

# BNEF Executive Factbook

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

Jon Moore, CEO

Nat Bullard, Chief Content Officer

April 22, 2020

BloombergNEF

# Cover letter

The world is currently undergoing a huge challenge with the coronavirus pandemic. It is a challenge that is having a major impact on how we lead our lives in all parts of the planet. It is affecting how we work, travel, communicate and the safety of society. The response to this challenge has engaged governments, companies, the financial community and civil society. It has consumed our attention and driven a desire for data and analysis from research organizations.

However, there is another challenge that can have equally wide ranging impact, and that is addressing the challenge of climate change. This challenge has the added benefit and drawback of being one which will play out over a number of decades. Like the current pandemic it will require a large amount of data and analysis to understand, but the slower pace means that more effort needs to be spent on deciding which data will be most useful in planning a strategic response.

The aim of this Executive Factbook is to set out some of the data points that we believe are important for everyone in positions of influence to consider. We have chosen data that highlights some of the strategic solutions that have a realistic chance of meeting the decarbonisation challenge in the timescale available, and we have laid out these facts as they relate to the key areas of the economy that must be transformed. As the changes needed will be systems changes, we believe that considering a broad set of possible solutions will be beneficial to everyone's thinking.

We are issuing this first version of the Factbook in lieu of discussions which would have taken place at our New York Summit in April, discussions that can't be replaced but will be continued virtually as Strategic Briefings and Dialogues from our Munich Summit in May onwards. We hope that this information will prove to be a limited but valuable replacement and will stimulate some thoughts. We welcome any feedback you might have, and if useful, we will update the Factbook annually.

We hope you find this interesting and thought-provoking, and look forward to hearing from you.

Kind regards,

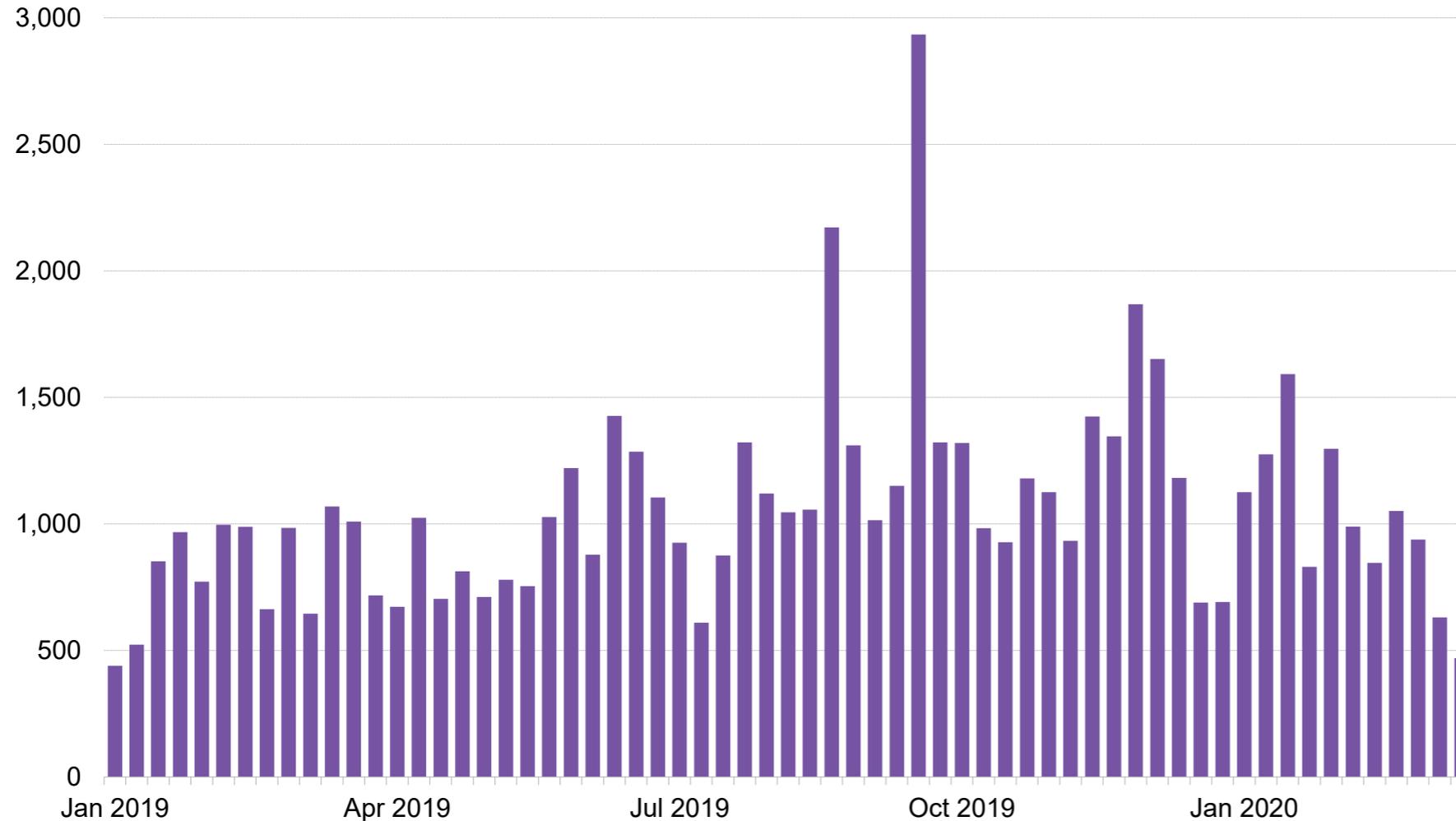
Jon Moore and Nat Bullard

# Table of contents

<b>Introduction: the moment we are in</b>		<b>3</b>
	A cleaner future	12
	Power	21
	Transport	40
	Industry and Buildings	55
	Commodities	70
	Food and Agriculture	87
	Capital	93
BNEF Summit series / About BNEF		102

# Climate change in the headlines

## News stories mentioning “global warming” and “climate change”



For much of 2019, global warming and climate change were mentioned more than 1,000 times a week in news stories.

Headline mentions peaked in late September 2019, during the UN General Assembly meeting in New York.

Headline mentions began to trail off in early 2020.

Source: [Bloomberg link](#), BloombergNEF. Weekly data.

# Climate change and coronavirus in the headlines

## News stories mentioning “global warming” and “climate change”, “coronavirus” and “Covid”



“Coronavirus” and “Covid” were first mentioned in international news stories in late 2019.

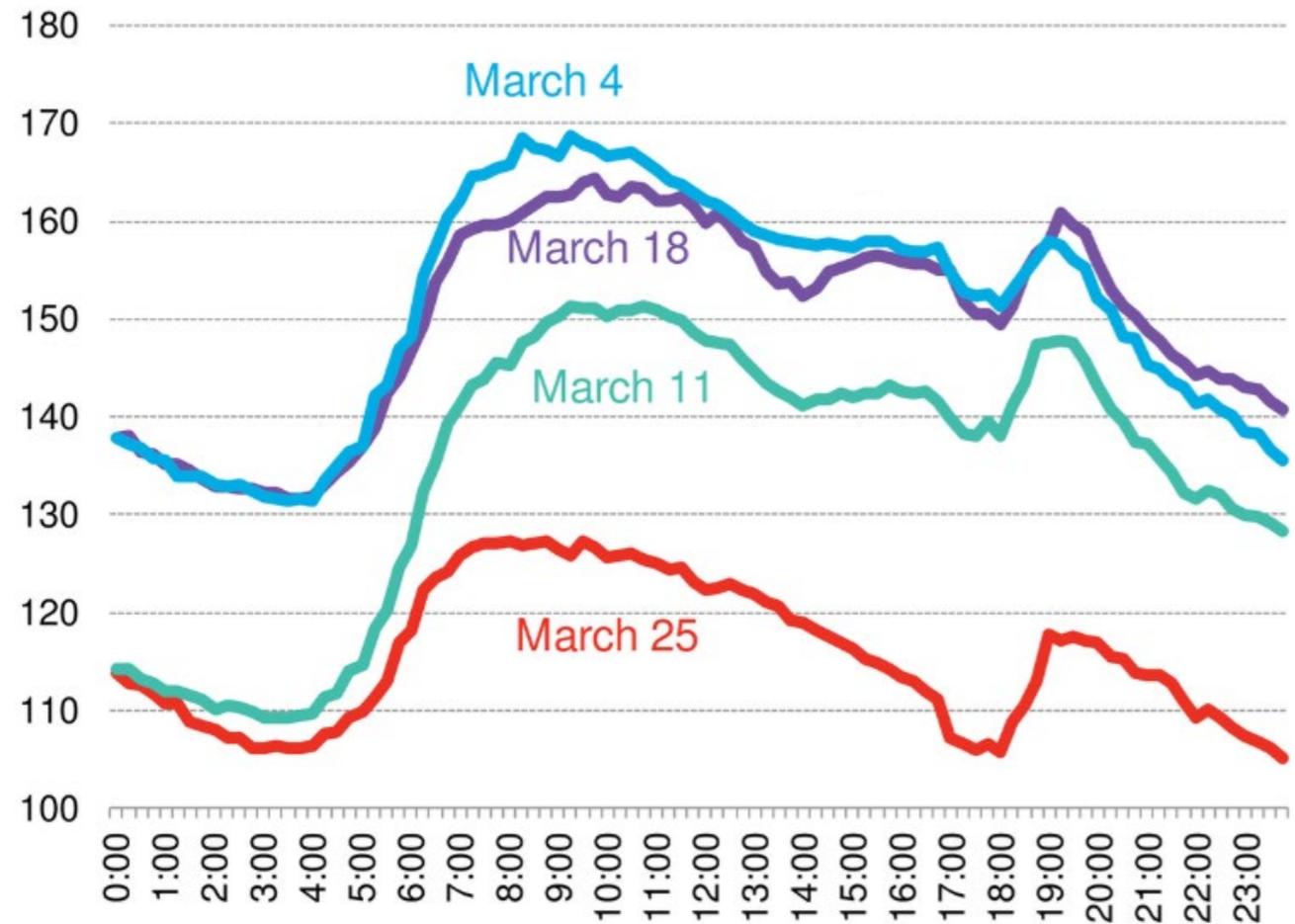
In a matter of weeks, the virus causing the current pandemic was mentioned more times than climate change or global warming.

The two systemic risks – climate change and Covid-19 – are now on entirely separate scales of news interest.

Source: [Bloomberg link](#), BloombergNEF. Weekly data.

# Covid-19 lockdown has crushed India power demand

India power demand, last four Wednesdays in March 2020 (gigawatts)



## India Locks Down 1.3 Billion People in Biggest Isolation Effort

By [Archana Chaudhary](#) and [Bibhudatta Pradhan](#)

March 24, 2020, 10:47 AM EDT

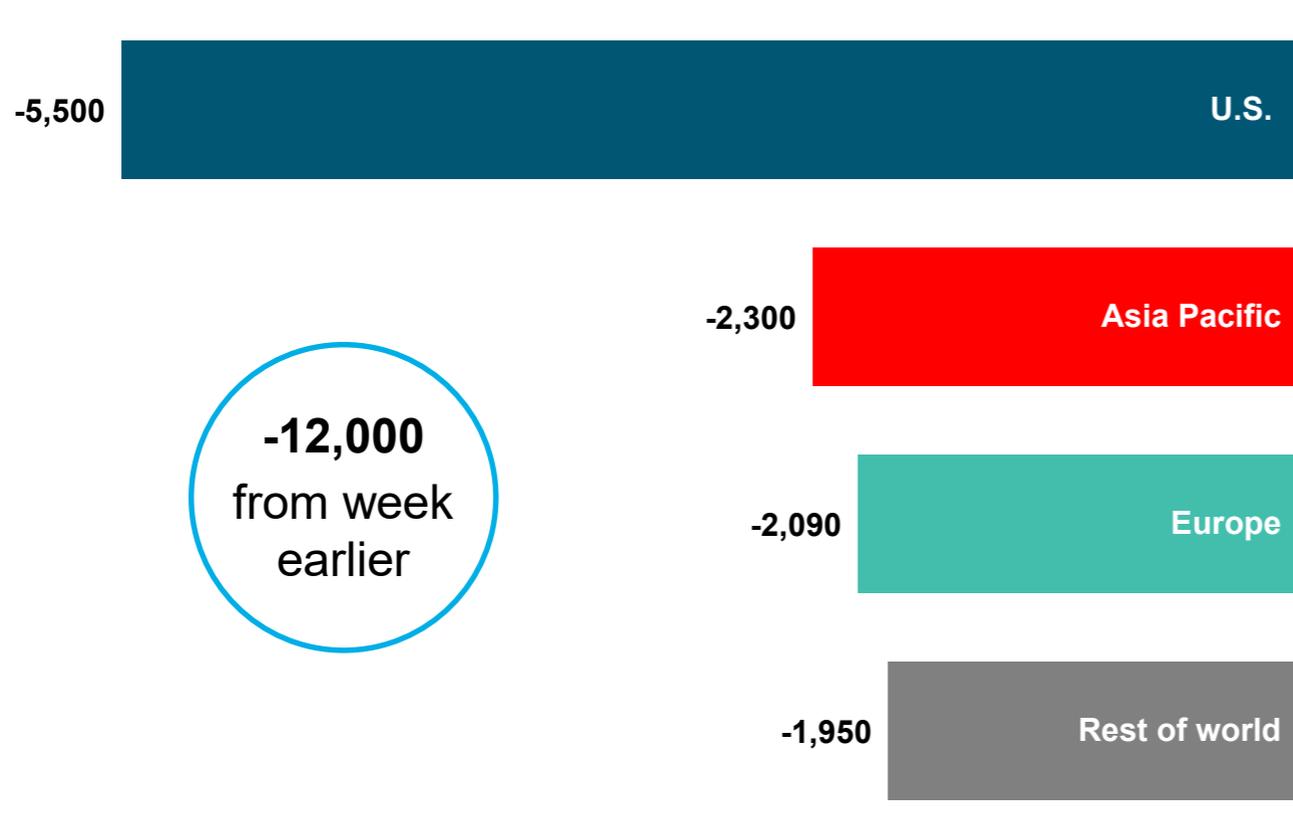
Updated on March 24, 2020, 8:46 PM EDT

**-25%**  
Week on week

Source: BloombergNEF Covid-19 Indicators series

# Covid-19 is having a massive impact on civil aviation, with more than 12,000 fewer daily flights

March 24 2020 daily flight departures, compared to March 17 2020



## Cathay Pacific Scraps 96% of Flights as Virus Stops Travel

By [Anurag Kotoky](#)

March 20, 2020, 1:02 AM EDT

Updated on March 20, 2020, 4:22 AM EDT

## World's Largest Long-Haul Airline to Halt All Flights

By [Layan Odeh](#)

March 22, 2020, 9:45 AM EDT

Updated on March 23, 2020, 3:20 AM EDT



# Supply and demand are in such disarray that prices are going negative

## Generic 1<sup>st</sup> 'CL' Future, WTI



On April 20, 2020 West Texas Intermediate physical futures settled at **-\$37.63** per barrel, a day before the monthly contract expired.

Speculators were desperate to get out of their contracts before trading stopped, when they would be required to take delivery.

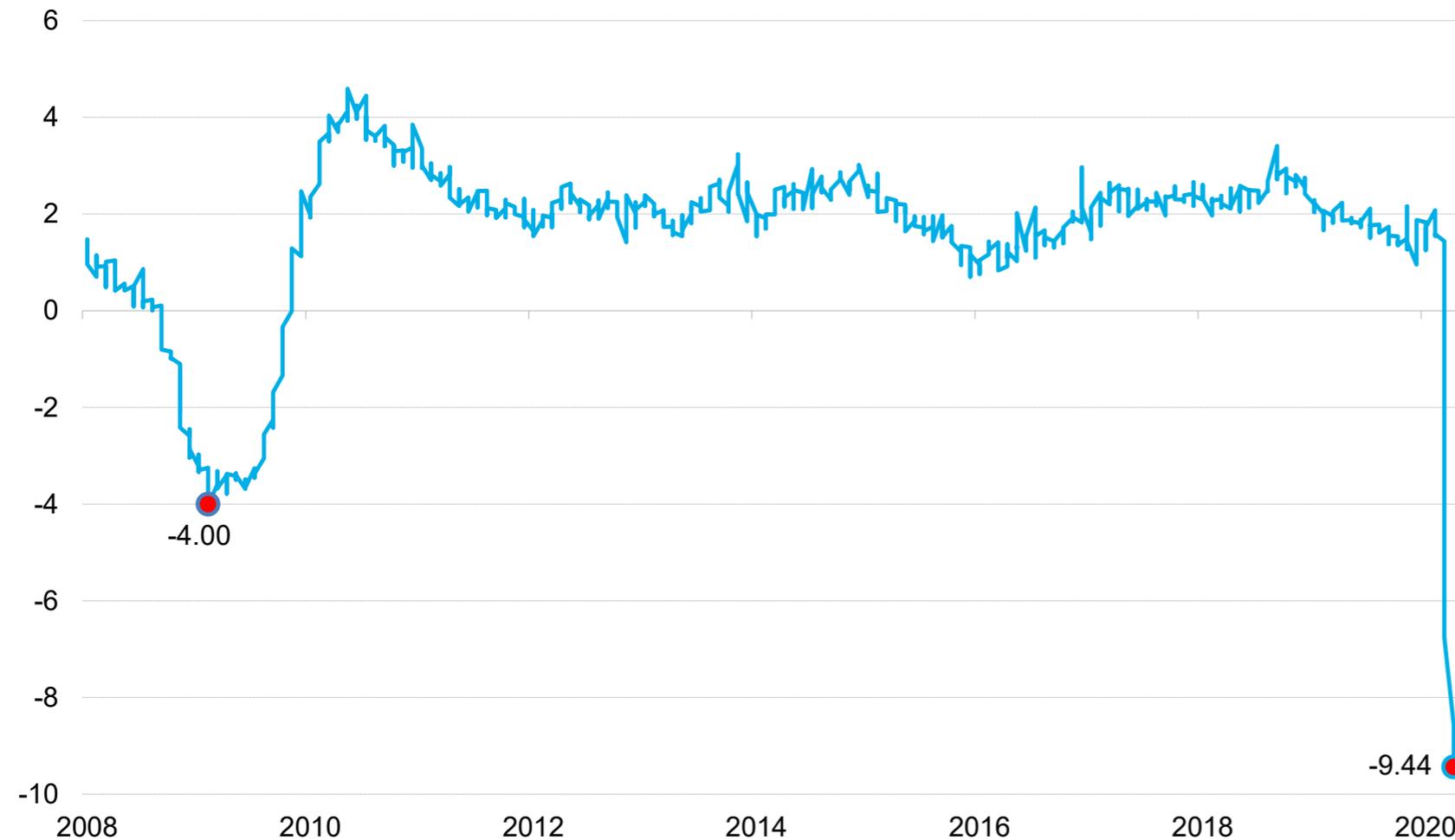
Falling demand meant the market was oversupplied. With minimal storage available, prices dropped below zero for the first time.

WTI has limited storage capacity; the Brent crude contract, which can be shipped or stored at sea, closed trading at \$25.57.

Source: Bloomberg

# Economic activity has plunged further, and faster, than during the global financial crisis

## U.S. Federal Reserve Bank of New York Weekly Economic Index



The Weekly Economic Index tracks 10 weekly indicators of real economic activity, scaled to have the units of four-quarter percent change of real GDP.

Steel production has fallen to its lowest level since 2009; retail sales have turned negative, and consumer confidence has decreased.

Source: Federal Reserve Bank of New York

# Two public imperatives right now: long-term climate, and near-term pandemic



Source: Jason Alden/Bloomberg, Betsy Joles/Getty Images AsiaPac

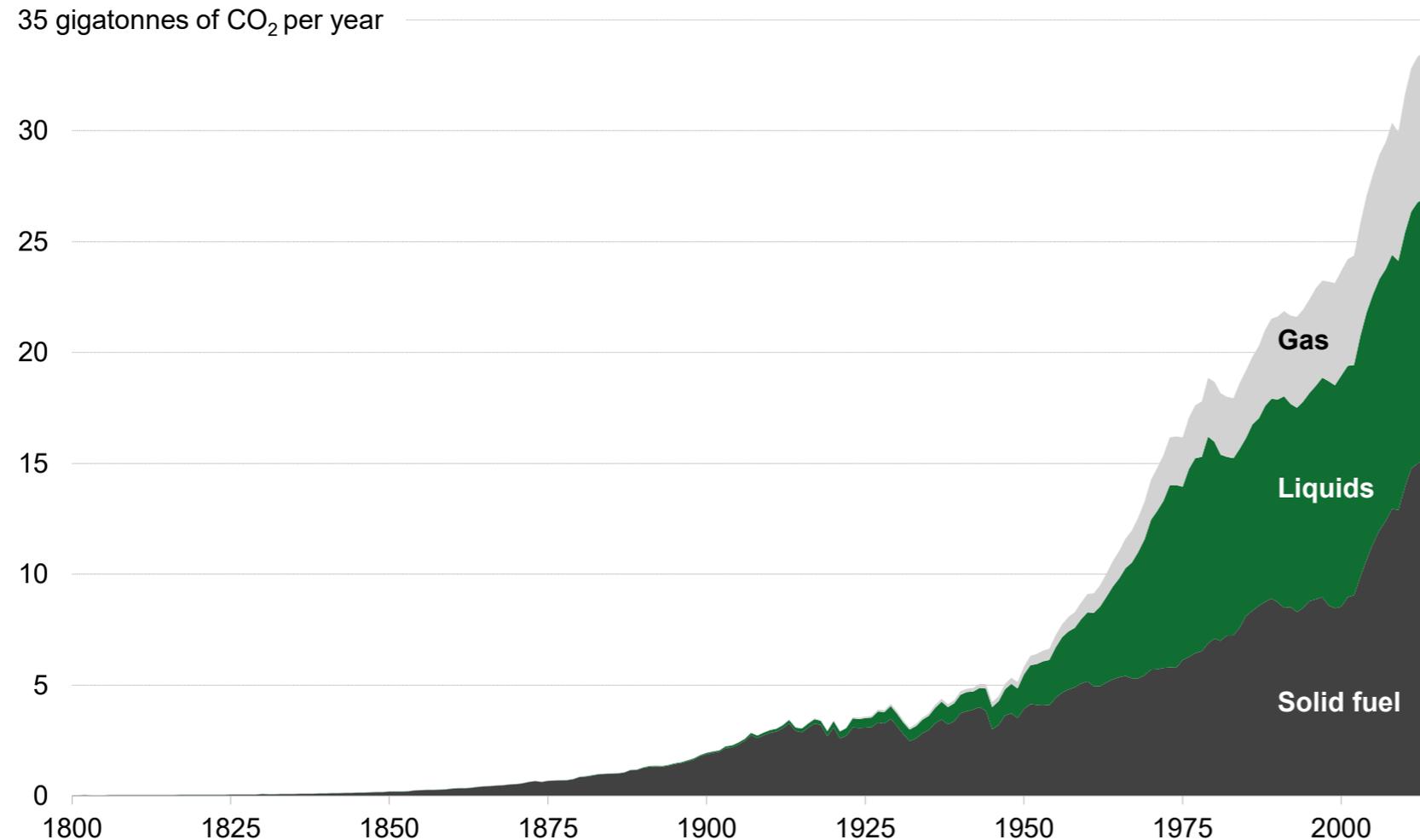
# Table of contents

Introduction: the moment we are in	3
 <b>A cleaner future</b>	<b>12</b>
 Power	21
 Transport	40
 Industry and Buildings	55
 Commodities	70
 Food and Agriculture	87
 Capital	93
BNEF Summit series / About BNEF	102

# Our systems of transforming matter are transforming the planet



## Carbon dioxide emissions from fossil fuels



Since 1751 more than 400 billion metric tons of carbon have been released to the atmosphere from the consumption of fossil fuels and cement production.

Half of these fossil-fuel CO<sub>2</sub> emissions have occurred since the late 1980s.

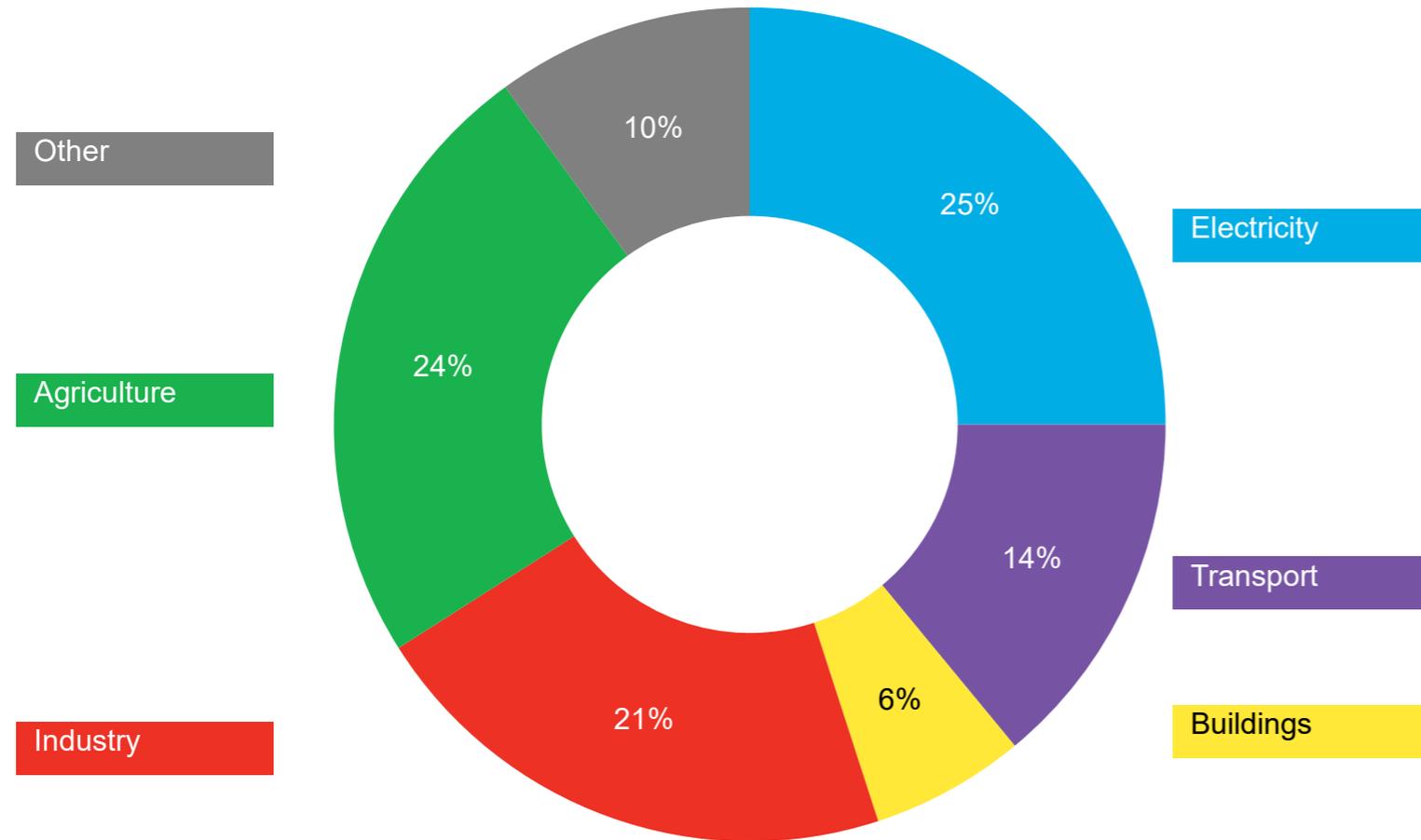
Liquid and solid fuels combustion accounted for more than three-quarters of all emissions from fossil fuel burning and cement production in 2014.

Source: Carbon Dioxide Information Analysis Center [link](#), International Energy Agency

# Our systems of transforming matter are transforming the planet



## Greenhouse gas emissions by sector



Three sectors dominate greenhouse gas emissions: electricity, agriculture, and industry.

Transport emissions, while regionally significant, are relatively smaller than emissions from other sectors.

