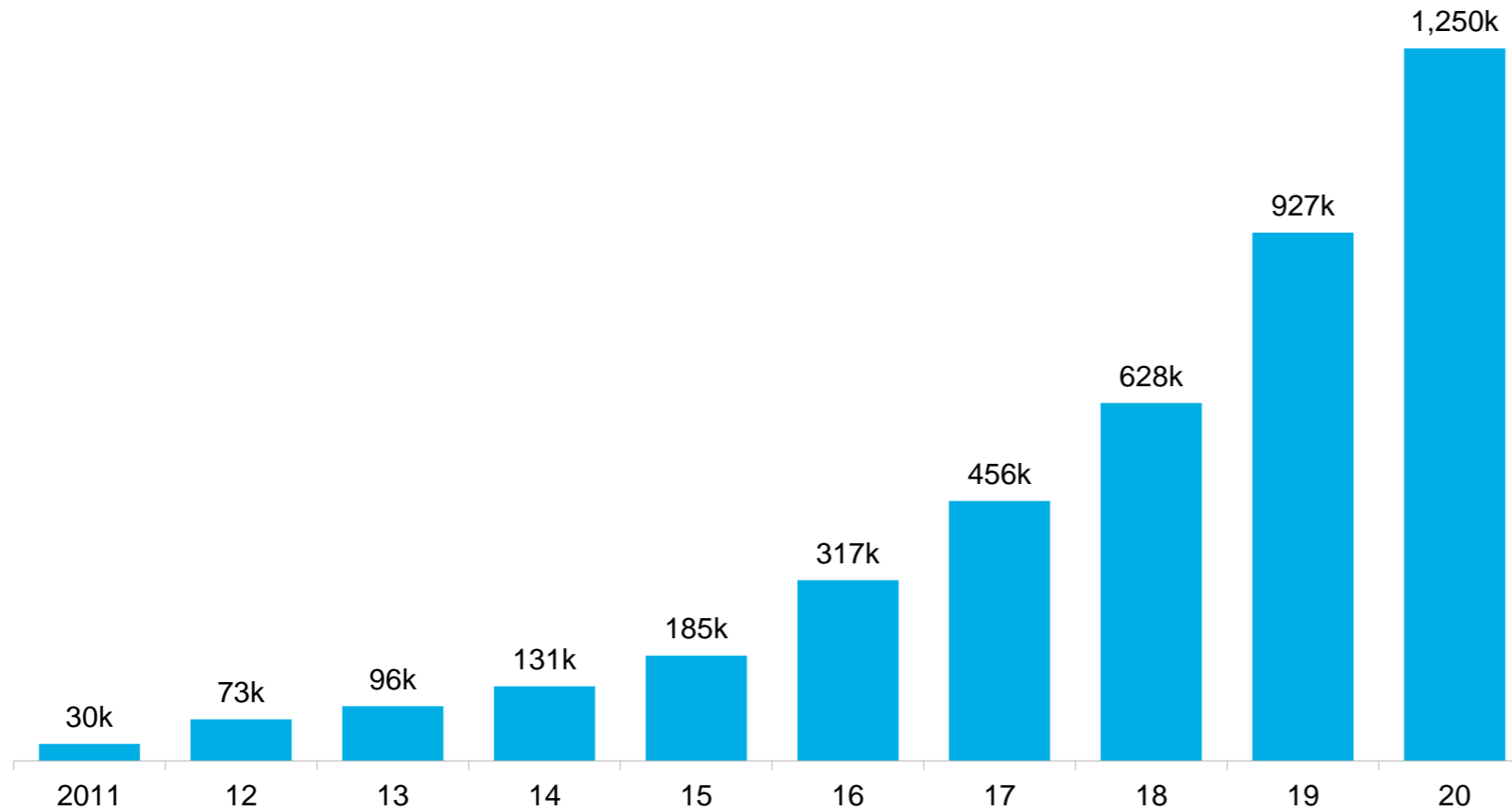
The U.S. auto market was not as depressed as the European market – passenger internal combustion engine sales fell only 17% - but EV sales fell as well, by 3%.

Source: BloombergNEF

There are more than 1 million public electric vehicle charging connectors worldwide



Total number of public EV charging connectors installed



There are now 1.25 million electric vehicle charging connectors worldwide

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 another 3 to 5 years.

Viable business models are emerging

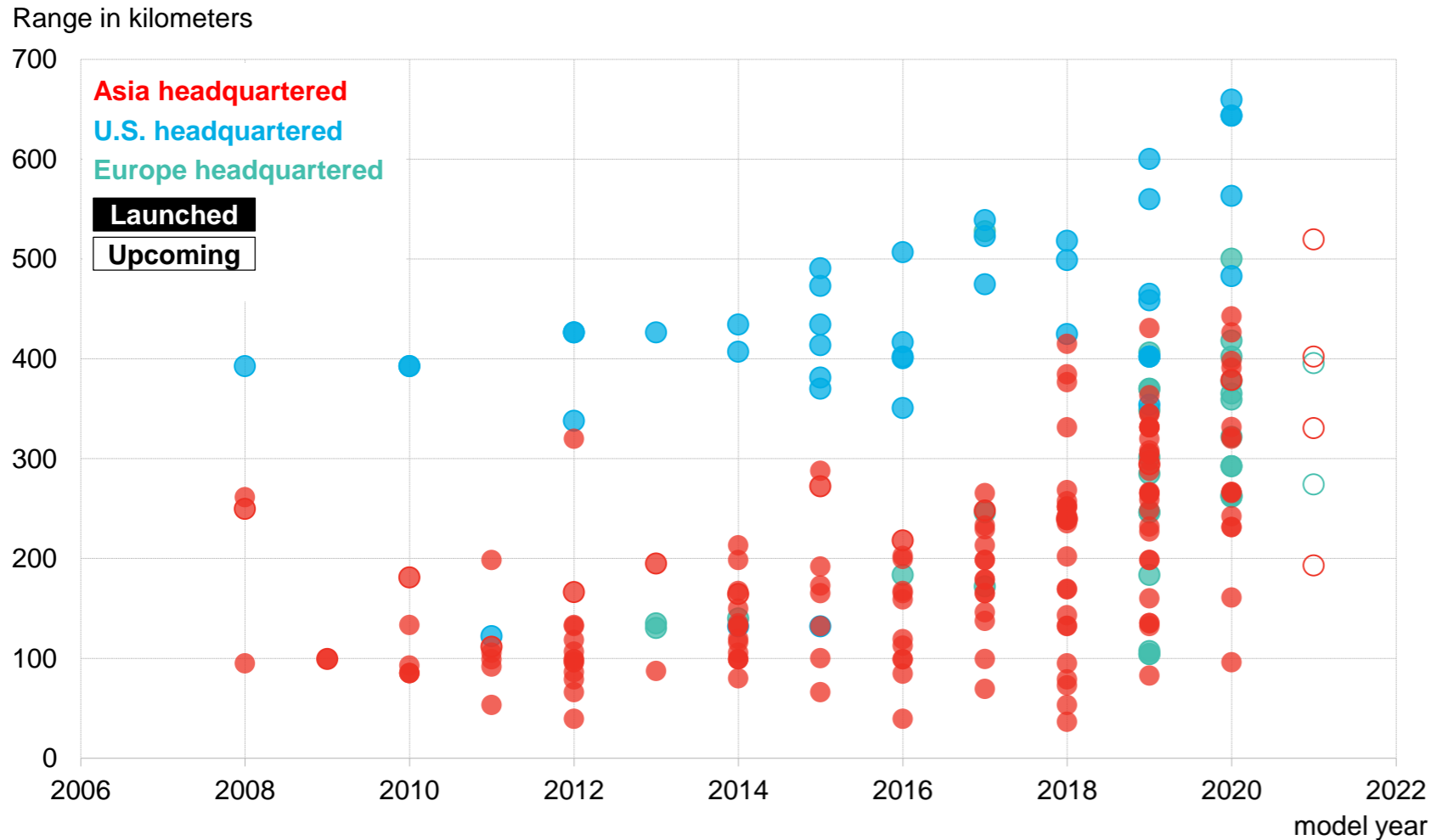
However, there are a number of critical questions outstanding for network operators, such as the optimal speed for charging, ideal location of public chargers, and the approach to billing customers.

Source: BloombergNEF

Electric vehicle ranges continue to increase



Range of launched and upcoming BEV models by launch year



Electric vehicle ranges have increased markedly in a decade

Prior to 2010, Tesla models had by far the longest vehicle range, with Asian models a small fraction of Tesla range.

Asian manufacturer ranges have more than doubled

2019 and 2020 Asian electric vehicle ranges cluster around 300 kilometers, much closer to that of U.S. models.

European model ranges are 300-400 kilometers

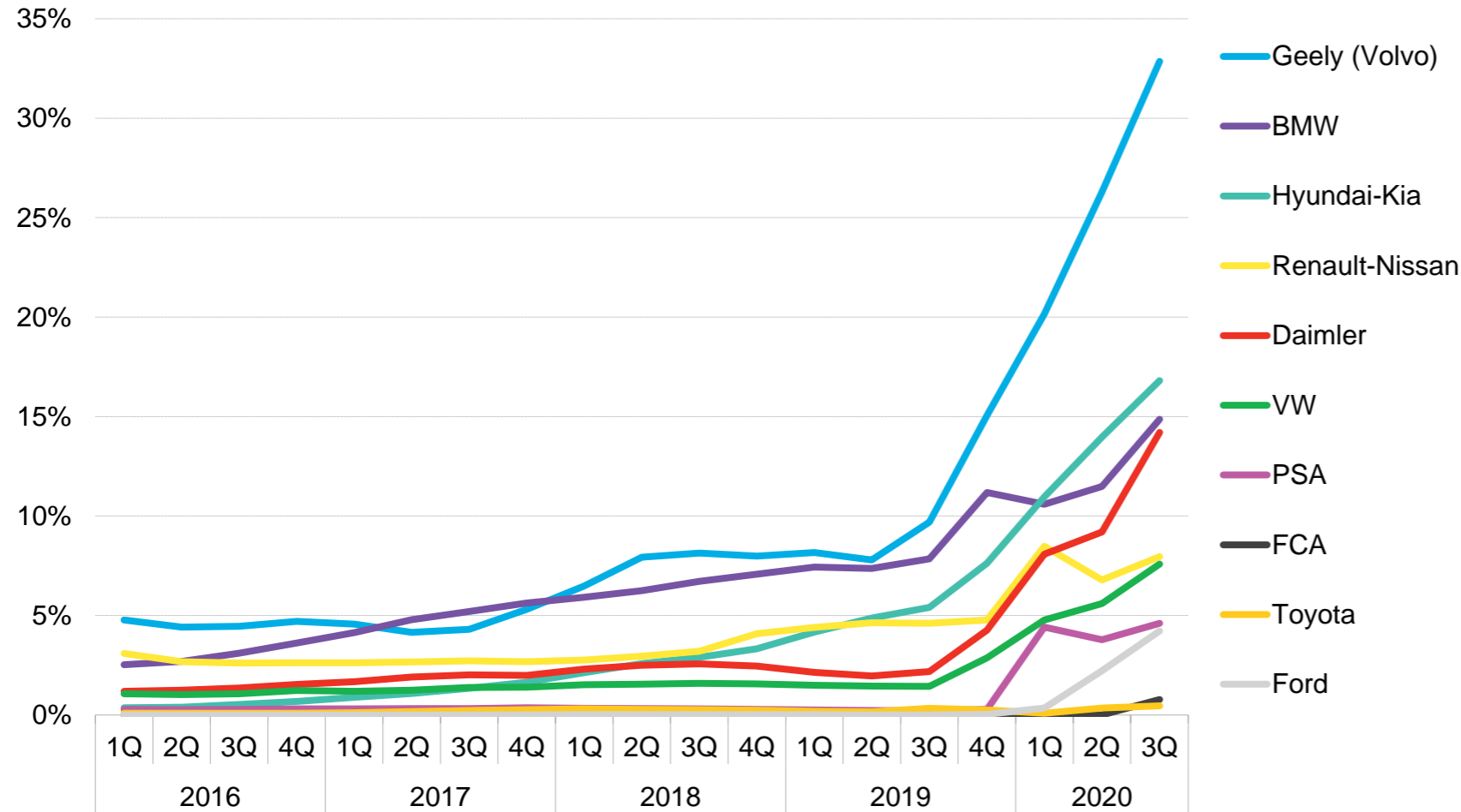
European models released in the past two years will be similar to the low end of U.S. electric vehicle ranges.

Source: BloombergNEF

Electric vehicles are now at least 5% of sales for major automakers in Europe



Automakers' EV sales share in Europe



Electric vehicle sales are close to or well above 5% of sales for almost every manufacturer selling in Europe

Only two companies, Fiat Chrysler and Toyota, had substantially less than 5% electric vehicle sales in the third quarter of 2020.

Geely has by far the highest share of electric vehicle sales

The company, selling mostly its Volvo brand, has been the electric vehicle sales leader on a proportional basis since early 2018, and now has more than 30% EV sales.

Electric vehicle sales begin to accelerate in 2019

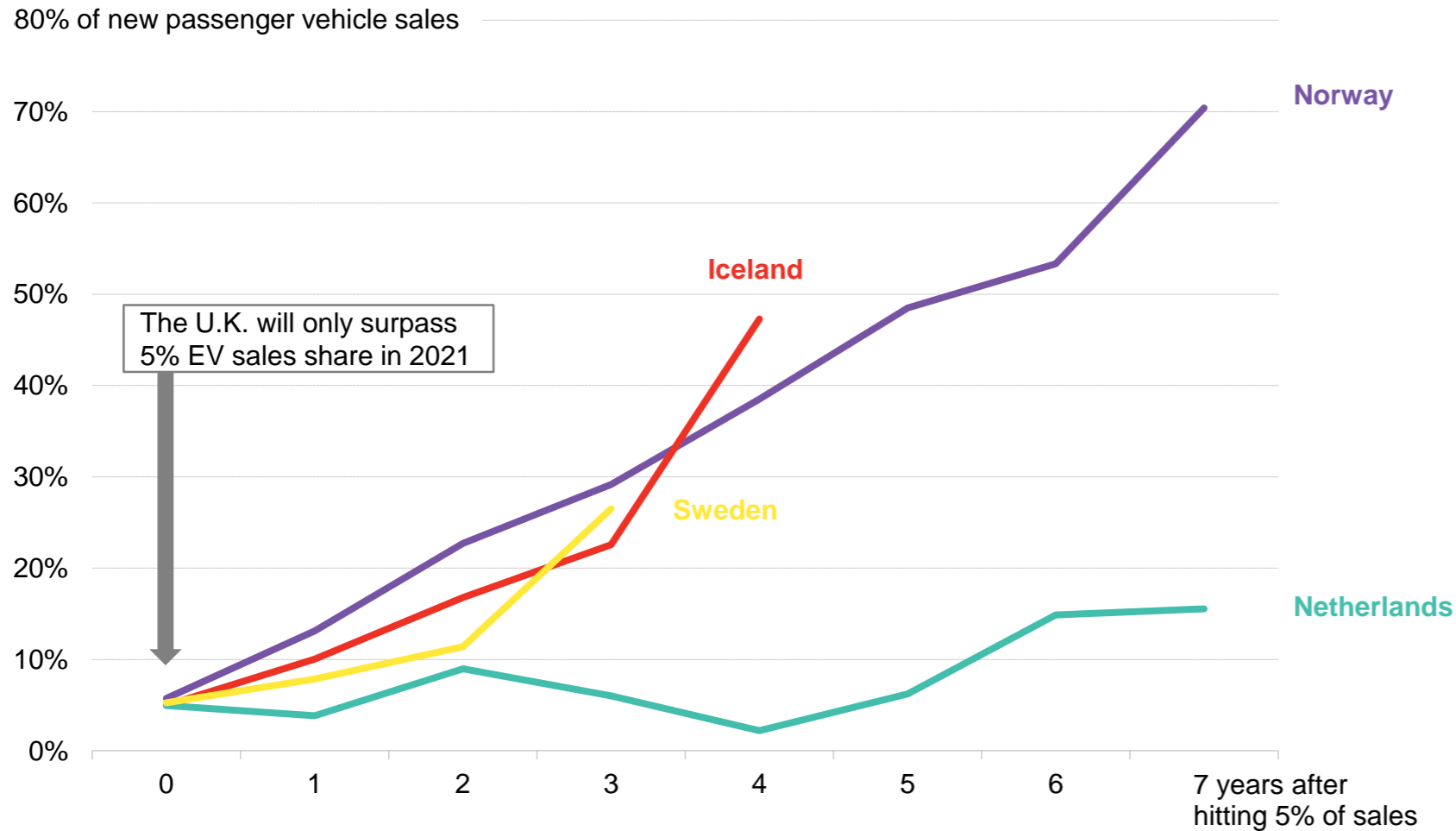
By mid-2020, six manufacturers were selling more than 5% electric vehicles in Europe, and three were selling more than 10%.

Source: BloombergNEF. Note: Europe (trailing 4 quarter average until 2Q 2019 and actual quarterly from 3Q 2019 onward).

Electric vehicle sales tend to keep increasing steadily after reaching 5% (with one exception)



EV share of new passenger vehicle sales after EVs hit 5% of new vehicle sales



Once markets achieve an electric vehicle new sales share of 5%, EV sales usually take off

Countries that achieve 5% EV sales usually hit 10% within a year, or less, and 20% within two to three years.

Norway now has an EV sales share of 70%

Seven years after achieving 5% sales, electric vehicles are now more than two-thirds of passenger vehicle sales

The Netherlands is the only auto market in which EV sales share has not grown dramatically

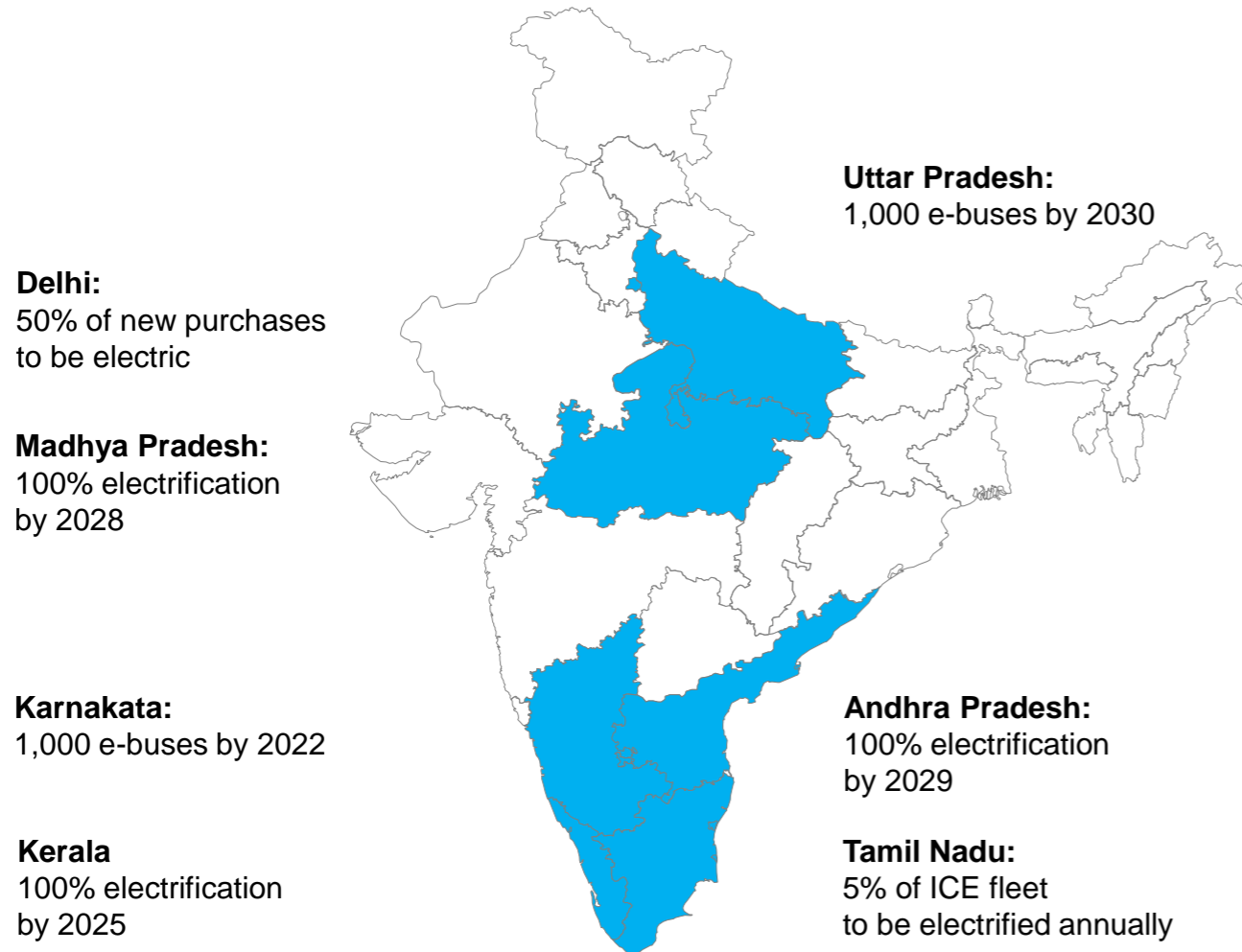
Dutch EV tax incentives have phased in and out, and a subsidy introduced in July 2020 ran out almost immediately. EV sales are still more than 10% but have not risen as in other markets.

Source: BloombergNEF

Seven Indian states or administrative areas have municipal bus electrification targets



India municipal bus electrification targets



India has a number of municipal bus electrification targets

The most aggressive, in terms of immediate action, is Kerala, which targets 100% electrification by 2025.

Targets differ in nature

Targets include percentage of new sales, a percentage of fleet electrification per year, full electrification target dates, and absolute targets by certain years.

Electric bus sales are likely to pick up next decade, based on economics

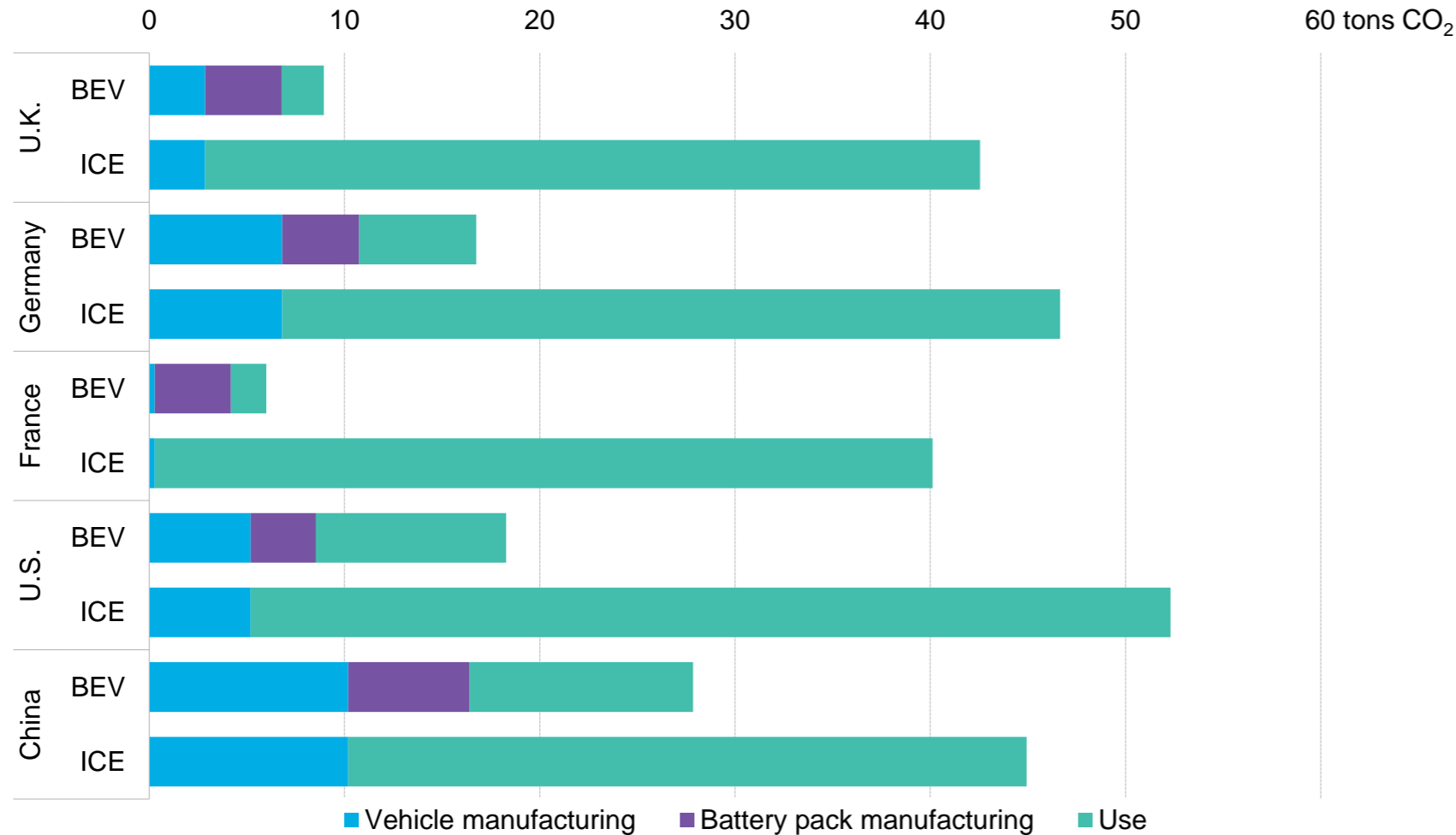
BloombergNEF expects the total cost of ownership of electric buses to be lower than that of internal combustion buses by 2030.

Source: State transport departments

Electric vehicles have superior lifecycle emissions to comparable internal combustion engine models



Electric and internal combustion engine vehicle lifetime CO2 emissions



Battery electric vehicles have substantially lower lifecycle emissions than peer internal combustion engine vehicles

In countries with low electricity emissions, such as France, the gap is almost ten-fold. In China, with its coal-heavy power fleet, the difference is much less.

EVs have higher lifecycle emissions from manufacturing than ICE peers


Battery pack manufacture accounts for almost all of the difference, with some variation by country.

The lower the power fleet emissions intensity, the bigger the lifecycle emissions gap

The U.K. and France, with their substantially decarbonized power fleets, have the greatest lifecycle emissions advantage.