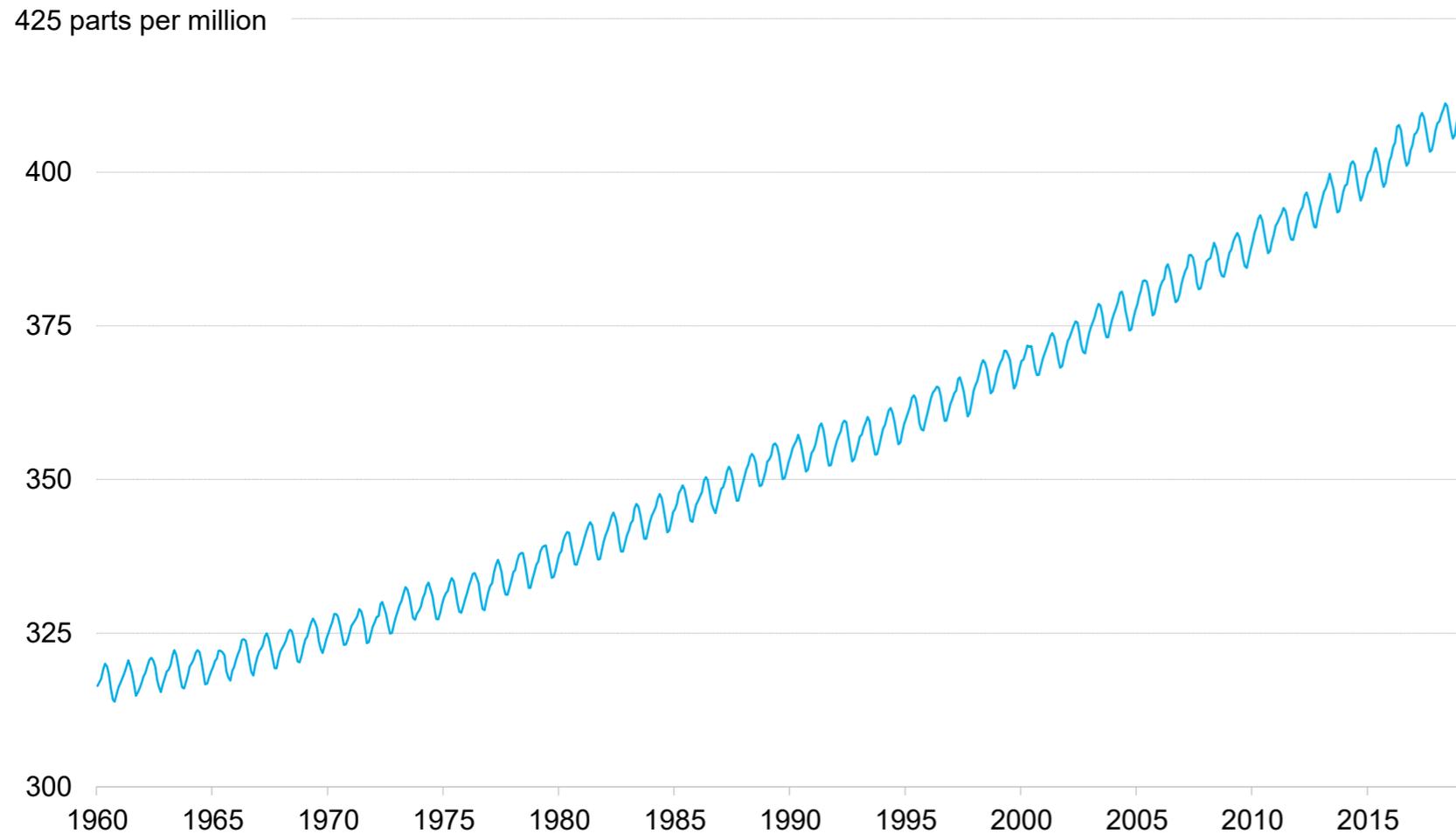
All sectors will need to be addressed to achieve the emissions goals of the Paris Agreement.

Source: International Energy Agency

# Our systems of transforming matter are transforming the planet



## Atmospheric carbon dioxide concentration



Prior to the industrial revolution, atmospheric CO<sub>2</sub> never exceeded 300 parts per million in human history.

In the 20<sup>th</sup> century, atmospheric CO<sub>2</sub> concentration passed 300 parts per million.

In 2015, atmospheric CO<sub>2</sub> concentration passed 400 parts per million.

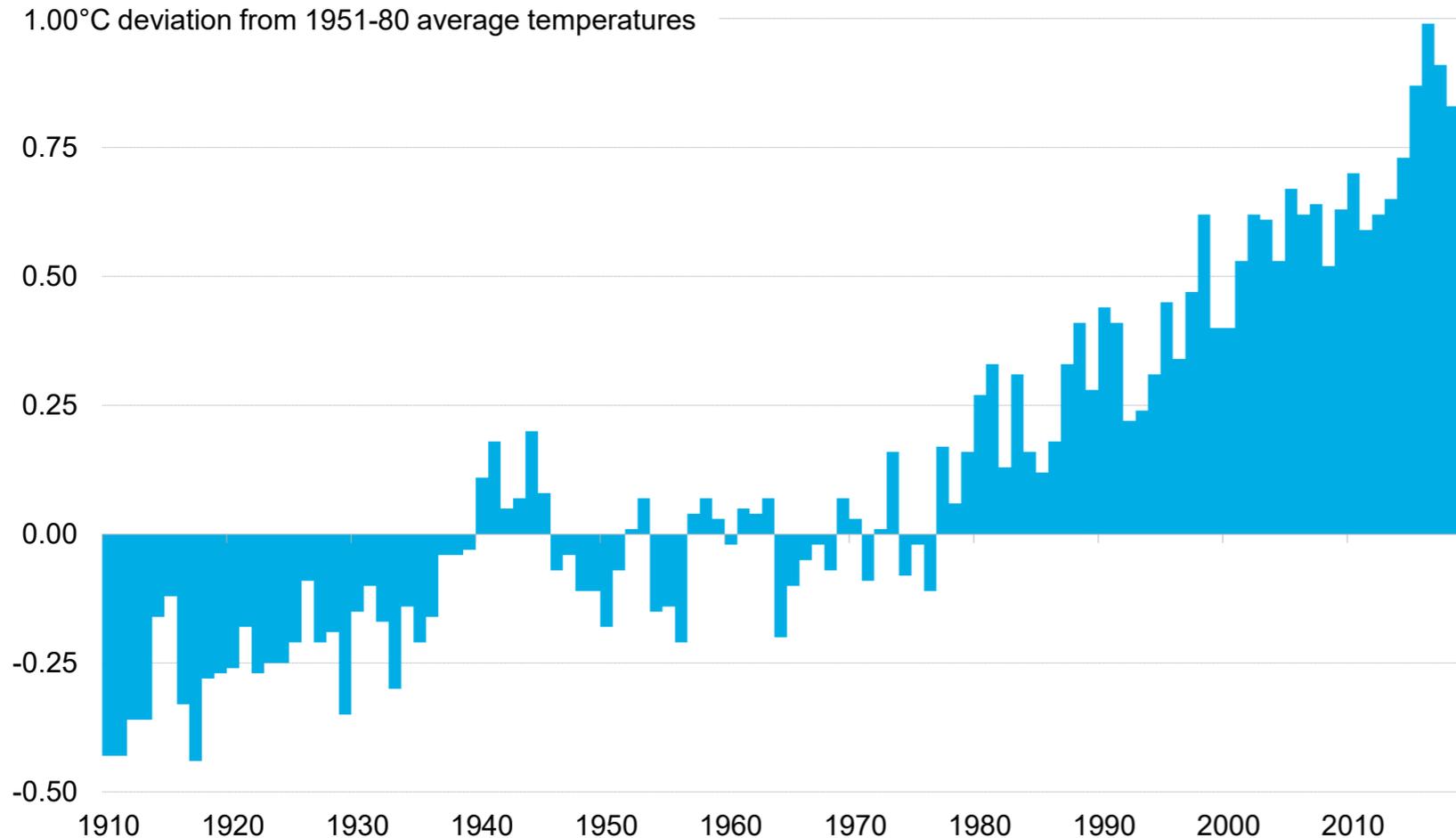
Global atmospheric concentrations of carbon dioxide are at their highest levels in 800,000 years.

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

# 2019 was the second-warmest year on record



## Increase in average temperatures



2019 was the second-warmest year since recordkeeping began in 1880

December's combined global land and ocean surface temperature departure from average for 2019 was also second highest in the 140-year record.

The 2019 average temperature was 1.71°F (0.95°C) above the 20th century average

This was just 0.07°F (0.04°C) less than the record value set in 2016.

Since 1981 the average annual rate of temperature increase is (+0.32°F / +0.18°C)

The 2019 global land and ocean temperature was 2.07°F (1.15°C) above the pre-industrial (1880-1900) average.

The five warmest years in the 1880–2019 record have all occurred since 2015, while nine of the 10 warmest years have occurred since 2005.

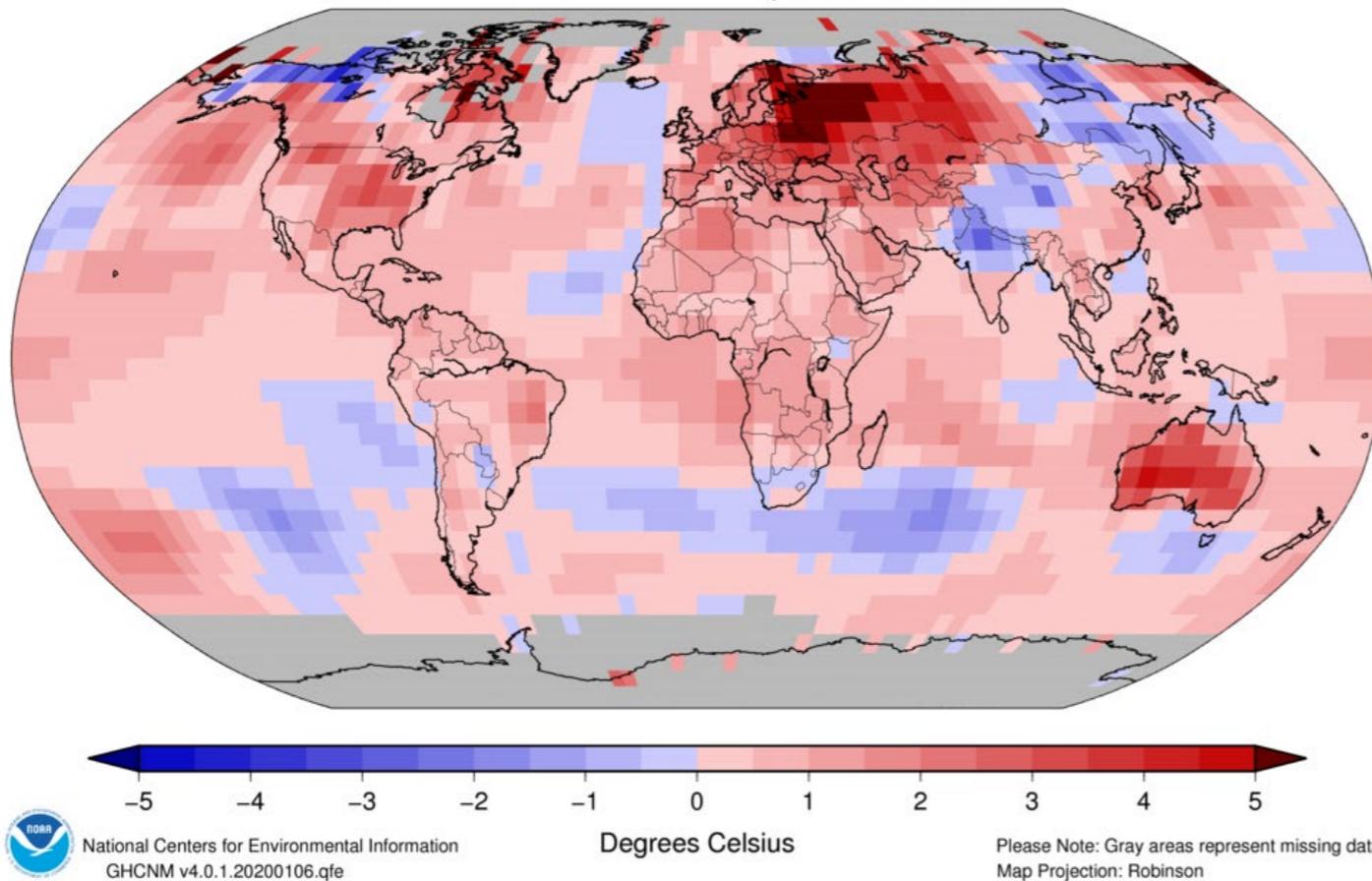
Source: [Earth Systems Research Laboratory link](#), [NASA link](#)

# 2019 was the second-warmest year on record



## Land & Ocean Temperature Departure from Average Dec 2019 (with respect to a 1981–2010 base period)

Data Source: NOAA GlobalTemp v5.0.0–20200108



## Tropical Cyclones Are Intensifying More Quickly

Island nations bear brunt of powerful storms, scientists say



Climate Adaptation

## Climate Change Is Raising Risks of Fierce Wildfires in Australia

By [David Stringer](#)

March 4, 2020, 12:00 PM EST



## Influence of Global Warming on Extreme Weather Events Frequently Underestimated

Mar 18, 2020

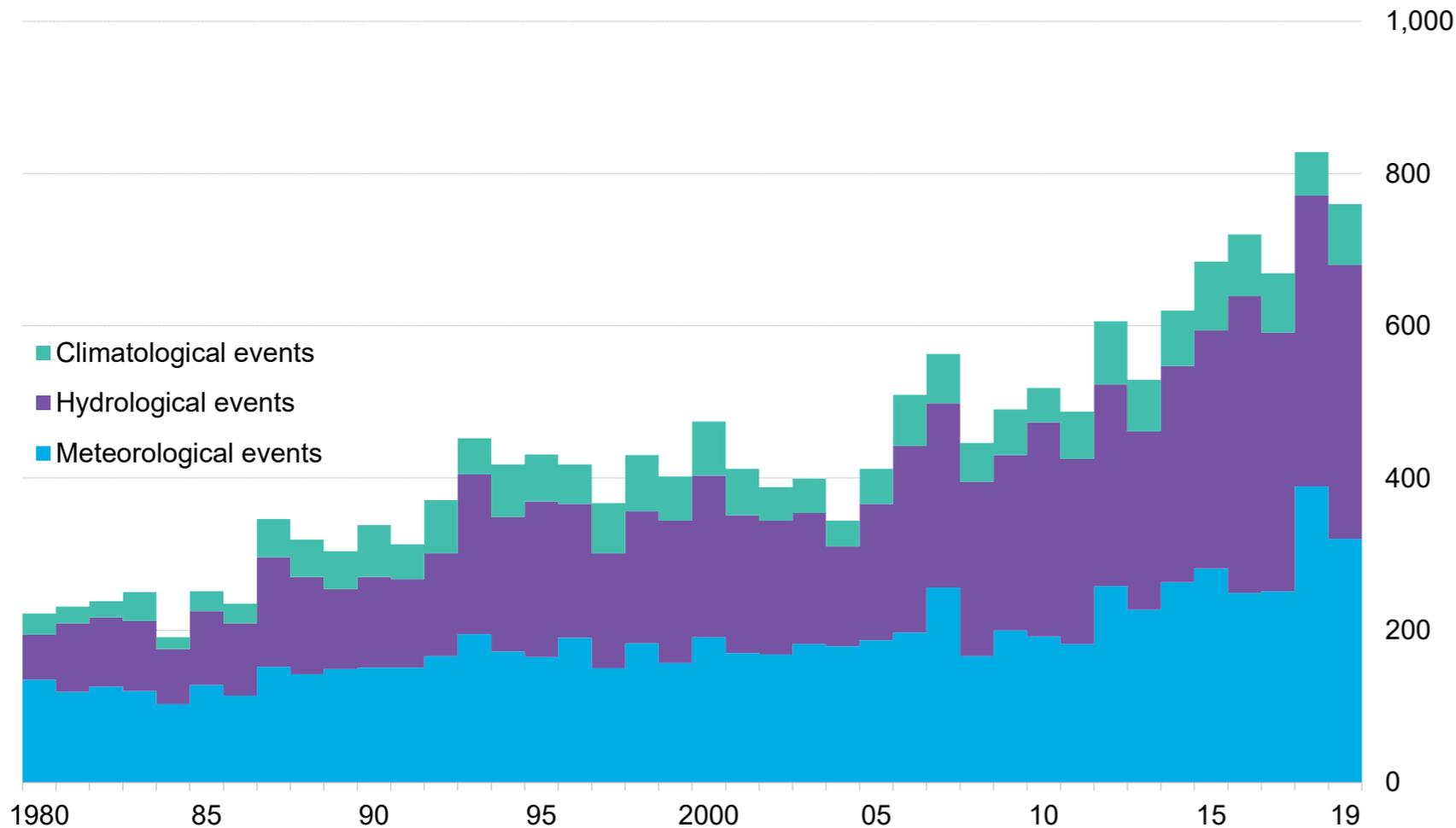
BY: ROB JORDAN

Source: [NOAA link](#), [Bloomberg Green link](#), [Stanford University link](#)

# Weather-related natural catastrophes have been increasingly steadily



## Number of major weather-related loss events worldwide



### There were nearly 800 weather-related natural catastrophes in 2019

The costliest event was Typhoon Hagibis in Japan, with \$17 billion in losses (of which \$10 billion was insured).

### Extreme precipitation was a feature of 2019's costliest event

As much as 1,000 milliliters of rain fell within two days in some parts of Japan, which represented 40% of the usual annual rainfall.

### Insured losses were only 35% of total losses from natural catastrophes

This insured portion matches the average of the past 10 years.

### Natural climate variations influence weather catastrophes from year to year

"Longer-term climate change effects can already be felt and seen", according to MunichRe.

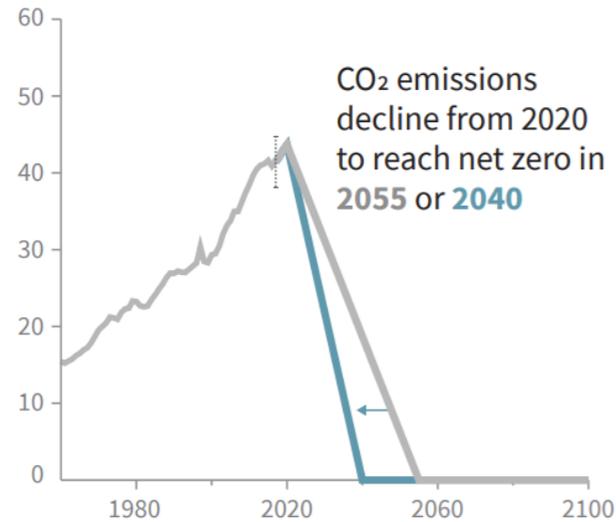
Source: MunichRe [link](#) [link](#)

# Our transformation of matter is transforming the planet. Changing trajectories is an unprecedented challenge.



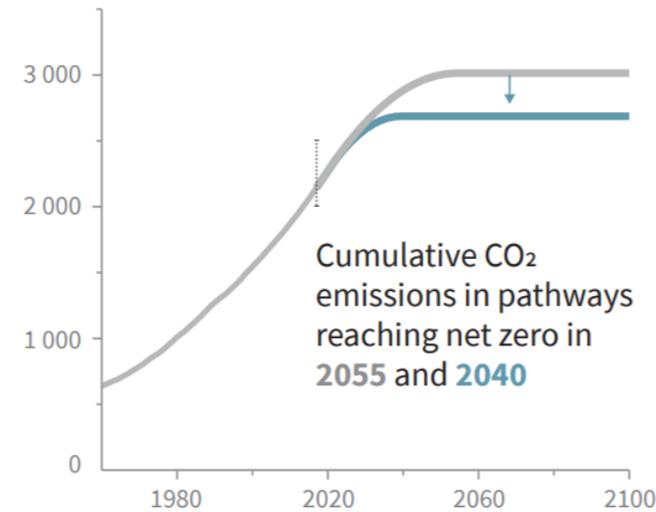
Intergovernmental Panel on Climate Change, October 2018

**b) Stylized net global CO<sub>2</sub> emission pathways**  
Billion tonnes CO<sub>2</sub> per year (GtCO<sub>2</sub>/yr)



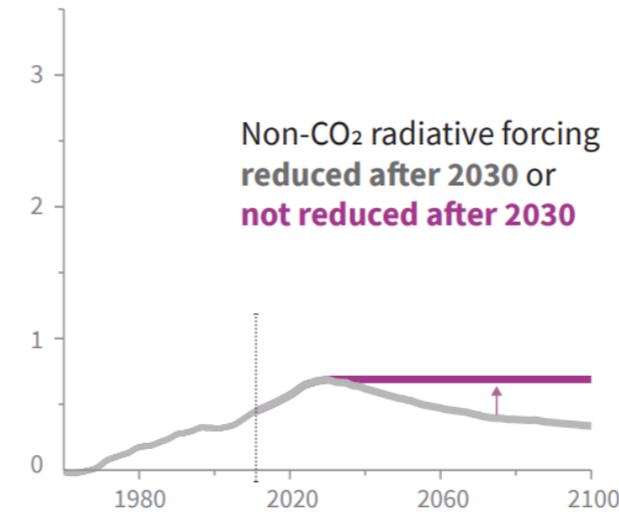
Faster immediate CO<sub>2</sub> emission reductions limit cumulative CO<sub>2</sub> emissions shown in panel (c).

**c) Cumulative net CO<sub>2</sub> emissions**  
Billion tonnes CO<sub>2</sub> (GtCO<sub>2</sub>)



Maximum temperature rise is determined by cumulative net CO<sub>2</sub> emissions and net non-CO<sub>2</sub> radiative forcing due to methane, nitrous oxide, aerosols and other anthropogenic forcing agents.

**d) Non-CO<sub>2</sub> radiative forcing pathways**  
Watts per square metre (W/m<sup>2</sup>)



These systems transitions are unprecedented in terms of scale...

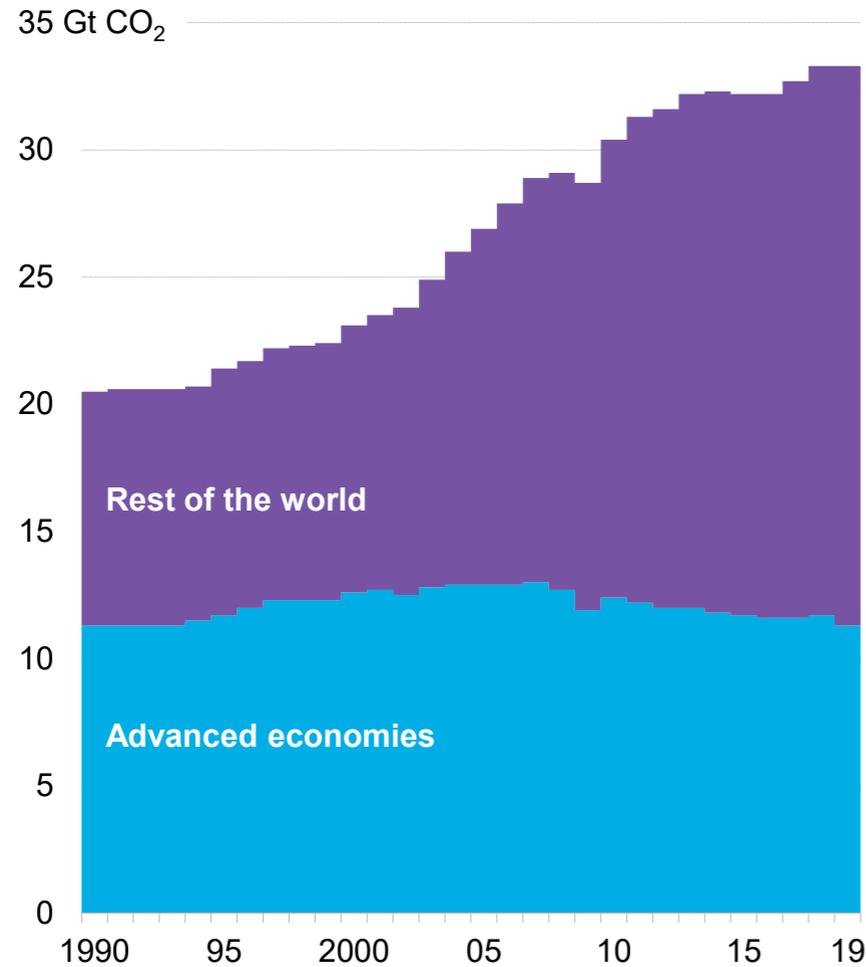
Intergovernmental Panel on Climate Change  
*Global Warming of 1.5 °C, Summary for Policymakers*, section C2  
October 2018

Source: [Intergovernmental Panel on Climate Change link](#)

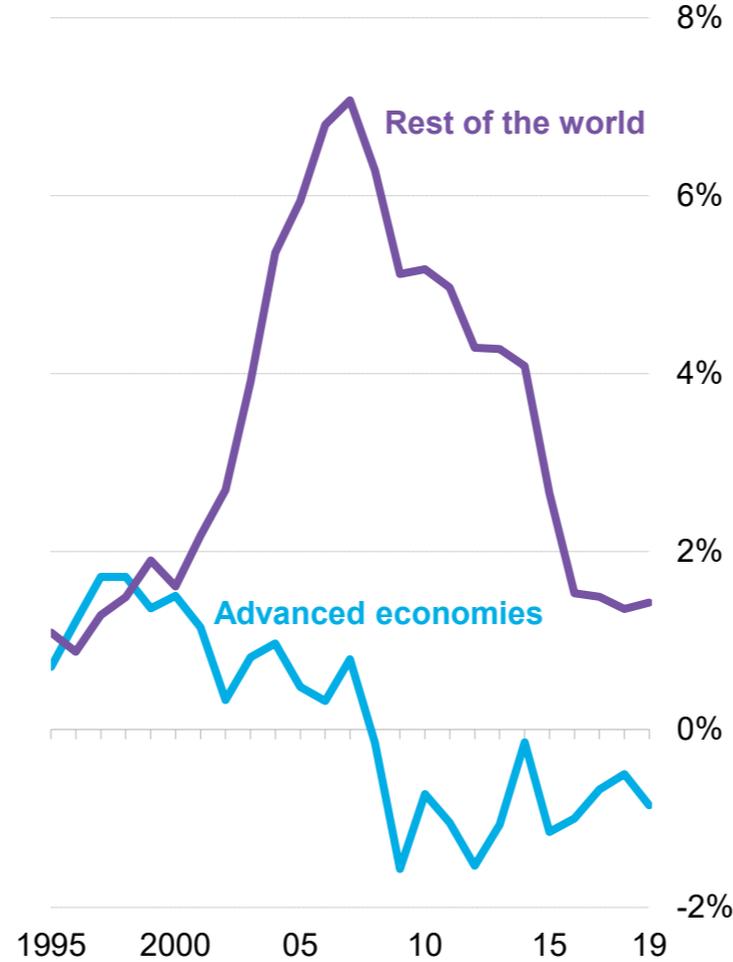
# Energy-related CO<sub>2</sub> emissions growth has slowed significantly, and been stable for two years



## Energy-related CO<sub>2</sub> emissions



## Trailing 5-year growth rate



In 1990, advanced economies emitted 55% of all energy-related carbon dioxide.

In 2004, economies outside the OECD became the main emitters of energy-related CO<sub>2</sub> for the first time.

In 2019, rest of the world economies emitted more than 66% of all energy-related CO<sub>2</sub>.

Source: [IEA link](#)

# The BNEF view: Cleaner, transitioning, transforming



A group of integrated systems underpin the global economy and humanity's interaction with our earth system.



## Power

Generation, transmission, distribution, network operations, operational strategy



## Commodities

Hydrocarbons, metals, supply and demand, emissions regulations, energy intensity, implications of global trade



## Transport

Passenger vehicles, personal automobiles, commercial transport, logistics, shipping, electrification, intelligent mobility, autonomy



## Food and agriculture

Climate change impacts, novel production techniques, digitalization, new business models, new proteins and products



## Industry and buildings

Manufacturing, heating and cooling, digitalization, advanced materials, commercial partnerships and collaboration



## Capital

Green financial products, portfolio decarbonization strategies, innovative financing structures, transition risk, policy and regulation

These systems are responsible for the overwhelming majority of anthropogenic carbon dioxide emissions, and with it the rapid climate changes unprecedented in human history.

These same systems are also where our collective responses to climate change will take place. They are where climate adaptation and mitigation will occur. They are where company strategy will determine the fate of industries.

In addressing our global climate challenge, all industries will become cleaner. Some companies will transition into lower-carbon products and services. Some will transform their businesses completely.

This presentation is BloombergNEF's integrated view on the sectors it covers, the challenges they face in decarbonizing, and the opportunities to come from doing so successfully. It identifies key trends in the data of our biggest integrated systems. Some trends are now well-established; some are emergent; all are critical to understanding a cleaner, transitioning, transforming world.

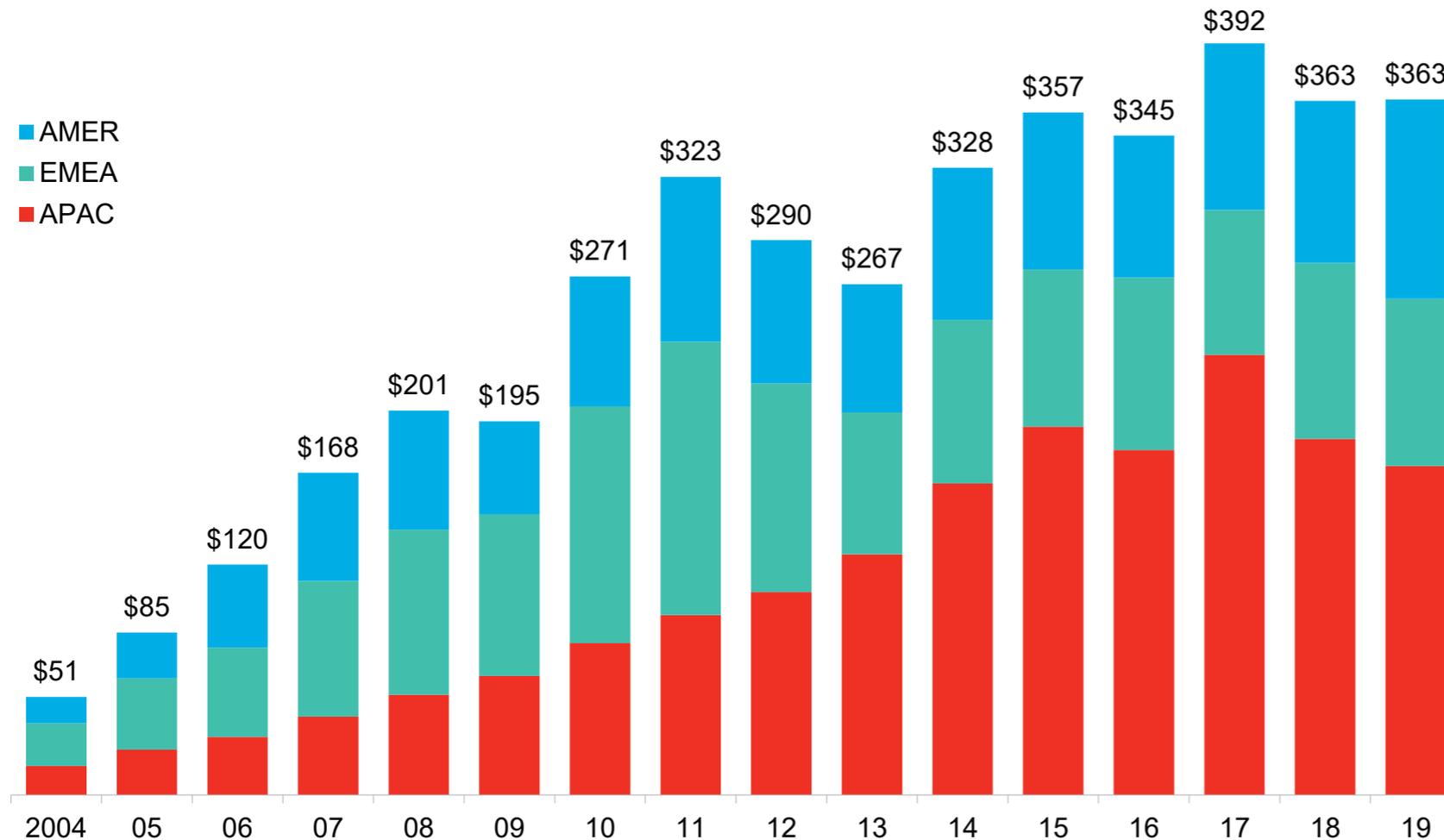
# Table of contents

Introduction: the moment we are in	3
 A cleaner future	12
 <b>Power</b>	<b>21</b>
 Transport	40
 Industry and Buildings	55
 Commodities	70
 Food and Agriculture	87
 Capital	93
BNEF Summit series / About BNEF	102

# More than \$4 trillion has been invested in clean energy since 2004



New financial investment in clean energy by region (\$ billion)



More than \$4 trillion has been invested in clean energy since 2004

Annual financing of clean energy has risen seven-fold, in nominal terms, between 2004 and 2019.

Asia Pacific has invested \$1.75 trillion in clean energy

Within Asia, China is by far the largest market for clean energy investment.

Europe, Middle East, and Africa have invested \$1.31 trillion in clean energy

The majority of EMEA investment is in western Europe.

The Americas have invested \$1.06 trillion in clean energy

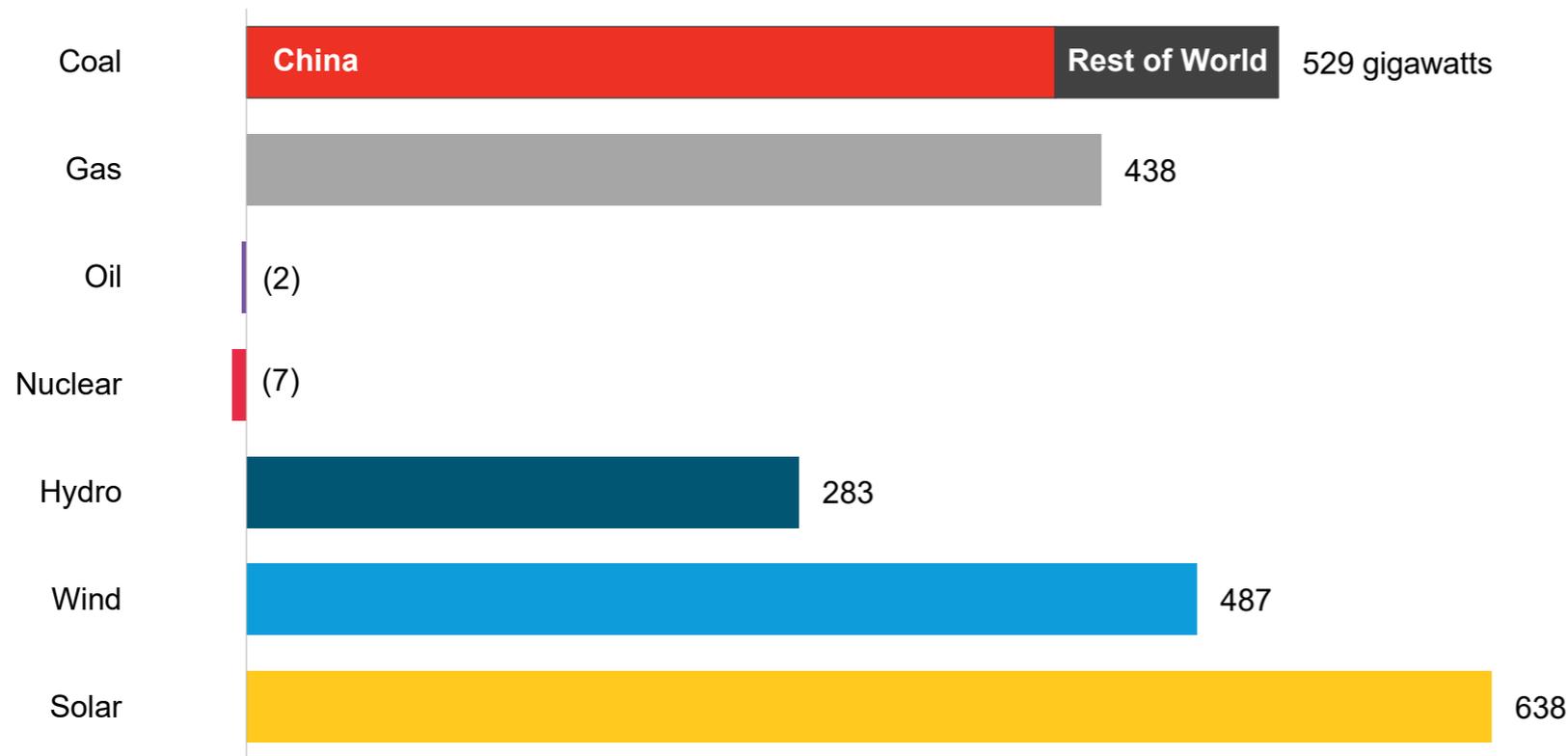
The United States is the largest market for clean energy investment, with Brazil, Mexico, and Canada being significant markets as well.

Source: BloombergNEF

# More solar generation capacity was installed in the past decade than any other technology



## Power generation capacity additions, 2009 – 19



From 2009 to 2019, solar photovoltaic power generation installed more gigawatts than any other power generation technology.

Wind power capacity additions were slightly ahead of global additions of natural gas generation capacity.

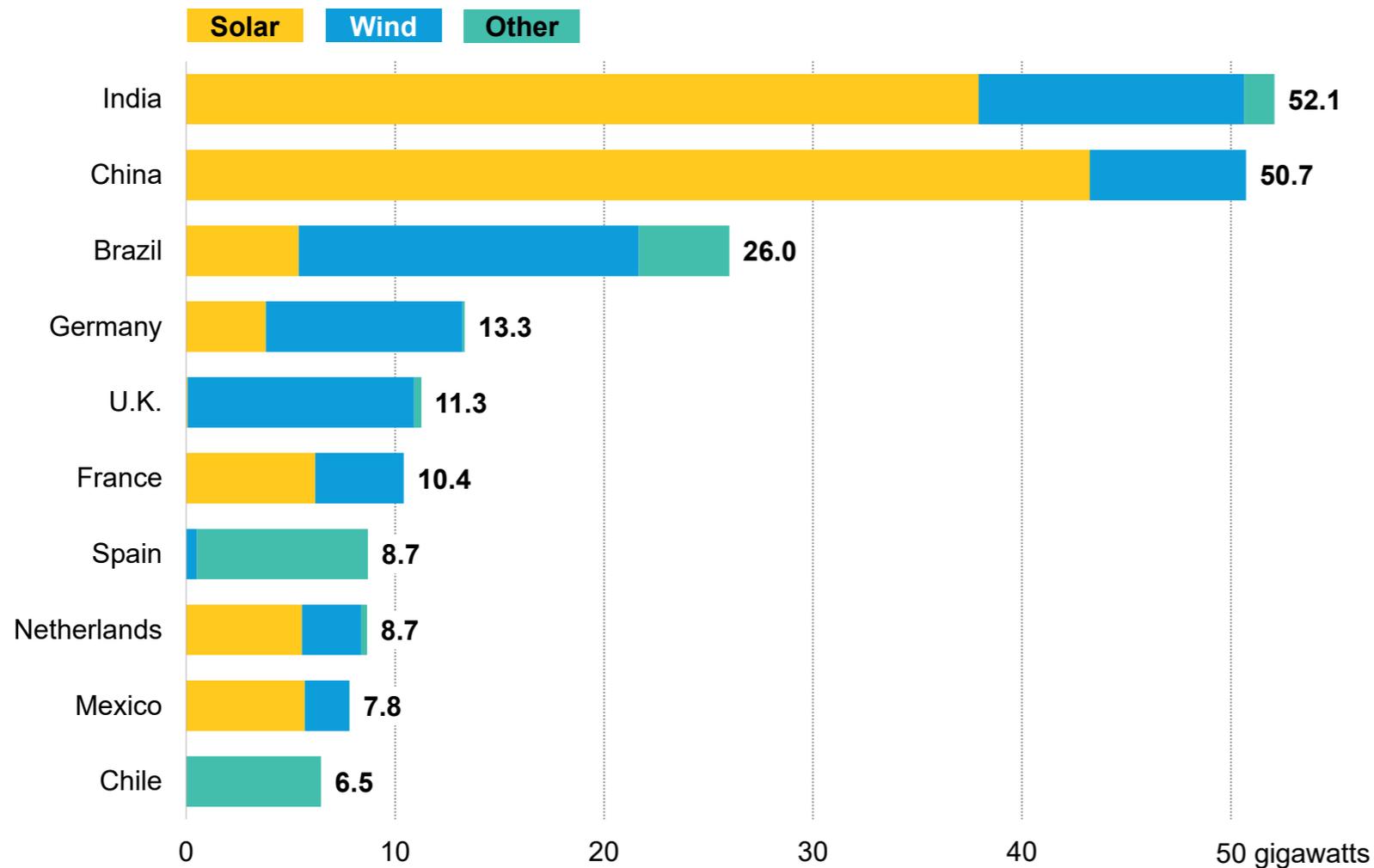
On a net basis, oil-fired power and nuclear power actually decreased from 2009 to 2019.

New coal power generation capacity increased by more than 500 gigawatts, with most of that expansion was in China.

# More than 150 gigawatts of renewable generation capacity has been auctioned worldwide



## Renewable power generation capacity auctions by country



Since 2014, governments have moved away from setting fixed prices for large renewable energy generation toward holding competitive auctions and tenders.

India and China have auctioned the most capacity, and in most auction markets, solar is the predominant technology.

Tenders are revealing how cheap solar and wind power have become. However, tenders carry the risk of speculative bidding pushing prices so low that projects that are not built on time.

Source: BloombergNEF

# Solar photovoltaic module costs fell 91% in the past decade



Spot price of multicrystalline silicon PV modules (\$/Watt)



PV module prices have fallen by more than 90% in the past decade.

At the same time, global module manufacturing capacity has expanded more than 18 times.

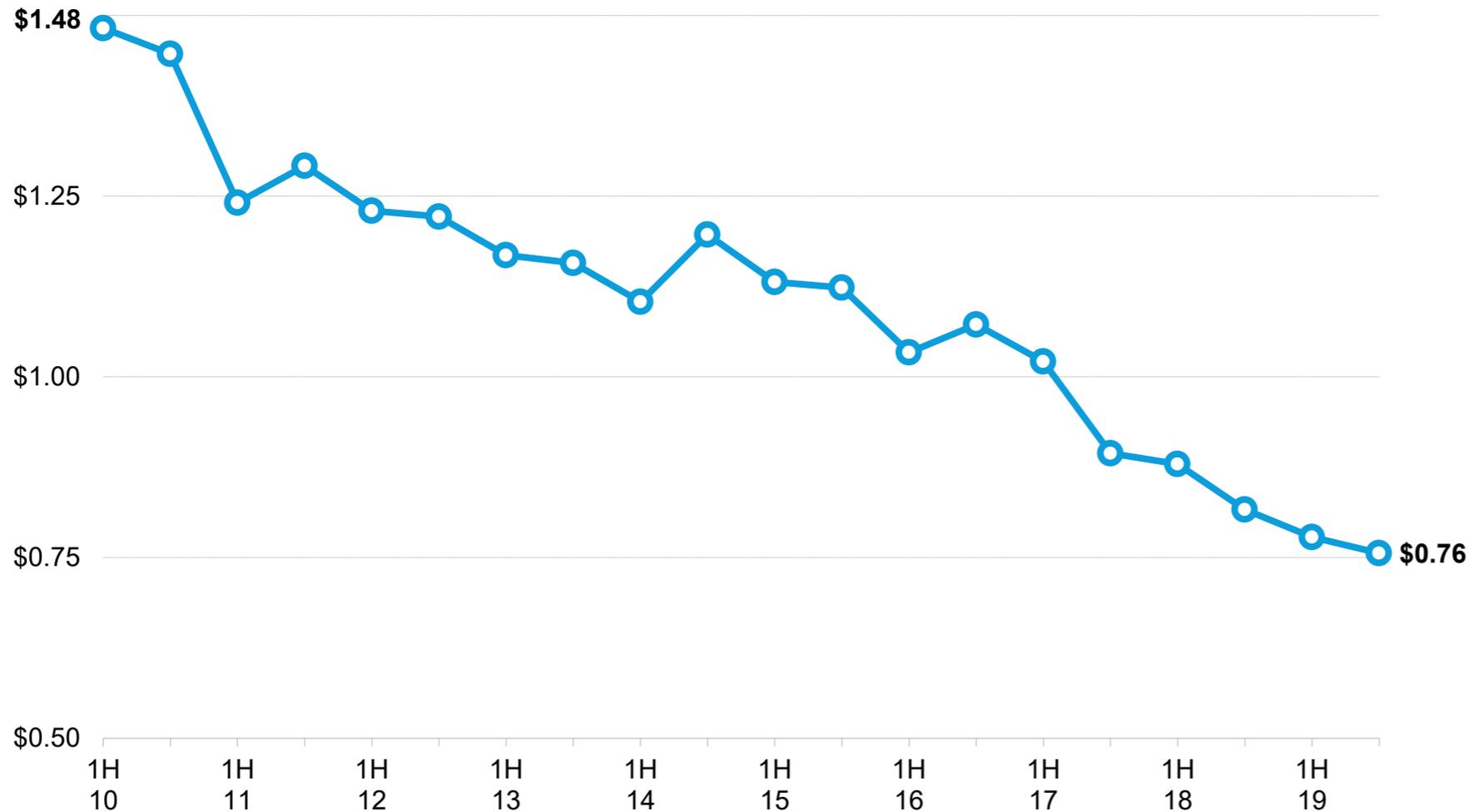
Global crystalline silicon PV manufacturing capacity in 2009 totaled 14.3 gigawatts. In 2019, it totaled more than 262 gigawatts.

Source: BloombergNEF

# Wind turbine costs fell 49% in the past decade



## Wind turbine price index by turbine delivery date



Wind turbine prices have fallen by nearly 50% in the past decade.

At the same time, global turbine manufacturing capacity has nearly doubled.

Global wind turbine nacelle manufacturing capacity in 2009 totaled 66.8 gigawatts. In 2019, it totaled more than 128 gigawatts.

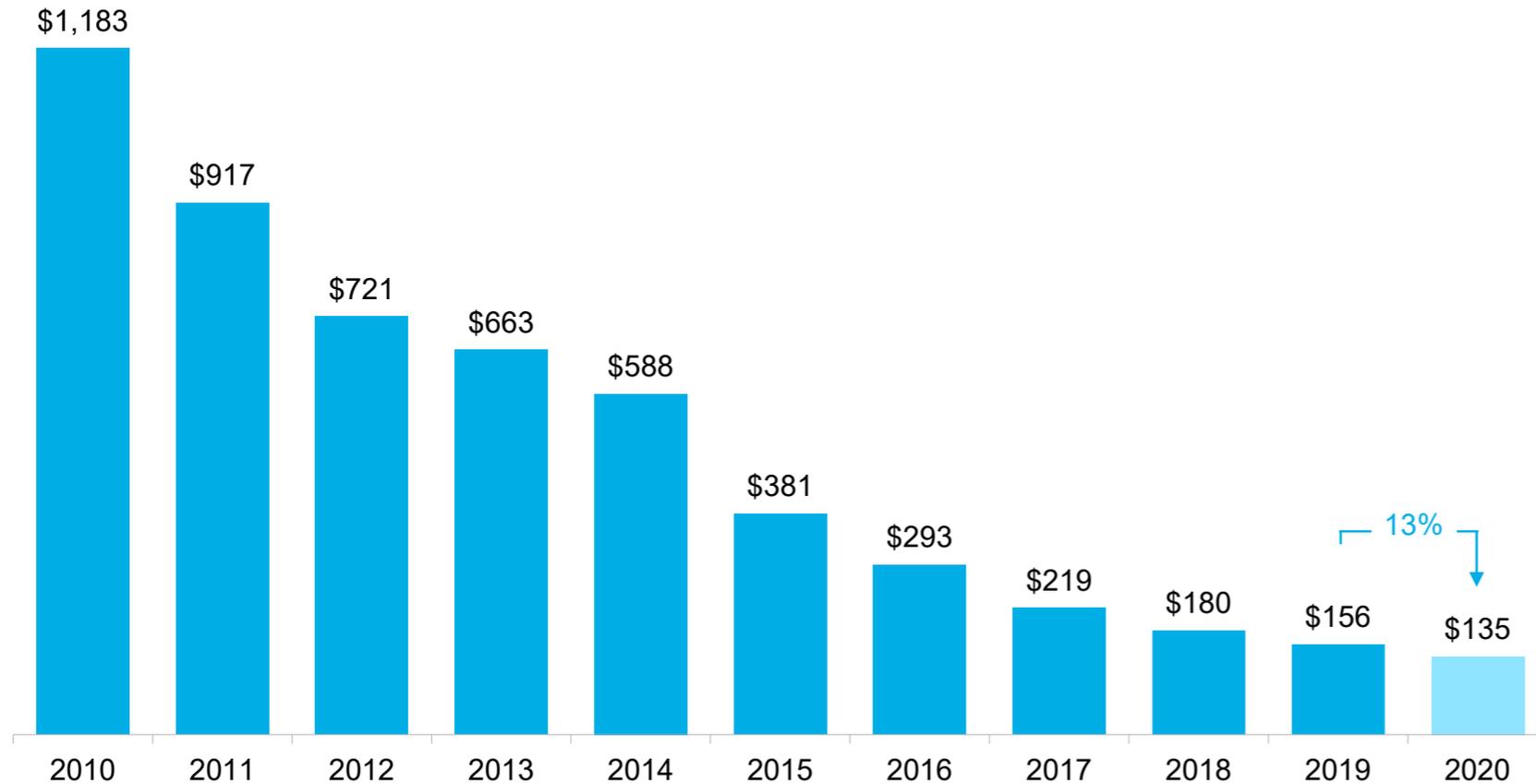
Source: BloombergNEF

# Lithium-ion battery costs fell 87% in the past decade



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

real 2019 \$/kWh



### Lithium-ion battery pack prices fell 87% from 2010 to 2019

BloombergNEF surveys battery buyers and sellers to determine the volume-weighted average price for lithium-ion storage batteries.

### 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

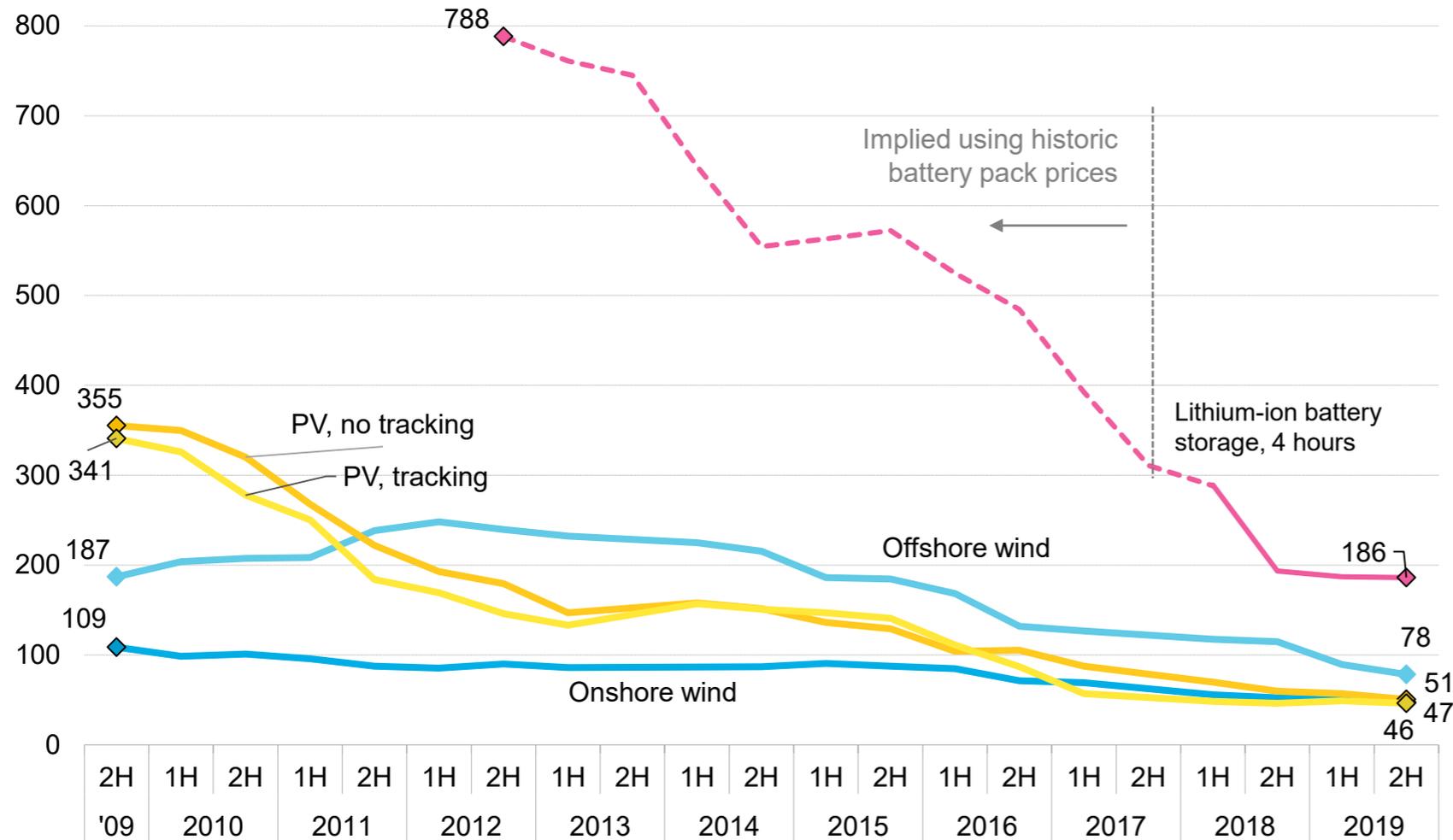
Larger plants, new battery chemistries, new manufacturing techniques and intense competition will keep prices falling in the years ahead. We expect them to cross below \$100/kWh by 2024.

Source: BloombergNEF

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



Global levelized cost of energy benchmarks (\$/MWh, 2018 real)



In 2009, solar photovoltaic power generation cost twice as much as offshore wind, which in turn was 80% more costly than onshore wind.

Today, onshore wind and solar PV with and without tracking have nearly identical benchmark levelized cost of energy.

Offshore wind, which increased in levelized cost as the technology was first widely deployed, is now competitive with fossil fuel-fired power in many markets.

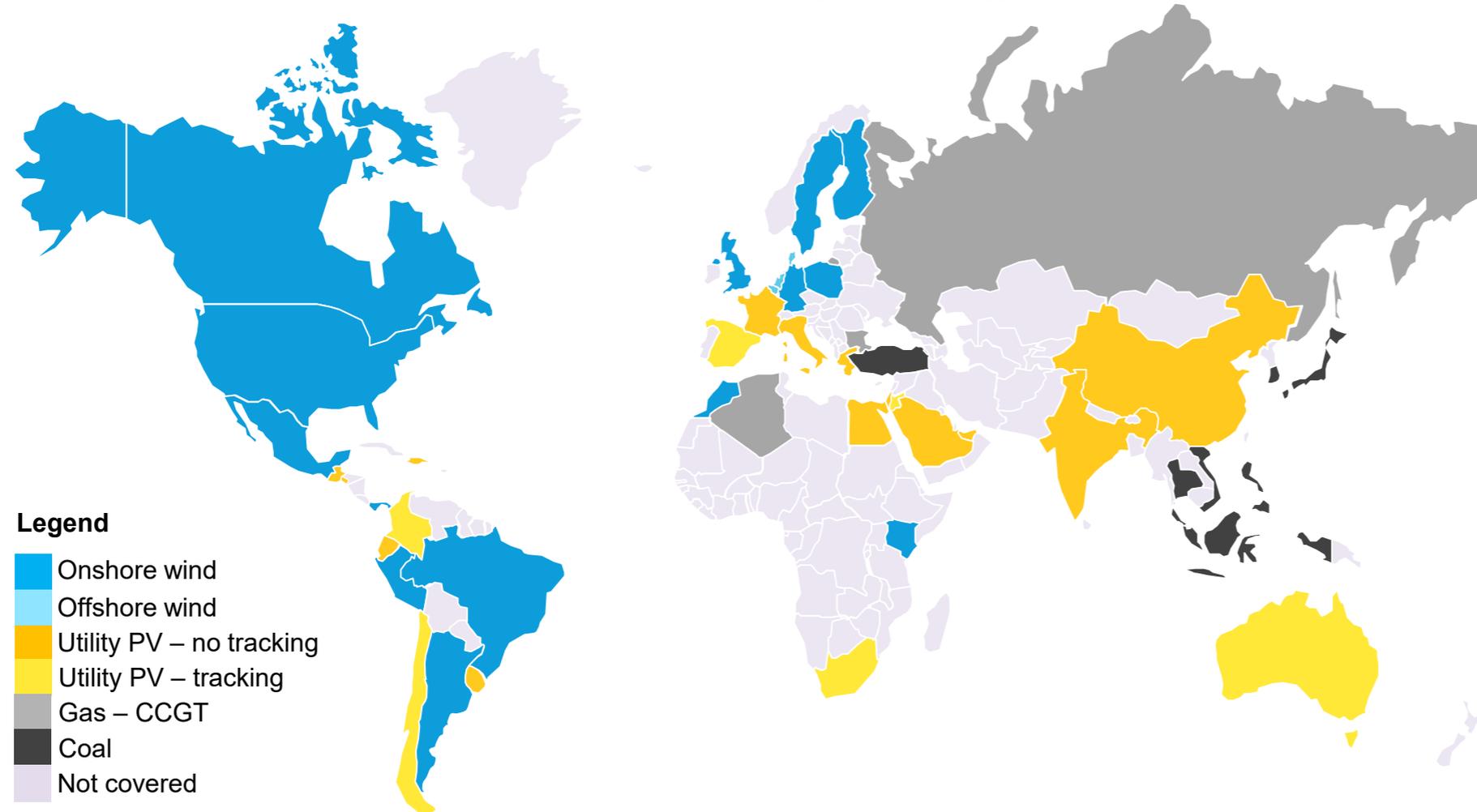
The cost of storage using lithium-ion batteries is on a steep downward trajectory as well.

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, 2019



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

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

Power plant developers can make a clear economic choice for renewables

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.