Source: BloombergNEF

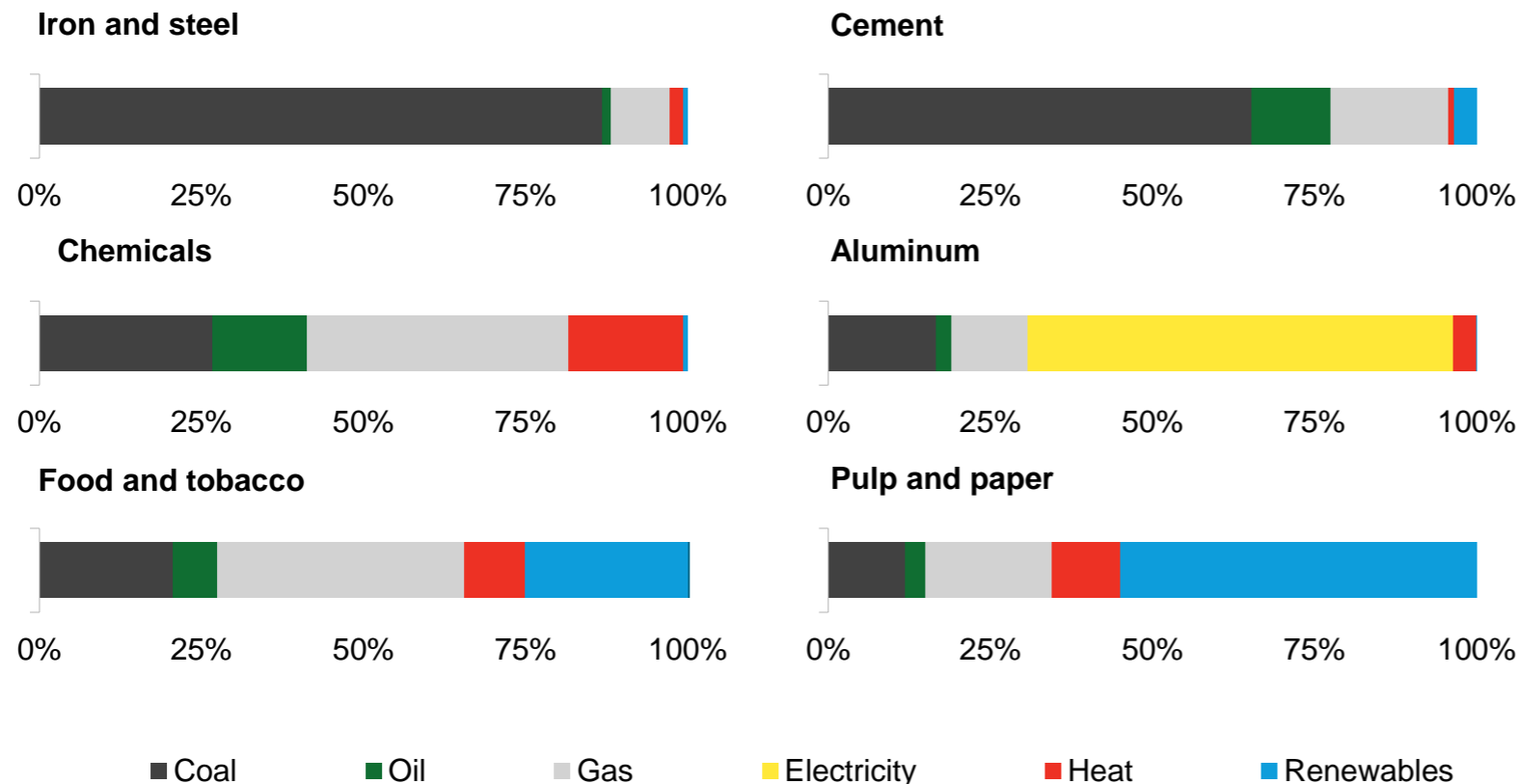
Table of contents

	Introduction: A Cleaner Future	3
	Power	23
	Transport	42
	Industry, Buildings, and Digital	52
	Commodities	68
	Food and Agriculture	82
	Capital	88
	About BNEF	97

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

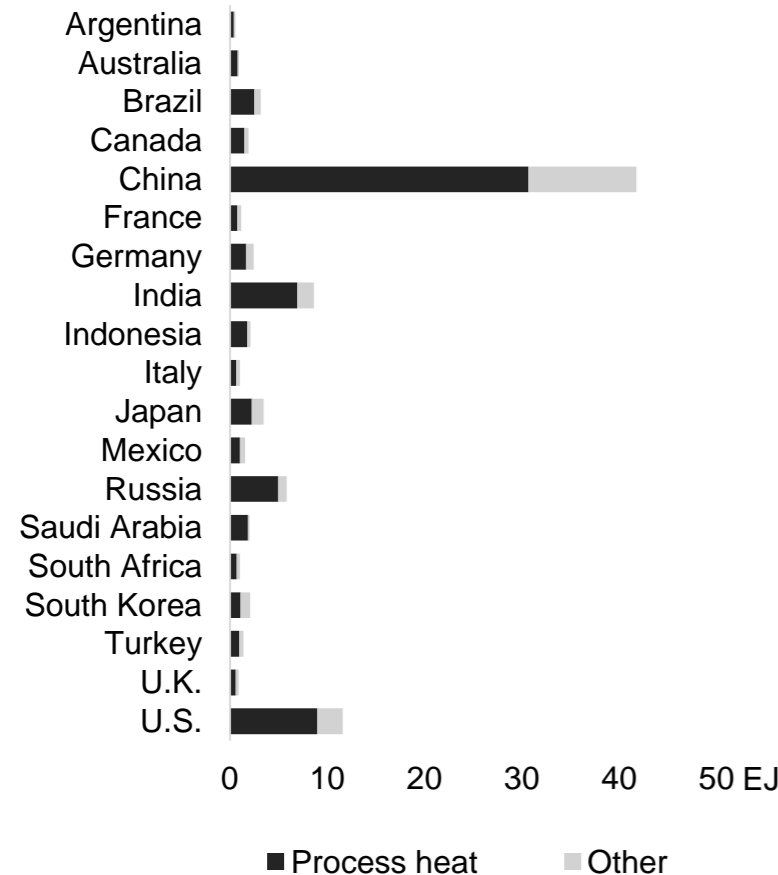
Chemicals, cement and iron and steel use a higher proportion of fossil fuels. These industries have high heat requirements and use fossil fuels as feedstocks as well.

Source: BloombergNEF, IEA

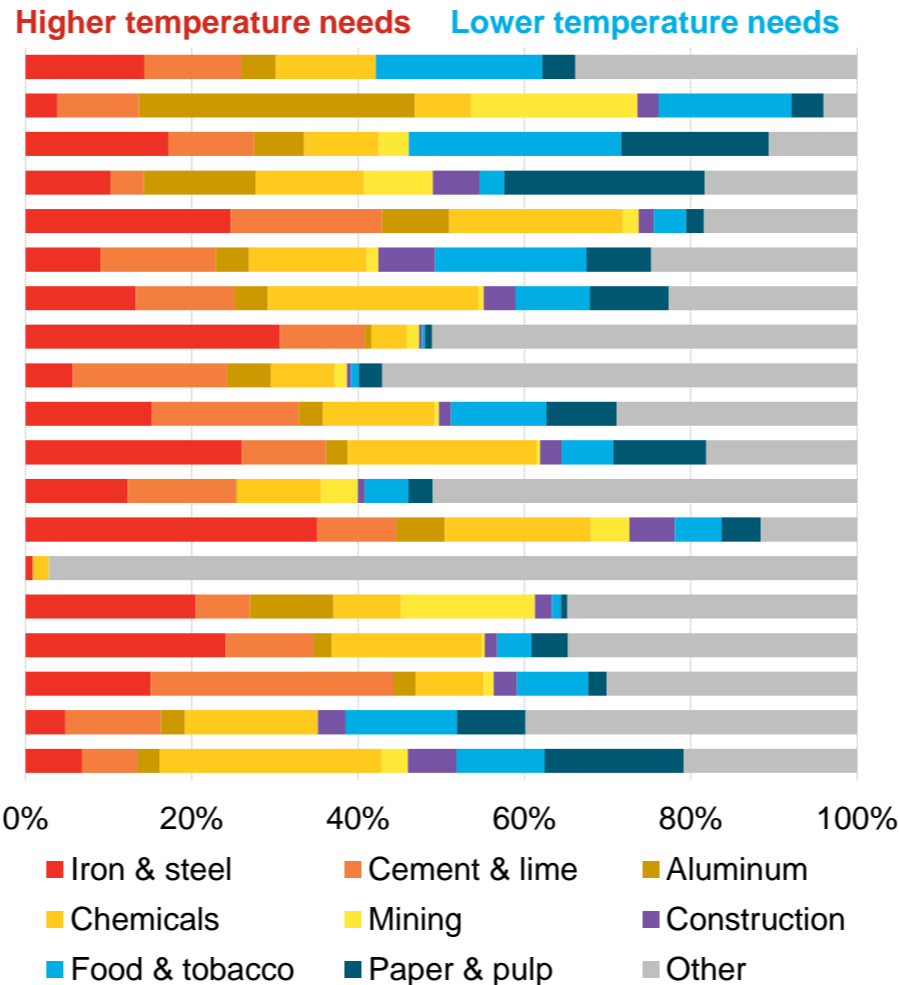
Industry has a number of specific decarbonization challenges



Industrial energy consumption, type



Industrial energy consumption, sector



Industry is 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

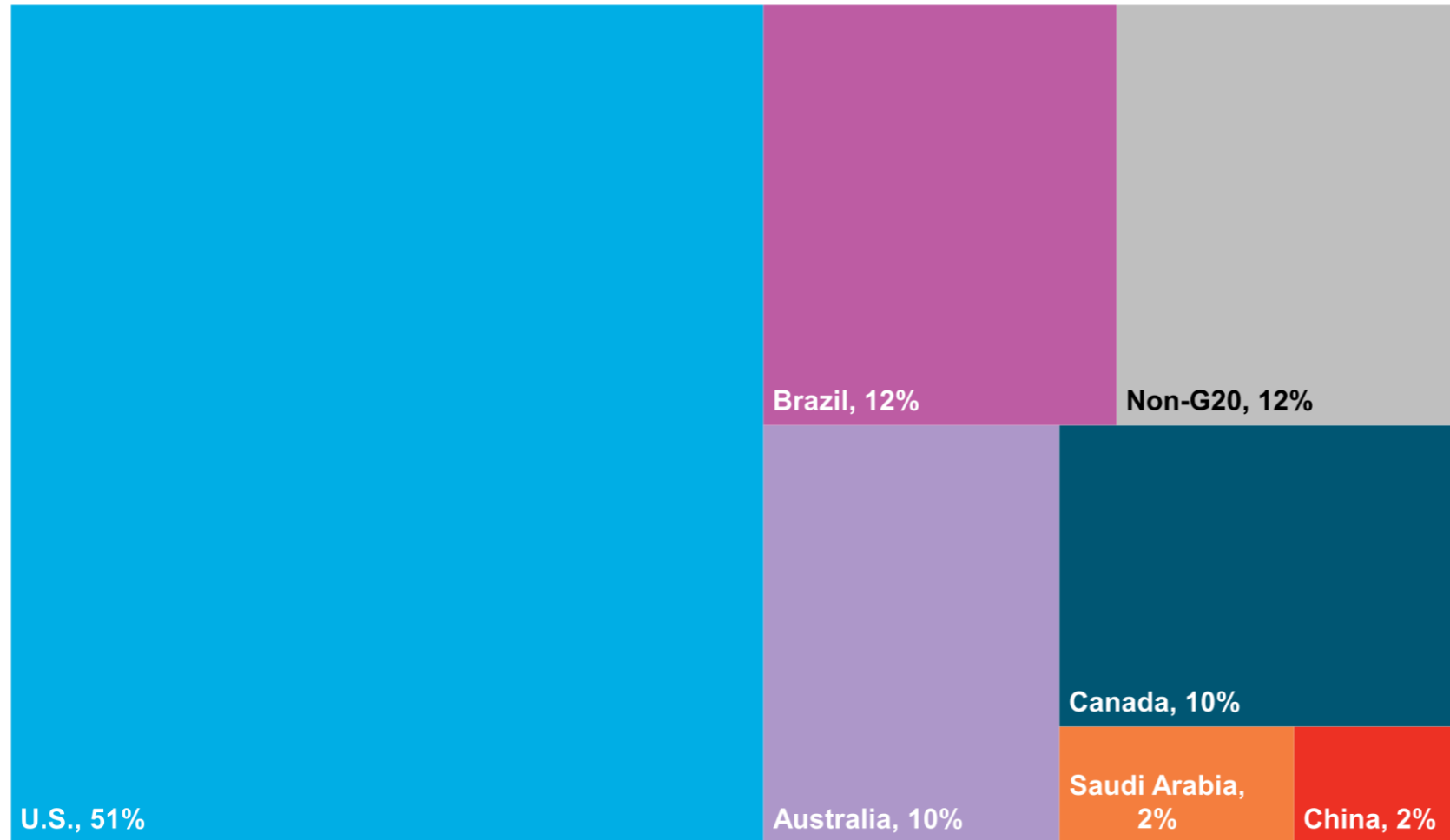
Those challenges range from scale (China is by far the largest industrial energy consumer) to particular heat demand (some countries have mostly high-temperature heat demand, which makes it harder to find lower- or zero-carbon substitutes).

Source: Global CCS Institute, BloombergNEF

The U.S. leads in operational carbon capture capacity



Share of global operational carbon capture capacity, by location, end-2020



Carbon capture, utilization, and storage (CCUS) separates industrial carbon dioxide emissions for use

The process separates, compresses, and transports the gas for use in industrial processes, drilling processes, or storage.

CCUS can contribute to the circular economy

CO₂ can be 'upcycled' into new products including concrete, carbon nanotubes, chemicals or fuels. It can also be used in the process of producing hydrogen from natural gas.

The U.S. is the leader in CCUS capacity

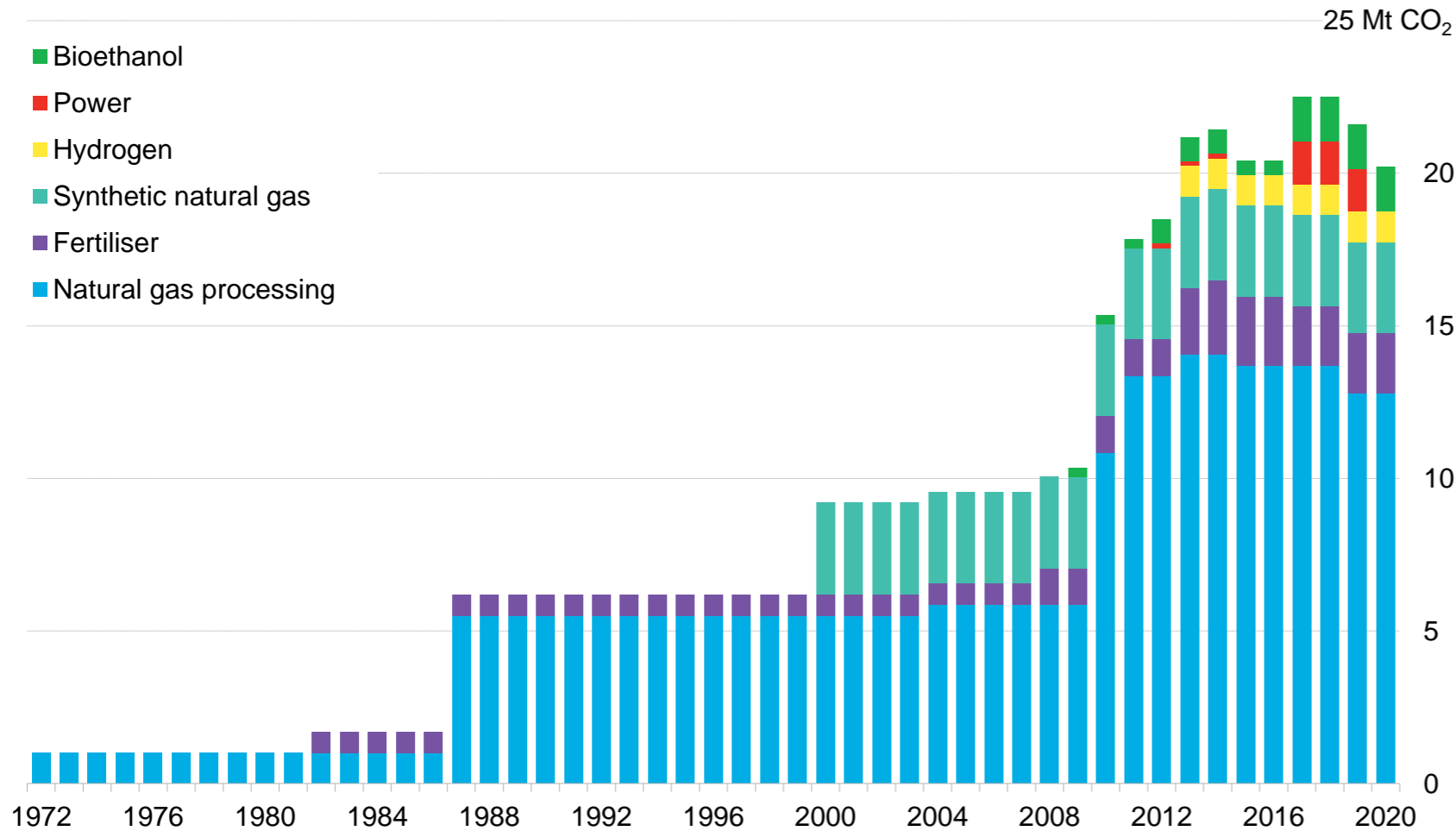
The U.S. has more than half of the global CCUS capacity of 38 million metric tons per annum. Current global CCUS capacity is equivalent to only 0.1% of global emissions.

Source: Global CCS Institute, BloombergNEF

Carbon capture and storage in the U.S. has not progressed since 2017



Cumulative U.S. installed carbon capture and storage capture rate



Carbon capture and storage is attracting U.S. government funding and technology development

The U.S. Department of Energy has said it expects hubs of CCS infrastructure to develop in certain industrial areas, suggesting some momentum behind U.S. CCS projects linked to chemicals production and other industries.

However, the net capacity of carbon dioxide captured and stored peaked in 2016

That year, the Illinois Industrial Carbon Capture and Storage project came online, using geologic storage.

Work on two major projects has been suspended

The Lost Cabin gas plant suspended operations in 2019, and the Petra Nova carbon capture plant suspended operations in 2020.

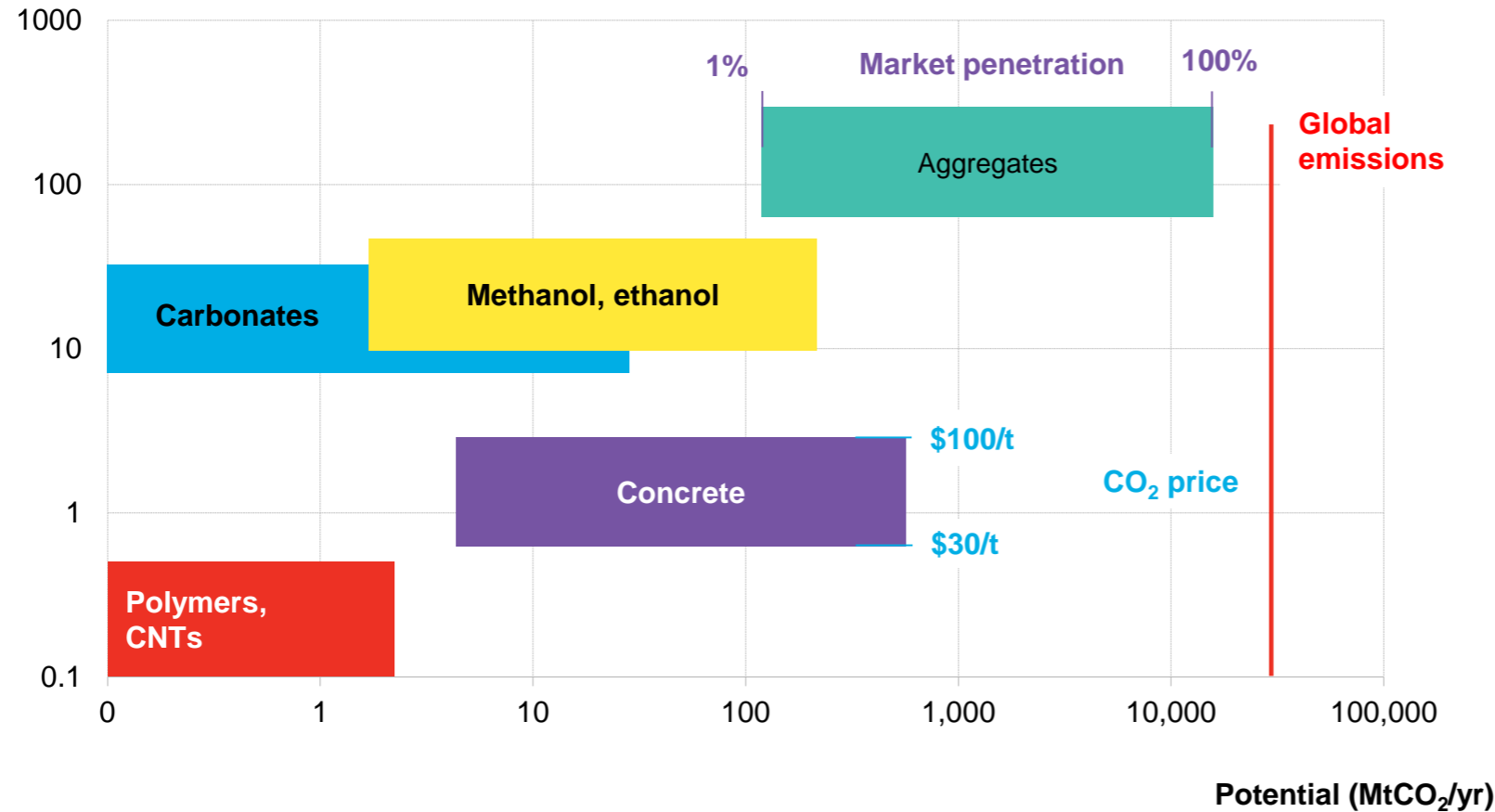
Source: BloombergNEF, Global CCS Institute

CO₂ utilization markets are too small and too cost-sensitive to significantly offset capture costs



CO₂ utilization markets and sensitivity to CO₂ prices

CO₂ cost (% of product price)



Once carbon dioxide is captured, it can be used

Uses include making new materials and chemicals, or adding to concrete to increase its strength. These applications will purchase CO₂, offsetting some of the cost of capture.

Creating new demand means new applications, or price premiums

Buyers paying a price premium for lower-emissions products will need to do so despite no added performance benefit.

Concrete is the current targeted application for a reason

Concrete demand is significant, and CO₂ use adds little, if any, cost to the final product.

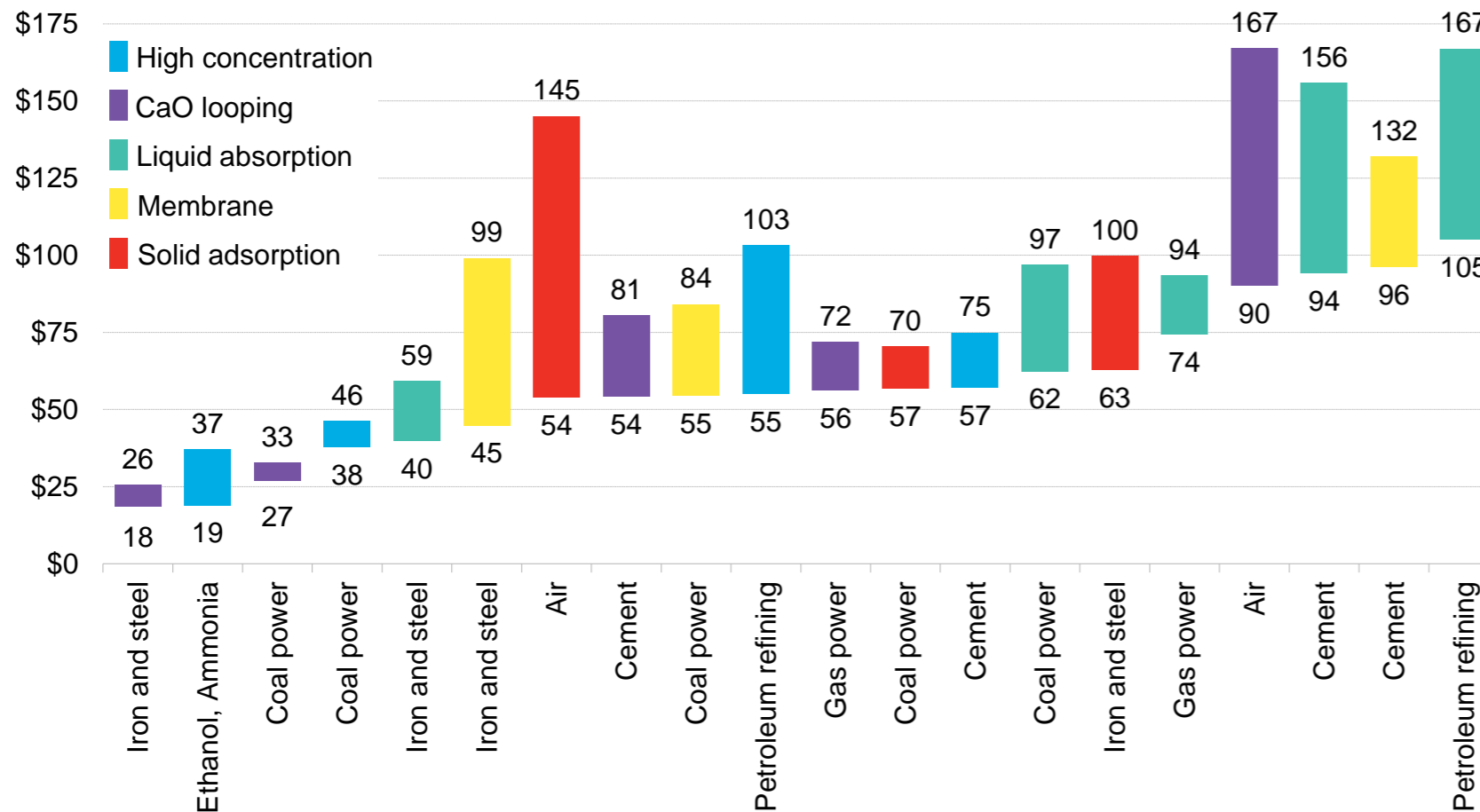
Source: BloombergNEF

Industrial carbon capture costs can fall within the carbon price range once many plants have been built



Cost of avoiding CO₂ emissions at scale (Nth-of-a-kind plants)

Avoidance Cost (\$/tCO₂, real 2019)



Future carbon capture costs could be within range of today's carbon prices

Iron, steel, chemicals, and coal-fired power could all have viable carbon capture if economies of scale are realized.

High-concentration and liquid absorption are mature capture technologies used today

CaO looping is early-stage, but the industry has high hopes for its success.

Capture costs are specific to each project

Capture costs depend highly on energy, consumable costs, and what fraction of emissions are captured.

Direct-air capture could provide negative emissions, but at a cost

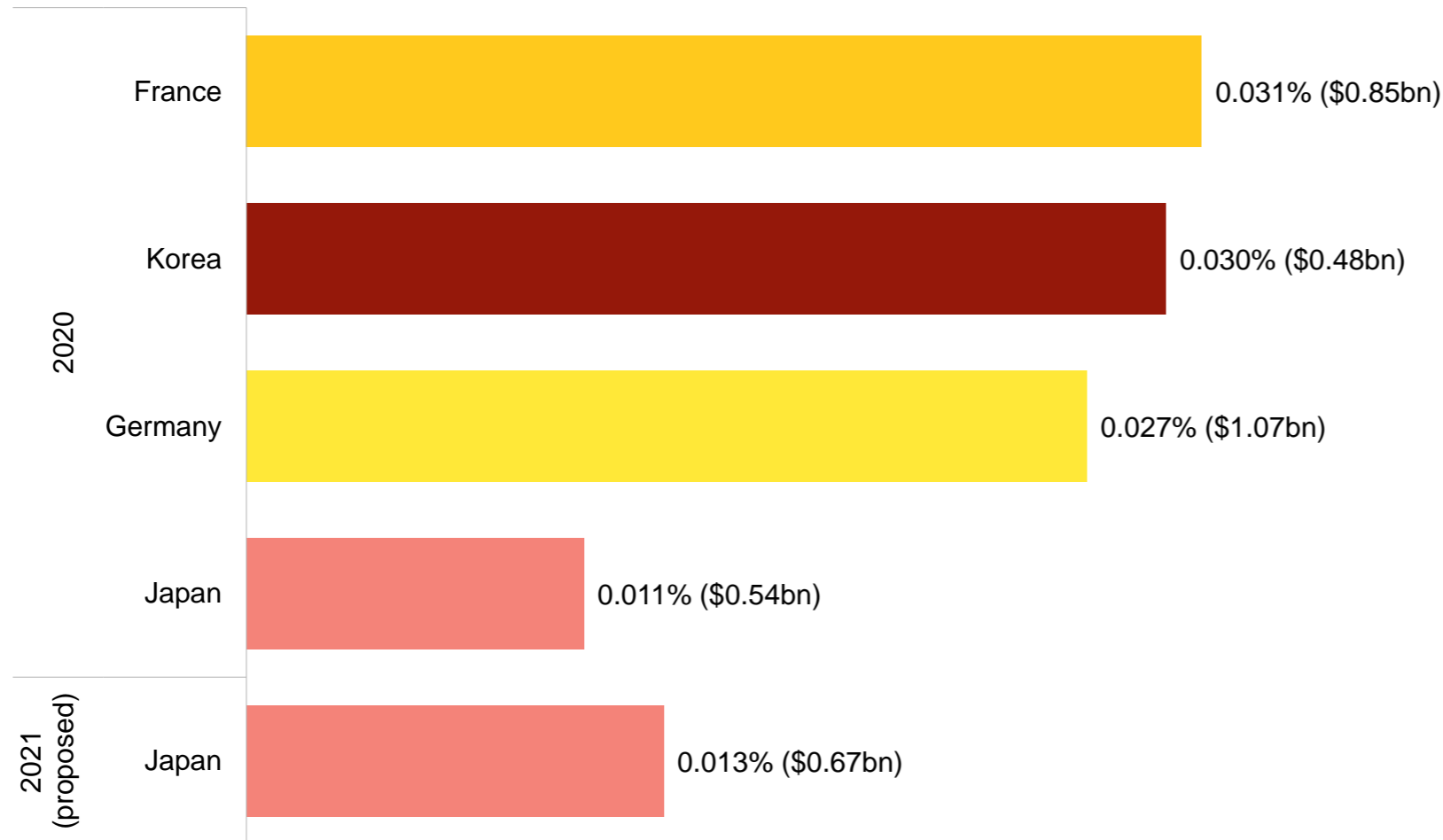
It is the only technology with potentially negative emissions, but it will remain expensive even with much iteration.

Source: BloombergNEF. Note: Nth-of-a-kind is a cost estimate that includes the economies of scale achieved by building several identical projects. CaO is calcium oxide.

France is providing the largest subsidies to hydrogen, in GDP terms, while Germany leads in dollar terms



Public spending on hydrogen as a percentage of GDP



Four countries are all providing significant subsidies for hydrogen

France is the largest in terms of GDP, while Germany is devoting the most funding in absolute terms.

Japan is devoting more support funding for hydrogen than Korea

However, on a GDP basis, Korea is devoting more funding to hydrogen.

Japan proposes to spend substantially more on hydrogen

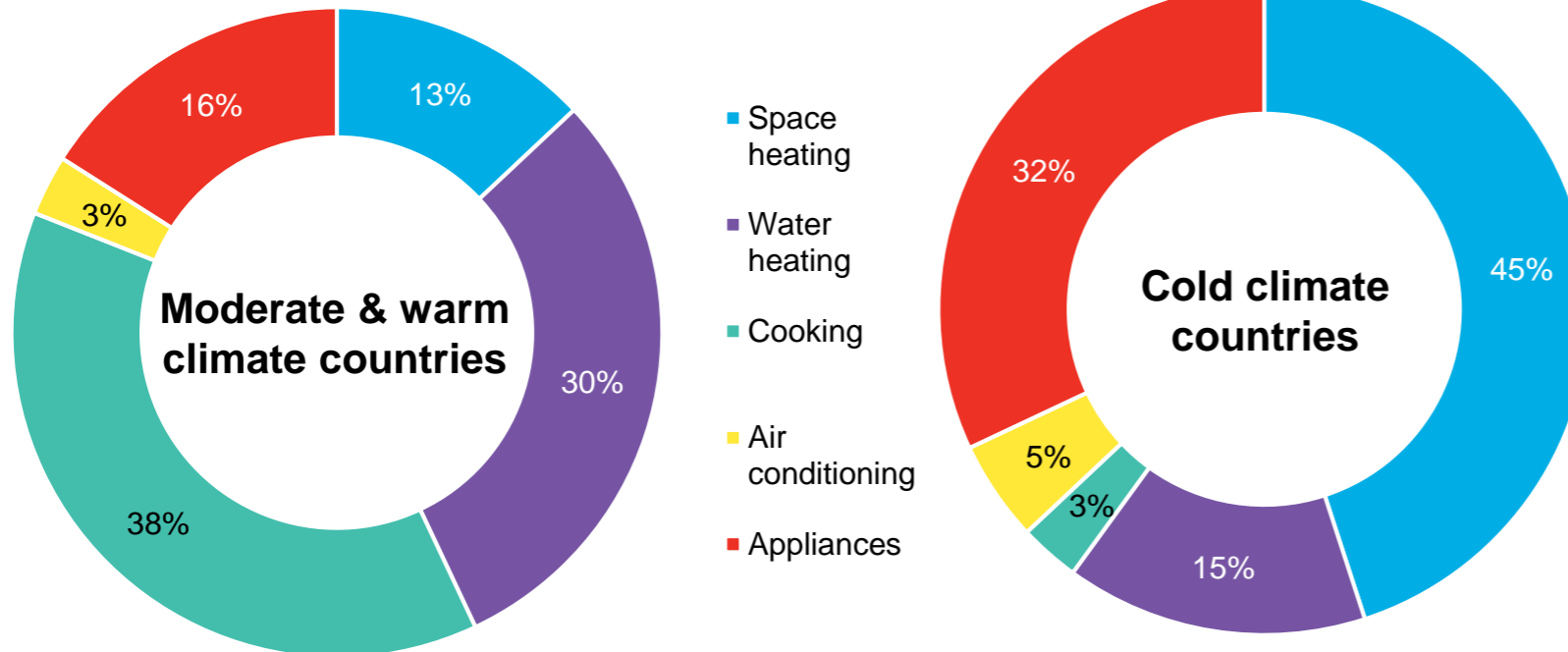
Its 2021 proposal would increase spending on hydrogen by \$130 million.

Source: World Bank, BloombergNEF

Warm and cold climates have very different building energy demand profiles



Final energy demand by end-use in buildings, by climate



Building energy consumption varies significantly based on the climate

Moderate and warm climate countries have very different final energy demand use in buildings.

Water heating and cooking require most of the energy consumed in buildings in moderate and warm climate countries

Space heating and appliances are also significant energy consumers, but not to the same degree.

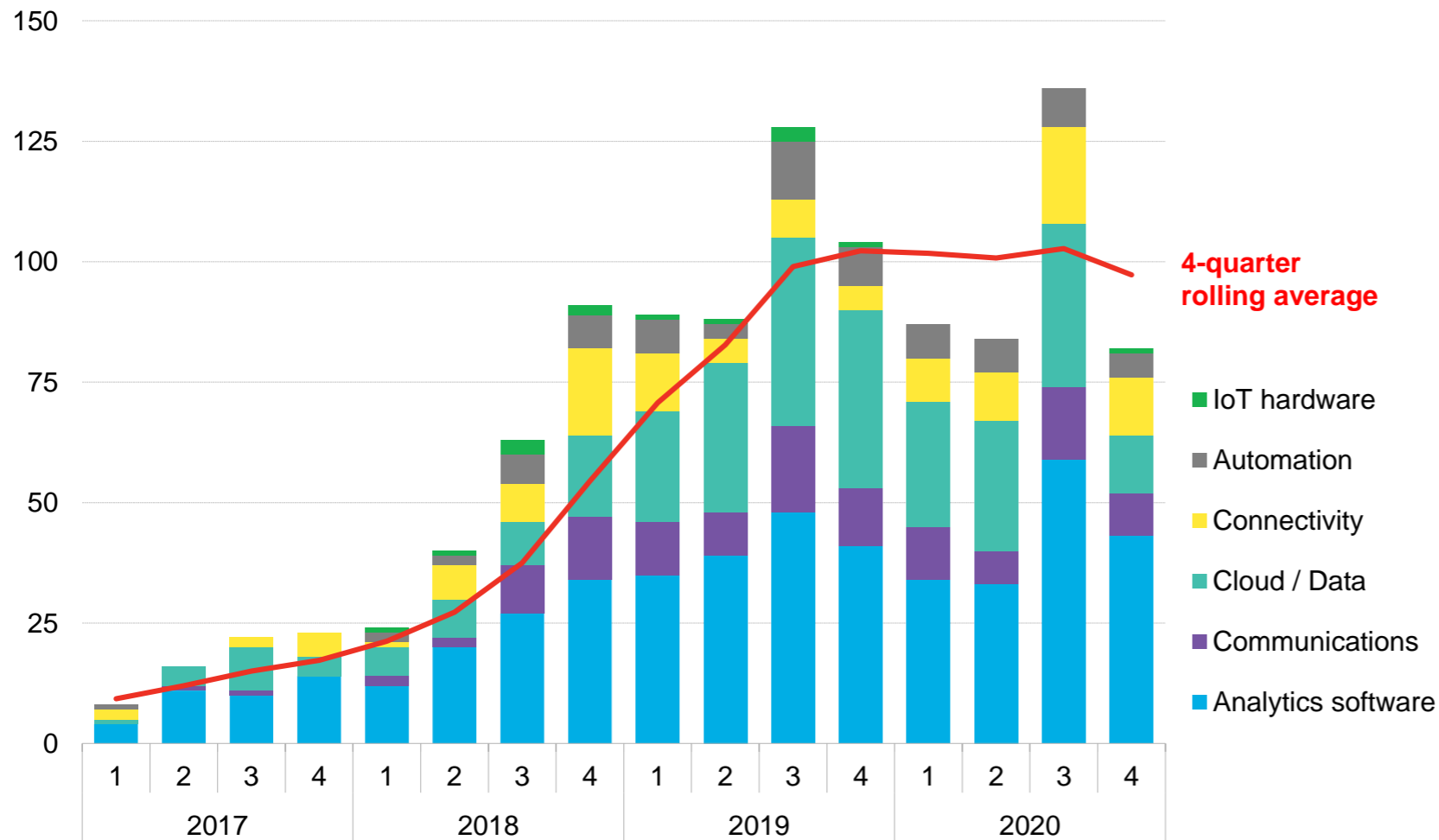
Space heating and appliances are the largest energy consumers in cold climate countries

Water heating and cooking play a much smaller role, relatively, in building energy demand in cold countries.

Industries are rapidly digitalizing business operations



Digital industry projects and partnerships (count of activities)



Industrial companies have become more reliant on remote monitoring and cloud computing to continue operations

Covid-19 has meant cloud and data-related projects and partnerships have been growing and accounted for 25% of digitization activity in 2020.

Analytics software-related digital projects and partnerships account for the largest proportion of activity

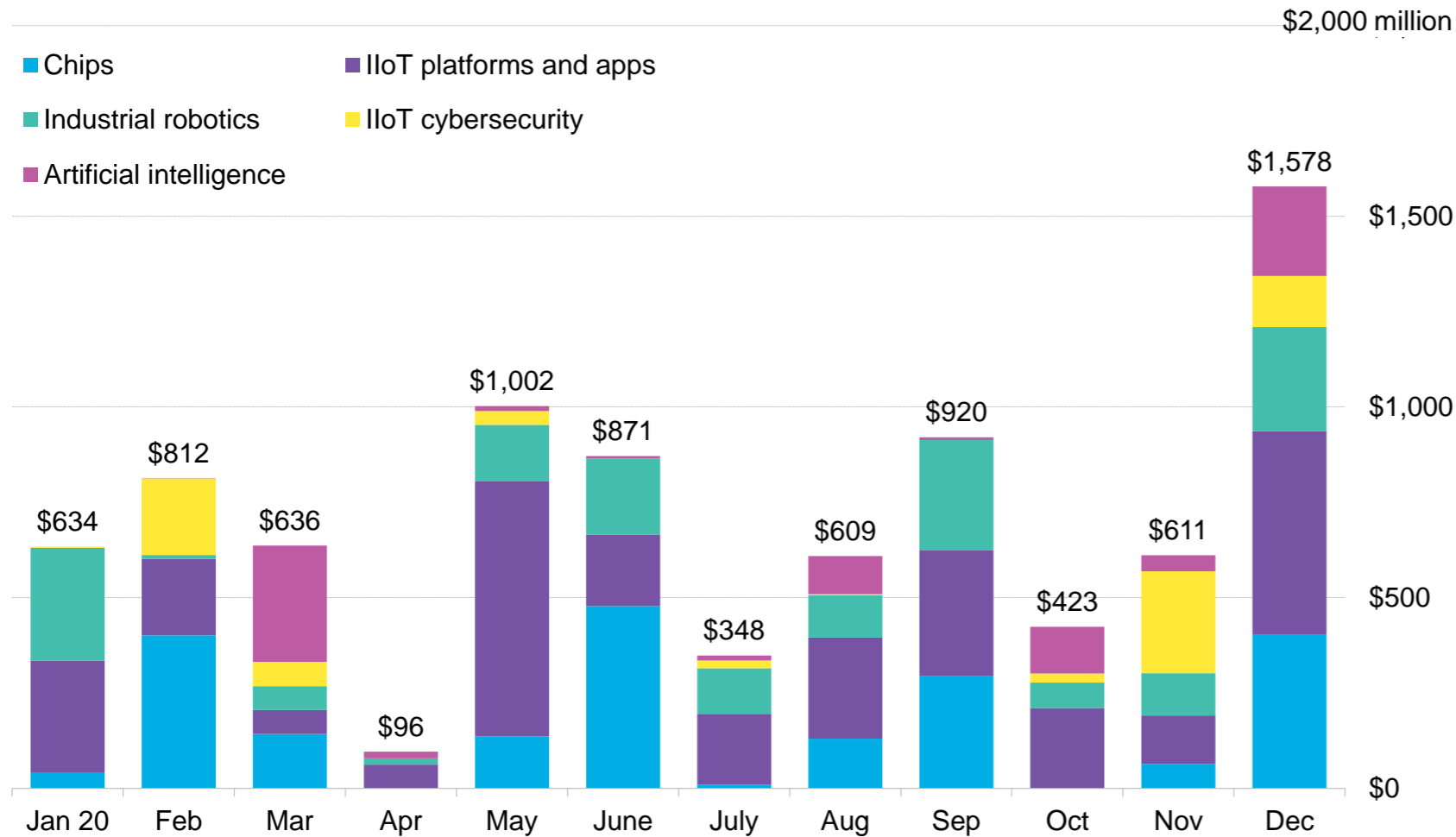
This includes technologies such as artificial intelligence, digital twins and predictive maintenance.

Source: BloombergNEF

Private industrial IoT, AI, analytics, and robotics companies raised more than \$13 billion in 2020



VCPE fundraising by startups selling industrial IoT, AI, analytics, robotics products



There are thousands of startups building software, sensors, chips, drones for industrial digitalization. However, most are very small, raising seed or Series A.

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

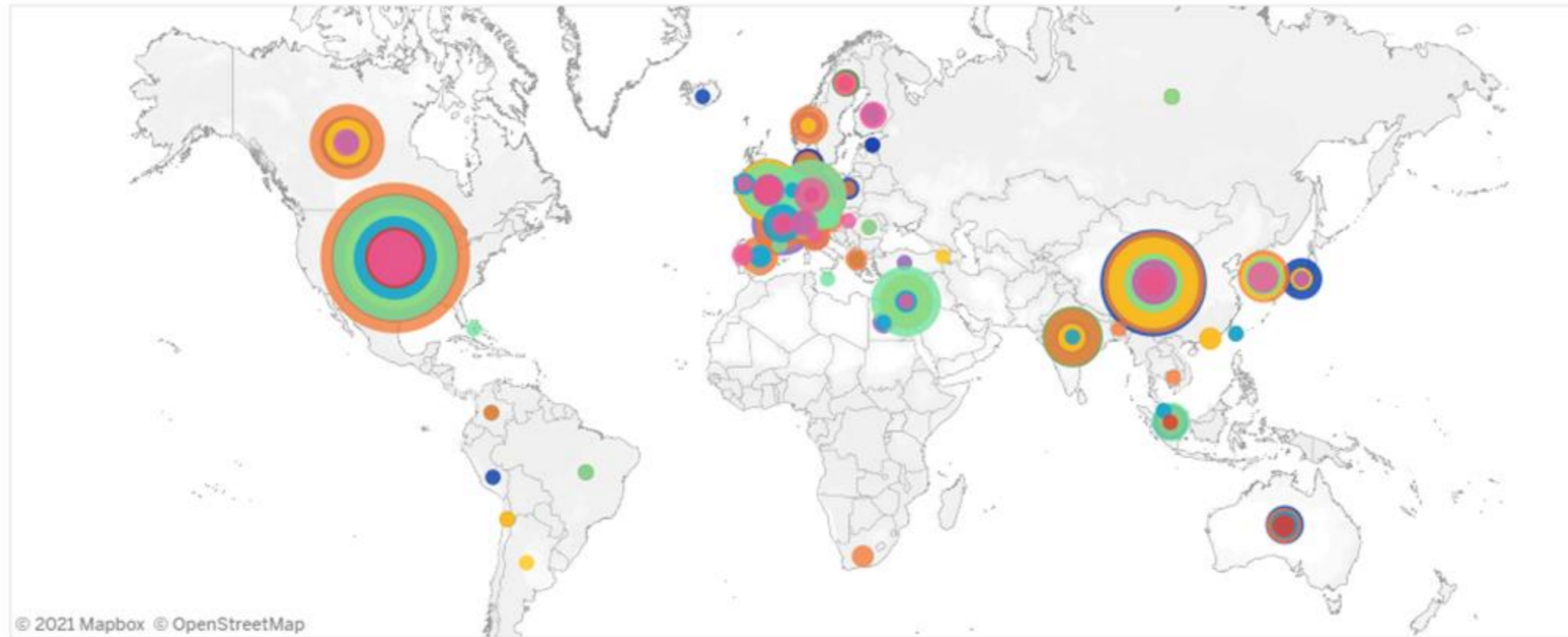
Much more money is being spent by large corporations in R&D, like by GE or Siemens or Schlumberger, than is being spent on startups.

Source: BloombergNEF

The U.S. dominates digital industry startups



Global digital industry startups tracked by country of headquarters and technology



© 2021 Mapbox © OpenStreetMap

Technology:

- Augmented/Virtual reality
- Cloud, edge
- Communications
- IoT security
- Machine learning
- Analytics software
- IoT connectivity
- Robotics, drones, automati..
- Sensors and/or AI chips

Number of startups



Source: BloombergNEF

Companies have a roadmap to building digital capabilities



Roadmap to building digital capability

	Steps to building digital capability	Governance	Talent and culture	Technology	Representative companies
1	Launching a digital strategy	Long-term commitment and investment	Digital-oriented mindset among employees	Clear goal for technology development	uni per, ENGIE, enel, bp
2	Appointing a digital executive	Clear responsibility for digital business	More streamlined reporting lines, better coordination between OT and IT	Comprehensive view on digital tech	ENGIE, enel, e-on, Exelon
3	Training and knowledge sharing among employees		Equipping personnel with digital skills, domain knowledge and business acumen	Talent resources for tech innovations	Shell, TOTAL, bp, ENGIE
4	Running employee innovation programs		Cultivating innovative culture, good opportunities for cross-team work	Lowering costs for tech and product development	ENGIE, bp, NEXTera ENERGY, enel
5	Deploying ideas internally to test			Targeting a real pain point; tailoring products to fit user needs	uni per, THE KANSAI ELECTRIC POWER CO., INC., bp, TEPCO

High impact on the metric at top
 Moderate impact on the metric on top

Energy companies are building digital products and services to strengthen their existing businesses and diversify into new revenue streams

Digital products can generate a higher margin than energy retail, and help companies enter new markets.

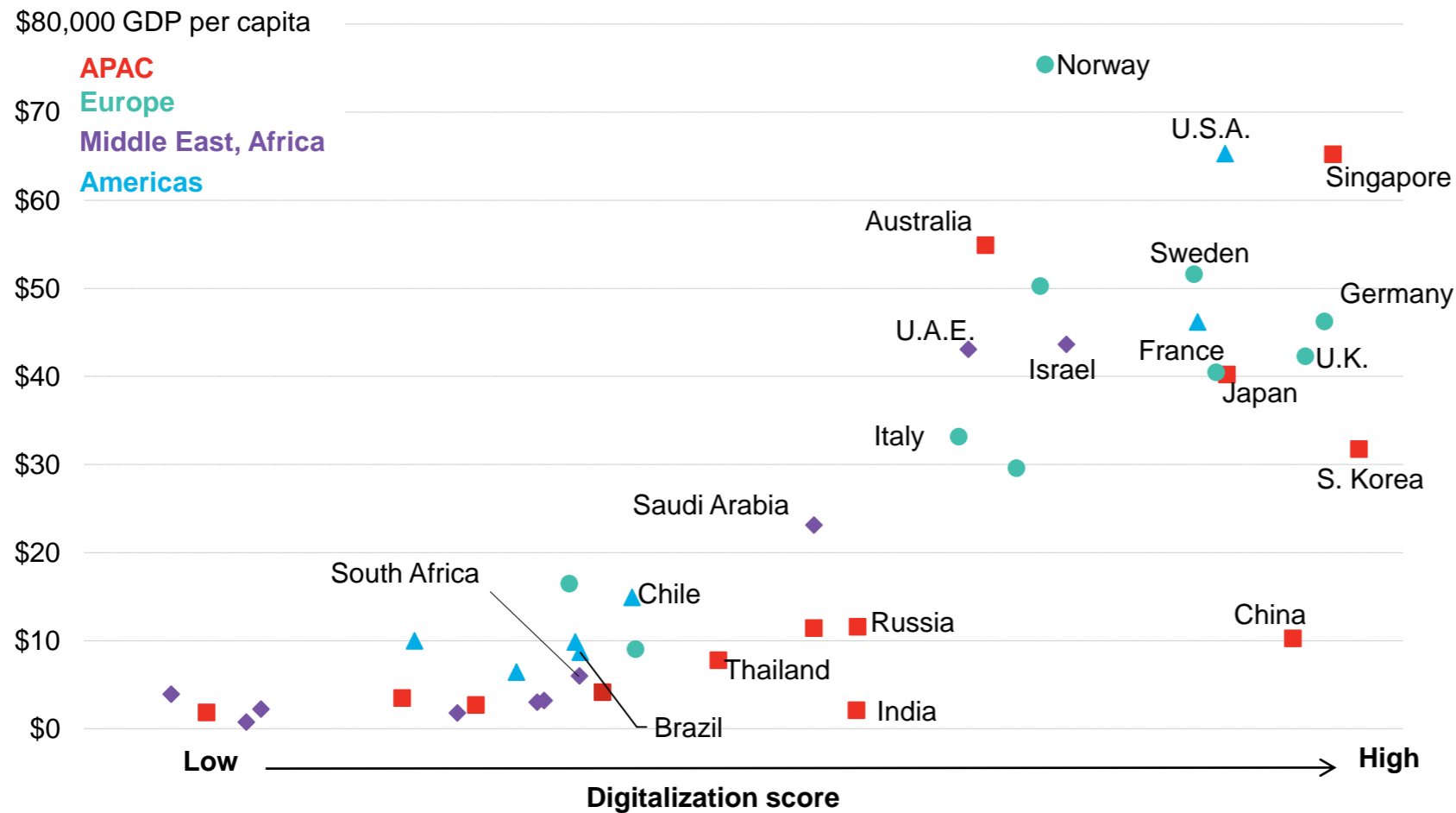
Some oil and power companies are selling software to customers and peers

However, a few oil and gas companies have indicated significant profits or winning business models from software sales.

South Korea, Singapore, and Germany top the national digitalization ranking



BloombergNEF 2020 country digital score and GDP per capita



BloombergNEF's annual country digitalization ranking measures current and future potential for digitalization of industries and workforces

The ranking uses a range of public and proprietary data sets to determine which country has the strongest digital policies, industrial policies, innovation schemes, startup communities, R&D hubs and education environments.