Renewables will be the cheapest option in nearly every market by 2025

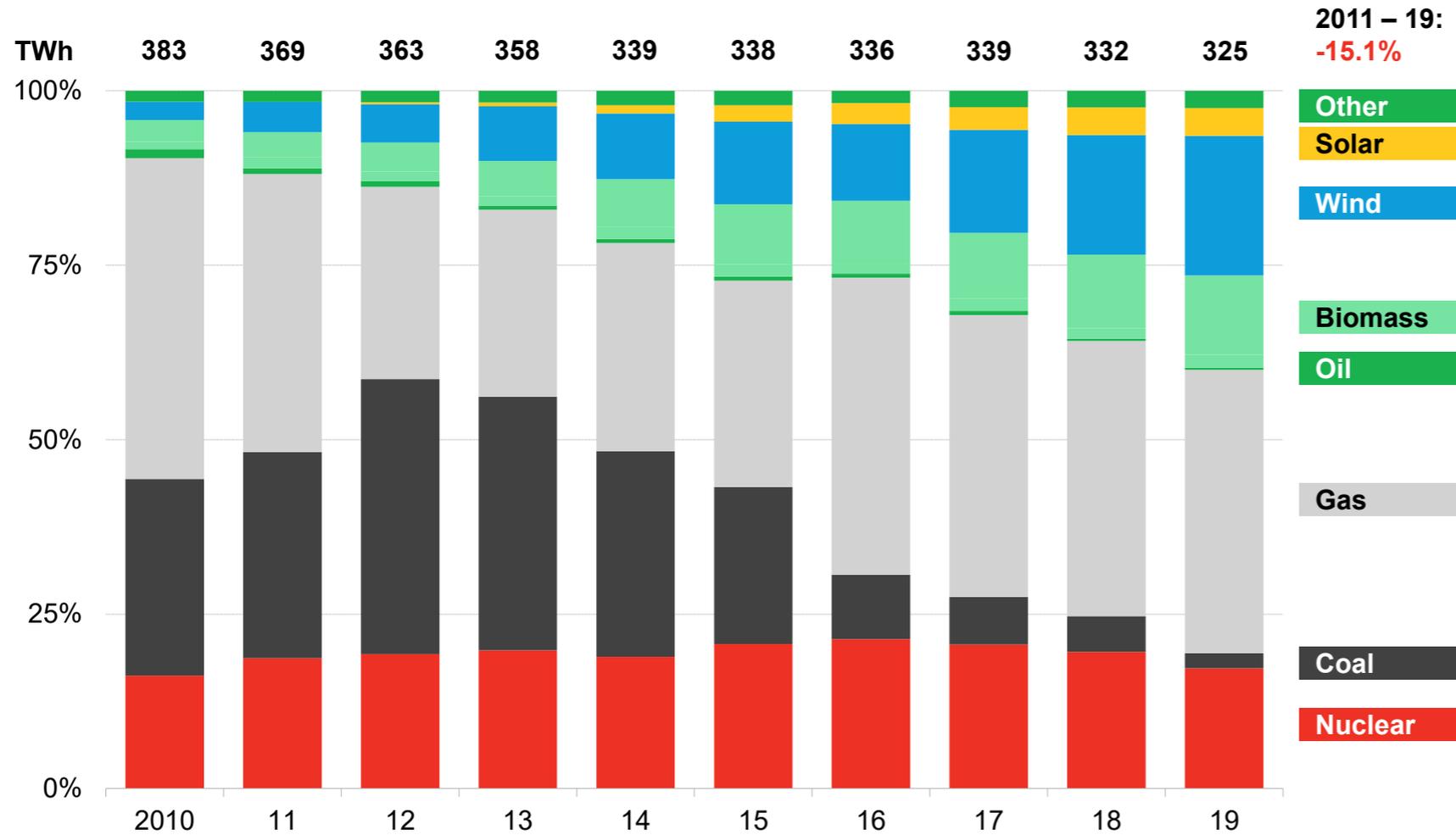
Japan, Southeast Asia, and Turkey are still markets where coal-fired power remains the cheapest option today.

Source: BloombergNEF

# Major power systems are decarbonizing



## U.K. power generation mix



In 2010, coal-fired power was the second-largest source on the U.K. power grid, after natural gas

Natural gas supplied 46% of power demand; coal, 28%; nuclear, 15%.

In 2016, coal fell below nuclear, thanks to increasing renewable energy generation

In 2015, wind power was 11% of U.K. power generation.

Coal-fired power was only 2.1% of U.K. power generation in 2019, a smaller contribution than solar power

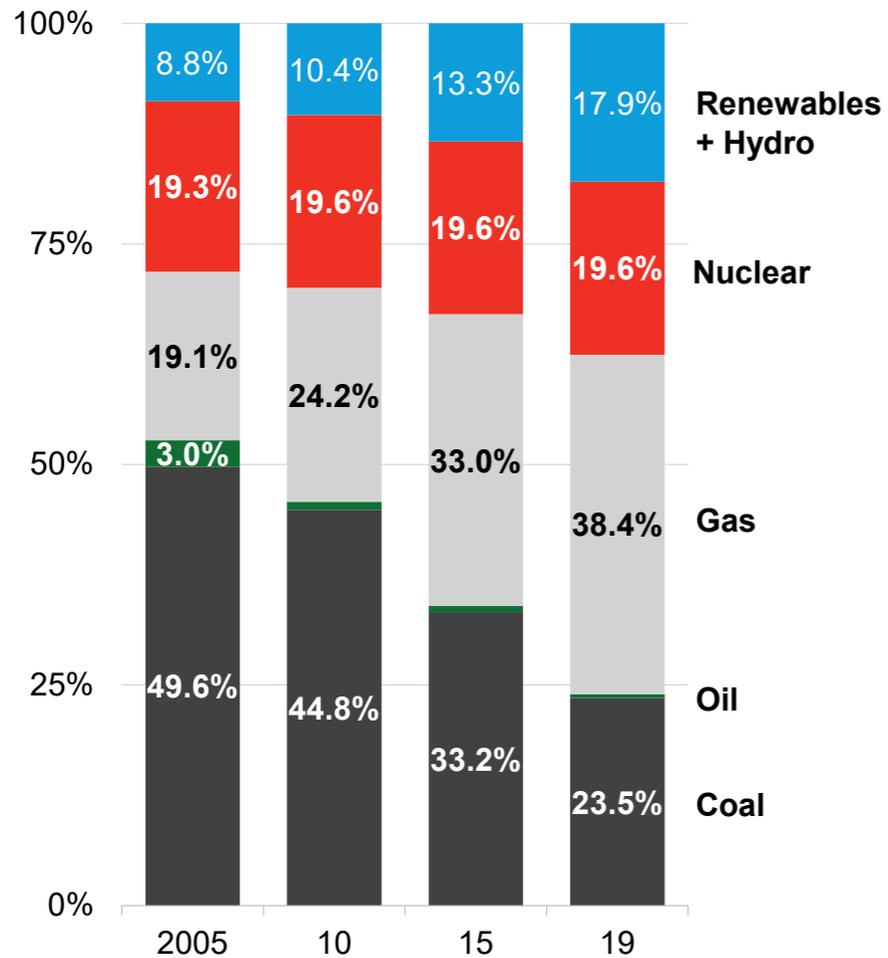
The U.K. power grid now goes days without any coal-fired power generation.

Source: Carbon Brief, BloombergNEF

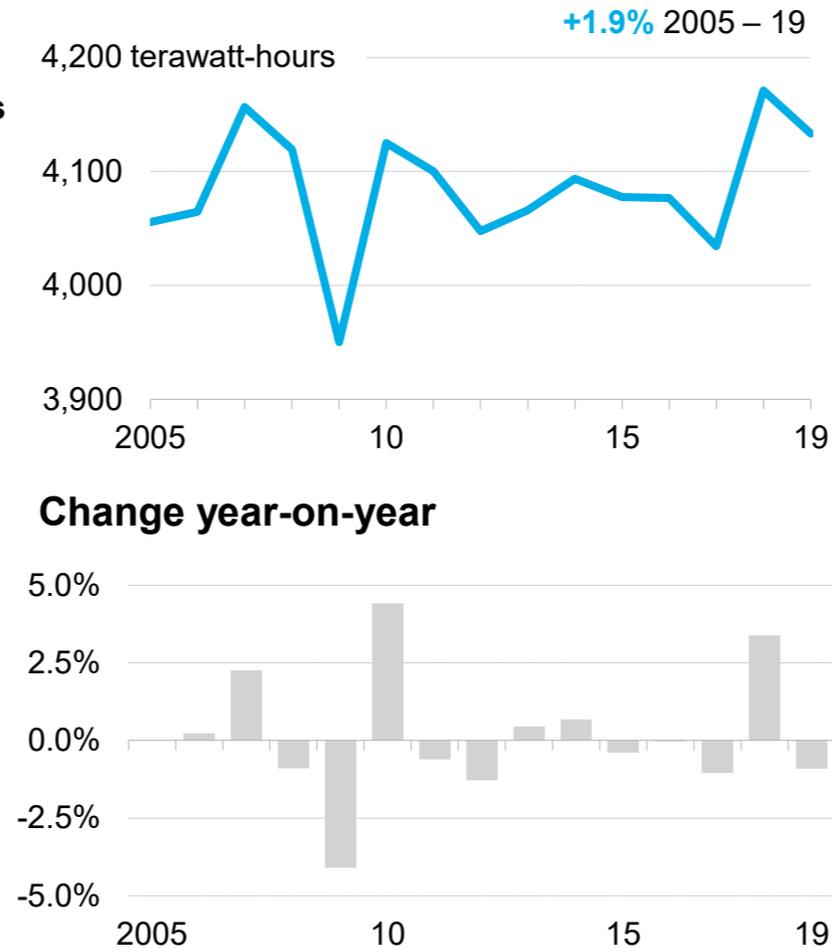
# U.S. power generation is decarbonizing



## U.S. electricity generation, by fuel type



## U.S. electricity generation, total



U.S. power generation has decarbonized significantly in the past 15 years, thanks to coal-to-gas switching and renewable energy.

Renewable and hydro generation has more than doubled, from less than 9% to nearly 18% of the total.

Coal's share of U.S. power generation has fallen more than 50%, and is now less than a quarter of the total.

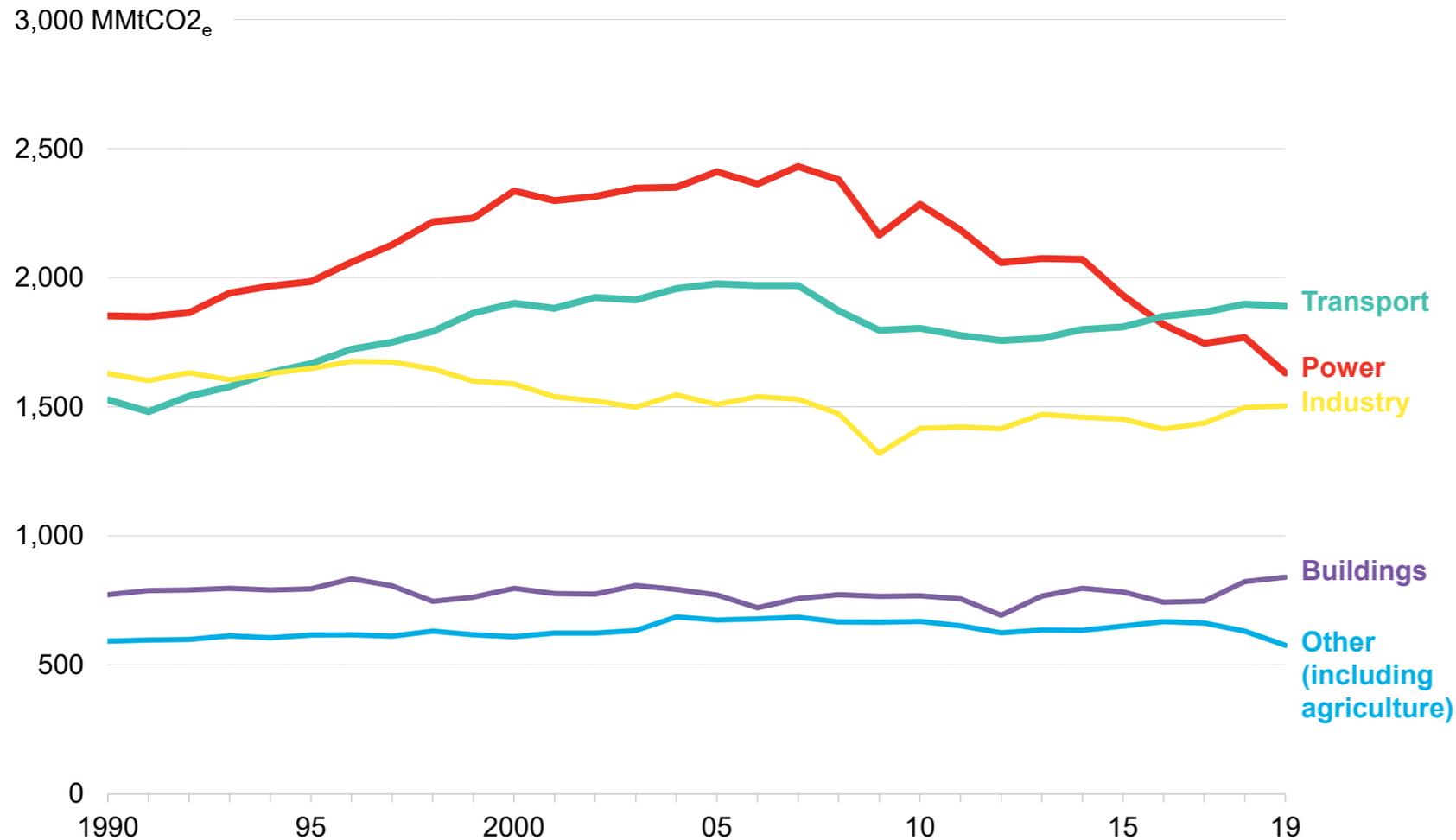
Total electricity generation growth has been minimal, up less than 2% in 15 years.

Source: 2020 Sustainable Energy in America Factbook [link](#)

# Falling power sector emissions make transport the biggest source of emissions in major markets



## U.S. greenhouse gas emissions by sector



U.S. greenhouse gas emissions fell 2.7% in 2019, after ticking up slightly in 2018.

Total GHG emissions are now 12% below 2005 levels, putting the U.S. slightly under halfway to its Paris Agreement targets of 26-28% by 2025.

Power generation emissions fell 7.8% in 2019, thanks to coal-to-gas switching and greater renewable generation.

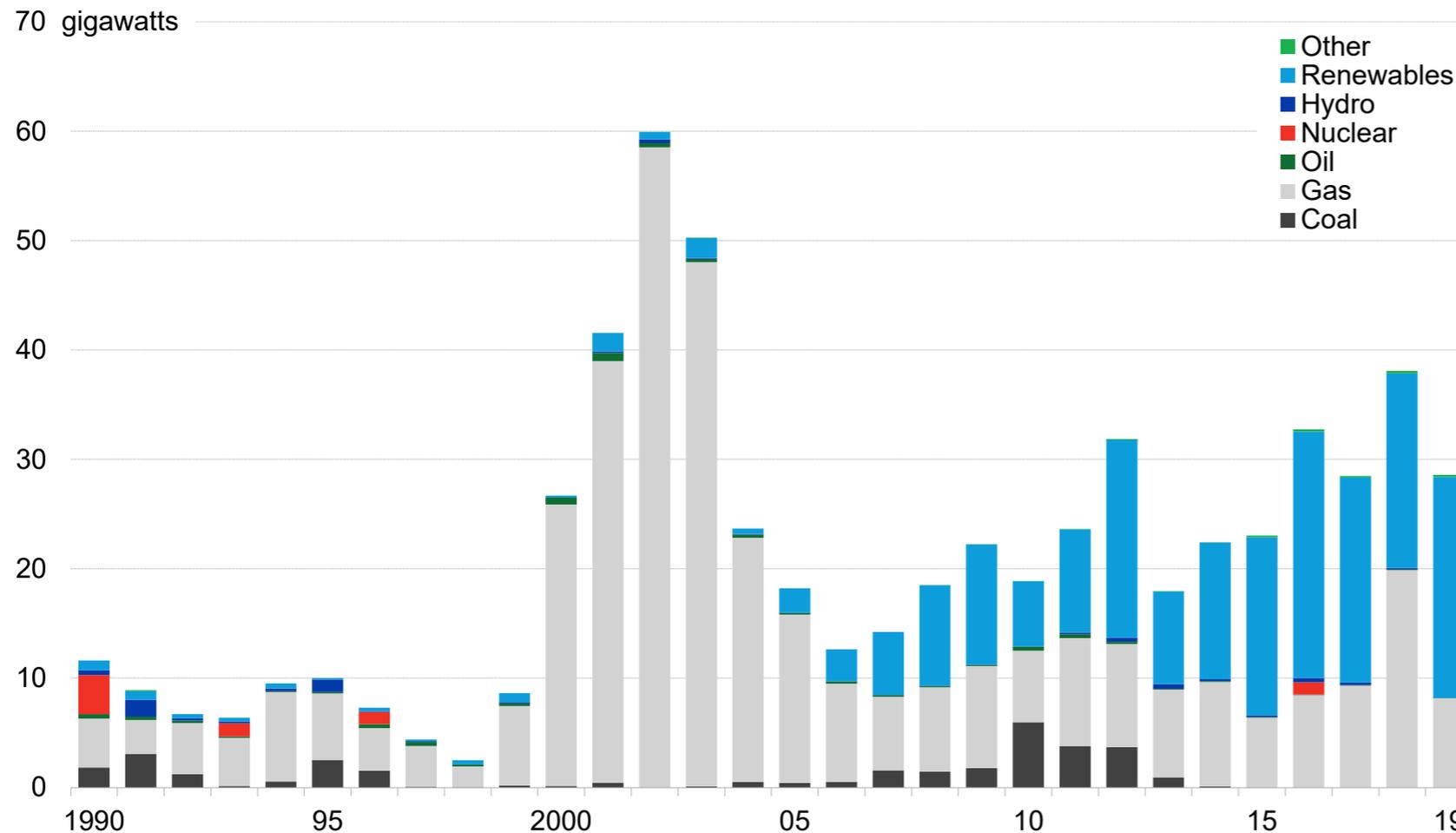
Transport has been the single largest source of GHG emissions for the past four years.

Source: 2020 Sustainable Energy in America Factbook [link](#)

# Renewables and gas are now almost the entirety of new U.S. power generation capacity additions



## U.S. electric generating capacity additions, by fuel type



Natural gas-fired power plant capacity additions boomed in the U.S. in the late 1990s and early 2000s, thanks to deregulation and growing electricity demand.

Coal-fired power additions ceased in 2014.

Renewable capacity additions accounted for 71% of all new capacity in 2019, and 56% of total additions in the past decade.

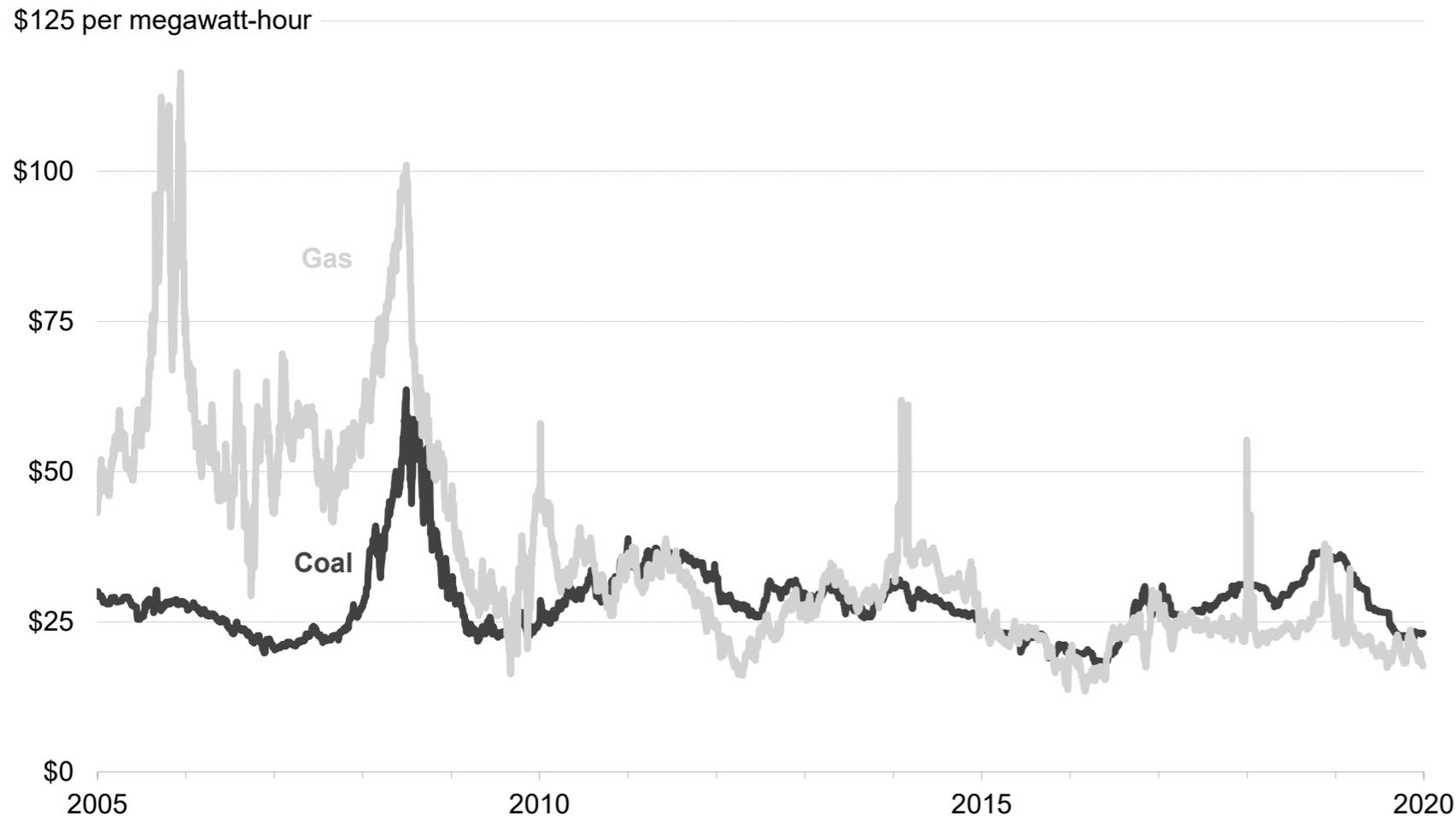
Gas and renewables account for 93% of all build in the past decade, and 94% in the last 25 years.

Source: 2020 Sustainable Energy in America Factbook [link](#)

# Natural gas now routinely underprices coal for U.S. power generation



## U.S. natural gas and coal realized prices



In the U.S., power generation is the primary source of gas demand price elasticity.

When the price of gas falls below that of coal, gas burn rises until the price differential (in dollars per megawatt-hour) between the two fuels closes.

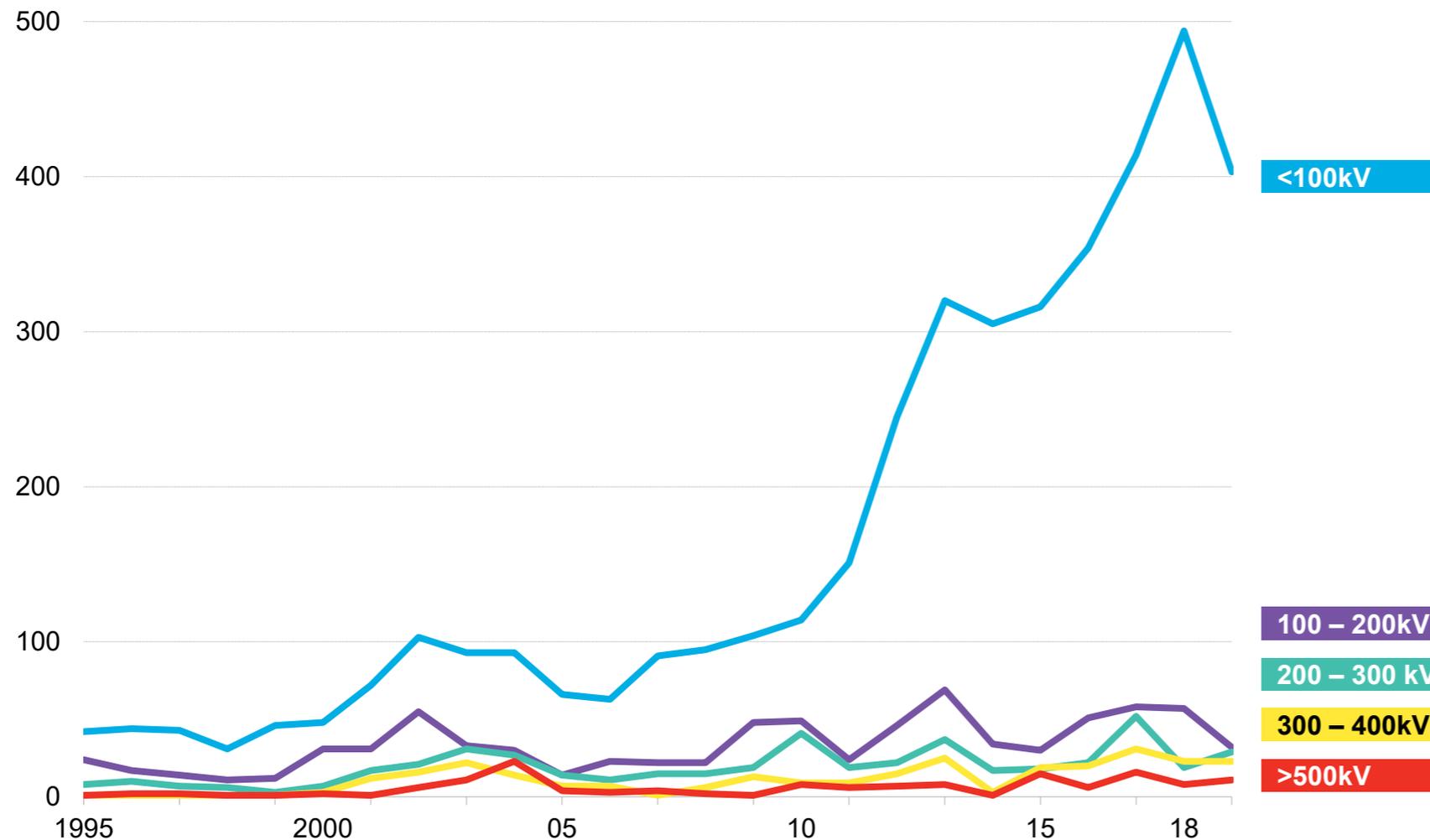
In 2019, natural gas prices had to realize lower than coal prices in order to increase gas demand and slow the pace of gas injection into storage.

Source: 2020 Sustainable Energy in America Factbook [link](#). Note: combined-cycle gas plant, heat rate 7,410Btu/kWh, Henry Hub price. Coal plant 10,360Btu/kWh, Appalachian coal price. Further assumptions in Factbook.

# Renewable energy is leading to a decentralized and lower-capacity grid



## U.S. generator requests by voltage



Expansion of U.S. renewable energy is leading to a more decentralized grid.

Nearly 500 new generators were connected to <100 kilovolt transmission lines in 2017.

However, this increase in lower-voltage interconnection has not led to greater investment in lower-voltage grids.