South Korea, Singapore and Germany top BNEF's 2020 national industrial digitalization ranking

Since our last review in 2019, leading countries have used policy to formalize ties between digitalization and overall economic growth

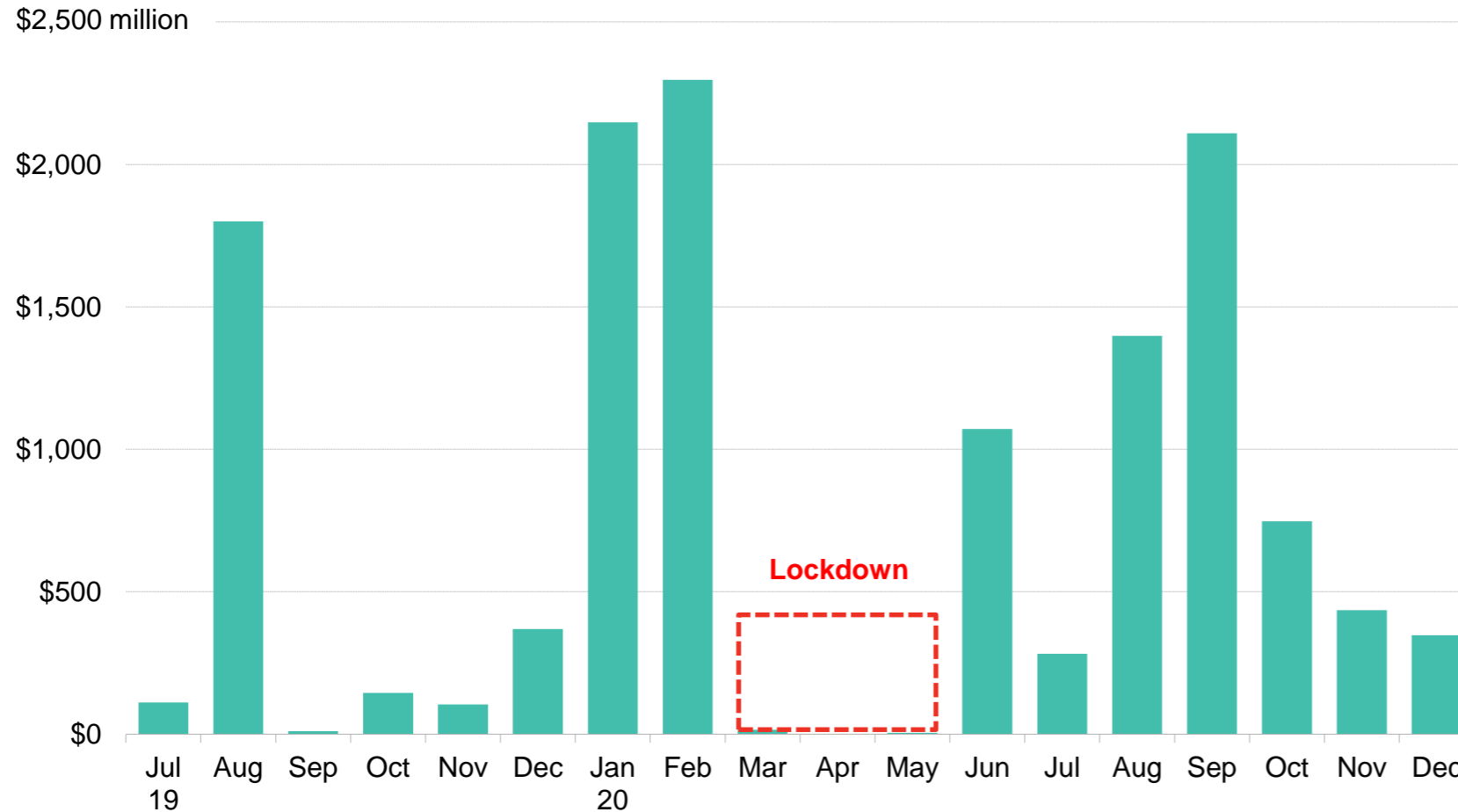
AI continues to attract the most policy attention

Covid-19, however, disrupted some countries' progress and ambitions

Covid-19 paused circular economy investment – but it did not kill it



Announced public investment in the circular economy



Companies were still getting to grips with their circular economy targets when Europe and North America went into their first lockdowns.

Consumer demand was a major factor in diminished investment

Uncertainty about demand for sustainable products, and about oil prices, halted most public investment in recycling, sustainable materials, and circular technologies.

That uncertainty passed by June 2020

As uncertainty passed, companies announced ambitious new circular economy targets, with funding to match.

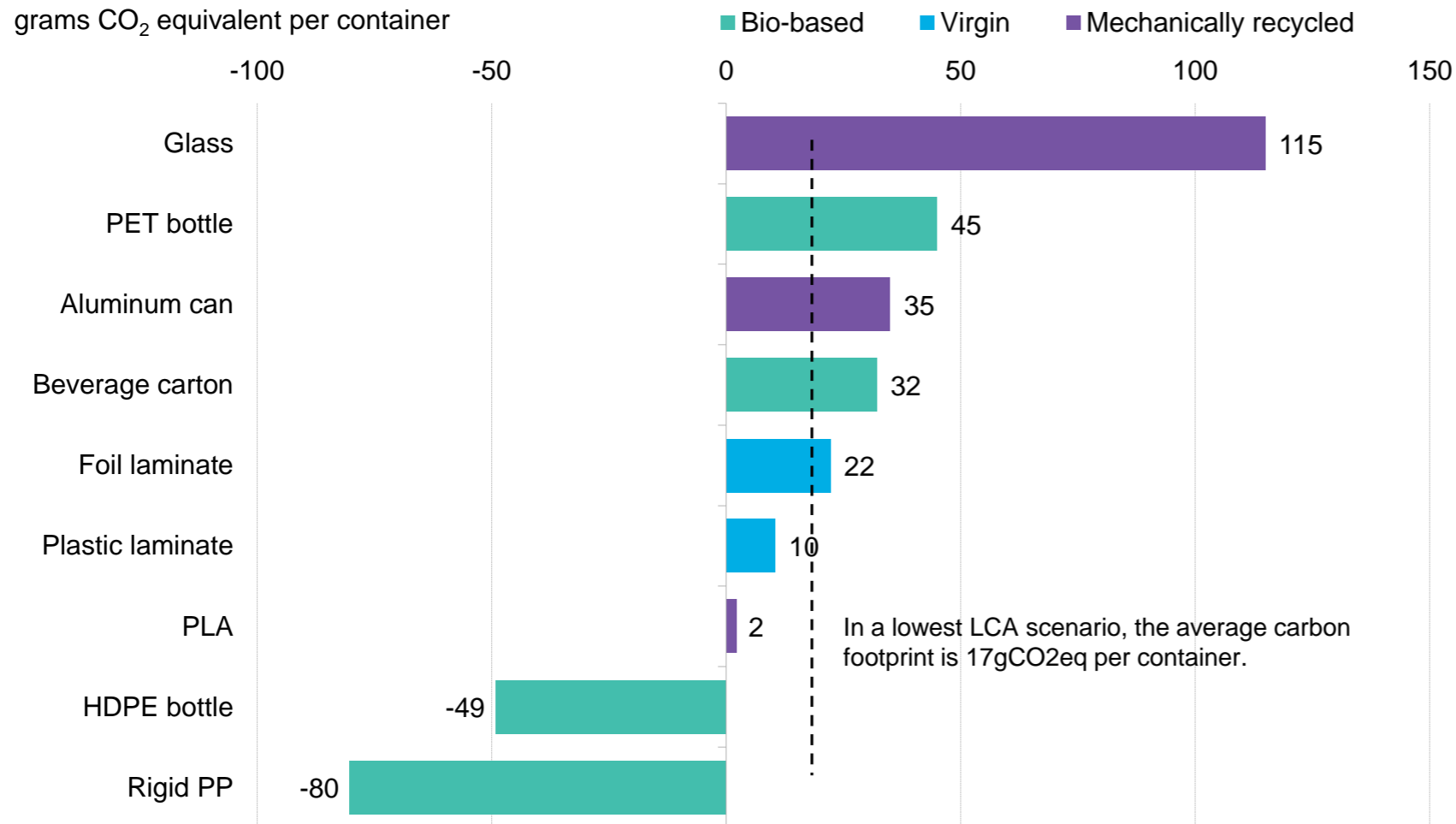
Disruption to waste supply chains may mean some targets are delayed, but there are no signs of them being scrapped.

Source: BloombergNEF

Plastic packaging can win the low emissions race, but only if it is bio-based



CO₂ footprint of packaging in a 'lowest life cycle analysis' scenario



Bio-based packaging can have negative carbon dioxide emissions

Doing so, however, requires optimization.



More-recycled items have larger carbon footprints

100% recycled glass and aluminum have larger footprints than plastic, but are more commonly recycled than plastics, which have recycling rates as low as 10%.

Companies aiming for sustainable packaging must prioritize

Companies have two choices to make: targeting emissions to meet a net-zero target, or targeting proper disposal to address the plastic waste crisis.

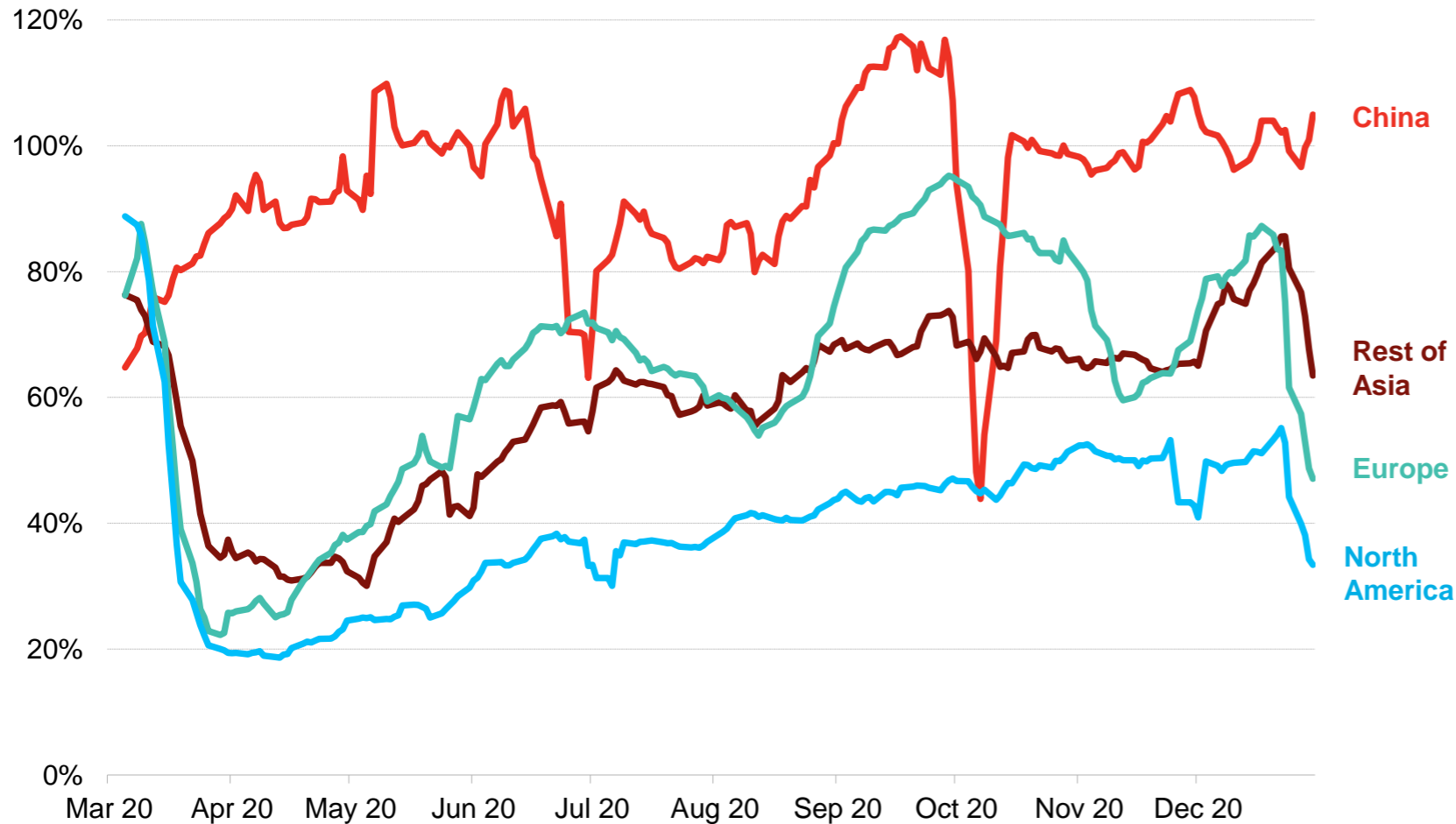
Table of contents

	Introduction: A Cleaner Future	3
	Power	23
	Transport	42
	Industry, Buildings, and Digital	52
	Commodities	68
	Food and Agriculture	82
	Capital	88
	About BNEF	97

China road travel is back above pre-pandemic levels, while it has not recovered elsewhere



Road congestion index by country



The post-pandemic recovery in road traffic has been uneven

Congestion levels quickly recovered in China and some parts of Europe and South East Asia following the lifting of lockdowns in early 2020, but the recovery has been uneven and volatile with restrictions re-imposed in many cities throughout the year.

U.S. has lagged behind other regions

The notable laggard is the U.S., with road congestion in major cities recovering to only half of pre-pandemic levels on average.

Relationship between congestion and road fuel demand is non-linear

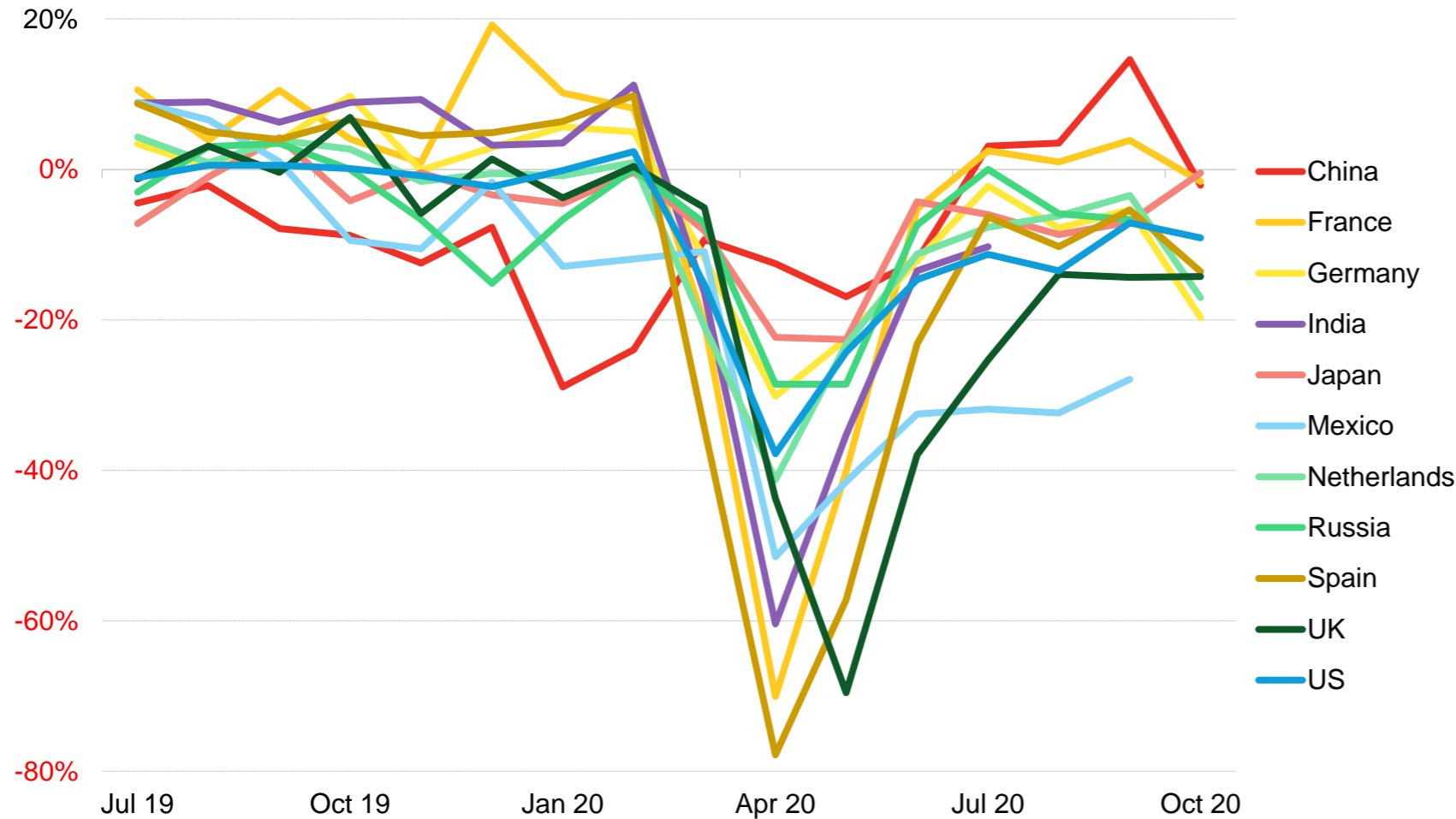
It's clear from the data on road fuel consumption that the relationship between urban congestion and gasoline and diesel demand is non-linear. U.S. gasoline consumption has significantly recovered, but the absence of traffic indicates that journeys outside of cities have increased.

Source: TomTom Traffic Index

Gasoline demand recovery is incomplete



Monthly gasoline demand, year-on-year change



Recovery in road fuel demand is incomplete

Gasoline demand has recovered from the worst impact of lockdowns in early-2020, but consumption levels remain below normal in almost all countries.

Subsequent lockdowns had a lesser impact than the first spring lockdown

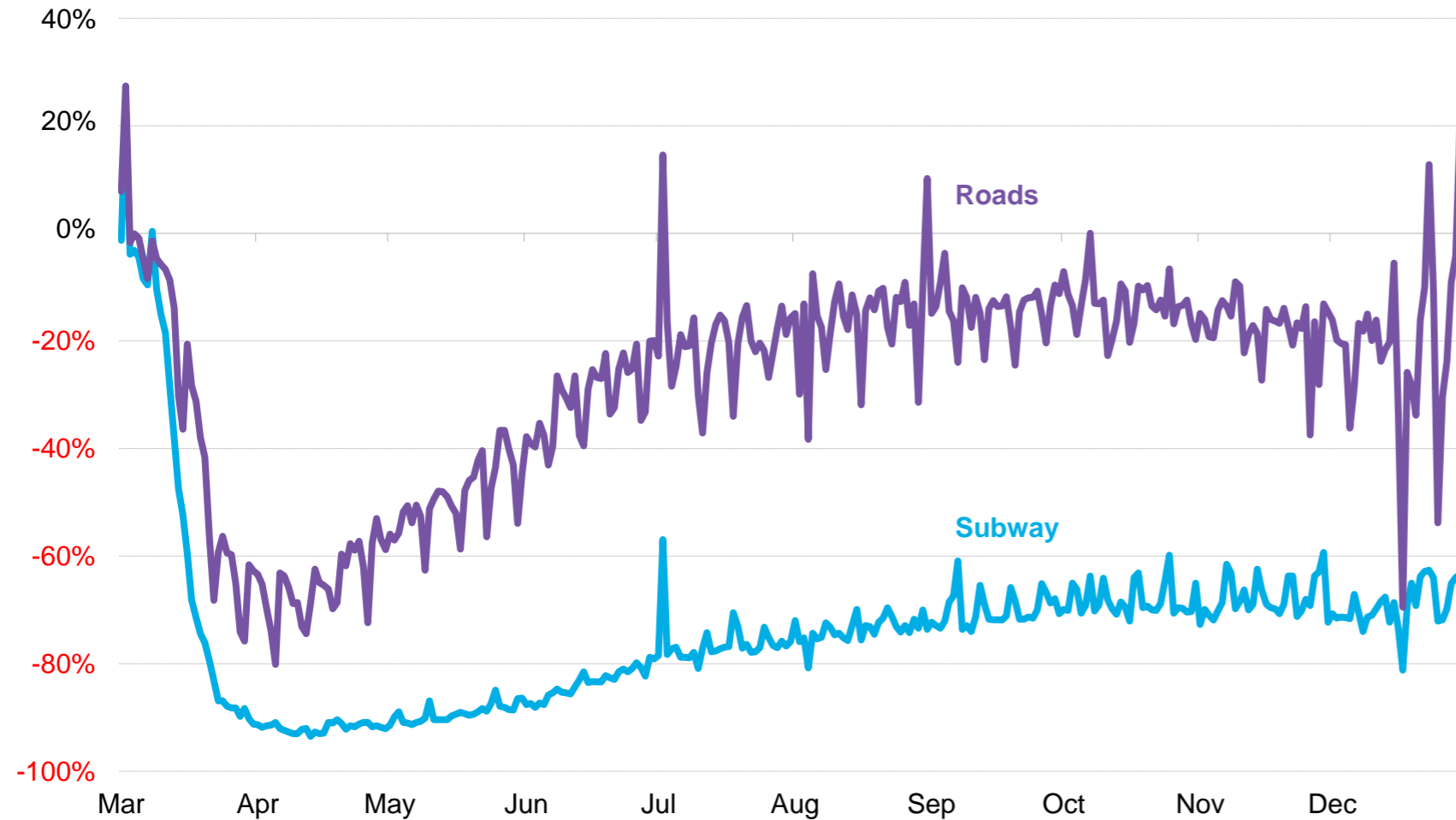
Although lockdowns were re-imposed in many countries throughout 2020, it is clear from the data that the impact of these subsequent restrictions were less severe for road fuels demand than the initial lockdown in the spring.

Source: JODI

Transit and driving patterns diverged in 2020



New York City traffic, 2020% of equivalent day in 2019



Workers yet to return to the office

A clear trend that is visible across all major cities is an increase in road traffic ahead of the recovery in passenger number on mass transit. Empty trains and buses are one of the clearest reminders that workers are yet to return to the office in significant numbers.

Social distancing concerns to boost gasoline demand in the near-term

Where workers are embarking on the commute, concerns over social distancing are encouraging people to switch from mass transit to cars, either private or shared vehicles, which is likely to boost road fuel demand in the near-term.

Mass transit passenger numbers are a key indicator of the return to 'normal'

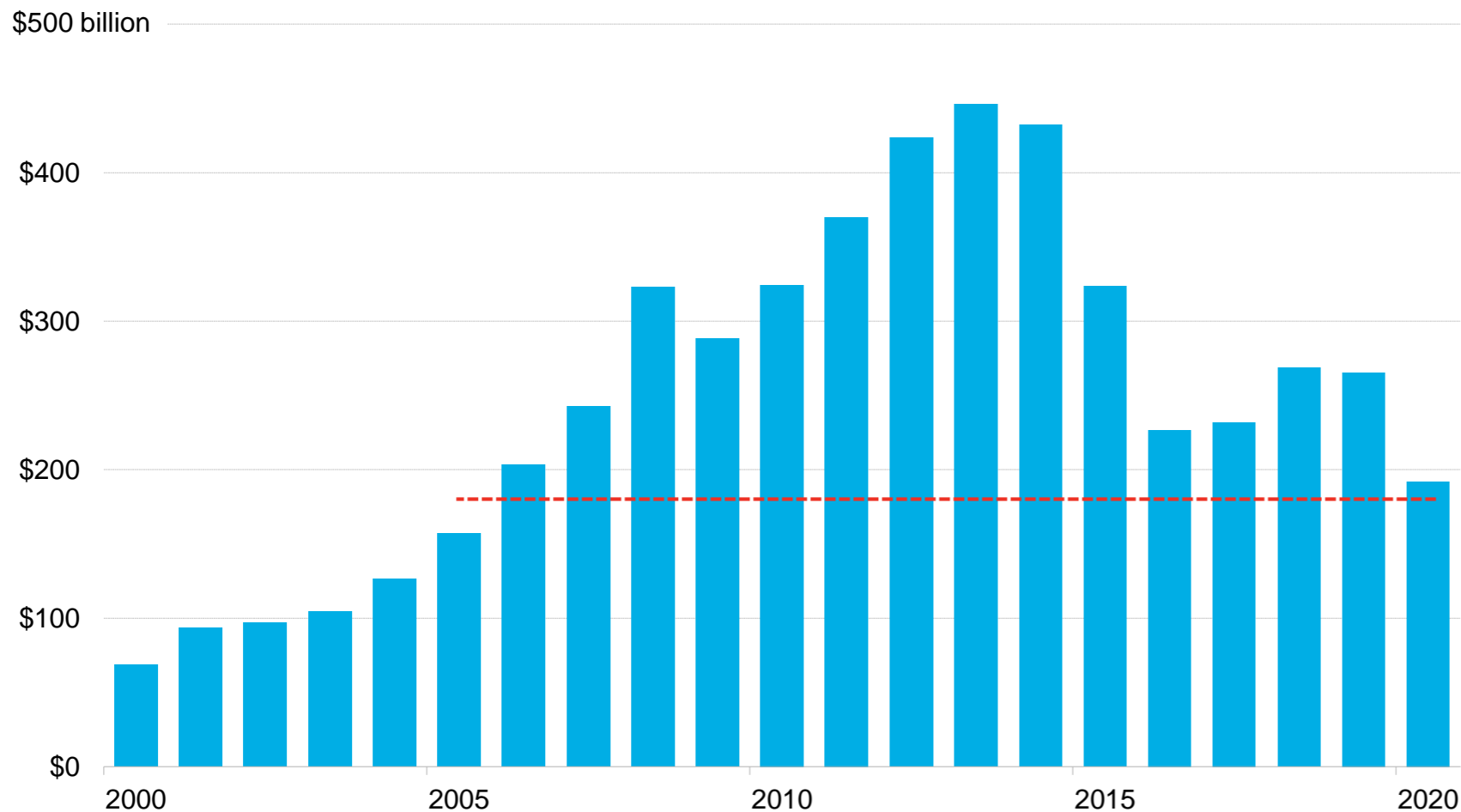
As the post-pandemic recovery plays out, one of the clearest indicators of 'normality' will be the trend in train and bus passenger numbers. If journeys bounce back to pre-pandemic levels it will signal a return to business-as-usual, but if they don't it could signal a 'new normal' for commuting and working patterns.

Source: New York City MTA [link](#). Note: "roads" are bridge and tunnel traffic readings.

Publicly listed oil company capital expenditures are back to the levels of the mid-2000s



Publicly listed oil company annual capex



Decline in oil sector capex shows companies have reigned in ambitions

Oil sector capex, predominantly exploration and development of upstream production, fluctuates with the oil price cycle. But the boom times of the late 2000s/early 2010s are clearly over. As companies recalibrate to a 'lower forever' mindset on oil prices, large high-risk upstream capital projects are becoming a thing of the past.

Ceding ground to NOCs

An unavoidable consequence of the decline in upstream investment from the independent sector is a ceding of market position and future revenues to state-owned producers.

Sowing the seeds of the next cycle

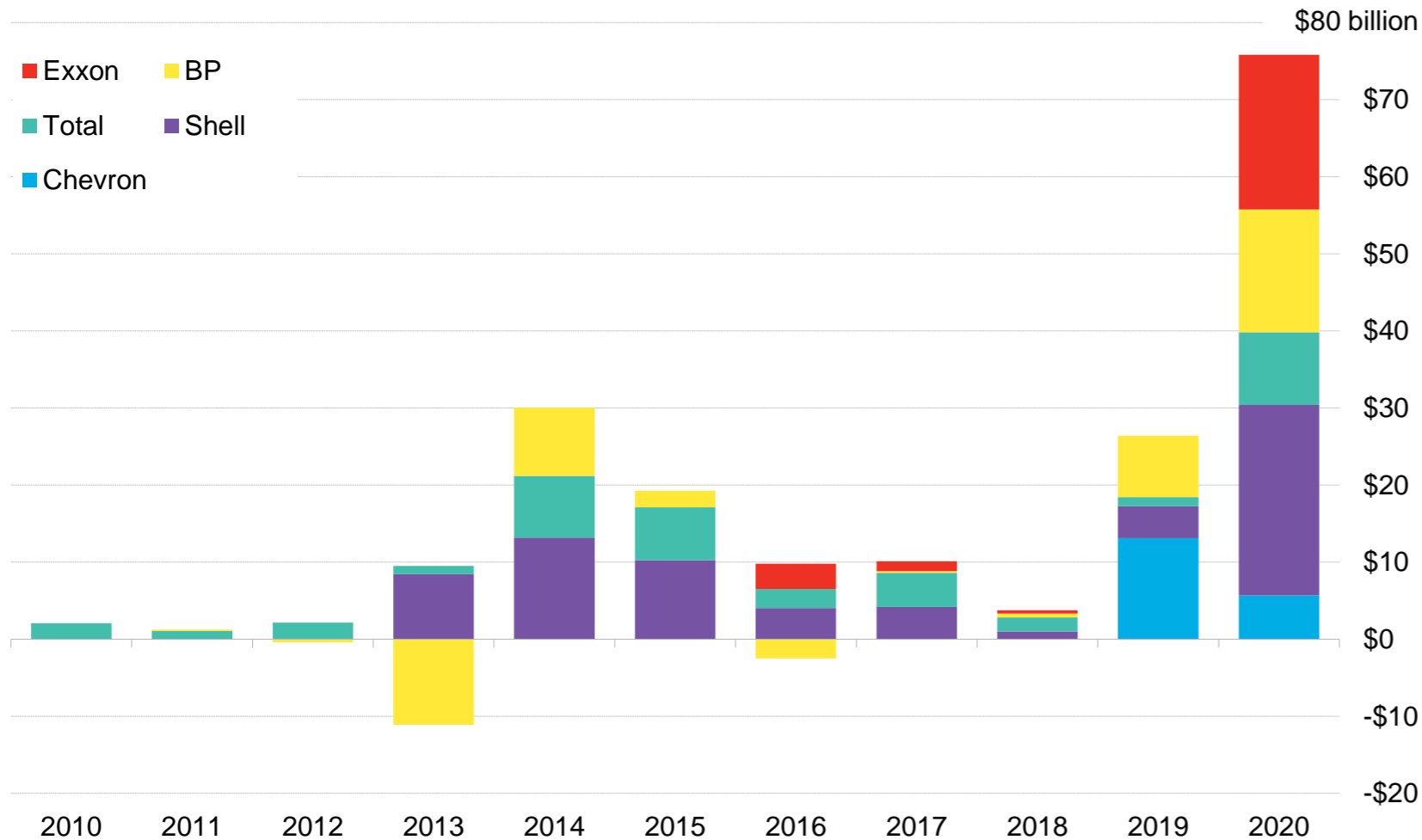
Furthermore, the pullback from upstream investment may sow the seeds of the next upswing in oil prices, putting the majors in a difficult position as they risk destroying value in their oil and gas businesses by pivoting too quickly to clean energy.

Source: Bloomberg

Oil and gas supermajors had a record amount of asset impairments in 2020



Oil and gas supermajors annual asset impairments



Record write-downs to chasten the majors

Changes in the outlook for oil and gas prices are reflected in asset impairments that hit the profitability of oil companies during downturns. 2020 has been a brutal year in this respect, with a record level of write-downs wiping almost \$80bn from the balance sheets of the big five oil majors.

This time is different

The write-downs reflect a fundamental change to the outlook, not only for oil and gas prices, but for the strategic direction of the majors that are looking to consolidate their core businesses around their best quality assets.

On a more solid financial footing

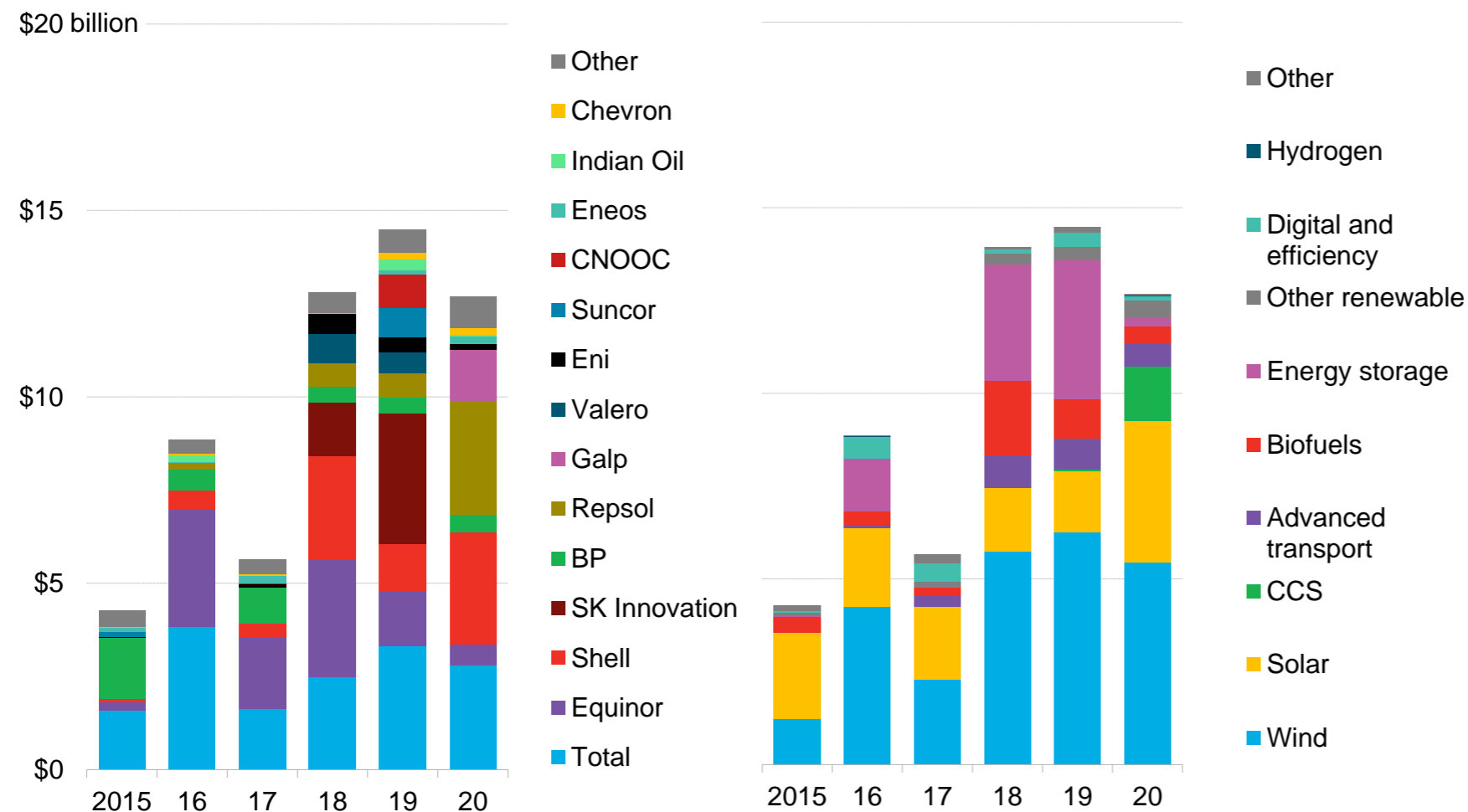
2020 was a good time for the majors to bury bad news, with write-downs taken on some assets that were arguably long over-due. Where this leave the majors, however, is on a more sound financial footing, which should assist profitability ratios.

Source: BloombergNEF. Note: does not include Exxon's \$19.3 billion impairment announced in February 2021.

Oil company energy transition capital expenditure fell in 2020



Oil company energy transition capital expenditure



Oil and gas sector clean energy investment held up well despite large cuts in overall capex

Investment by the oil and gas sector in low-carbon assets and technologies totaled \$11.3 billion in 2020, 17% lower than 2019. This compares to an estimated 20% decline in total capital expenditure across the industry.

Investment activity is heavily concentrated

Since 2015, Total, Equinor, Shell, BP and Repsol have accounted for over 70% of low-carbon investment.

There is a long, long way to go

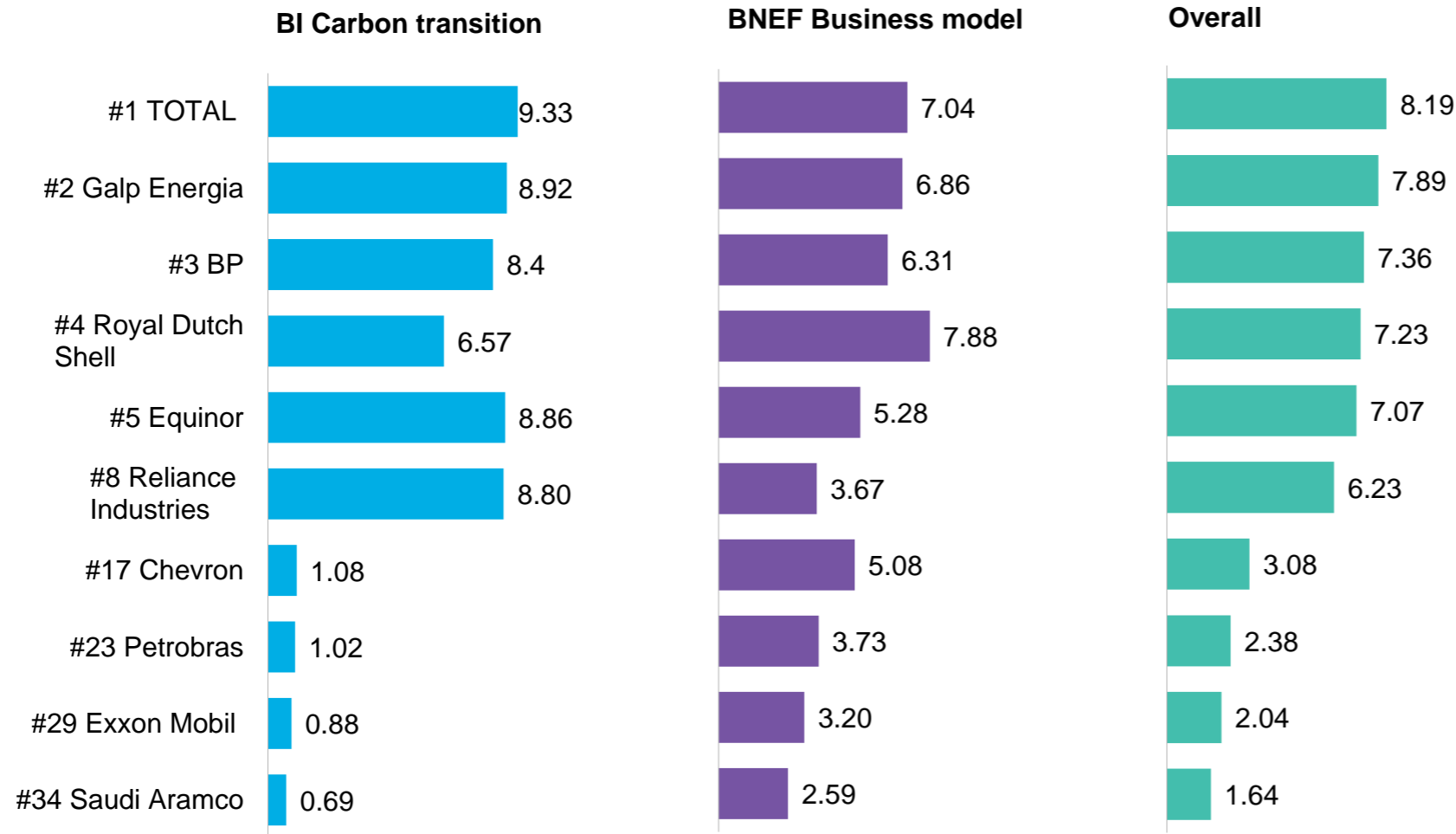
As it stands, the energy transition is a growing investment trend for the sector, but there is a long way to go before dollars spent reach a level sufficient to steer the oil and gas sector meaningfully toward a low-carbon future. The share of total oil and gas sector capex spent on low-carbon investments in 2020 was 4.3%.

Source: BloombergNEF

Bloomberg Climate Transition Scores track and rank company activities in energy transition



Bloomberg Climate Transition Scores



Bloomberg Climate Transition scores are a new collaboration between BloombergNEF and Bloomberg Intelligence

Scores shine a light on energy companies' actual energy transition activities, an area where public disclosure is lacking and greenwashing is rife.

Scores rely on proprietary, bottom-up data

BloombergNEF has leveraged data including its renewables, CCUS, hydrogen and battery storage project databases to rank company transition.

European oil majors have the highest scores

Total, Galp Energia, BP and Shell have the highest combined scores, ranking both carbon transition and business model.

U.S. and Middle Eastern companies have the lowest scores

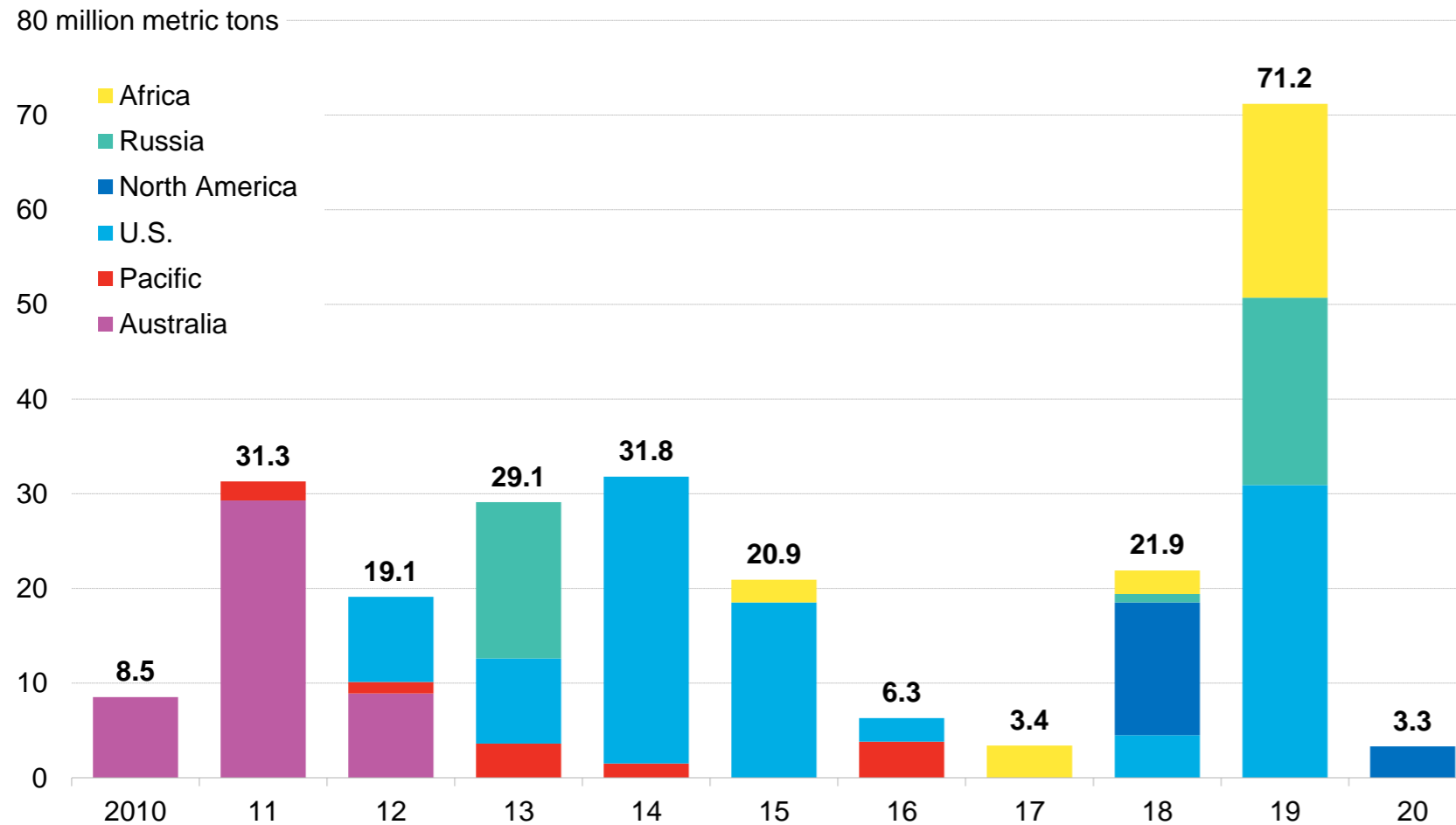
Exxon Mobil and Saudi Aramco both rank low on carbon transition, in particular.

Source: Bloomberg Intelligence, BloombergNEF

A record amount of liquefied natural gas capacity was approved in 2019, followed by a record low in 2020



Liquefied natural gas plant final investment decisions



A record 71 million tons of new LNG capacity was approved in 2019

The U.S. had the most approved capacity in 2019, followed by Russia and countries in Africa.

The oil price collapse meant almost no capacity was approved in 2020

Oil's Covid-19 performance removed any momentum from final investment decisions underway in 2020.

One project was approved in Mexico

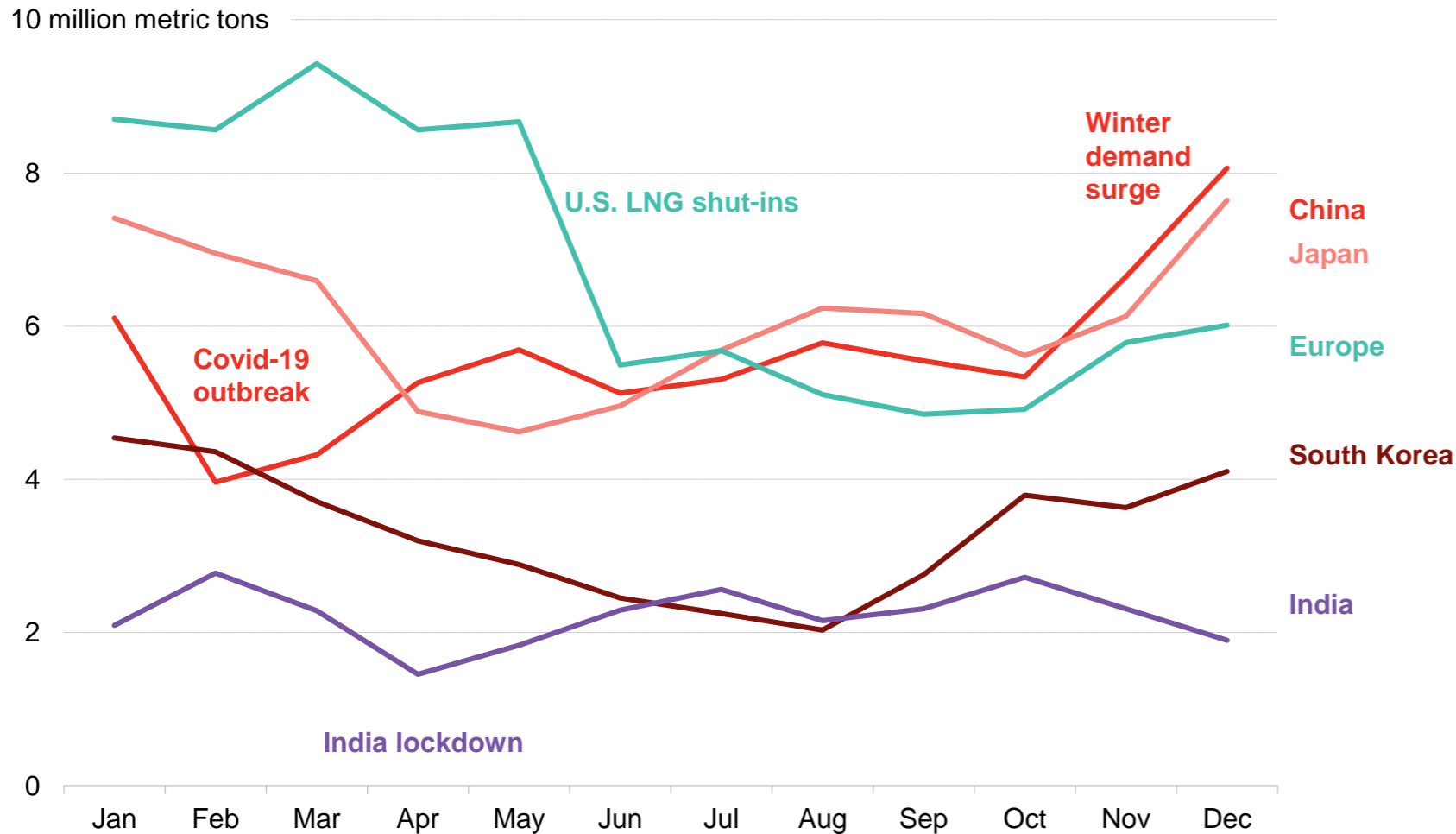
The Energia Costa Azul project is scheduled to come online in 2024.

Source: BloombergNEF

Covid-19 and a cold winter impacted LNG imports in 2020



LNG import in major markets



Covid-19's demand destruction meant that Asia imports fell in early 2020

China imports, which fell first, were also the first to recover.

U.S. exports were curtailed in early summer

As a result, European imports fell significantly.

Intense cold in early winter drove up imports almost everywhere

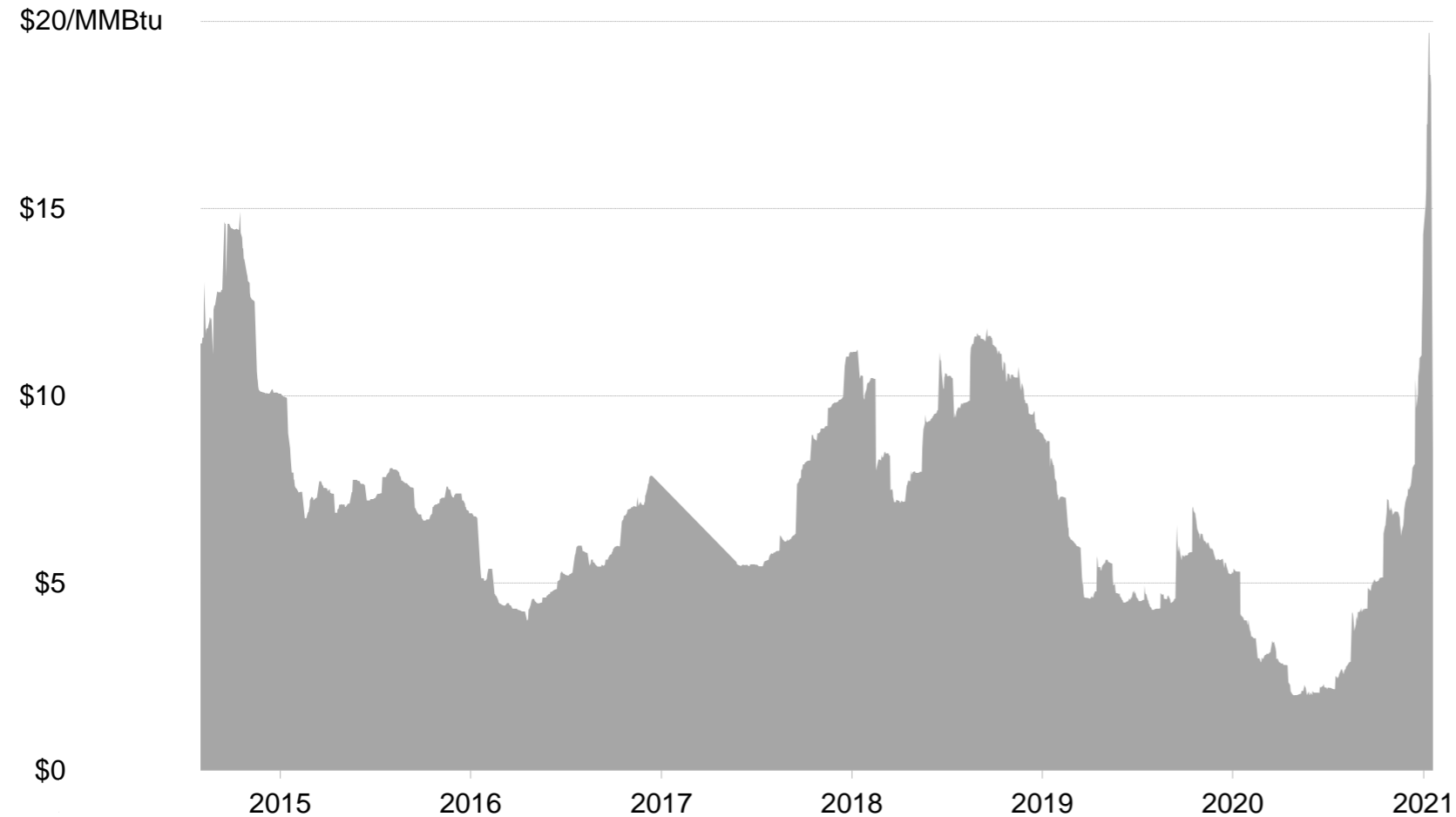
The only exception is India, where price sensitivity meant that as North Asia and Europe bid up prices, its own imports fell.