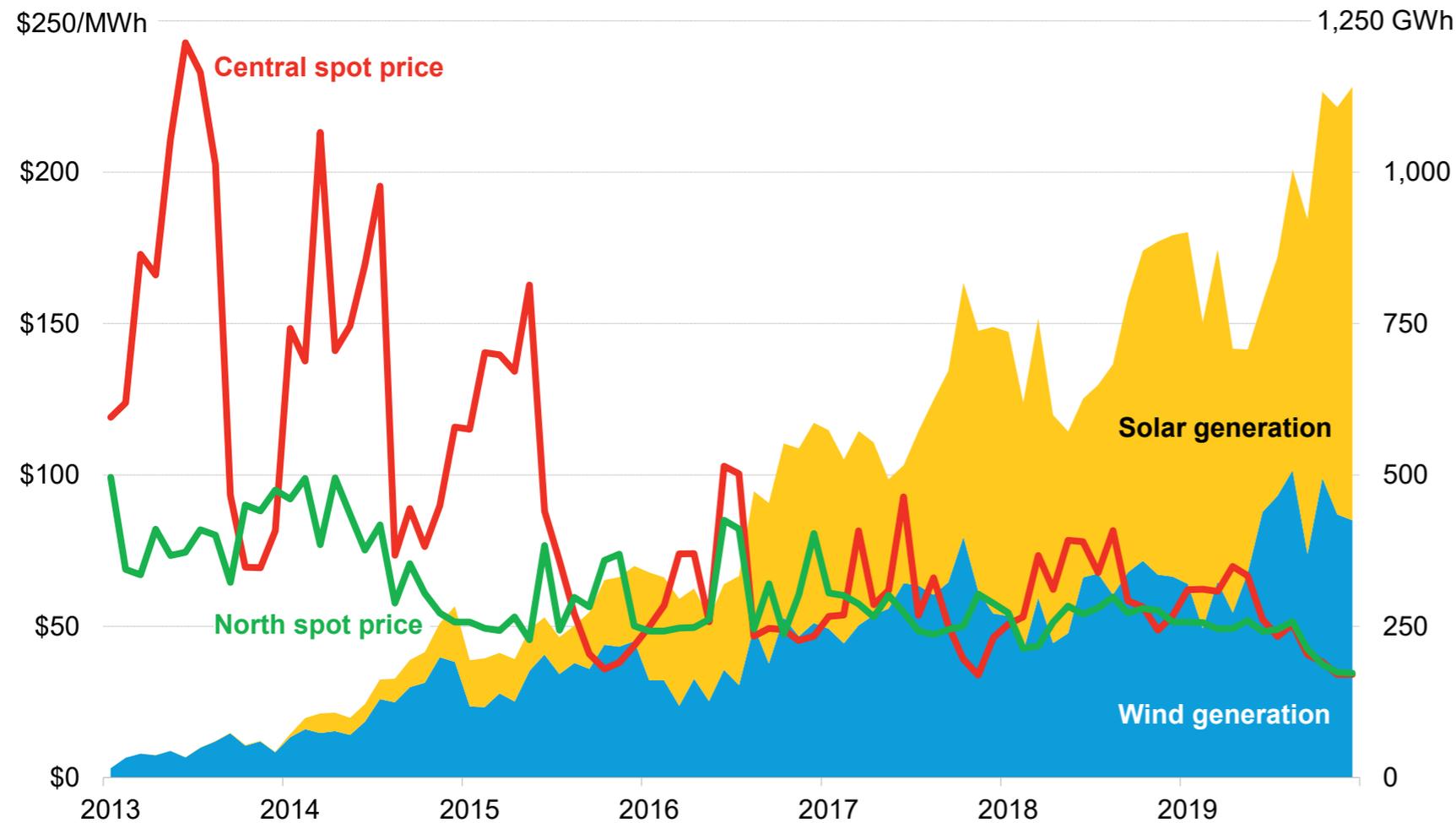
Continued expansion of renewable energy may force more construction of lower-voltage transmission in the future.

Source: BloombergNEF, FERC

# Renewable energy generation lowers spot electricity prices



## Chile spot power prices and renewable power generation



### Renewable generation can grow quickly in national power systems

Since 2013, wind and solar generation in Chile grew from virtually nothing to over 1TWh, meeting 14% of Chile's power demand in 2019 and overwhelming its wholesale market.

### Continued growth requires planning and market price signals

Depressed prices and heady volatility temporarily put the breaks on Chile's renewable revolution, new development faltered as its system struggled to absorb large volumes of intermittent power.

### Infrastructure is key to further renewables build-out

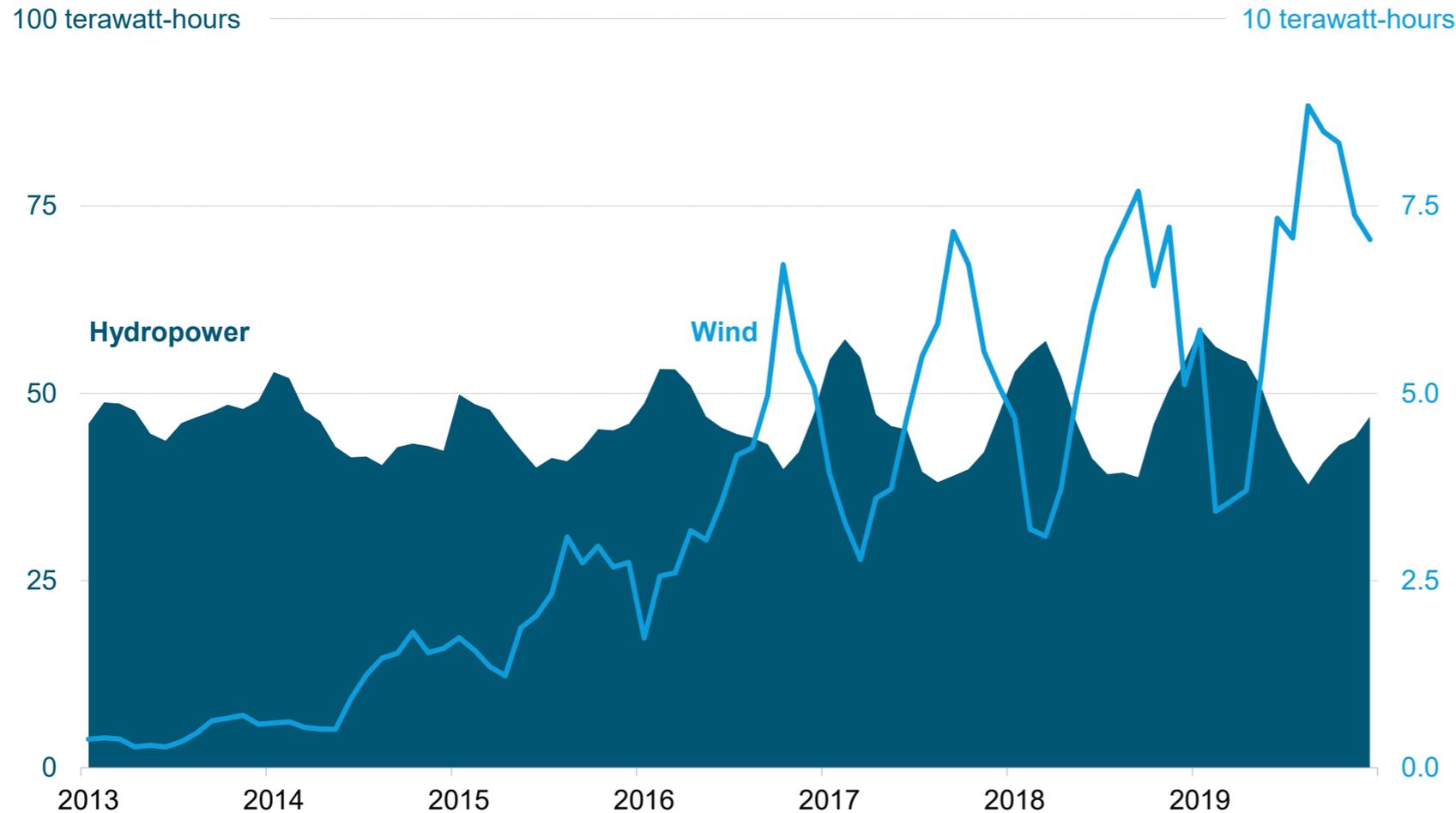
Chile's disjointed grid, since interconnected, also meant that spot prices within the country's two main systems could be radically different. Prices have now converged, offering predictability, and large volumes of solar power generated in the north can flow to demand centers in the center of the country, easing curtailment.

Source: Coordinador Electrico Nacional, Comision Nacional de Energia, BloombergNEF.  
Note: Central is Sistema Interconectado Central; North is Sistema Interconectado del Norte Grande

# Large-scale renewable resources can be complementary



## Brazil hydropower and wind generation



### Renewables often show surprising complementarity

In Brazil, rapidly growing generation from wind has strong seasonal complementarity with large hydro, which is 63% of Brazil's generation capacity. Higher capacity factors for the country's excellent wind resources coincide with dry months, when hydro is less available.

### Complementary helps insulate power systems against external shocks

Wind helps offset increasingly volatile generation from large hydro generation driven by changing weather patterns, while also reducing exposure to fossil fuel prices.

### Complementarity supports growing intermittent additions

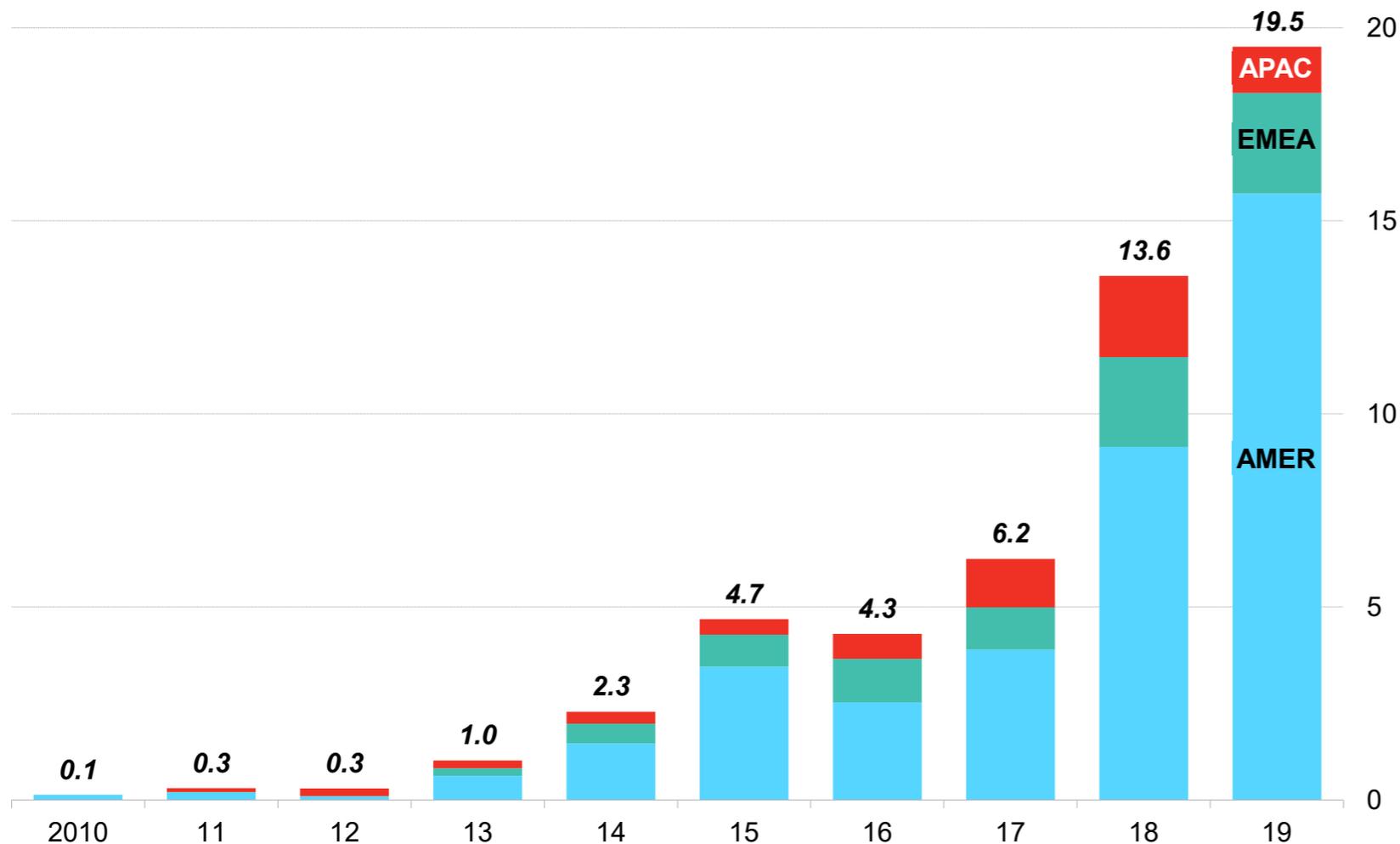
Wind complementing hydro generation allows more wind to be built, while boosting system flexibility. More generation from wind means hydroelectric power can be deployed when it's needed most, turning the country's reservoirs into giant batteries.

Source: BloombergNEF

# Corporations have signed more than 50 gigawatts of clean energy power purchase agreements



Corporate PPA volumes by year (gigawatts)



Private enterprises and public institutions bought power from 19.5 gigawatts of renewable energy in 2019, a nearly 20-fold increase in five years.

U.S.-based companies were 70% of contracted volumes in 2019, while Asia Pacific contract volumes shrank in absolute and relative terms.

Europe and Latin America had record years for contract volumes.

Source: BloombergNEF

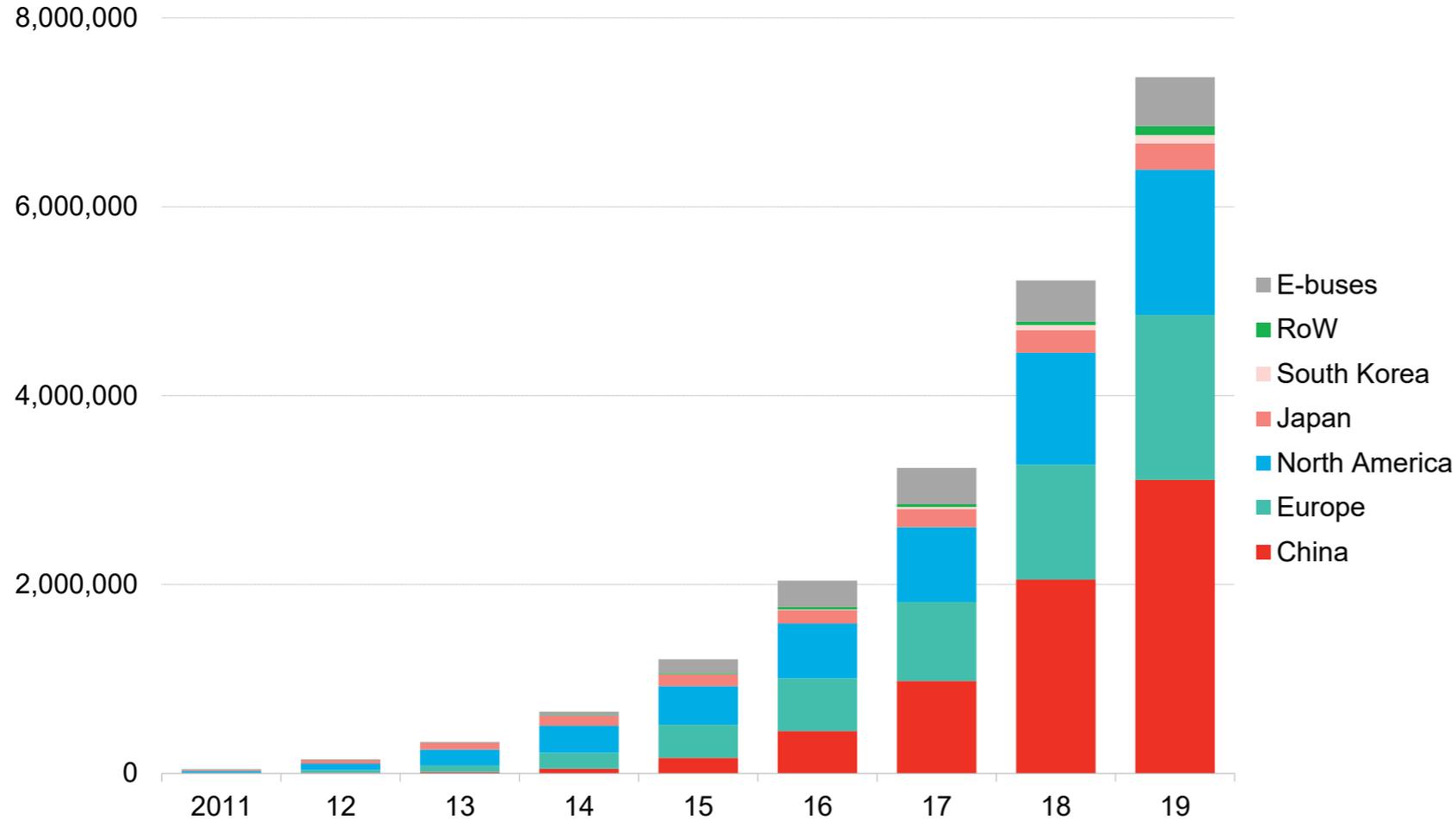
# Table of contents

Introduction: the moment we are in	3
 A cleaner future	12
 Power	21
 <b>Transport</b>	<b>40</b>
 Industry and Buildings	55
 Commodities	70
 Food and Agriculture	87
 Capital	93
BNEF Summit series / About BNEF	102

# The global passenger electric vehicle fleet exceeds 7 million



Global passenger electric vehicles by region



## The global electric passenger vehicle fleet exceeds 7 million

The global fleet includes more than half a million electric buses, almost all of them in China.

## China is more than 50% of the global electric vehicle market

BloombergNEF expects China to maintain its position as more than half of the global EV market through the middle of this decade at least.

## Industrial policy and clean air drive EV policies in major markets

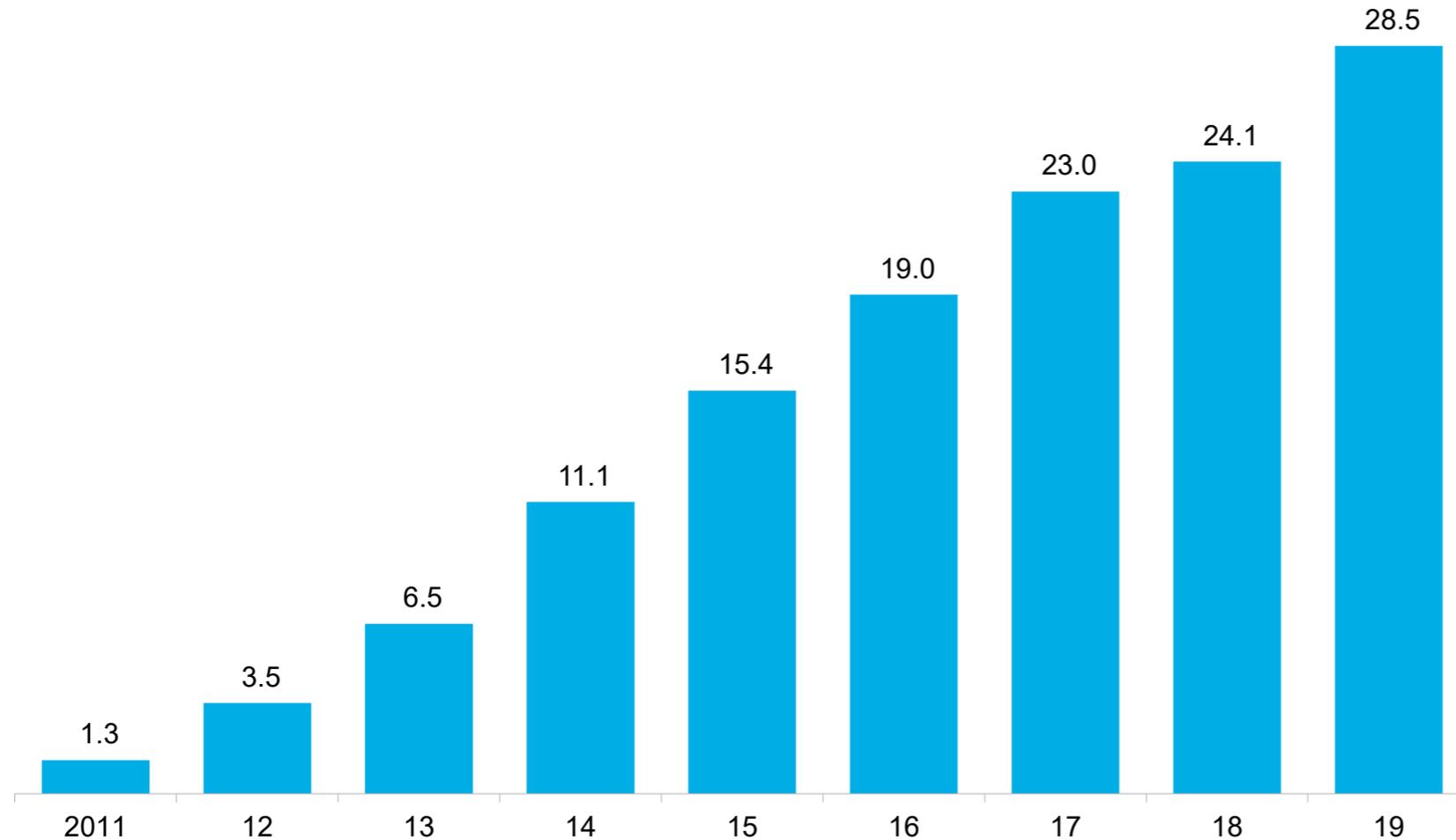
China in particular views electric vehicles as a key element of the national industrial policy. Clean air regulations – as well as consumer preferences for a better local environment – are increasingly important for EV market penetration as well.

Source: BloombergNEF

# Connected car sales have increased 20-fold from 2011 to 2019



Global connected car sales (millions)



## Connected car sales have increased 20-fold from 2011 to 2019

BloombergNEF tracks vehicles with embedded telematics as connected cars. BloombergNEF does not consider cars with basic emergency call devices to be connected cars.

## Automakers are still experimenting with connected cars

It is not yet clear what automakers will do with the data generated by connected cars, or what new business models or customer services connected cars might enable.

## Telecoms companies and cloud computing service providers are increasingly active in connected cars

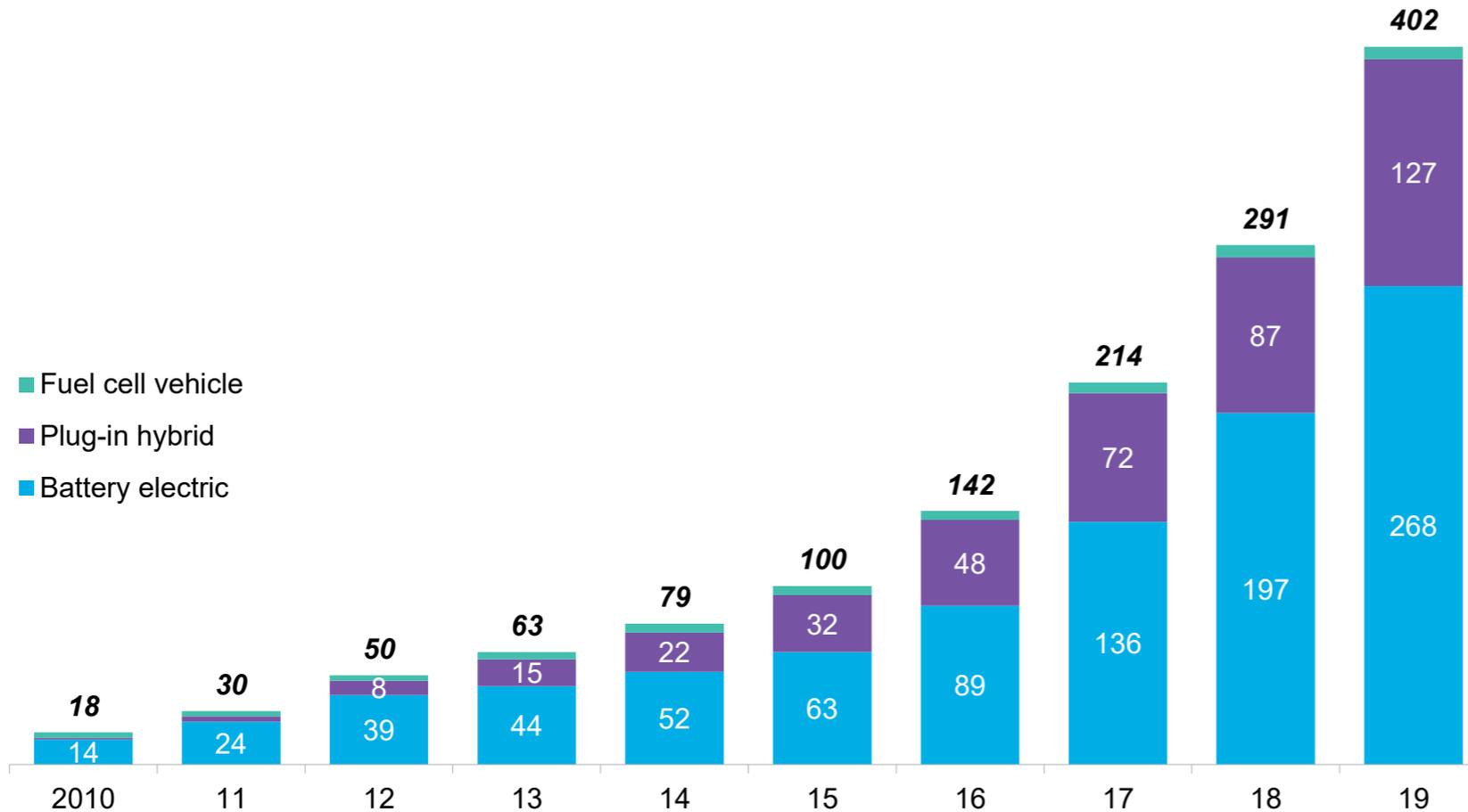
Exponential increases in data collected from connected cars require enhanced transmission, storage, and processing.

Source: BloombergNEF, MarkLines. Note: 4Q 2019 estimated.

# There are more than 400 electric and fuel cell passenger vehicle models offered today



Total number of battery electric, plug-in hybrid, and fuel cell vehicle models available



By the end of 2019, auto manufacturers offered more than 400 alternative-fuel vehicle models.

Prior to 2016, plug-in hybrid models were about half as prevalent as purely electric models.

Since 2017, the number of purely battery electric vehicles has risen significantly, while the number of plug-ins has not increased at the same rate.

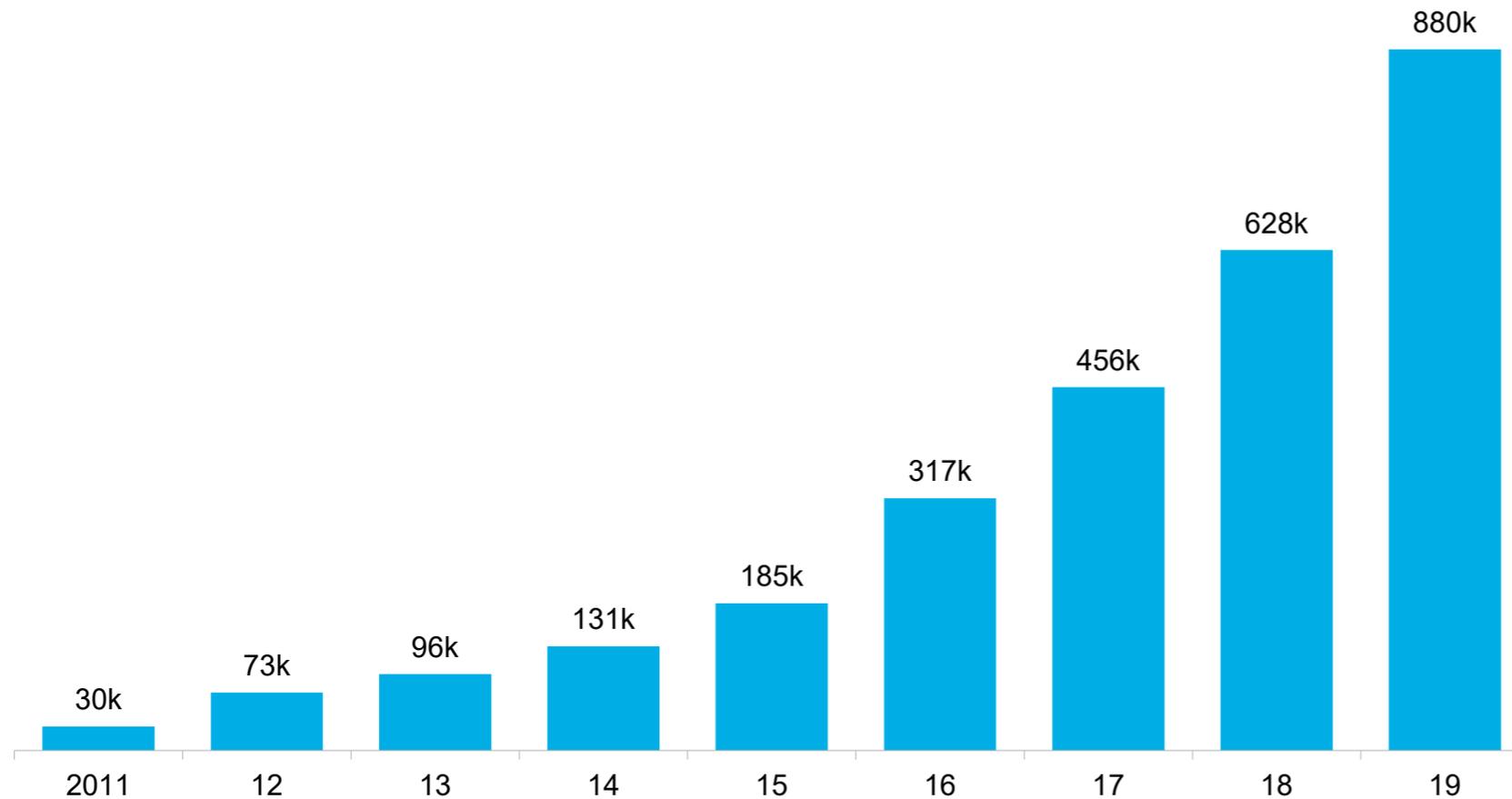
As of the end of 2019, China offered more than 300 battery electric and plug-in models, three-quarters of the global total.