Source: BloombergNEF

LNG spot prices hit a record low in summer 2020, and hit a record high in early 2021



LNG Japan-Korea Marker (Platts) Swap futures



Asia LNG cargoes had a wild ride in 2020 and early 2021

The Japan-Korea Market spot price is the benchmark for Asian LNG prices.

Asia LNG prices hit a record low in the summer of 2020

Spot prices were as low as \$2 per million British Thermal Units.

Prices then soared in late 2020 due to extreme cold in North Asia and Europe

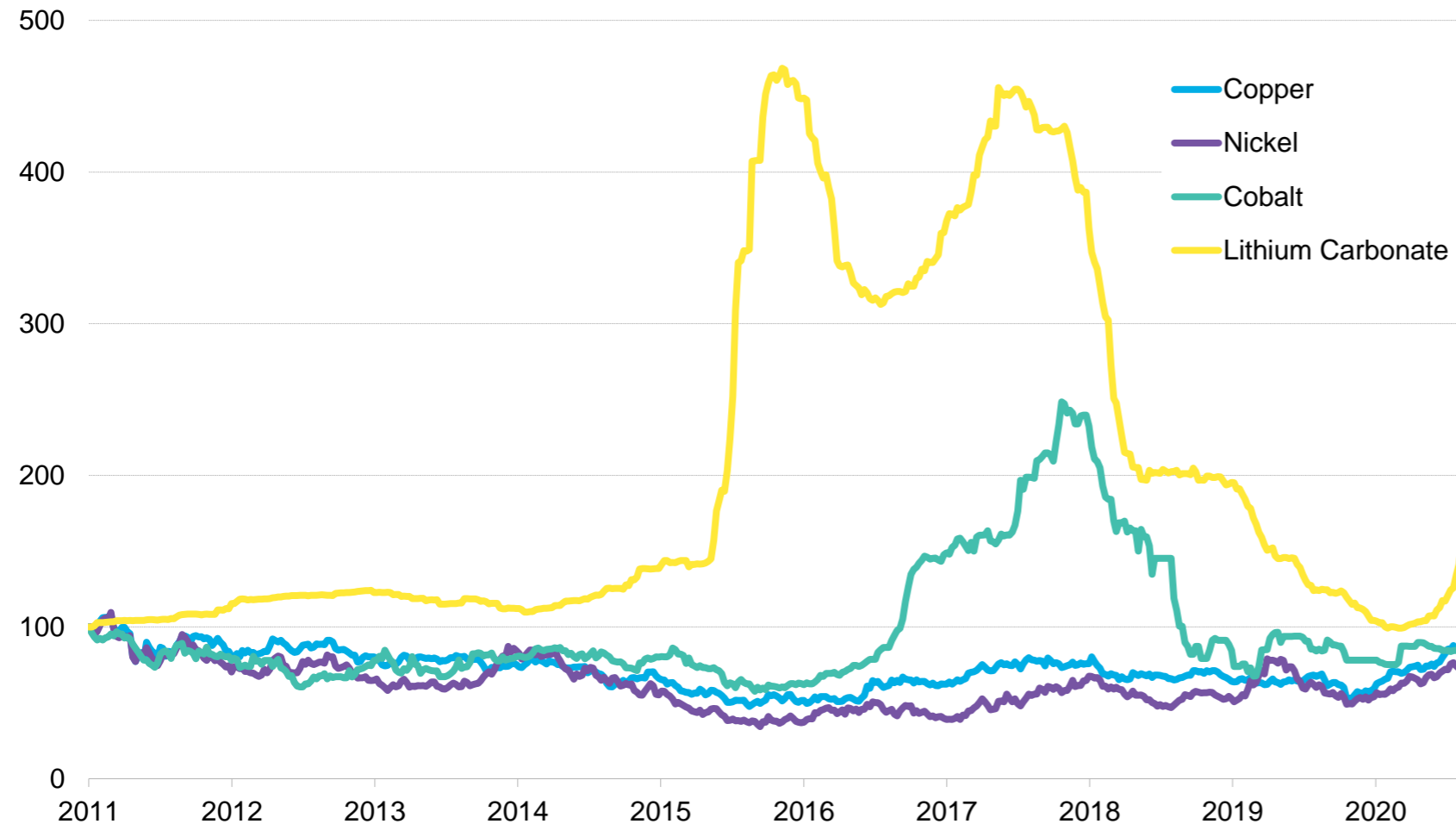
Market players scrambled to find cargoes for delivery, driving spot prices to nearly \$20/MMBtu. Bloomberg News reported one cargo sold for nearly \$40/MMBtu

Source: CME, BloombergNEF

Lithium and cobalt prices spiked last decade, while copper and nickel prices fell



Key energy transition metals prices, rebased June 2011=100



Lithium had several boom and bust cycles in the past decade

Lithium carbonate prices rose more than 400% from 2011 to 2016, fueled by optimism about booming demand from electric vehicles. Prices fell, rose, fell, and finally rose again in late 2020.

Cobalt had a similar, though less pronounced boom in 2016-18

Cobalt prices, which fell from 2011 levels through 2016, more than doubled from late 2016 to early 2018.

Copper and nickel prices were lower at the end of the decade than the beginning

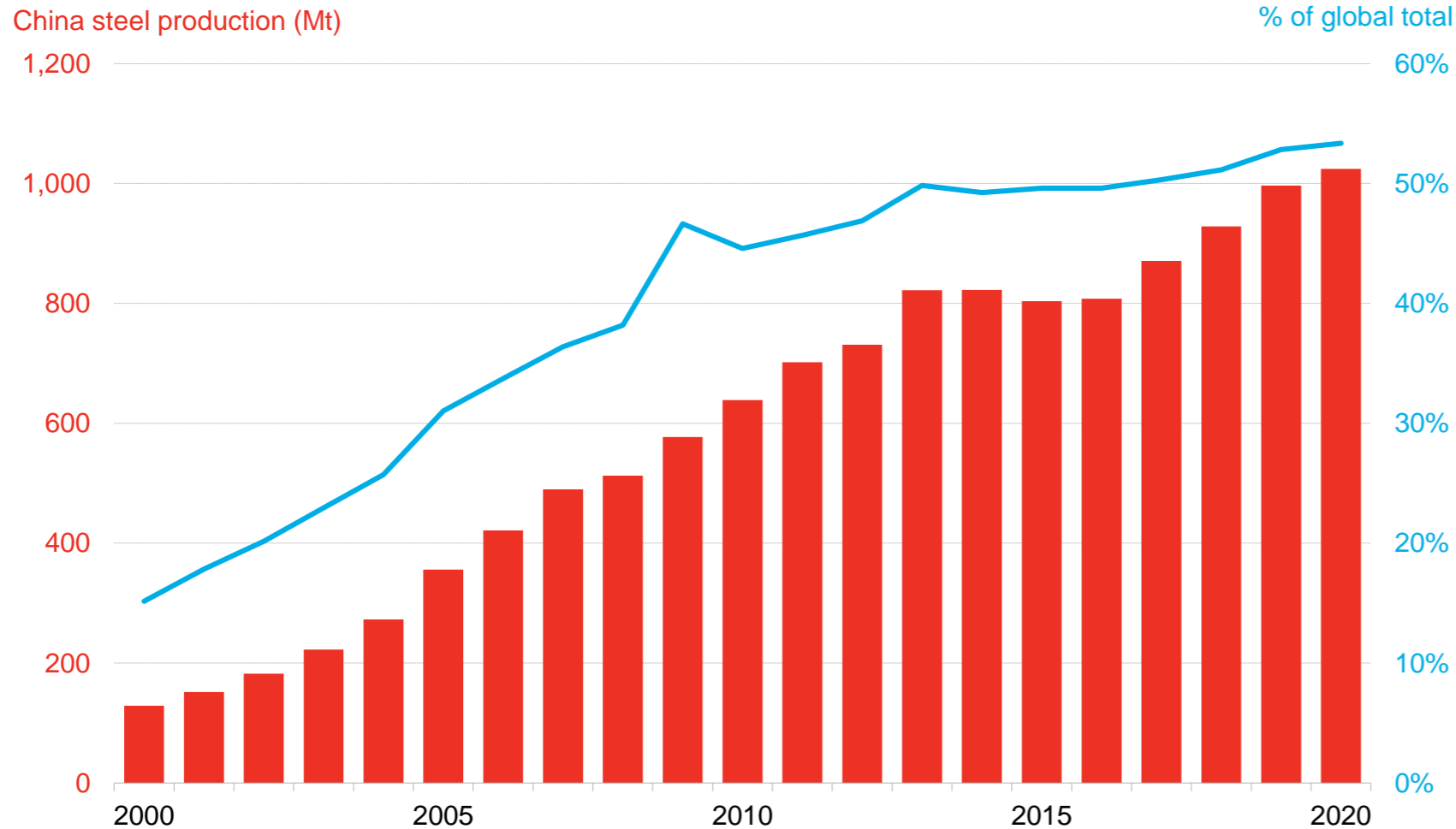
Prices began to rise again in the end of 2020, though are still below where they began the decade.

Source: Bloomberg

China produced more than one billion tons of steel in 2020



China steel production in global context



Global steel production has more than doubled this century

Production reached more than 1.9 billion tons in 2020, up from 849 million tons in 2000.

China is 53% of world steel production, producing more than a billion tons of steel in 2020

China production increased from 129 million tons in 2000 (less than European production of 195Mt), to 1.024 billion tons in 2020.

Without China's production increase, global production grew only 6% in two decades

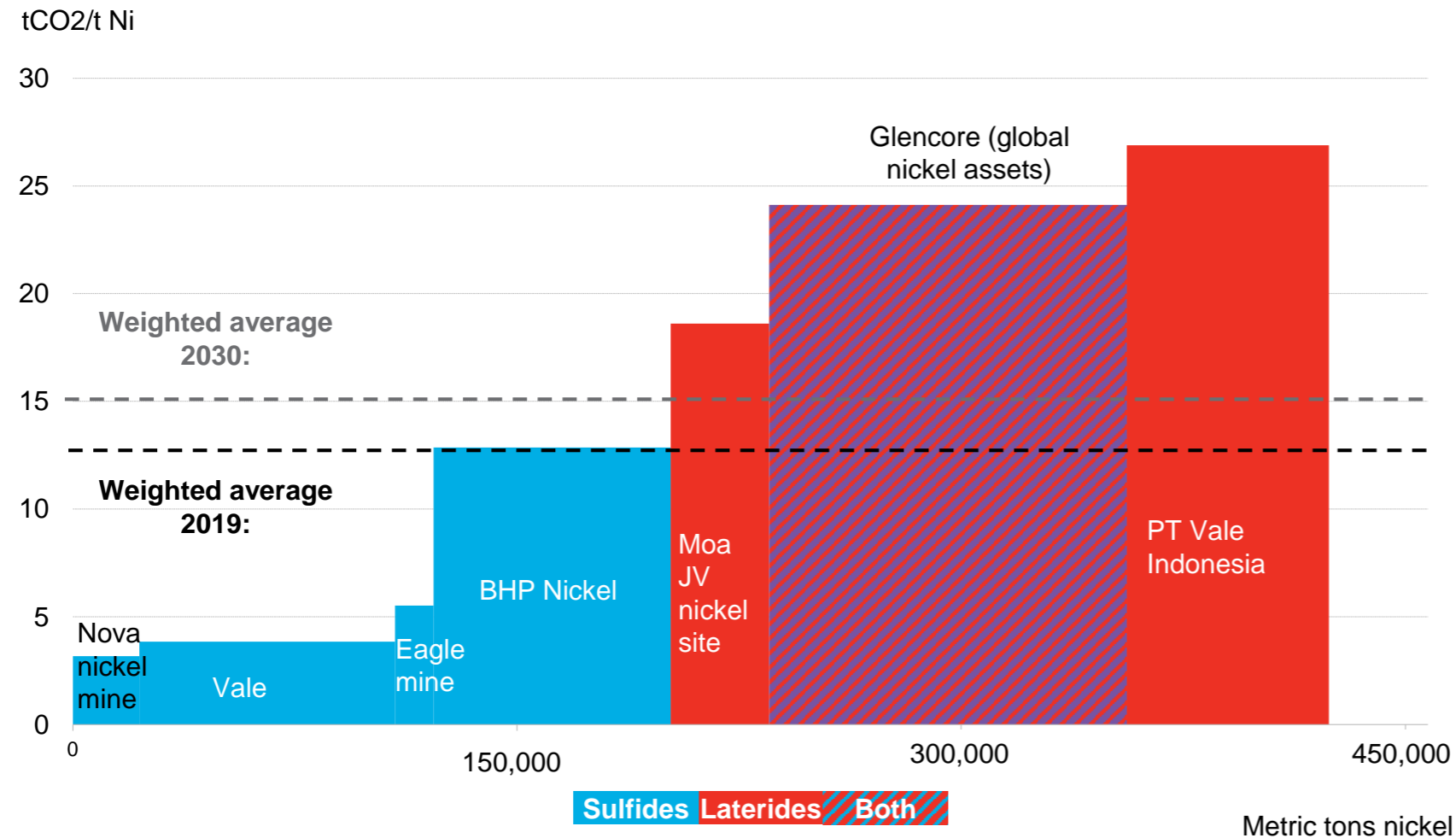
Leaving aside China's production growth, global steel production increased to 896Mt from 2000 to 2020.

Source: BloombergNEF

The carbon intensity of nickel production varies greatly depending on resource and location



Carbon intensity of select global Class 1 nickel producers, 2019



Nickel producers have a very wide range of carbon intensities

The highest- and lowest-intensity nickel producers vary in carbon intensity by a factor of 8.5.

Sulfide-based production has the lowest carbon intensity


Sulfide-based production has the lowest carbon intensity, lower than laterite-based production or blended production.

Producers in the U.S., Australia, and Canada have the lowest carbon intensity

Production in Indonesia has the highest carbon intensity of the Class 1 nickel market.

Source: BloombergNEF

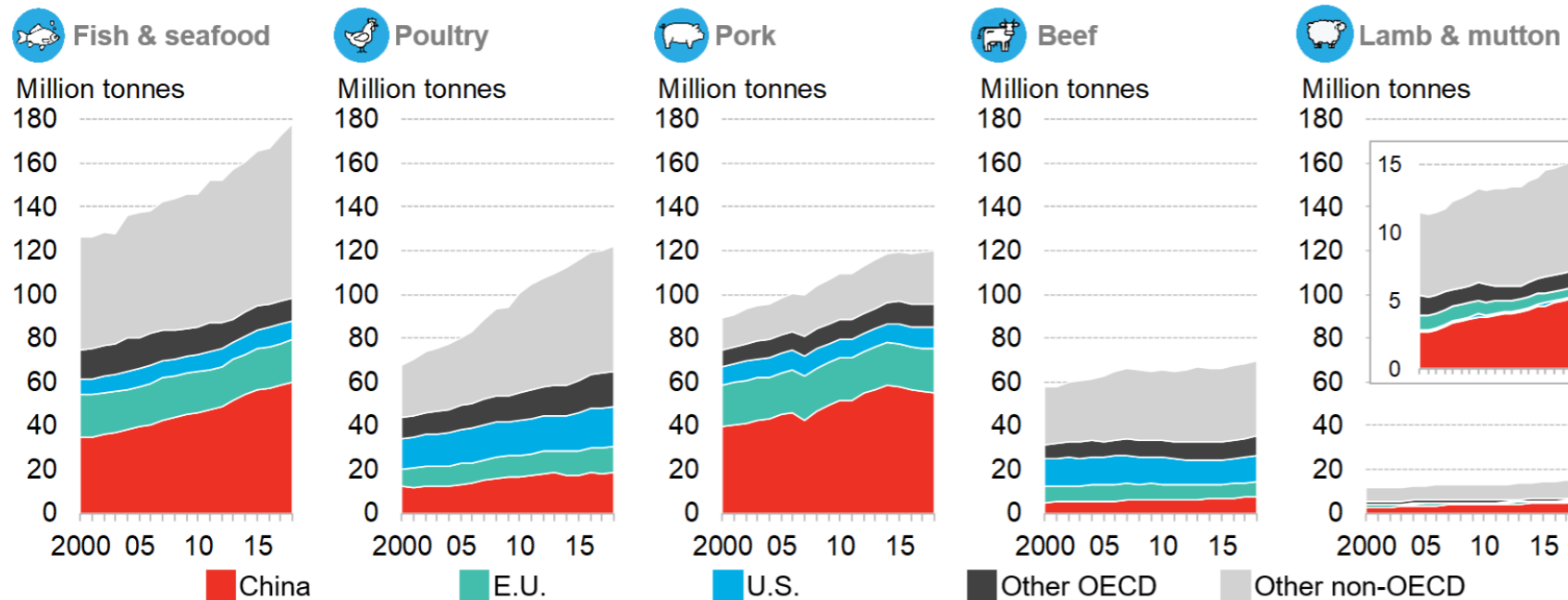
Table of contents

	Introduction: A Cleaner Future	3
	Power	23
	Transport	42
	Industry, Buildings, and Digital	52
	Commodities	68
	Food and Agriculture	82
	Capital	88
	About BNEF	97

The world's appetite for meat is growing, but beef consumption is nearly flat



Global meat consumption by retail weight



Growing appetite for meat among emerging economies has pushed meat consumption to new highs

Growth over last two decades was fueled by China and other emerging economies where meat consumption rapidly expanded in the first decade of the third millennium.

The growth of the 2000's is unlikely to be repeated

The next wave of countries to reach middle-income – mostly Asian and Latin American nations -- either do not eat much meat traditionally or have smaller populations than countries that emerged at the beginning of this millennium, most notably China.

Emerging economies consume fish, poultry and pork in greater quantities than other meats

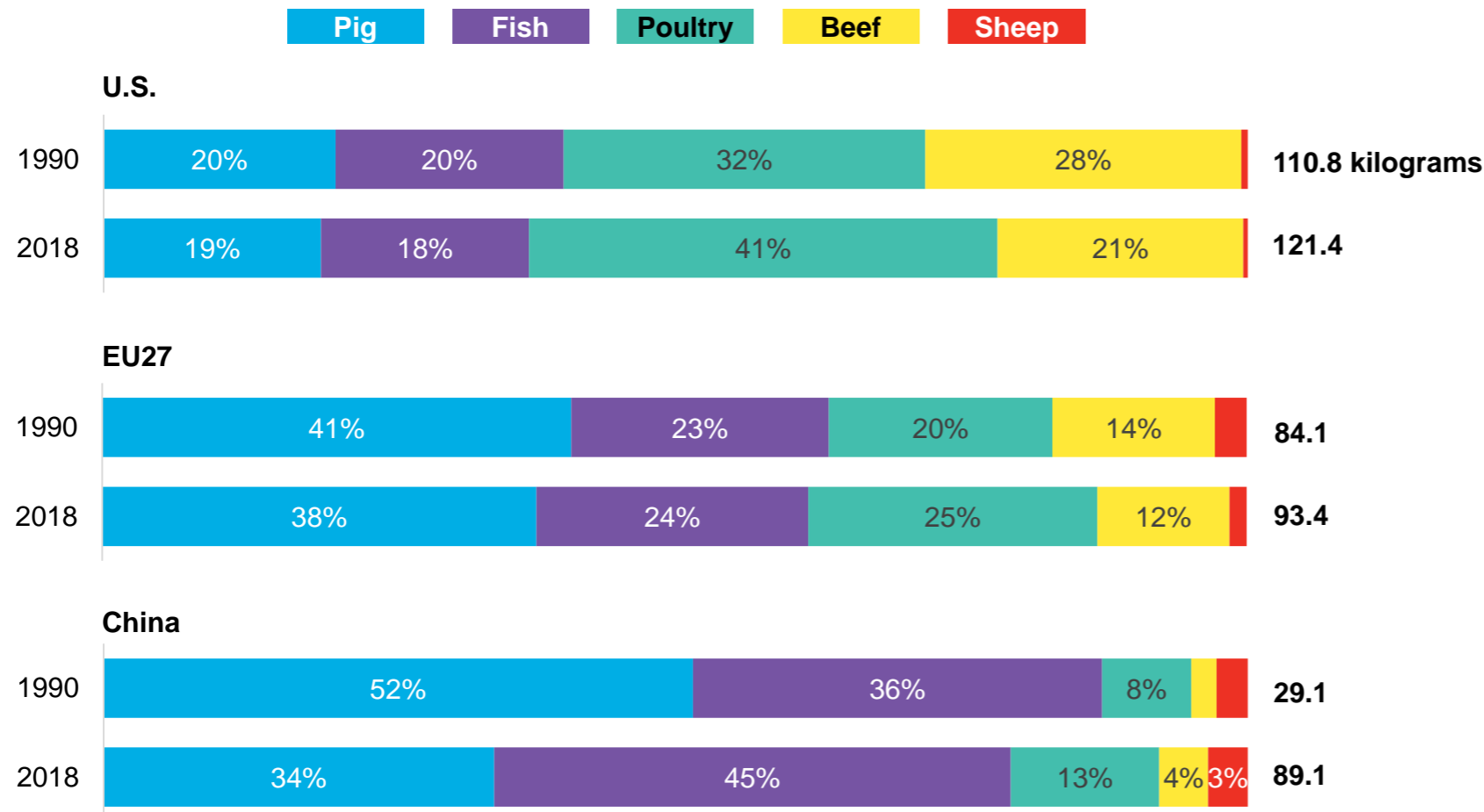
Poultry is also capturing most of the growth in meat demand in developed countries. Beef demand is flat or declining in OECD countries, while growth in pork demand since 2000 is under 1%.

Source: BloombergNEF, OECD. Note: 'Other OECD' excludes U.S. and all E.U. members including non-OECD nations (Bulgaria, Croatia, Cyprus, Malta, and Romania). 'Other non-OECD' excludes China.

Meat consumption patterns differ widely between major economies



Change in animal protein consumption in major economies (per person)



Europeans and Americans are consuming more poultry and less red meat than previous generations

The dietary shift complicates matters for suppliers of plant-based and cultured meats, most of which have so far focused on displacing red meat.

Poultry is cheaper and perceived as healthier

Chicken is easier to mass produce at a lower unit cost than other livestock. It is also less dependent on regional climate or land availability; chickens can be produced in indoor controlled environments.

Chinese diets now contain more seafood than any other type of meat

Seafood intake increased 68% in China from 2000 to 2018, displacing pork. Poultry and beef consumption in China also increased as diets diversified.

Substitution of poultry for livestock is likely to continue

OECD projections imply the trend will slow, but long-term data suggests meat consumption and substitution patterns are enduring.

Source: BloombergNEF, OECD Note: Charts not to scale in order to preserve detail. E.U. data not available prior to 2000.

Alternative meat performs significantly better than beef on emissions, land use, and water use



Environmental comparison per kilogram of beef burger

	Cultured	Plant-based	Livestock
Emissions, kgCO2e	2.07	3.51	32.46
ratio to cultured	-	1.7	15.7
ratio to plant-based	0.59	-	9.3
ratio to livestock	0.06	0.11	-
Land use, m2/year	0.21	2.63	33.33
ratio to cultured	-	12.5	159
ratio to plant-based	0.06	-	9.5
ratio to livestock	0.02	0.28	-
Water use, liters	444	9.65	1,916
ratio to cultured	-	0.02	4.3
ratio to plant-based	127	-	546
ratio to livestock	0.23	0.01	-

Alternative meat performs better than meat from livestock in emissions, land use and water use

According to Good Food Institute, meat from livestock has nearly ten times the amount of emissions as plant-based meat and more than fifteen times the amount as cultured meat. Plant-based and cultured meats also perform significantly better in terms of land and water use.

Environmental standings remain consistent regardless of study

Although life-cycle assessments for meat vary by methodology and assumptions from study to study, the difference in land use, water use and emissions are so great that tweaks to methodology or assumptions are unlikely to alter the standings.

Some cultured meat is not considered vegan or vegetarian

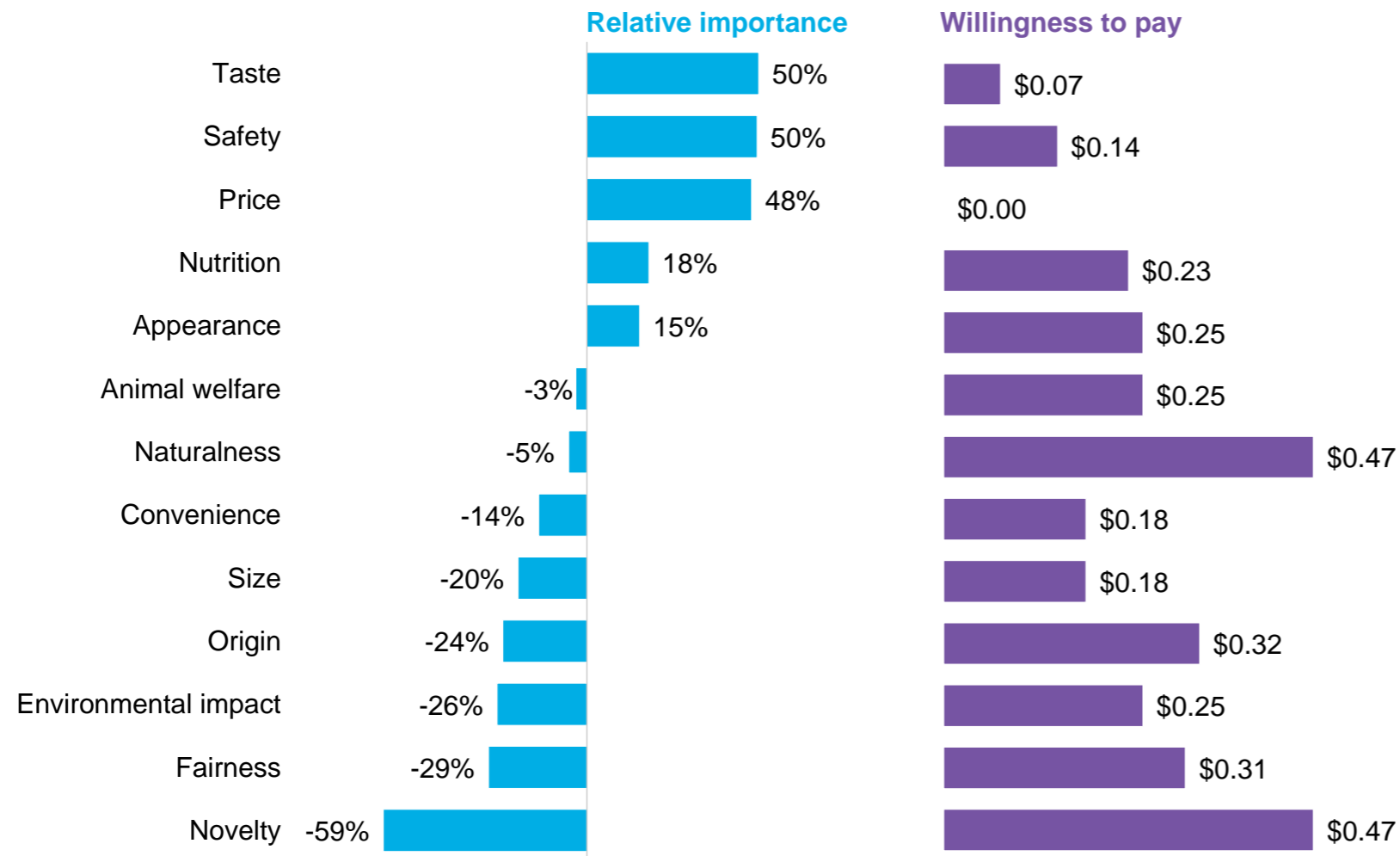
Most cultured meat companies initially used fetal bovine serum (FBS) as part of their production process, although some have moved away from it altogether. FBS comes from slaughtered pregnant cows, and as such, is not generally considered vegan or vegetarian.

Source: Good Food Institute, BloombergNEF

Perceived value determines consumer decisions about buying meat



U.S. consumers' relative importance and willingness-to-pay when buying chicken



In affluent countries, meat choice is driven by perceived value

In OECD countries, consumers' decisions are driven by a desire to purchase fresh and tasty protein at an affordable price.

While consumers in developing countries prioritize perceived food safety and religious beliefs

Quality and value are secondary considerations in developing markets, and externalities such as the environmental footprint and animal welfare are rarely top considerations of consumers.

In the US, taste, safety and price are most important drivers of poultry choice

Aspirational factors such as animal welfare and environmental impact and novelty (eg, not previously tried) were self-reported to be less important than more basic factors.

But consumers are willing to pay more for aspirational drivers

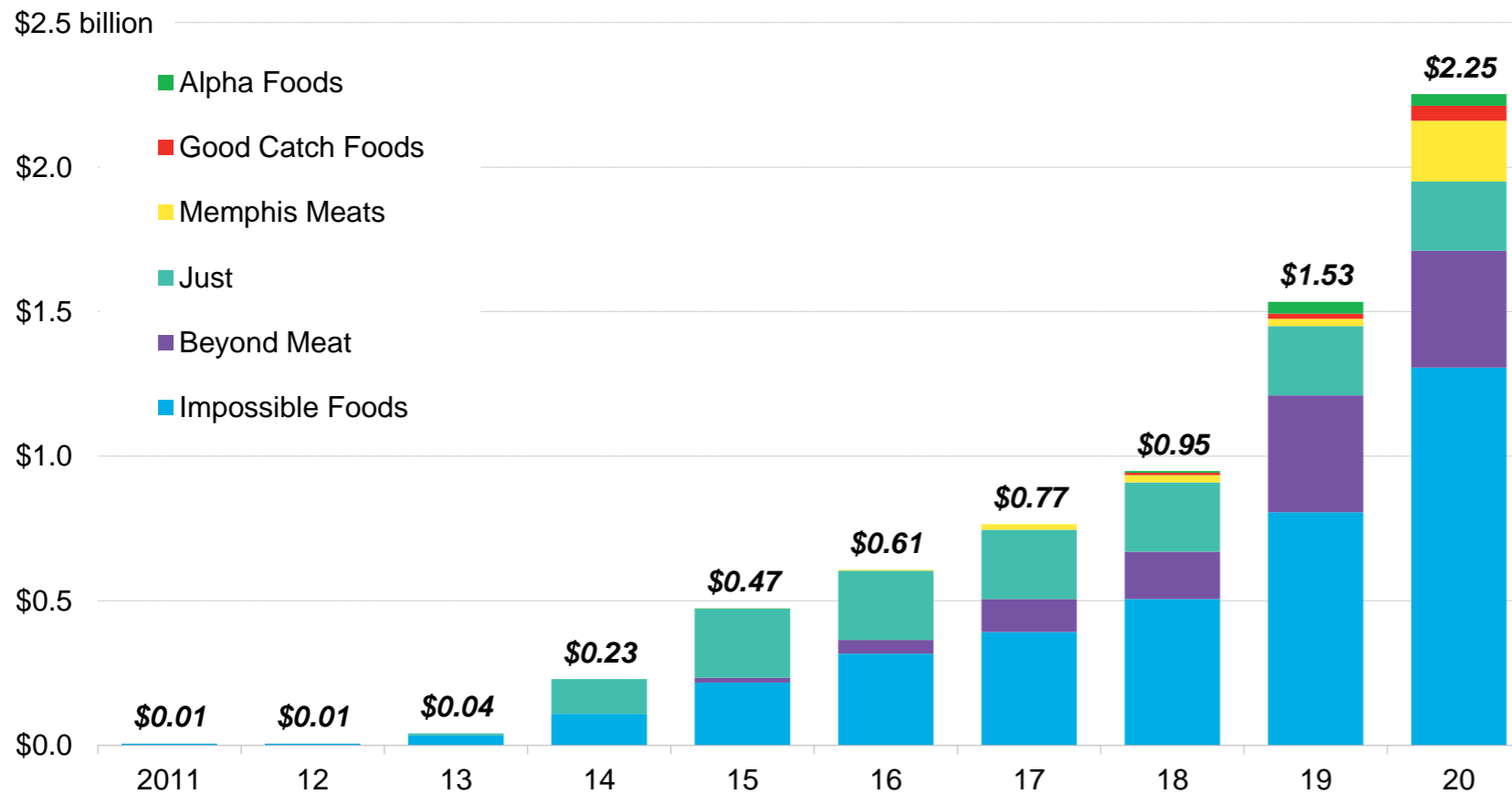
Non-GMO and Organic were among the most important labels to consumers. However, these labels were less important than a prominent brand name on the product.

Source: Lusk, J (2018), BloombergNEF. Note: results of control group shown.

Alternative protein companies have raised more than \$2 billion since 2011



Cumulative fundraising of leading alternative protein companies



Source: CB Insights, BloombergNEF. Note: includes companies with cumulative funding over 50 million USD. Includes only funding disclosed in the public domain, excluding corporate acquisitions.

Cumulative investment in the six largest alternative protein companies reached \$2.25bn in 2020

The largest cohort of investment (43%) came from private individuals and celebrities including Jay-Z, Jeff Bezos, Serena Williams, and Bill Gates.

Impossible Foods received 58% of the \$2.25bn

Despite being the last of the major alternative protein suppliers to enter the retail space, Impossible Foods has raised the most money. Their strategy has focused on curating interest from top chefs and high-end restaurants rather than the retail market.

Go-to-market strategies amongst top suppliers vary greatly

While Impossible Foods targeted restaurants and large chains, Beyond Meat went after the retail market. It sold in over 6,000 locations before the launch of its flagship product, the Beyond Burger. Its 2019 IPO raised \$240 million and was the best performing IPO over \$200 million since 2008. Impossible Burger remains private. It raised \$500m in its last funding round in March 2020.

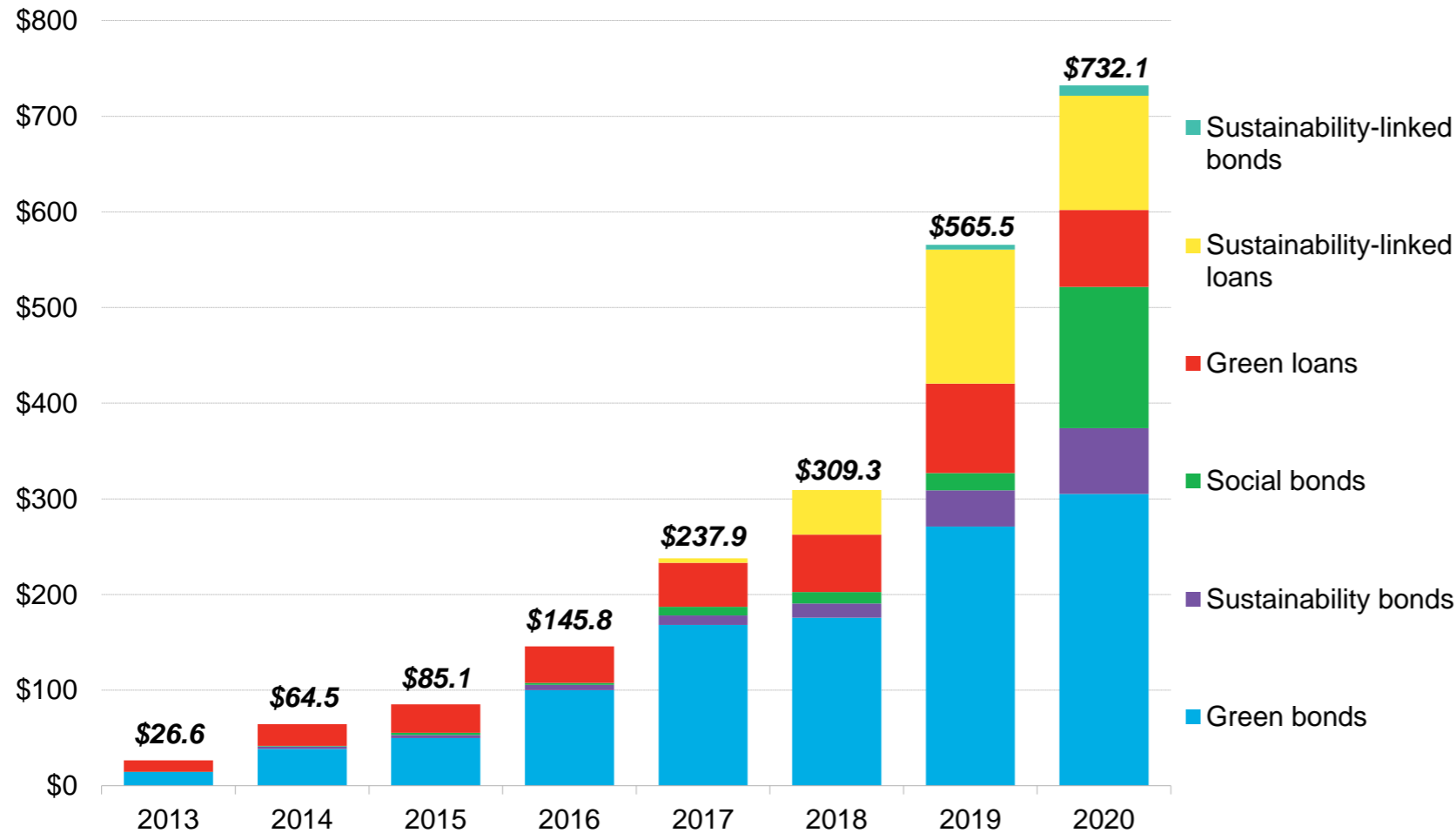
Table of contents

	Introduction: A Cleaner Future	3
	Power	23
	Transport	42
	Industry, Buildings, and Digital	52
	Commodities	68
	Food and Agriculture	82
	Capital	88
	About BNEF	97

Companies and institutions raised \$732 billion of sustainable debt in 2020



Sustainable debt issued by instrument type (\$ billion nominal)



Companies and governments raised \$732 billion in sustainable debt in 2020

That is more than \$160 billion above 2019's issuance, an increase of 29% year-on-year.

As the market grows, it is expanding in scope

Sustainable debt in the early part of the decade was almost entirely activity-based green bonds, specific to assets or projects.

Today, sustainable debt includes activity- and behavior-based instruments

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

Social bonds had a record year, issuing almost \$150 billion

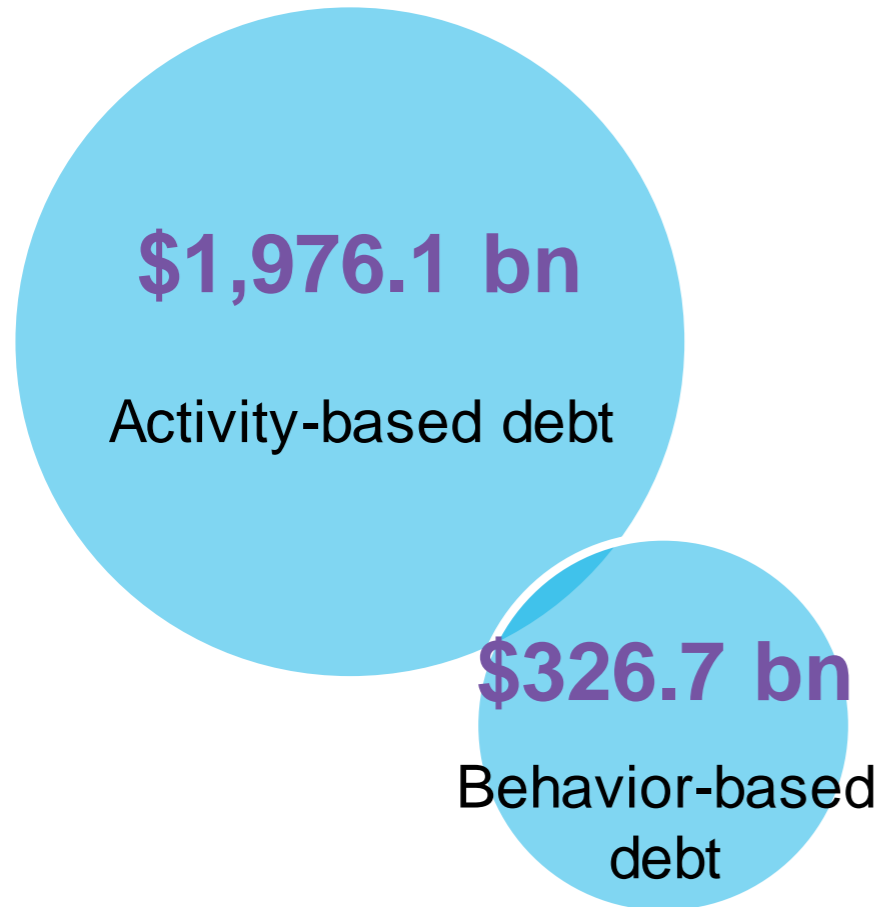
Sustainability bonds, green bonds, and sustainability-linked bonds also hit new records.

Source: BloombergNEF

Activity-based sustainable debt is the majority of the sustainable debt raised to date



Global activity-based and behavior-based debt market size, market inception through end-2020



Activity-based debt comprises 86% of sustainable borrowing

Debt instruments used to raise money for green projects or activities – termed “activity-based” – are the longest standing and still most popular style of borrowing.

Behavior-based instruments are on the rise

Instruments that are tied to sustainability targets of the issuer are called “behavior-based.” These sustainability-linked instruments came onto the scene first in 2017 and have grown quickly since. As of the end of 2020, nearly a third of a trillion dollars have been issued.

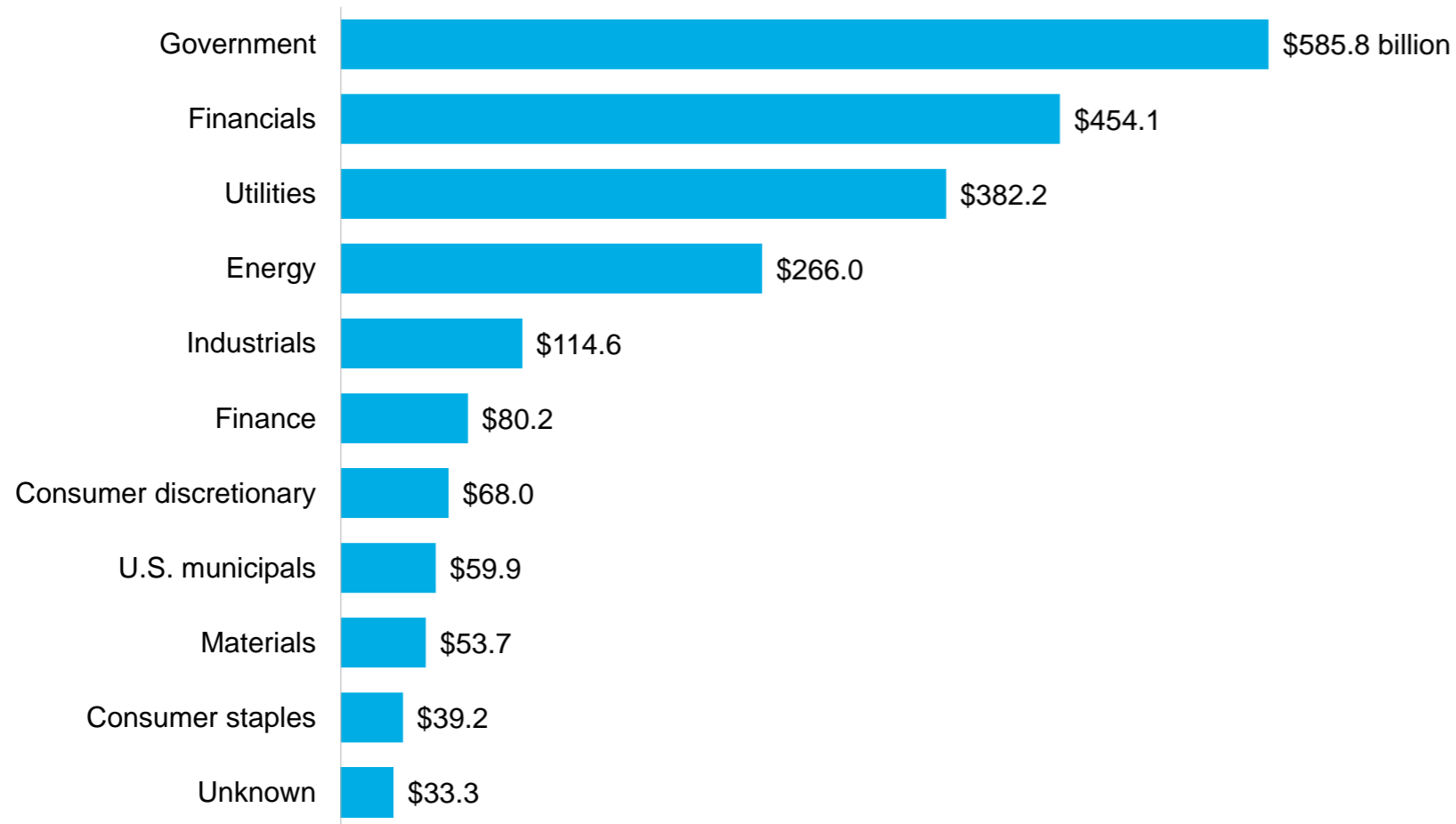
Sustainability-linked bonds are catching on

Nearly \$16 billion in these behavior-based bonds have been raised since they began in 2019. They are the newest of the sustainable debt themes.

Government agencies, financials, and utilities have issued the bulk of sustainable debt to date



Sustainable debt issued by issuer industry, global, 2012 to 2020



Government agencies, financial institutions, utilities, and energy companies are the largest issuers of sustainable debt

These four sectors have issued more than \$1.6 trillion in sustainable debt since 2012, with government the first sector to issue a half-trillion dollars cumulatively.

Other sectors are much smaller issuers to date

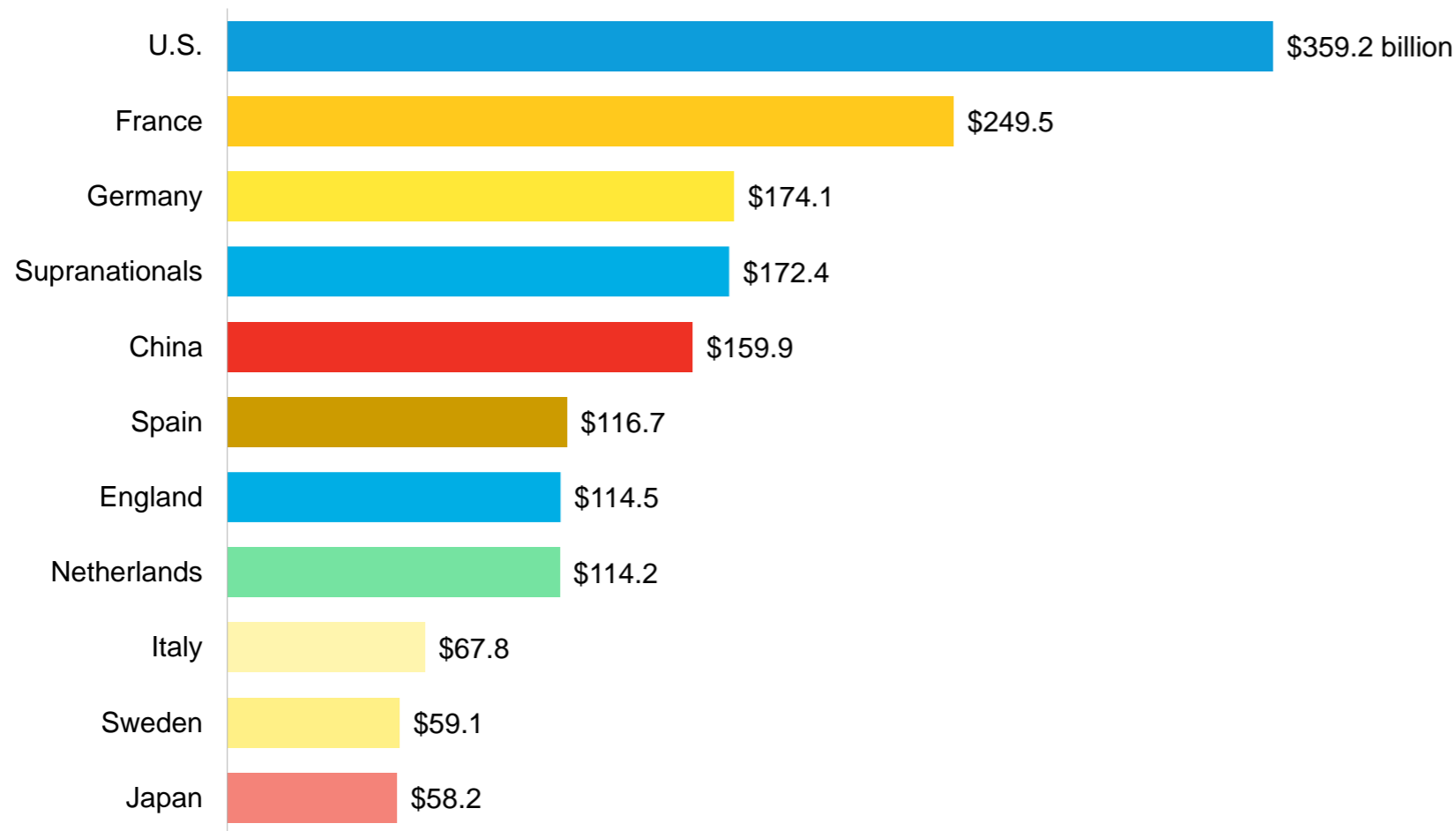
Consumer discretionary, materials, and consumer staples firms have together issued around \$160 billion in sustainable debt. U.S. municipals have issued more sustainable debt than materials companies.

Source: [BloombergNEF Sustainable Debt Data Hub link](#)

The U.S., France, and Germany are the biggest issuers of sustainable debt



Sustainable debt issued by issuer country, 2012 to 2020



The U.S. has issued the most sustainable debt to date

U.S. issuance of \$359 billion is more than \$100 billion greater than France. The U.S. market is boosted by substantial offerings from municipal bond and asset-backed security issuers.

China, which was the largest issuer in 2016, has slipped in cumulative ranking

China is now fifth in cumulative sustainable debt issuance, and has issued less than supranationals.

Japan is the only other country outside of Europe and the U.S. in the top rankings

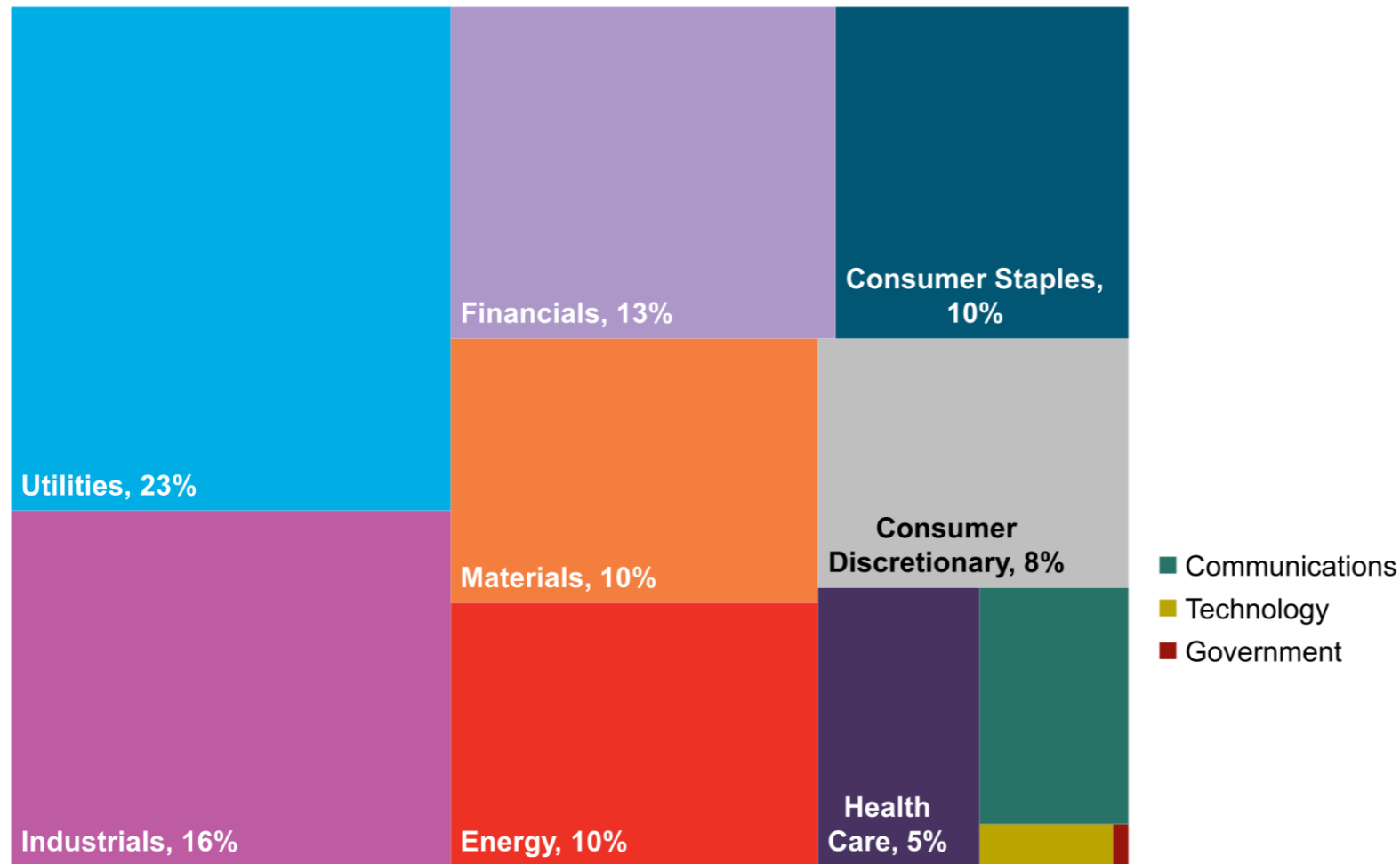
Japan's volume of offerings between 2019 and 2020 grew by about 51%, adding more than \$22 billion.