Source: BloombergNEF

# There are nearly 900,000 public electric vehicle charging connectors worldwide



Total number of public EV charging connectors installed



## The charging market is growing rapidly

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

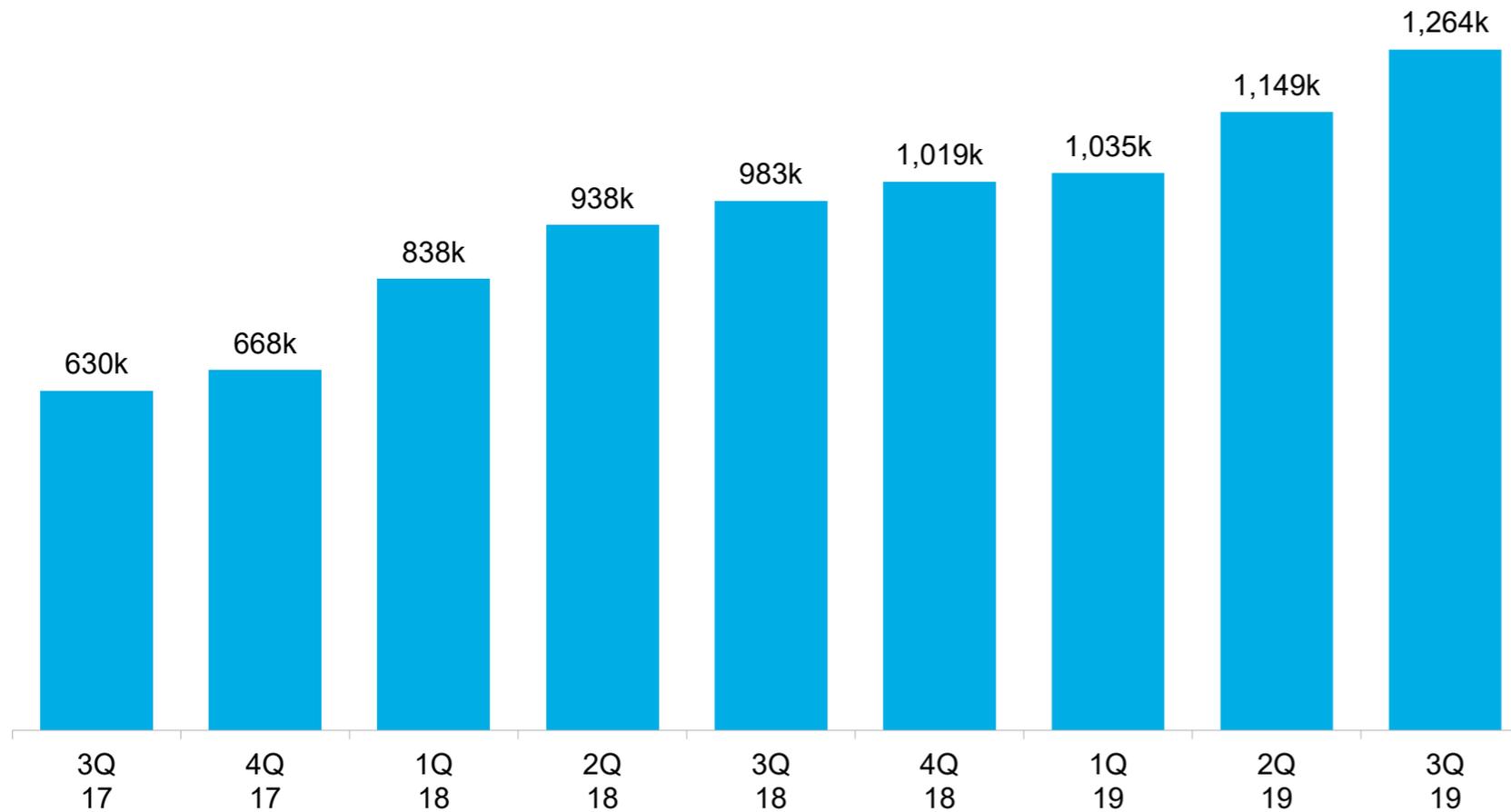
However, there are a number of critical questions outstanding for network operators, such as the optimal speed for charging, ideal location of public chargers, and the approach to billing customers.

Source: BloombergNEF

# Digital hailing apps have more than 1.2 billion users worldwide



## Active users of digital hailing services



The number of active users of digital hailing apps has doubled in two years. 630 million people actively used digital hailing apps in mid-2017; two years later, that figure was more than 1.2 billion.

### More digital hailing users are likely, even with greater regulation

The convenience, and in some cases price, of digital hailing services has made them part of urban and suburban transport's fabric.

### Most operators are still losing money and re-aligning their geographic focus

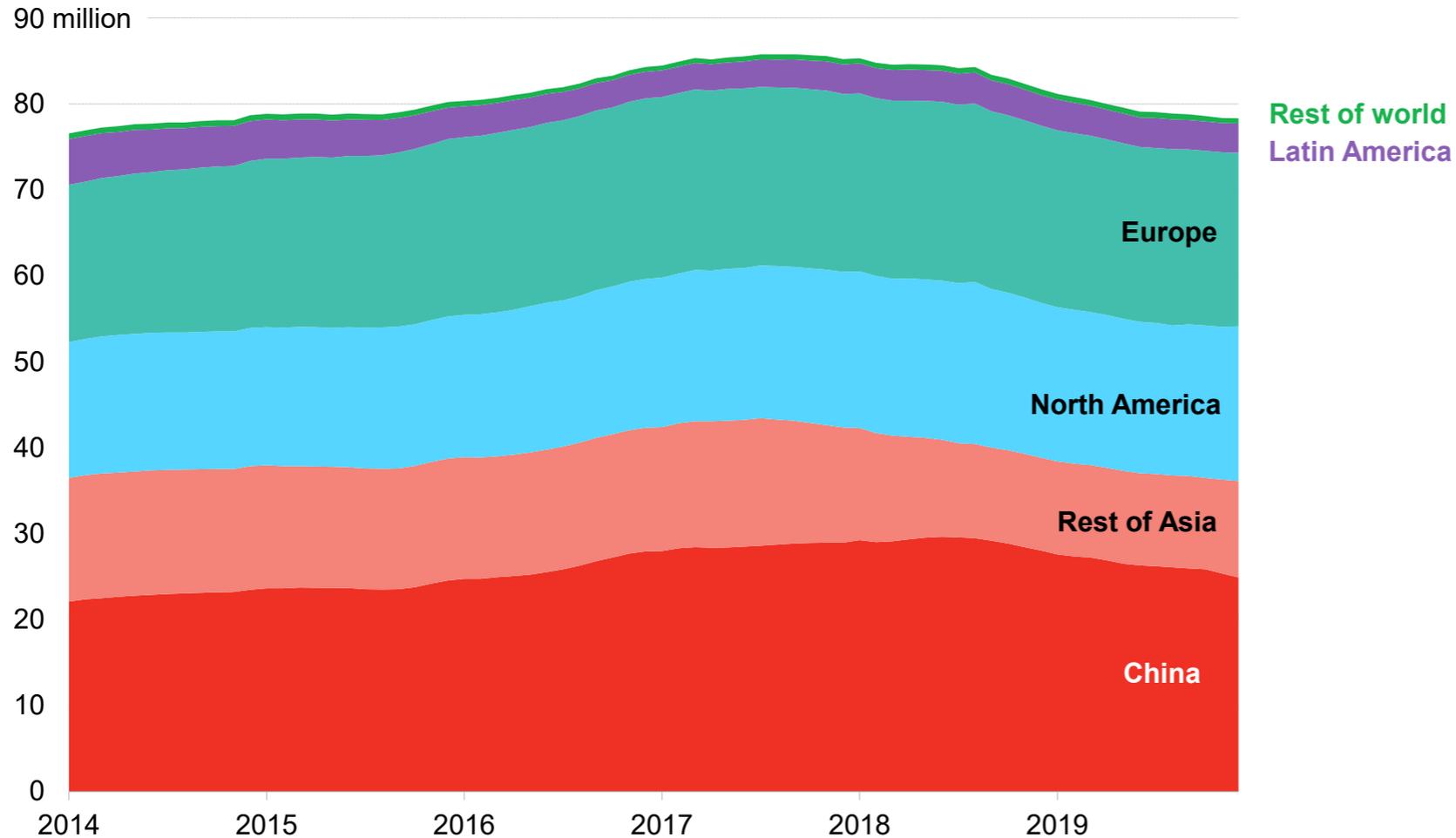
Additional services such as food delivery, and additional vehicle types such as pedal electric bicycles, scooters, and mopeds (collectively referred to as 'micromobility' offerings) are part of continued aggressive strategy to gain customers and market share.

Source: BloombergNEF

# Passenger vehicle sales peaked in 2017, and have since declined by almost 9%



Global passenger vehicle sales, trailing 12 months



## Global passenger vehicle sales peaked in 2017 at 85.8 million

Trailing 12 month sales have since fallen to 78.3 million in December 2019, a decline of 8.7% from their peak.

## China is the world's largest passenger vehicle market

Even after declining 16% from its peak, China is still larger than Europe or North America.

## North America and Europe have declined the least

North America passenger vehicle sales are only down 4.6% from their peak, while Europe sales are only down 4%.

## Other Asian markets have declined significantly

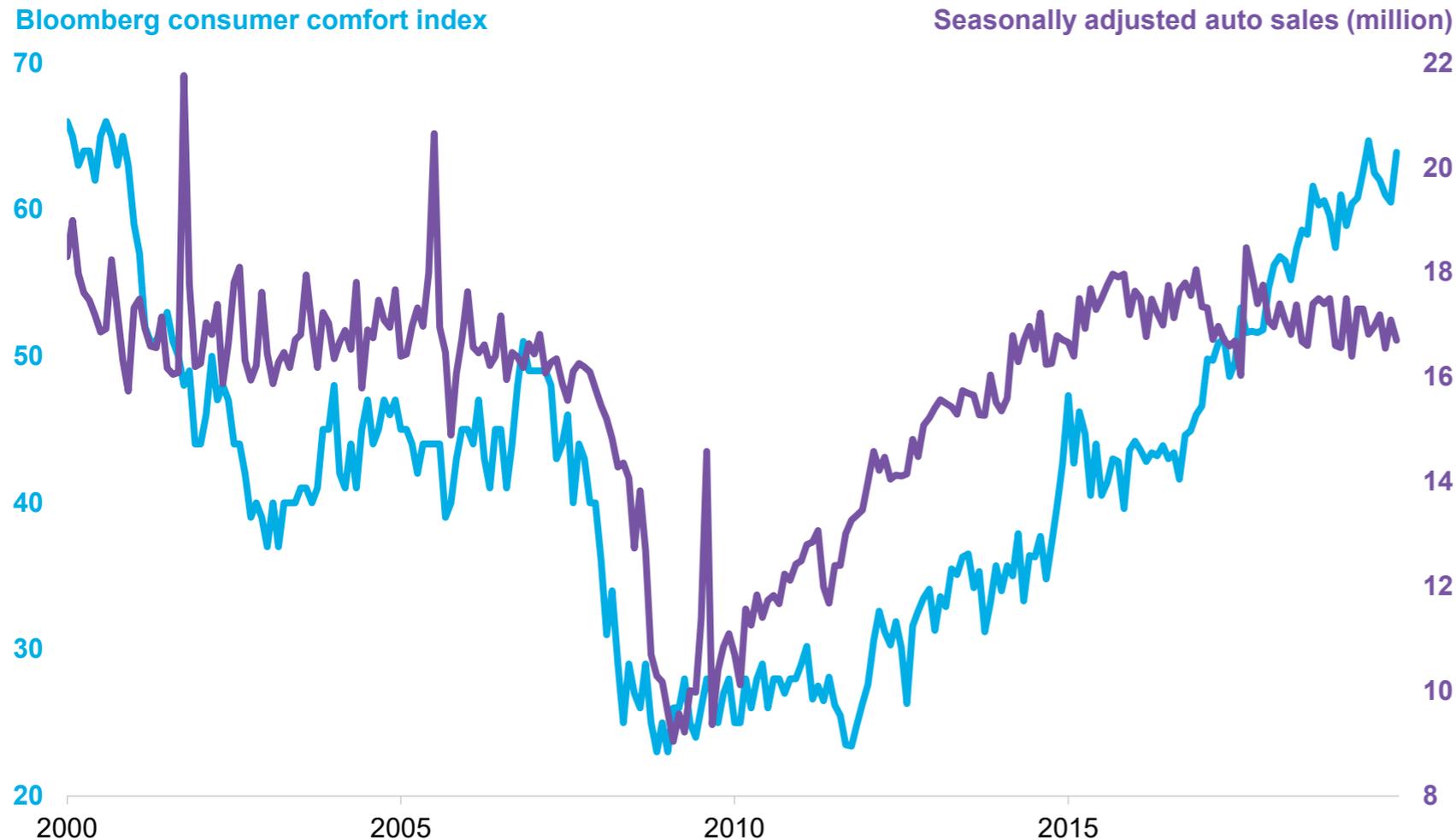
Sales in Asia ex-China have declined 24.2% from their peak. Latin America sales have declined almost 36% from their peak.

Source: Bloomberg Intelligence

# U.S. auto sales and consumer confidence decoupled in 2016



## U.S. consumer comfort and auto buying trends



U.S. consumer confidence and new passenger vehicle sales were highly correlated through 2016

From January 2000 to June 2016, the correlation between consumers' confidence and their auto buying behavior was 0.76

There is now an inverse correlation between consumer confidence and auto buying

Since July 2016, the correlation between consumer confidence and new auto buying is -0.35.

U.S. automobiles last longer, and are higher quality, than they once were

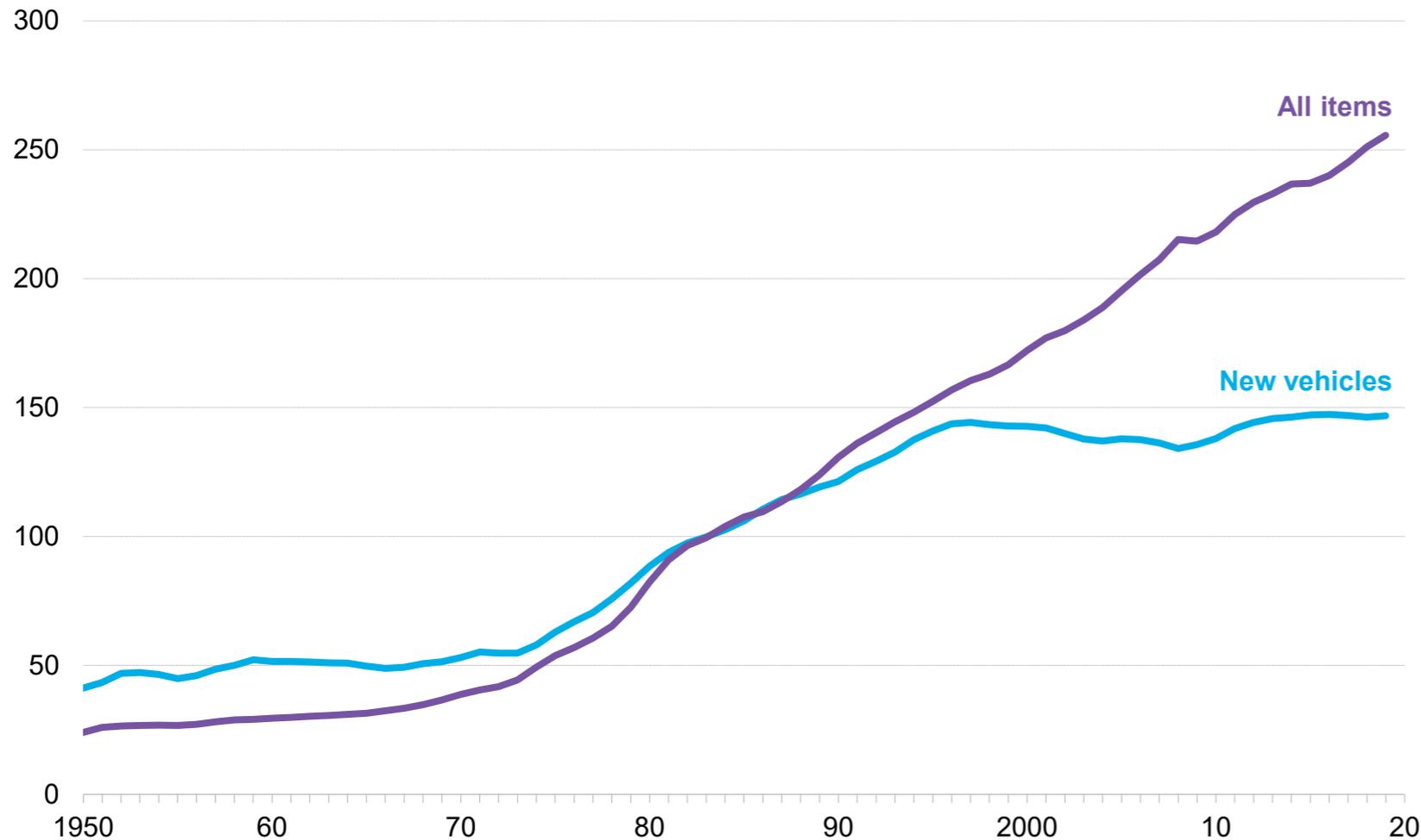
The average age of the U.S. passenger vehicle fleet is now more than 10 years, and automobile price inflation has been lower than inflation for more than two decades.

Source: Bloomberg, BloombergNEF

# The auto consumer price index has been below the general consumer price index since the 1990s



U.S. consumer price indices, new vehicles and all items in U.S. city average (1982-84=100)



Since the 1990s, automobile costs have increased less than the U.S. urban consumer price index.

At the same time, they have increased in quality and durability, and added safety and comfort features.

This combination of flat prices and improving quality makes disruptive innovation from within the automobile industry quite difficult.

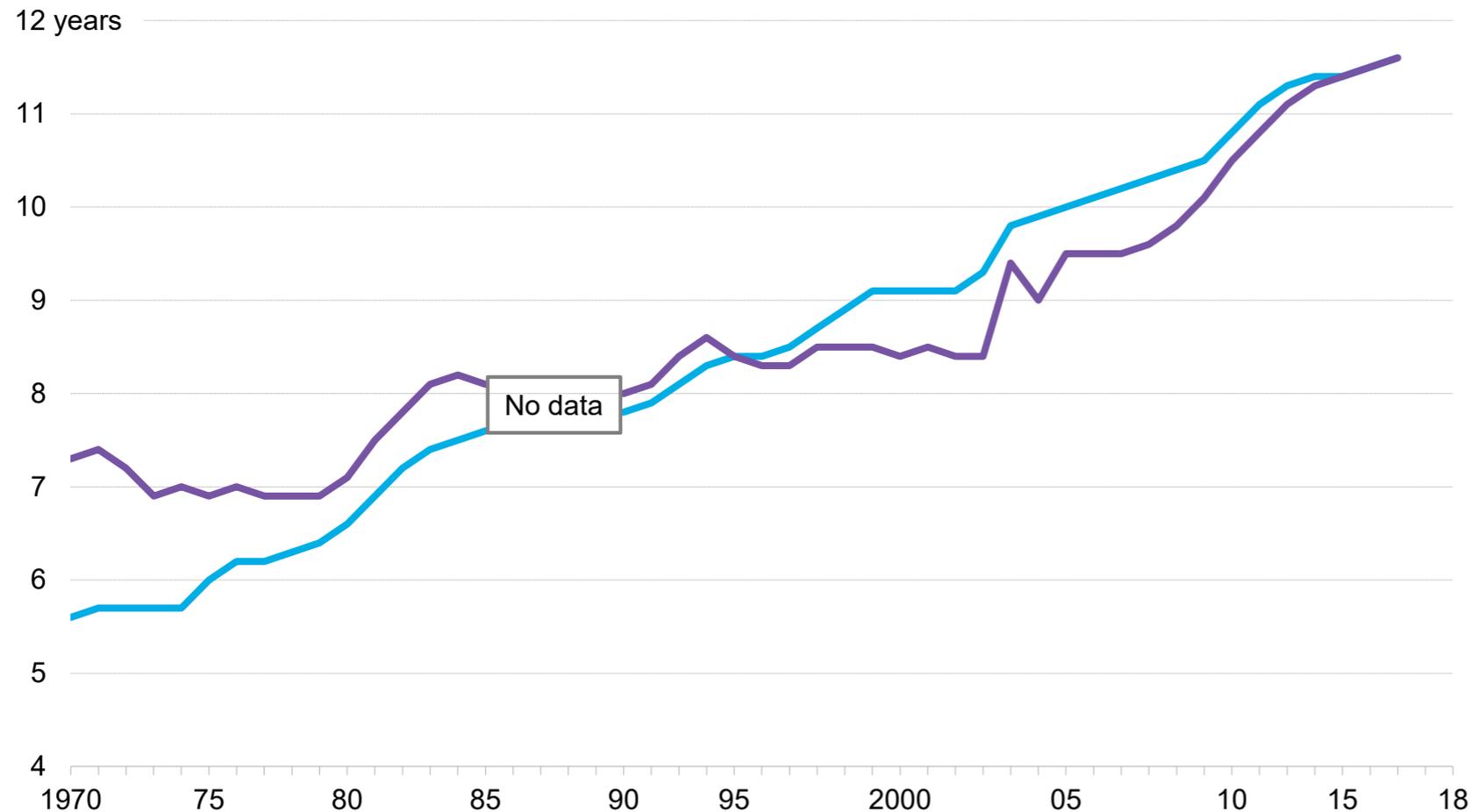
It does not, however, mean that automobiles are invulnerable to disruptive innovation from other modes of transport.

Source: U.S. Bureau of Labor Statistics, [BloombergNEF link](#)

# Vehicles on the road are older than ever today, and so are car buyers and licensed drivers.



## Average age of U.S. light-duty vehicles



The average age of a U.S. passenger vehicle has doubled in 50 years.

In 1970 the average vehicle age was 5.8. It is now double that.

U.S. licensed drivers are also trending older as well

Since 2000, the percentage of the population with driver's licenses has fallen in every age group from 16 to 59. For ages 60 and above, the percentage of the population with a license has risen.

U.S. auto buyers are trending older as well.

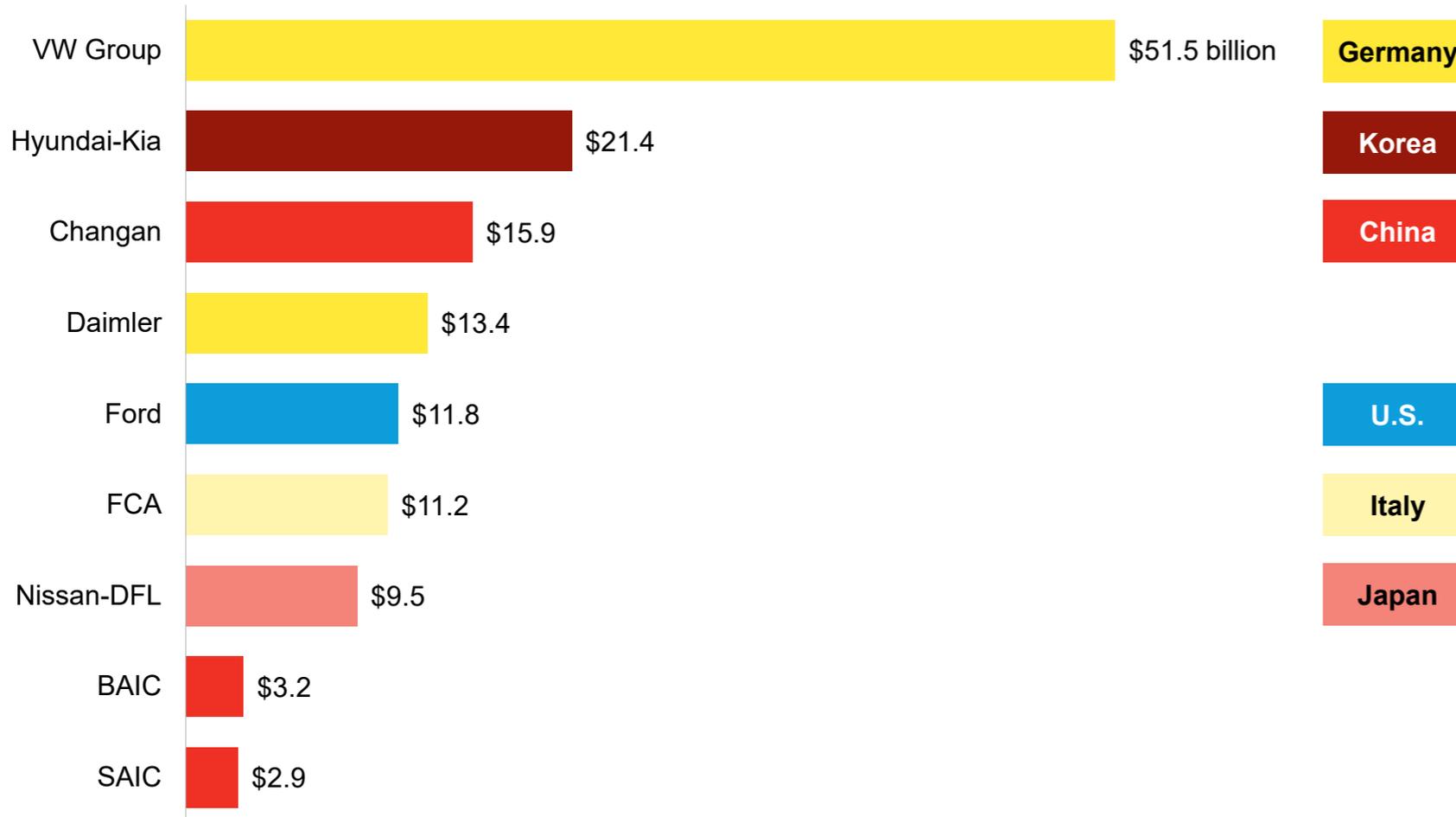
In 2007, nearly half of all light-duty vehicle buyers in the U.S. were under the age of 44; in 2017, more than half were over the age of 55.

Source: Oak Ridge National Laboratory [link](#). Note: data not available 1986-90.

# Automakers have committed more than \$140 billion to electrification



## Automaker capital spending commitments for electrification



Major automakers have committed more than \$140 billion of capital spending for electric vehicle production.

VW Group has committed more than twice the spending of Hyundai-Kia, the manufacturer with the next largest commitment.

Ford is the only U.S. diversified automaker with significant EV capital commitments.

Three Chinese manufacturers are in the top rank of EV capital spending commitments.

Source: BloombergNEF, Marklines, company press releases

# Electric vehicles mean far fewer moving parts, and potentially major changes for the auto workforce



Comparison of internal combustion engine and electric vehicle motor

**412 lbs / 186.9 kg**

Engine weight  
BMW M3

**70 lbs / 31.8**

Engine weight  
Tesla Model 3

**1,200**

Moving parts

**50**

Moving parts



## The Twilight of Combustion Comes for Germany's Empire of Engines

The nation that invented the heart of the car at the dawn of the 20th century might struggle to adapt to the coming electric era.

Auto manufacturing employs more than 800,000 workers in Germany and accounts for about 20% of the country's \$1.3 trillion in exports.

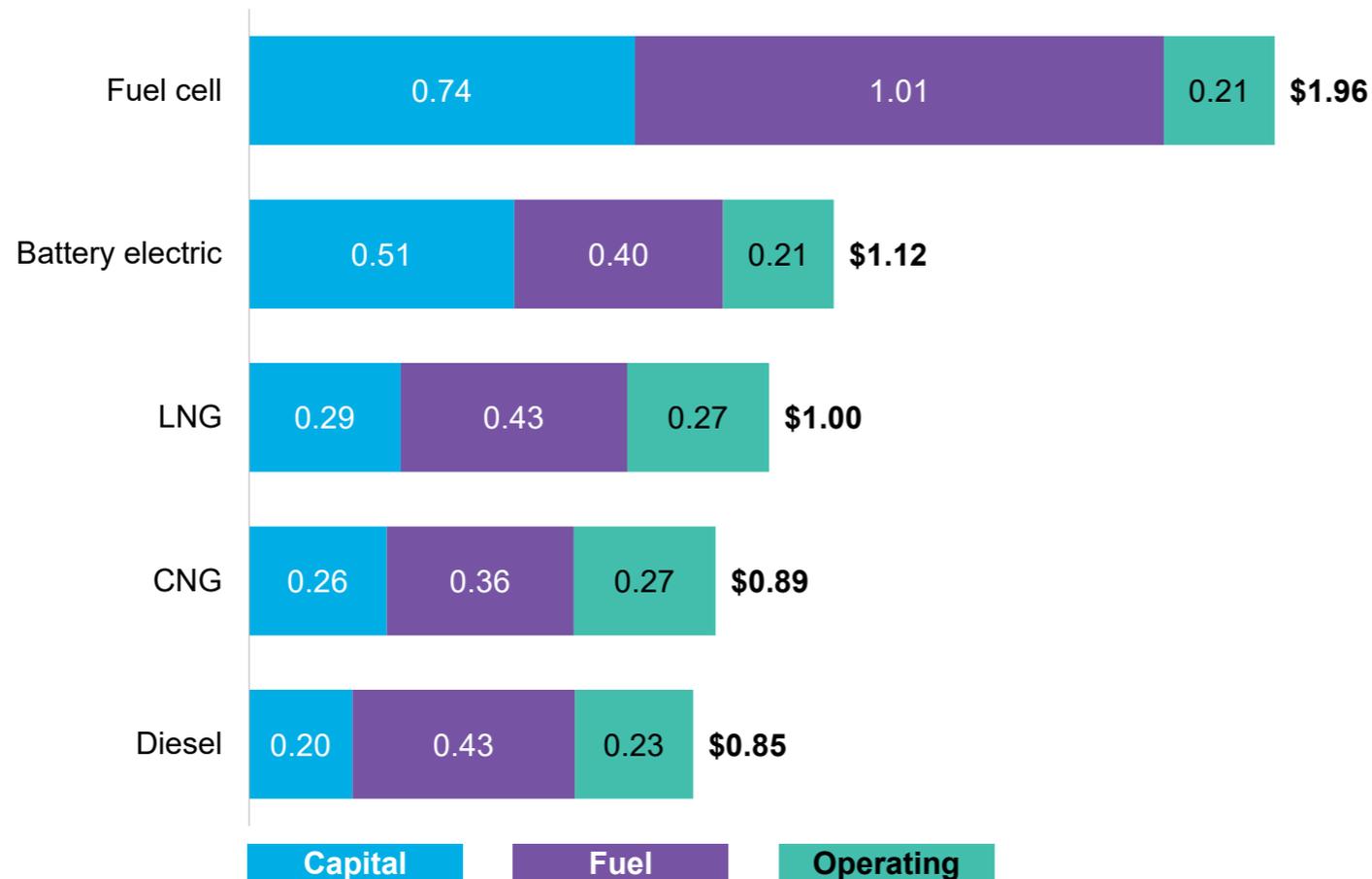
A joint study by the IG Metall union and the Fraunhofer Institute for Industrial Engineering concluded that 75,000 of 210,000 positions across Germany in engines and transmissions will be obsolete by 2030. Electrification will create about 25,000 jobs in that time frame.

Source: BMW USA, Tesla Motors, Bloomberg Businessweek [link](#)

# Diesel trucks currently have the lowest total cost of ownership for long-haul applications



**2018 Class 8 truck total cost of ownership per mile (long-haul, non-weight-limited application)**



In high-utilization, long-haul operations such as cross-country goods transport, diesel tractor-trailers have the lowest total cost of ownership for Class 8 trucks.

Class 8 trucks are highly sensitive to fuel prices. In 2018, fueling costs were 50% of the total cost of ownership of diesel trucks, and 40% of the cost of operating compressed natural gas trucks.

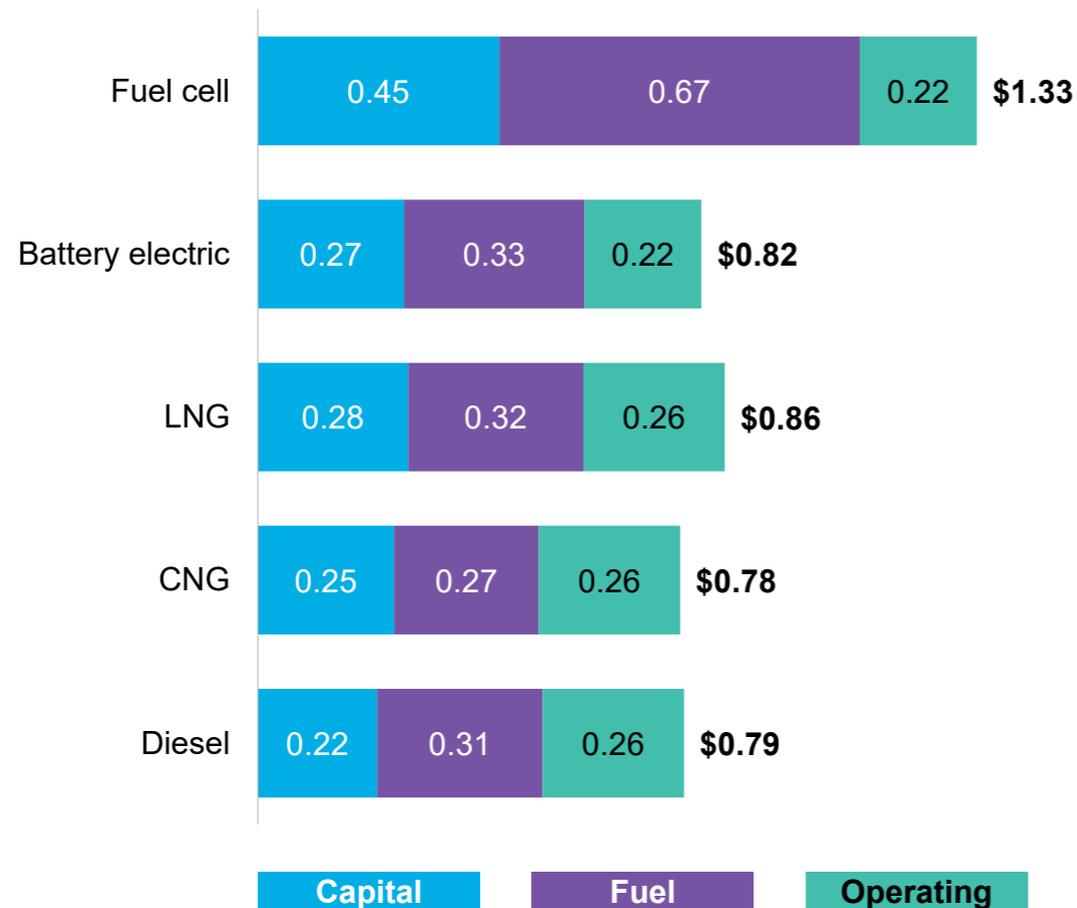
All three alternative-fuel trucks are heavier than the corresponding diesel tractor. For several applications, such as some agricultural transport trucks, the additional weight limits the carrying capacity of the truck and worsens its economics.

Source: BloombergNEF [link](#)

# By 2025, alternative fuels will compete with, or outcompete, diesel in long-haul applications



## 2025 Class 8 truck total cost of ownership per mile (long-haul, non-weight-limited application)



In high-utilization, long-haul operations By 2025, compressed natural gas and diesel class 8 trucks will cost roughly the same to own and operate.

Battery electric vehicles will only be a few percent more expensive to own and operate than diesel and CNG trucks.

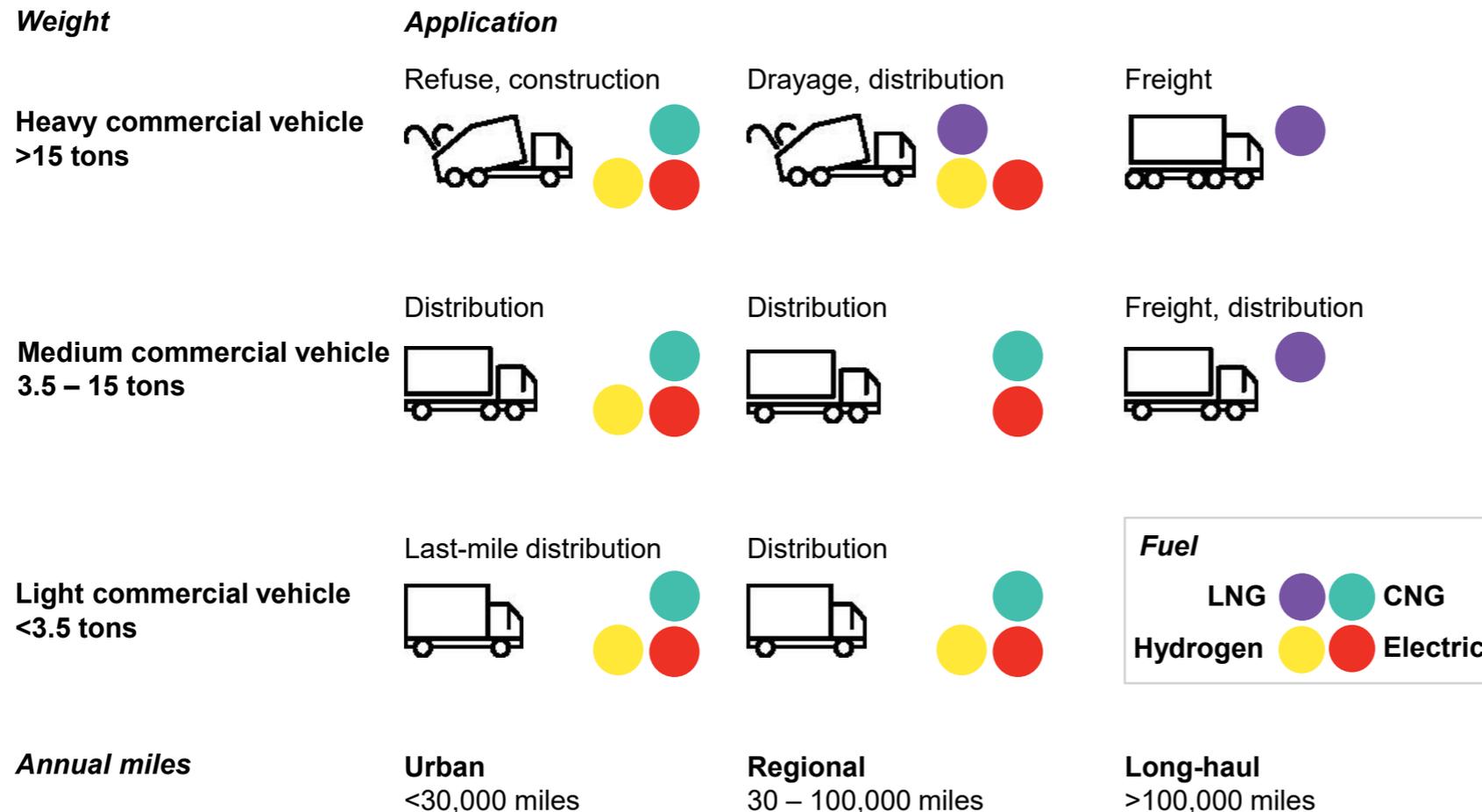
Fuel cell class 8 trucks will remain more expensive than any other type, and both technology and hydrogen fuel costs are less certain than for other fuels or energy sources.

Source: BloombergNEF [link](#)

# A range of fuels are now viable for commercial vehicles depending on weight, application, and annual miles



## Current activity of alternative fuels, by commercial vehicle segment



Road freight underpins global trade and has powered oil demand growth over the past decade. Trucks consume almost one in every five barrels of oil.

City fuel restrictions, noise regulations and stringent emission standards are forcing truck makers to diversify powertrains.

Four energy sources – liquefied natural gas, compressed natural gas, hydrogen, and electricity – can power a range of weight and distance applications.

Diesel technology will become more expensive in the next 10 years and costs for natural gas vehicles will drop slightly as storage options improve.

Source: BloombergNEF [link](#)

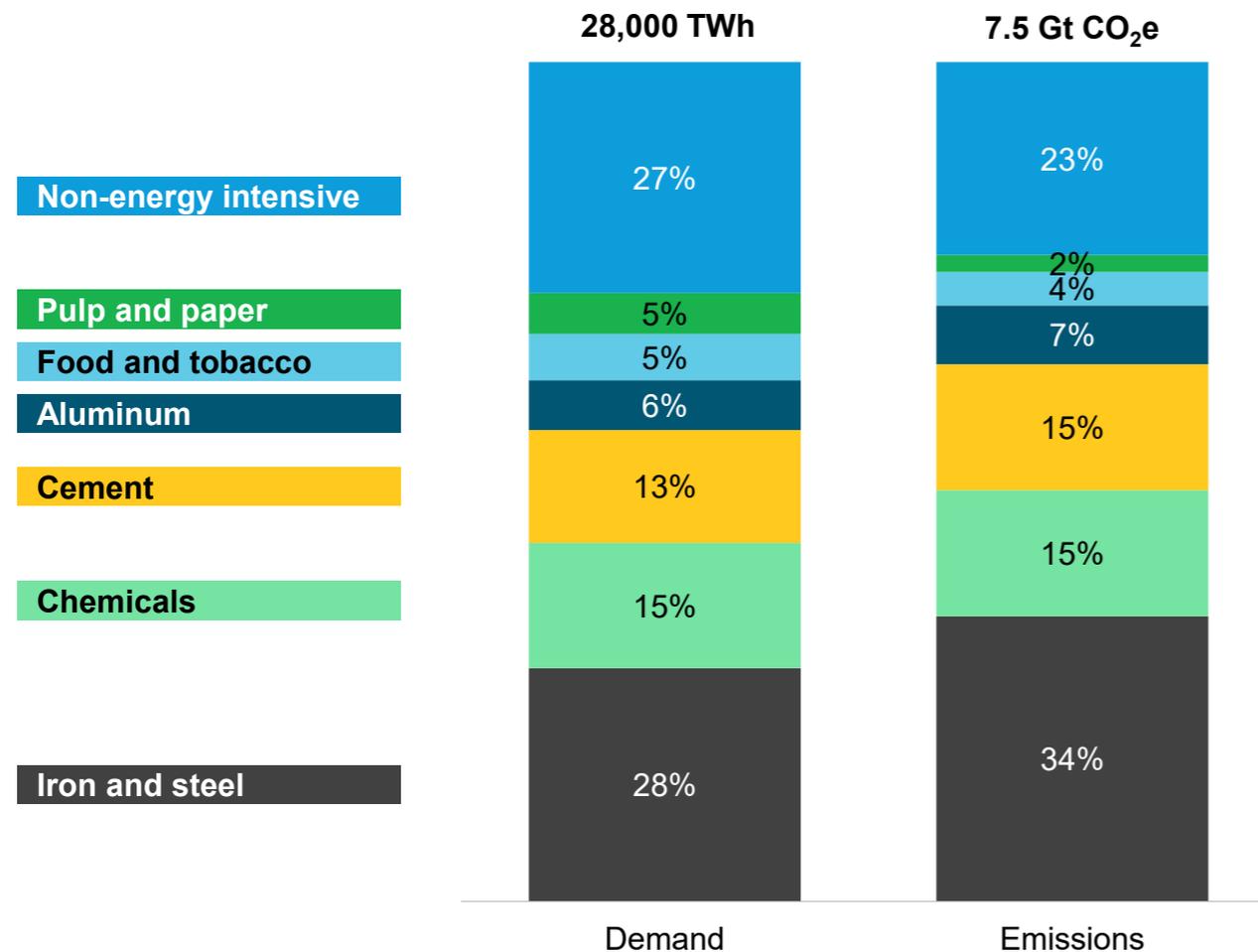
# Table of contents

Introduction: the moment we are in	3
 A cleaner future	12
 Power	21
 Transport	40
 <b>Industry and Buildings</b>	<b>55</b>
 Commodities	70
 Food and Agriculture	87
 Capital	93
BNEF Summit series / About BNEF	102

# Industrial heat is nearly a quarter of final energy demand, and 15% of global emissions



Global industrial heat demand and GHG emissions by sector, 2016



Industrial process heat is 24.5% of global final energy consumption.

Only residential and commercial sectors, and transport, are a larger percentage of global final energy consumption.

Industrial non-process heat is a further 6.2% of global final energy consumption, meaning that heat is the largest single end user of energy.

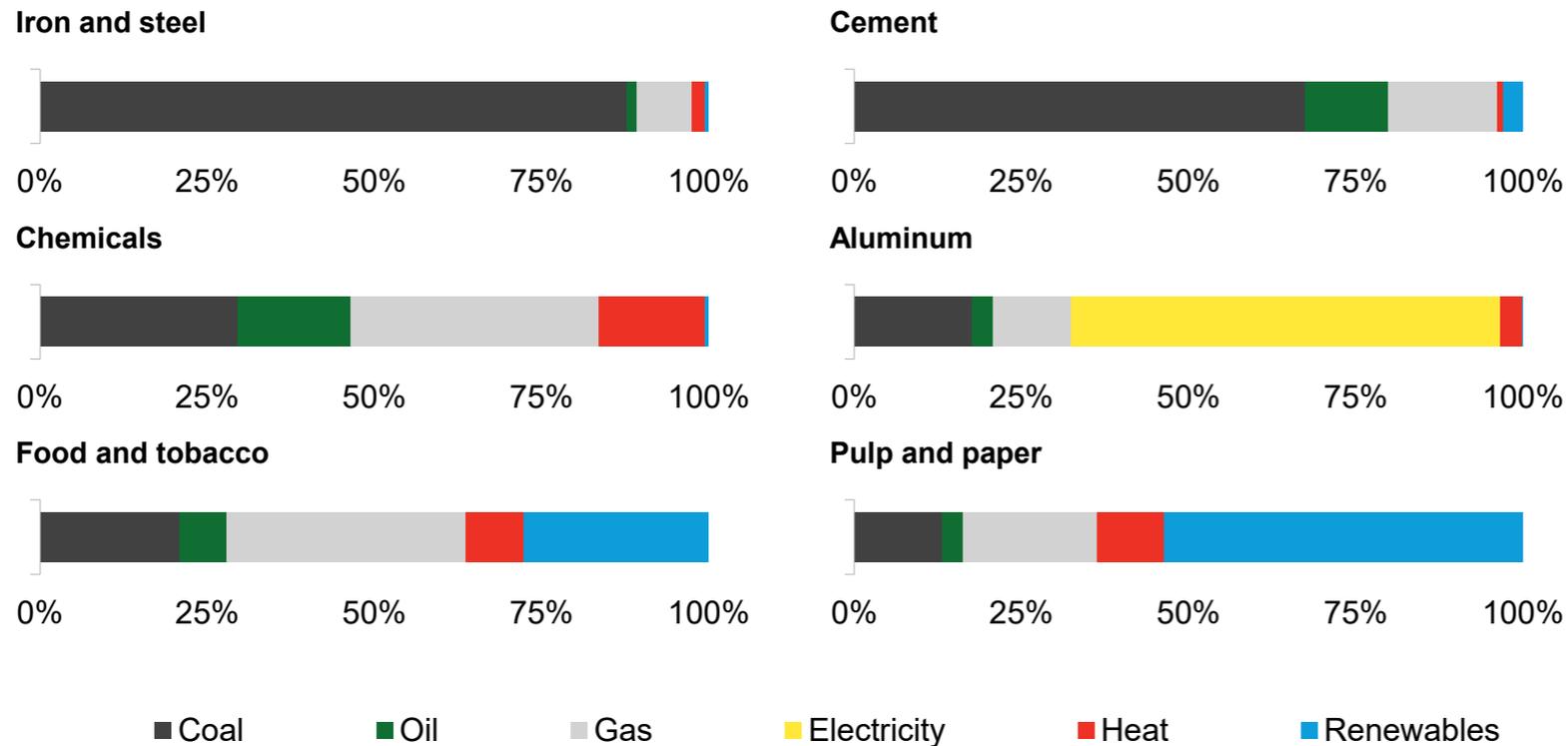
Three sectors – iron and steel, chemicals, and cement – are more than 50% of combined demand and combined emissions.

Source: BloombergNEF [link](#). Note: demand figures do not total 100 percent due to rounding. Aluminum accounts for the vast majority of all non-ferrous metals heat consumption. Cement accounts for the vast majority of all non-metallic minerals heat consumption.

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



## Share of energy supply for industrial process heat, 2017



### 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 fuels as feedstocks as well.

### Arc furnaces are an opportunity to decarbonize heat

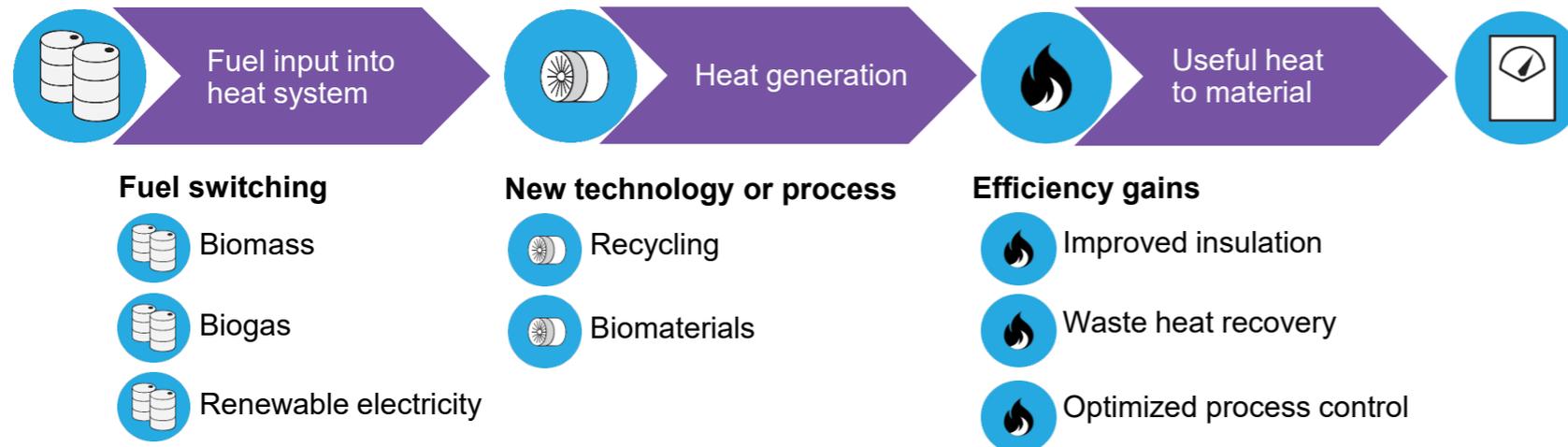
Aluminum and non-ferrous metals rely heavily on electric-arc furnaces, which means that they can decarbonize their electricity supply with renewables.

Source: BloombergNEF link, IEA

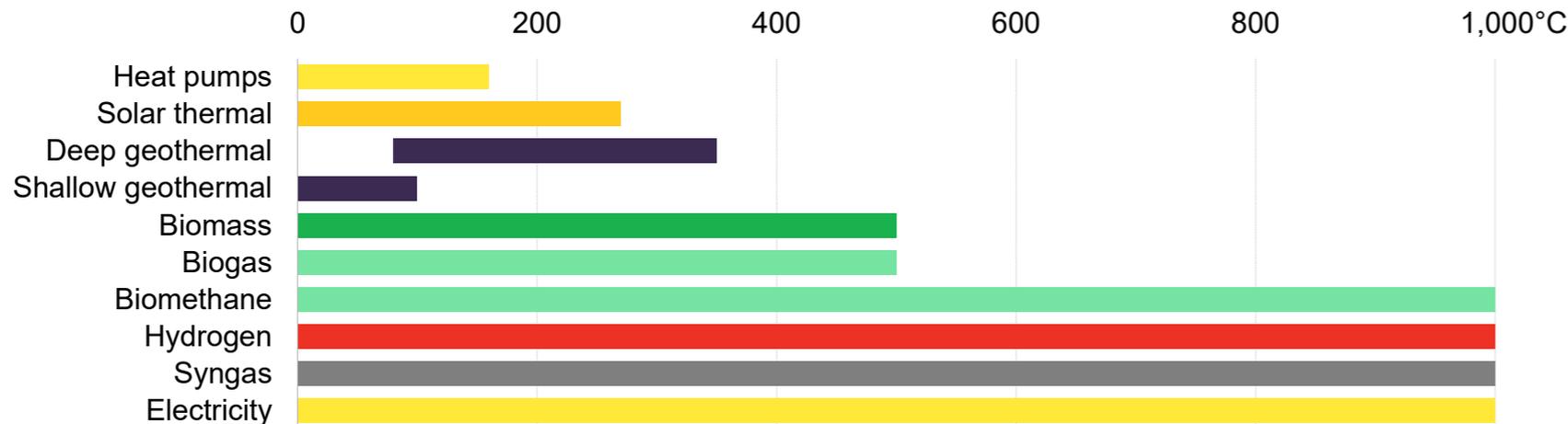
# Heat is essential for many industrial processes, and industries meet their demand in many different ways



## Three ways to decarbonize industrial heat



## Example technologies for supplying process heat



Industrial heat can be decarbonized by switching fuels, by using new technologies or processes, and by increasing efficiency.

There are a number of technologies capable of providing industrial process heat.

Renewable and zero-carbon sources can provide process heat temperatures up to 500°C, and some can do so without combustion.

Combustion, or electricity, is required for higher temperatures.

Source: BloombergNEF link, IEA

# Decarbonization potential varies significantly, but can have big rewards in big sectors



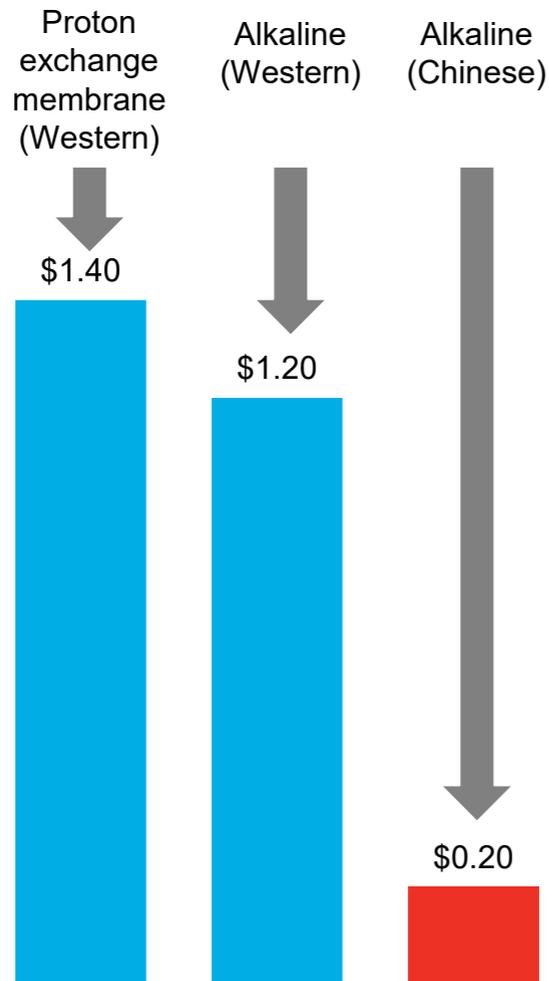
	Sector	Current status (2016)		Ease of heat decarbonization		
		Temperature	Major fuel	Efficiency gains	Fuel switching	New technology or process
<b>Big prizes (but hard to achieve)</b>	Iron and steel	High	Coal	Hard	Hard	Medium
	Non-metallic minerals (cement)	High	Coal	Hard	Medium	Hard
<b>Medium prizes (medium size/difficulty)</b>	Chemicals	High	Coal	Medium	Medium	Hard
	Non-ferrous metals (aluminum)	High	Electricity	Medium	Easier	Hard
<b>Small prizes (but easiest to achieve)</b>	Food and tobacco	Low	Gas	Medium	Easier	Medium
	Pulp and paper	Low	Renewables	Medium	Easier	Easier

Source: BloombergNEF link, IEA

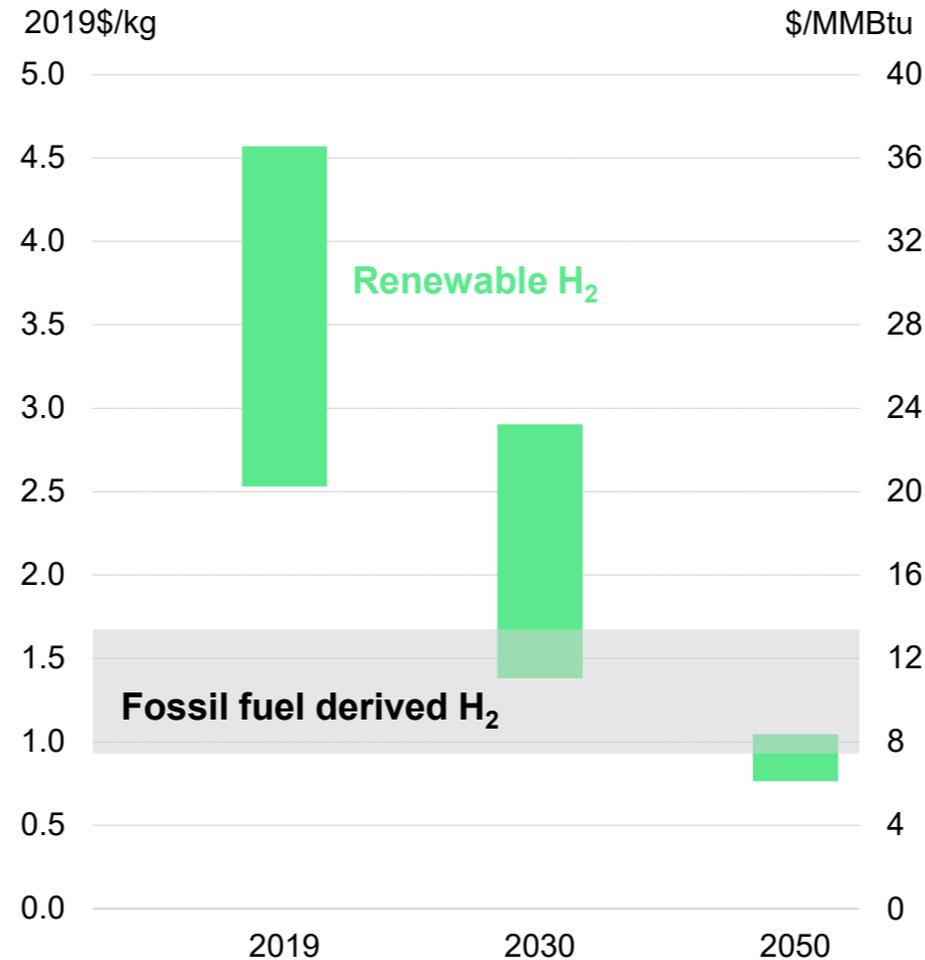
# Hydrogen can play a major role in decarbonizing industrial processes and transportation



Large-scale electrolysis system capex



Levelized cost of H<sub>2</sub> production (large projects)



Hydrogen is a clean-burning molecule that could become a zero-carbon substitute for fossil fuels in hard-to-abate sectors of the economy.