Source: BloombergNEF Sustainable Debt Data Hub [link](#). Country of risk.

Sustainability-linked loans do not play industry favorites



Sustainability-linked debt issued by sector



Sustainability-linked loans are accessible

Sustainability-linked loans engage sectors that are less represented in activity-based types of debt. Industries, such as health care, are able to issue sustainable debt without having large-scale green projects in mind.

More than \$119 billion in sustainability-linked loans were issued in 2020

These were linked to environmental, social and governance targets.

Sustainability-linked loan volumes went down since 2019

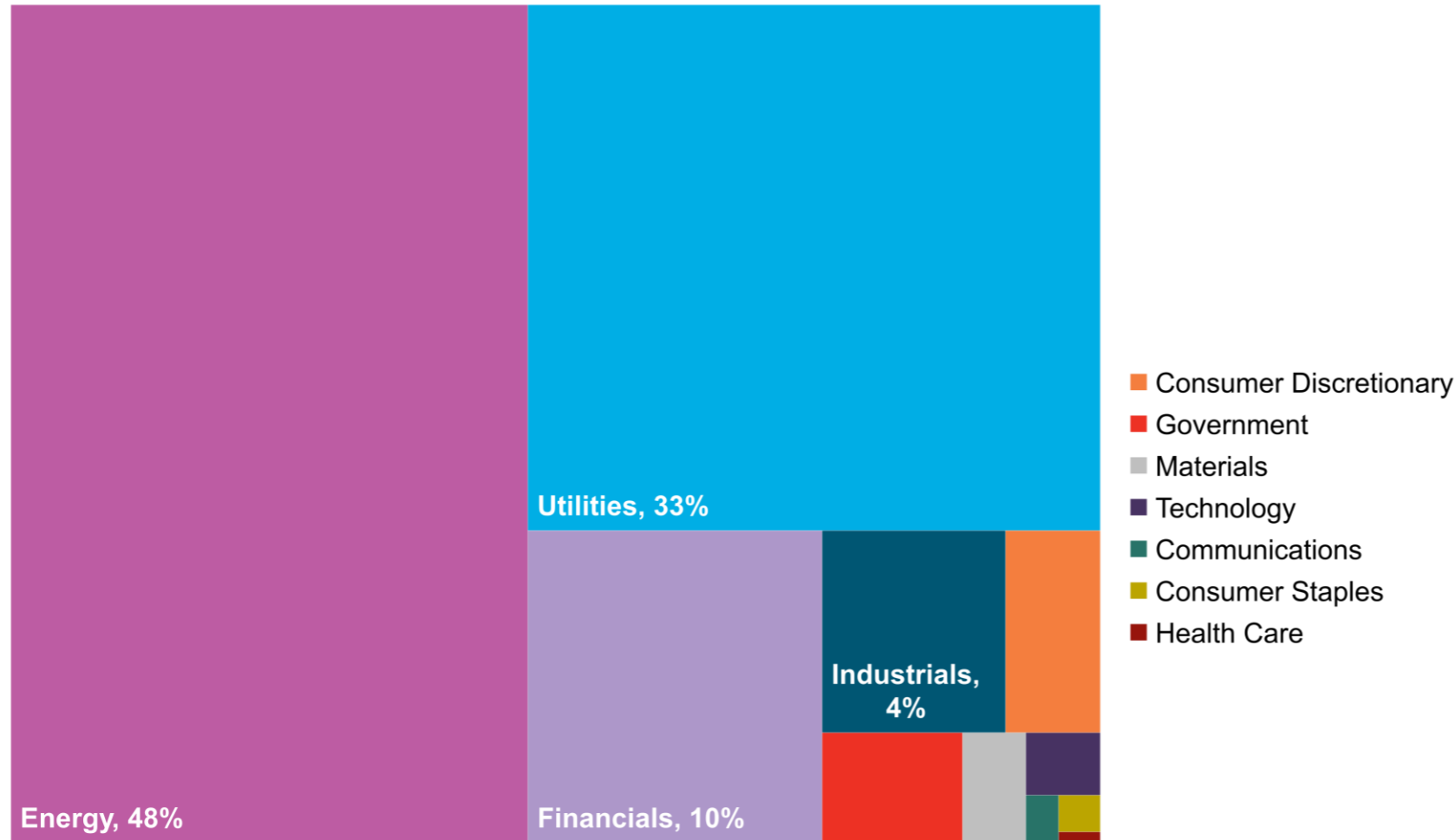
The first half of 2020 outperformed 1H 2019, but strong surges in December 2019 couldn't be caught in 2020, leading to an annual drop in volumes by 15%.

Source: BloombergNEF

Energy and utilities companies are key issuers of green debt



Green loans by sector



Green loans are dominated by energy and utility issuers

Activity-based debt engages some industries much more than others. Issuers of activity-based debt must have an environmental and/or social project or activity in mind to undertake earmarked debt financing, which limits the pool of potential issuers.

Some \$80 billion in green loans were offered in 2020

Despite volumes between 2019 and 2020 decreasing by 14%, green loans saw hefty volumes offered in 2020.

Utilities are a substantial issuer of green bonds and loans

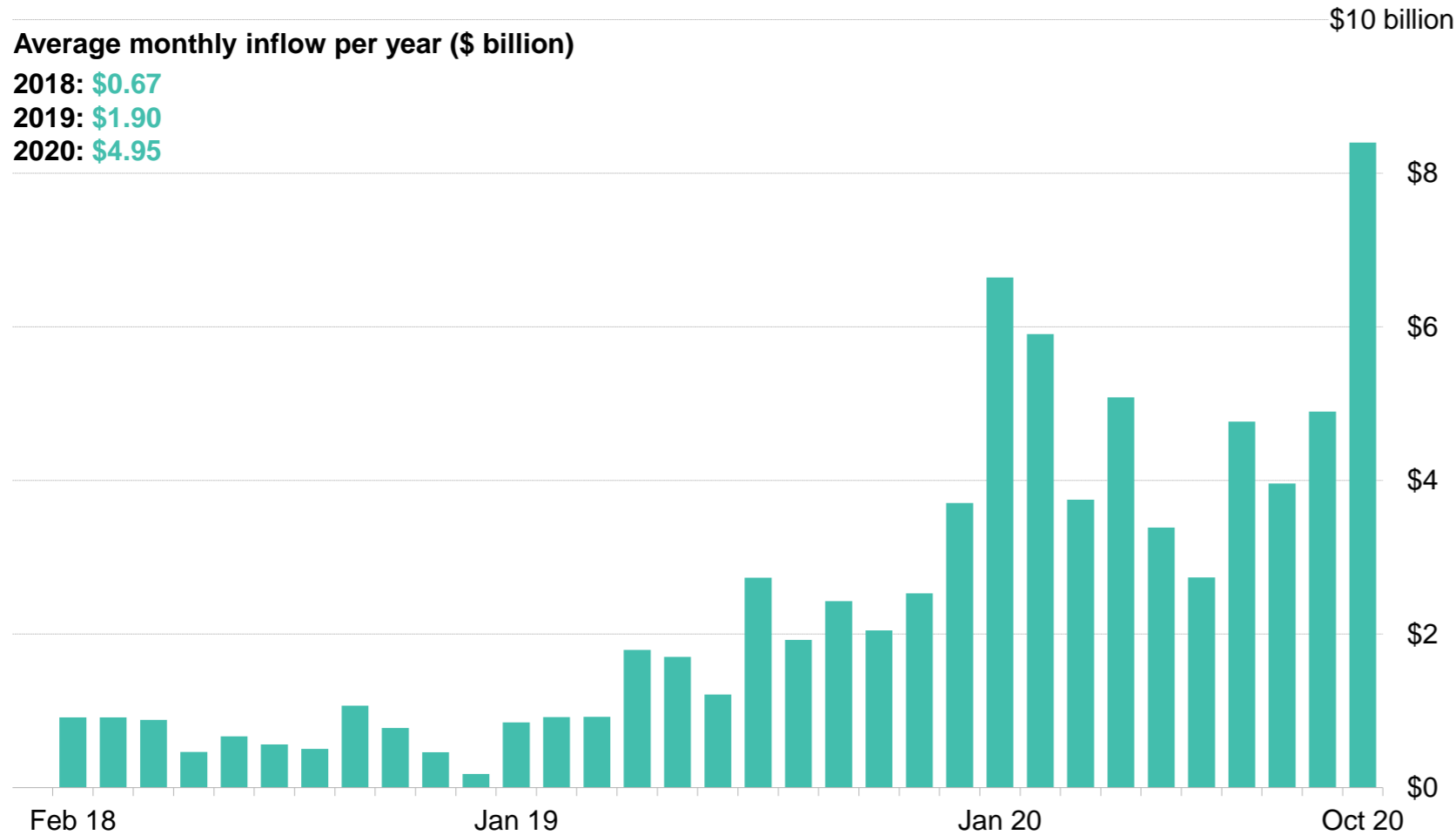
Utilities are the second most popular sector to issue green loans. Additionally, utilities offered \$40 billion in green bonds in 2020, making them the third most substantial issuing sector of 2020.

Source: BloombergNEF

Inflows to ESG exchange-traded funds hit record levels in 2020



Exchanged-traded ESG fund net inflows per month



Inflows to exchange-traded funds focused on sustainability and environmental, social, and governance-related investment hit record levels in 2020

October 2020 inflows were more than \$8 billion, a record.

ESG and sustainability-themed equity ETFs hold more than \$230 billion in assets

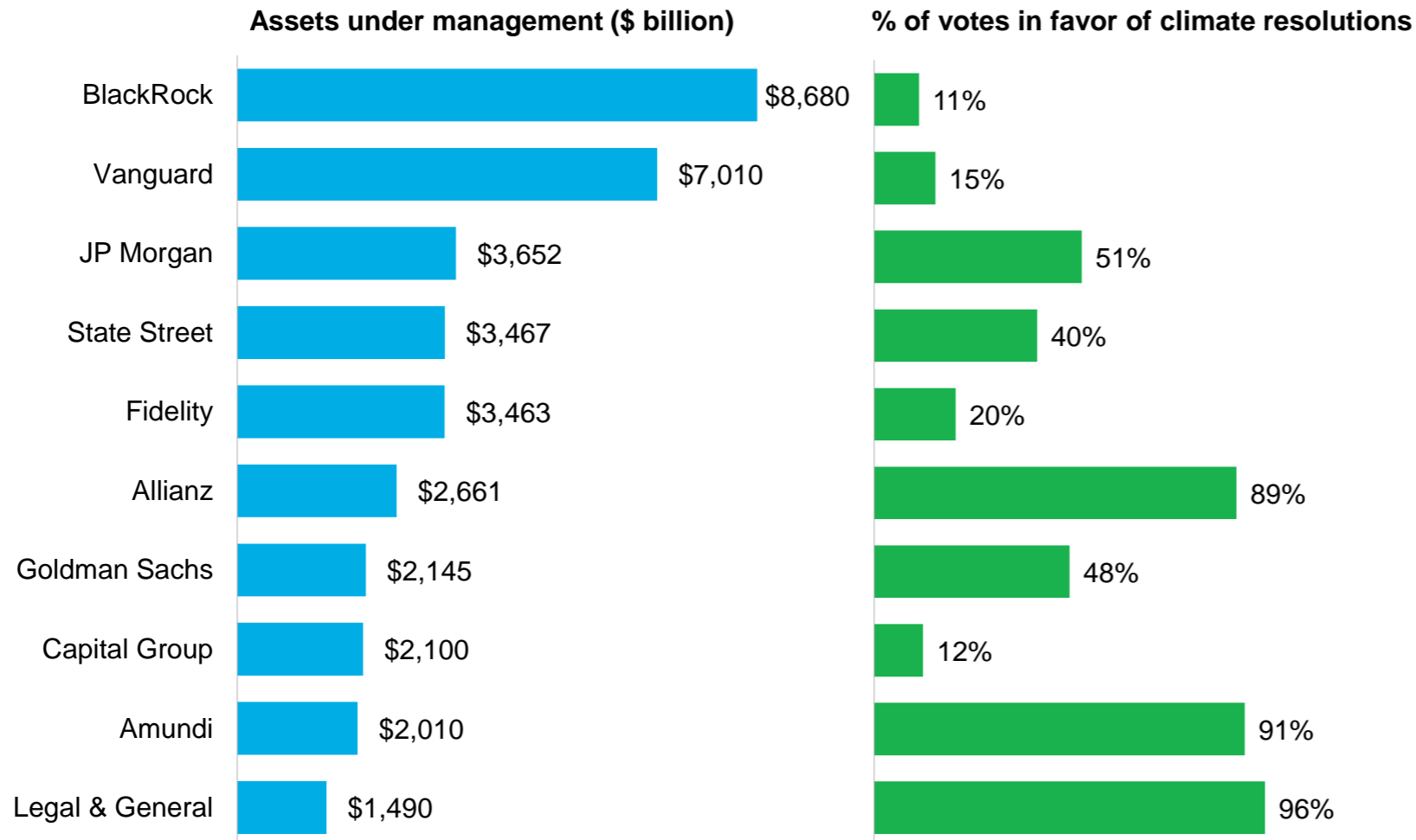
Equity funds are by far the largest sustainability ETFs, with \$206 billion in assets at the end of 2020. ESG and sustainability debt funds hold \$25 billion in assets.

Source: BloombergNEF, Bloomberg Intelligence

The largest asset managers are the least likely to vote for climate change shareholder resolutions



Assets under management and percentage of votes in favor of climate resolutions



The world's two largest asset managers supported very few shareholder resolutions on climate in 2020

BlackRock, which manages more than \$8 trillion, and Vanguard, which manages more than \$7 trillion, supported only 11% and 15% of climate resolutions, respectively.

U.S.-based managers were relatively less likely to support shareholder climate resolutions




JP Morgan and Goldman Sachs each supported about half of resolutions, while smaller Fidelity and Capital Group supported 20% or fewer.

European managers were much more likely to support

Amundi and Legal & General each supported more than 90% of shareholder resolutions on climate.

Source: Bloomberg, ShareAction [link](#). Latest public AUM as of December 2020

Table of contents

	Introduction: A Cleaner Future	3
	Power	23
	Transport	42
	Industry, Buildings, and Digital	52
	Commodities	68
	Food and Agriculture	82
	Capital	88
	About BNEF	97

The BloombergNEF insight service

250

BNEF professionals in 17 locations*

Primary research and forecasts

From quick commentary and short-term views to deep analysis and long-term forecasts

Summits

Premier invitation-only forums connecting leaders in London, Munich, New Delhi, New York, San Francisco and Shanghai

Analyst access

Specialists ready to answer your research questions on any sector, market, or technology

News

A tailored daily feed from Bloomberg News bureaus in 120+ countries, directly to your inbox or mobile app

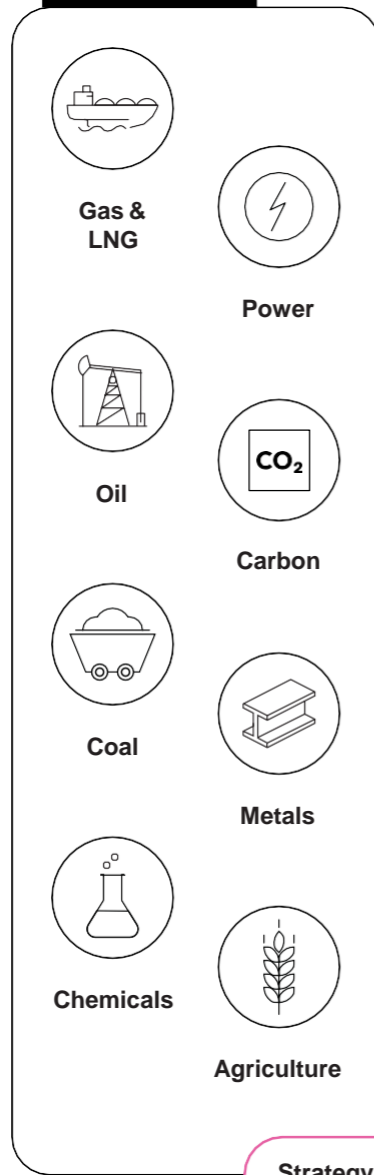
Data, models, tools

A rich suite of analytical tools and proprietary models, supported by Bloomberg's unparalleled data capabilities

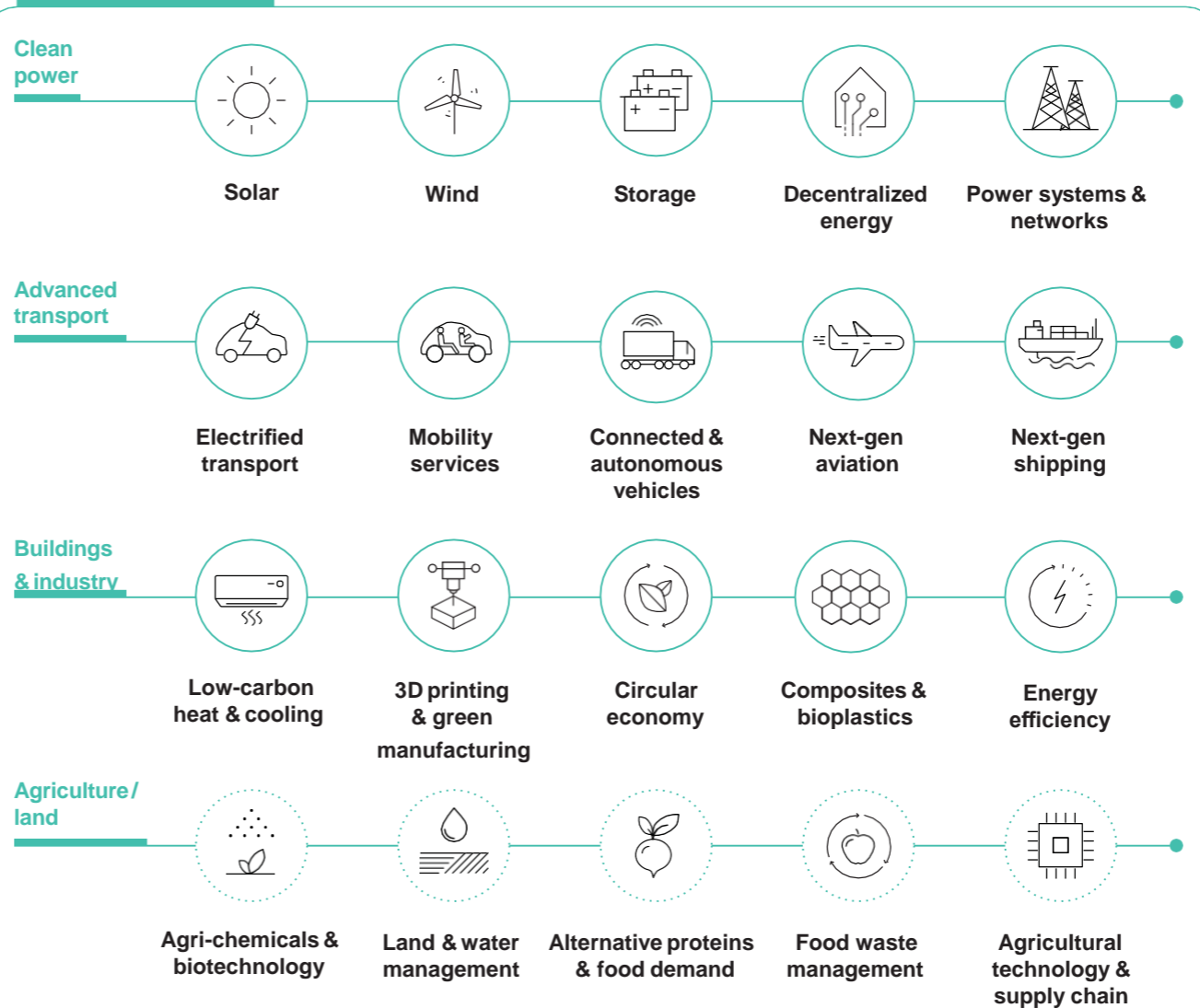
Briefings and webinars

Roundtables and live webinars focused on cross-cutting industry and regional topics

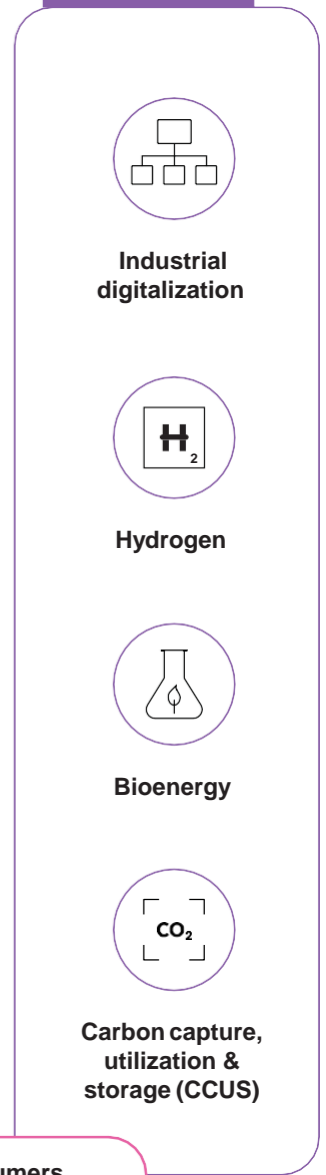
Commodities



Sector transitions



Cross-cutting technologies



*Part of the Bloomberg LP network of 19,000 employees in 176 locations

Copyright and disclaimer

The BloombergNEF ("BNEF"), service/information is derived from selected public sources. Bloomberg Finance L.P. and its affiliates, in providing the service/information, believe that the information it uses comes from reliable sources, but do not guarantee the accuracy or completeness of this information, which is subject to change without notice, and nothing in this document shall be construed as such a guarantee. The statements in this service/document reflect the current judgment of the authors of the relevant articles or features, and do not necessarily reflect the opinion of Bloomberg Finance L.P., Bloomberg L.P. or any of their affiliates ("Bloomberg"). Bloomberg disclaims any liability arising from use of this document, its contents and/or this service. Nothing herein shall constitute or be construed as an offering of financial instruments or as investment advice or recommendations by Bloomberg of an investment or other strategy (e.g., whether or not to "buy", "sell", or "hold" an investment). The information available through this service is not based on consideration of a subscriber's individual circumstances and should not be considered as information sufficient upon which to base an investment decision. You should determine on your own whether you agree with the content. This service should not be construed as tax or accounting advice or as a service designed to facilitate any subscriber's compliance with its tax, accounting or other legal obligations. Employees involved in this service may hold positions in the companies mentioned in the services/information.

The data included in these materials are for illustrative purposes only. The BLOOMBERG TERMINAL service and Bloomberg data products (the "Services") are owned and distributed by Bloomberg Finance L.P. ("BFLP") except (i) in Argentina, Australia and certain jurisdictions in the Pacific islands, Bermuda, China, India, Japan, Korea and New Zealand, where Bloomberg L.P. and its subsidiaries ("BLP") distribute these products, and (ii) in Singapore and the jurisdictions serviced by Bloomberg's Singapore office, where a subsidiary of BFLP distributes these products. BLP provides BFLP and its subsidiaries with global marketing and operational support and service. Certain features, functions, products and services are available only to sophisticated investors and only where permitted. BFLP, BLP and their affiliates do not guarantee the accuracy of prices or other information in the Services. Nothing in the Services shall constitute or be construed as an offering of financial instruments by BFLP, BLP or their affiliates, or as investment advice or recommendations by BFLP, BLP or their affiliates of an investment strategy or whether or not to "buy", "sell" or "hold" an investment. Information available via the Services should not be considered as information sufficient upon which to base an investment decision. The following are trademarks and service marks of BFLP, a Delaware limited partnership, or its subsidiaries: BLOOMBERG, BLOOMBERG ANYWHERE, BLOOMBERG MARKETS, BLOOMBERG NEWS, BLOOMBERG PROFESSIONAL, BLOOMBERG TERMINAL and BLOOMBERG.COM. Absence of any trademark or service mark from this list does not waive Bloomberg's intellectual property rights in that name, mark or logo. All rights reserved. © 2021 Bloomberg.

BloombergNEF (BNEF) is a leading provider of primary research on clean energy, advanced transport, digital industry, innovative materials, and commodities.

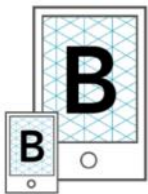
BNEF's global team leverages the world's most sophisticated data sets to create clear perspectives and in-depth forecasts that frame the financial, economic and policy implications of industry-transforming trends and technologies.

BNEF research and analysis is accessible via web and mobile platforms, as well as on the Bloomberg Terminal.

Coverage.

Clean energy
Advanced transport
Commodities
Digital industry

Get the app



On IOS + Android
about.bnef.com/mobile

BloombergNEF

Contact:

Nat Bullard nbullard@bloomberg.net

Client enquiries:

Bloomberg Terminal: press <Help> key twice

Email: support.bnef@bloomberg.net

Learn more:

about.bnef.com | [@BloombergNEF](https://twitter.com/BloombergNEF)