The cost of producing hydrogen from renewables is primed to fall, but demand needs to be created to drive down costs.

Creating that demand will require government targets, subsidies, and a substantial infrastructure build-out.

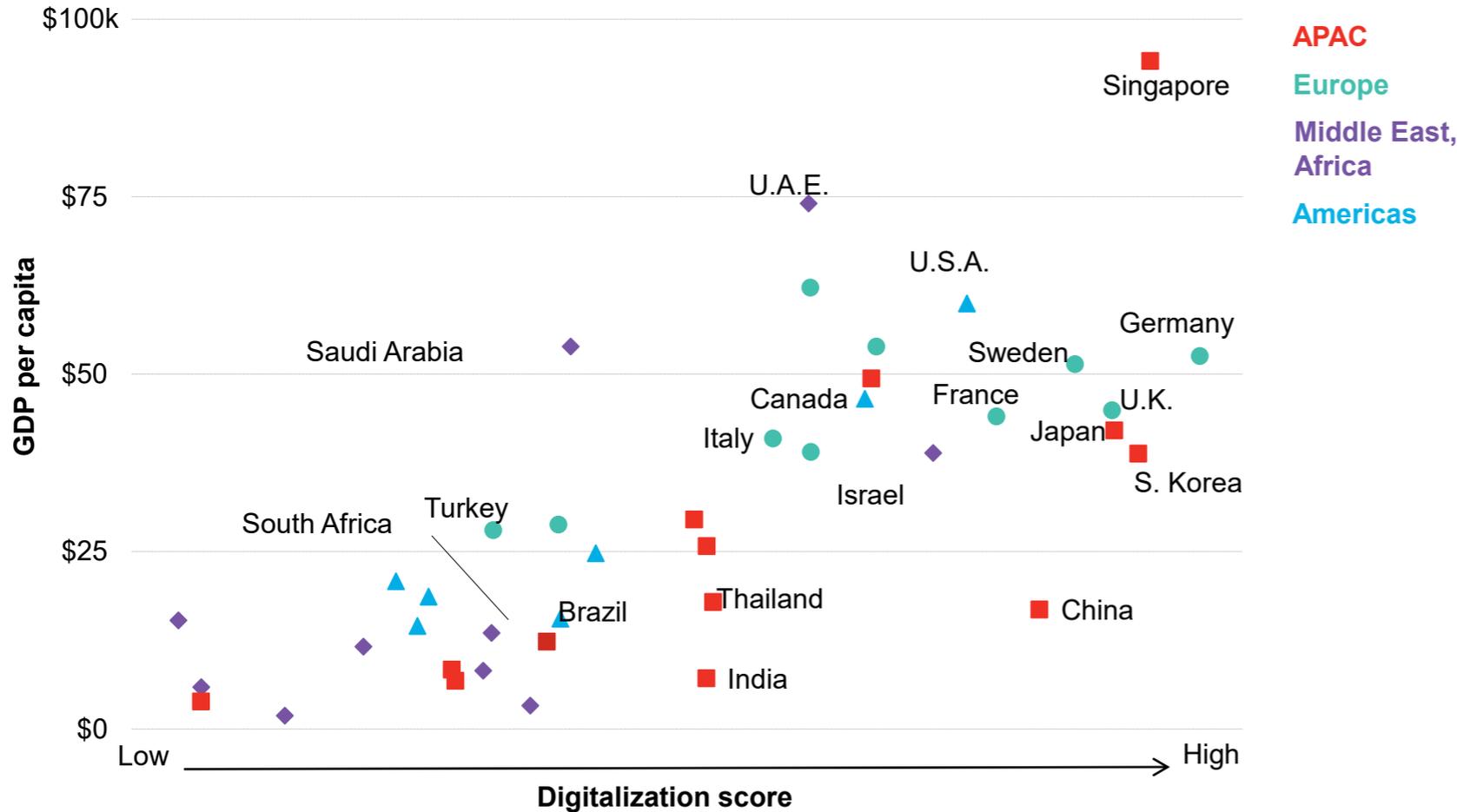
As renewable production costs fall, 'green' hydrogen will be competitive with fossil fuel-derived hydrogen.

Source: BloombergNEF [link](#). BloombergNEF Hydrogen Economy Outlook [link](#) Note: 2019 electrolysis system capex, 2-3MW system size.

# Digitalization is a country priority, not just a corporate priority



BloombergNEF 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.

**Smaller countries with strong manufacturing economies rank highly**

Some countries have policies that suggest they will improve their ranking in the next few years

**Some countries give little indication of planning for the future**

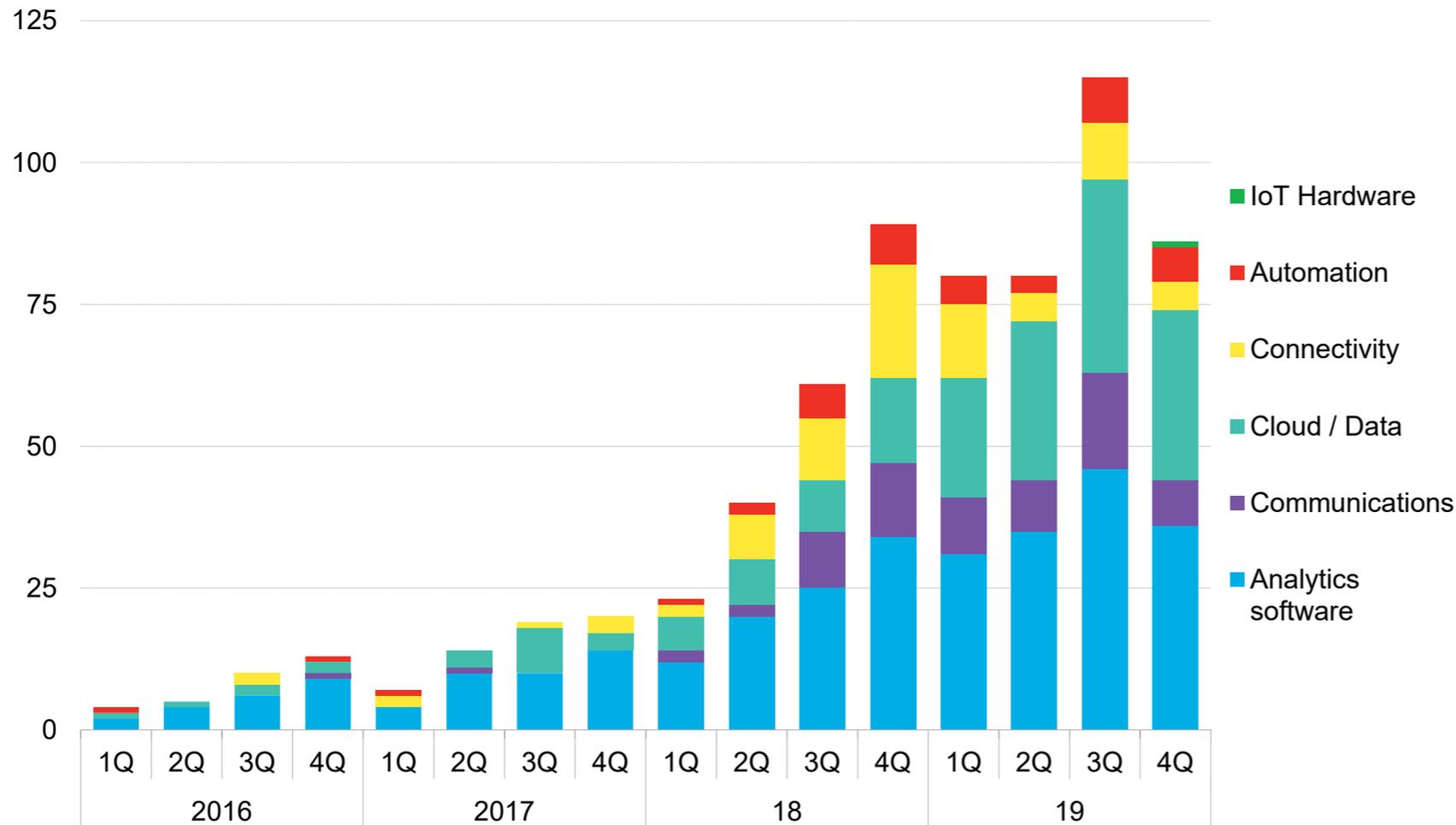
The U.S. has no clear plans for future digitalization, either through policies, subsidies for digitalization or government support of business efforts.

Source: BloombergNEF

# Industries are rapidly digitalizing business operations



## Digital industry projects and partnerships (count of activities)



437 companies announced 377 industrial digitalization partnerships and projects in 2019.

Digital industry projects and partnerships were made in 10 sectors and 49 countries in 2019.

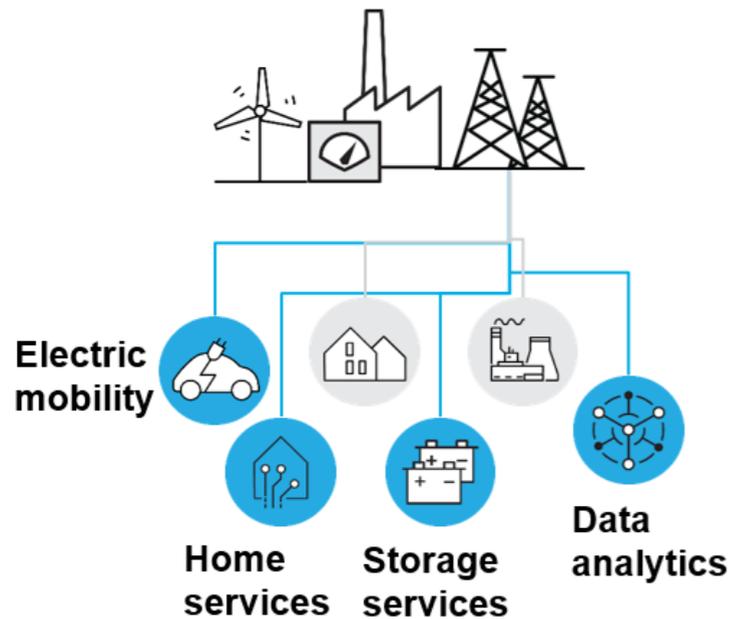
U.S. and Chinese companies were the most active across the sector in the second half of 2019.

Source: BloombergNEF

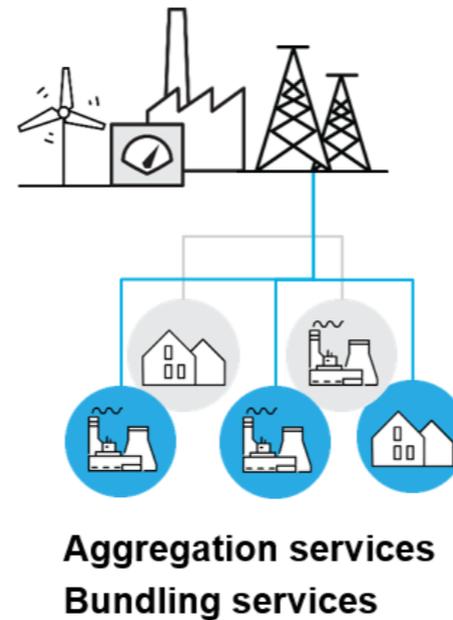
# There are three drivers of utility digital transformation strategies



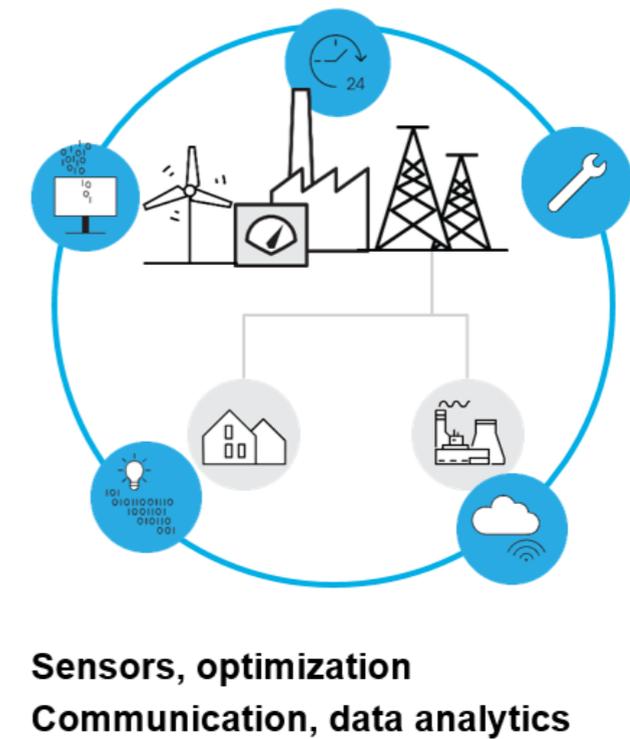
## New business offerings



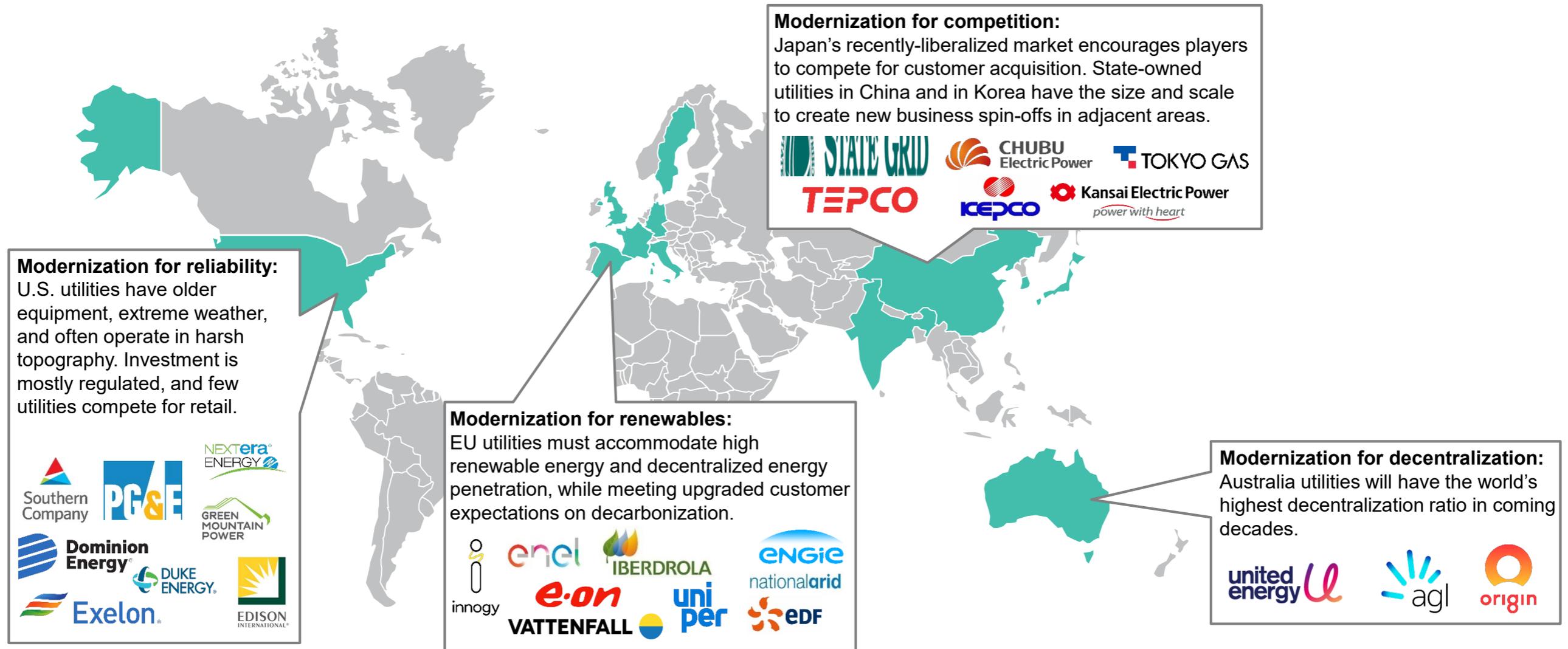
## More customers, with new services



## Greater operational efficiency

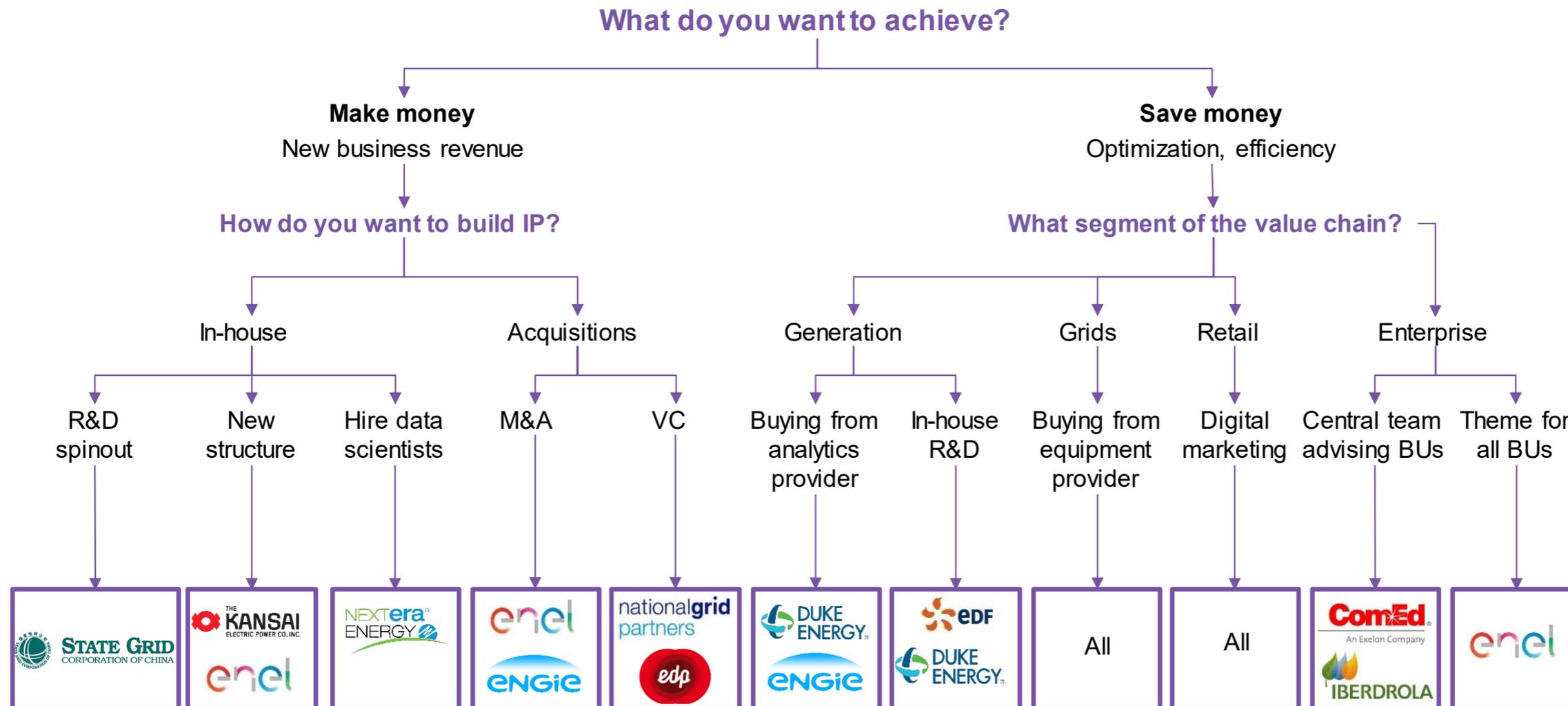


# Utility modernization efforts vary with geography, generation mix, and operational priorities



Source: BloombergNEF [link](#)

# Utilities adopt various strategies to digitalize, depending on what they aim to achieve

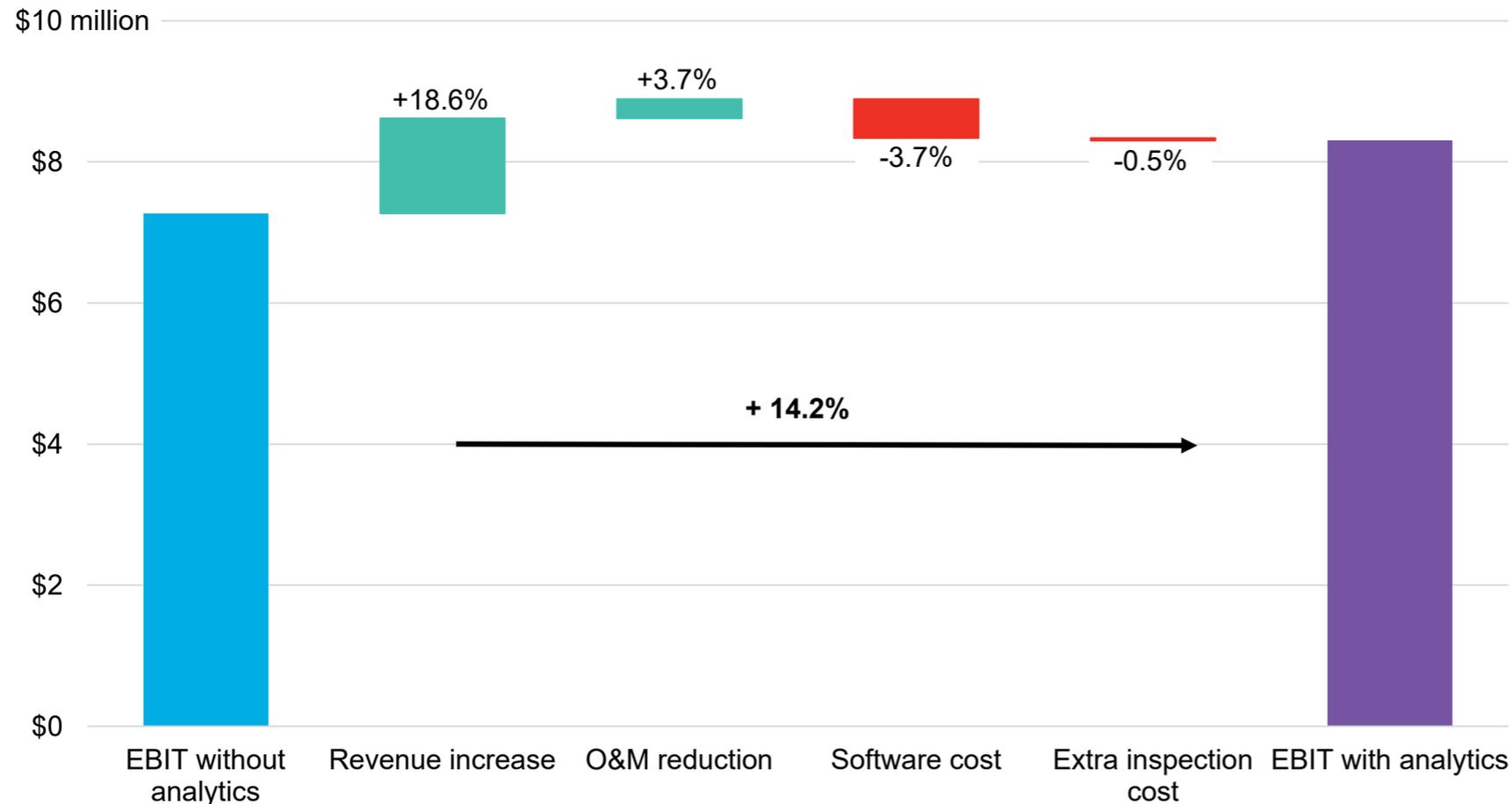


Source: BloombergNEF [link](#)

# Predictive maintenance can improve power generation economics



## EBIT improvement for a combined cycle gas plant with predictive maintenance software



Multiple systems can improve power generation operations and economics.

Artificial intelligence, Internet of Things (IoT) systems, and augmented reality could reduce refinery operating expenditure by \$0.44 per barrel.

Digitalization savings could result in 11.5% reduction in production costs

Savings of \$0.44 per barrel are possible, equivalent to 11.5% of typical U.S. production costs.

Maintenance will be the most significant savings

Maintenance costs could drop by 25% with digitalization.

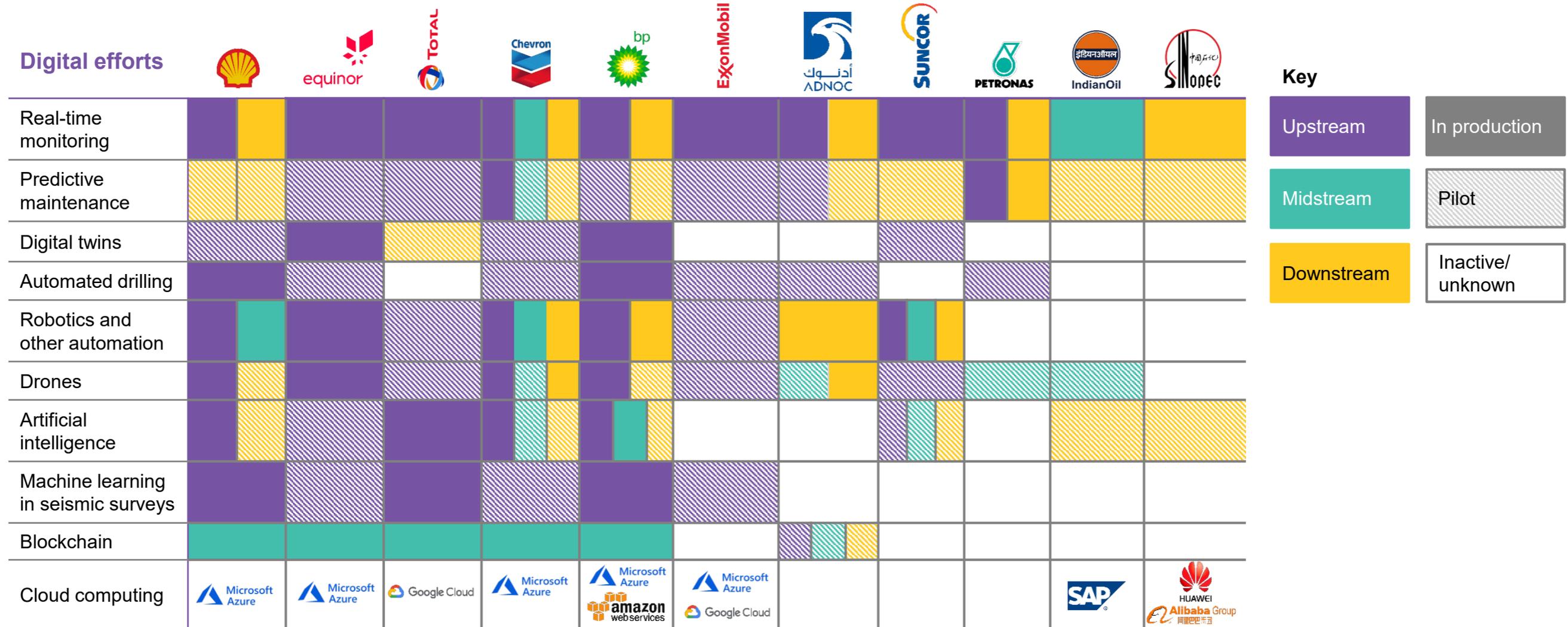
Labor and overhead will be the next most significant savings

Digitalization could lower labor and overhead costs by 13.4%

Overall operating margin can increase 7% with digitalization

Source: BloombergNEF. Note: Gas plant located in California ISO (CAISO) service area.

# Oil majors have major digitalization efforts underway



Source: BloombergNEF

# Oil majors have major digitalization efforts underway



## Oil refinery production cost reduction from digital technologies, 2019



### Digitalization of oil refining can bring cost savings and margin improvements

Artificial intelligence, Internet of Things (IoT) systems, and augmented reality could reduce refinery operating expenditure by \$0.44 per barrel.

### Digitalization savings could result in 11.5% reduction in production costs

Savings of \$0.44 per barrel are possible, equivalent to 11.5% of typical U.S. production costs.

### Maintenance will be the most significant savings

Maintenance costs could drop by 25% with digitalization.

### Labor and overhead will be the next most significant savings

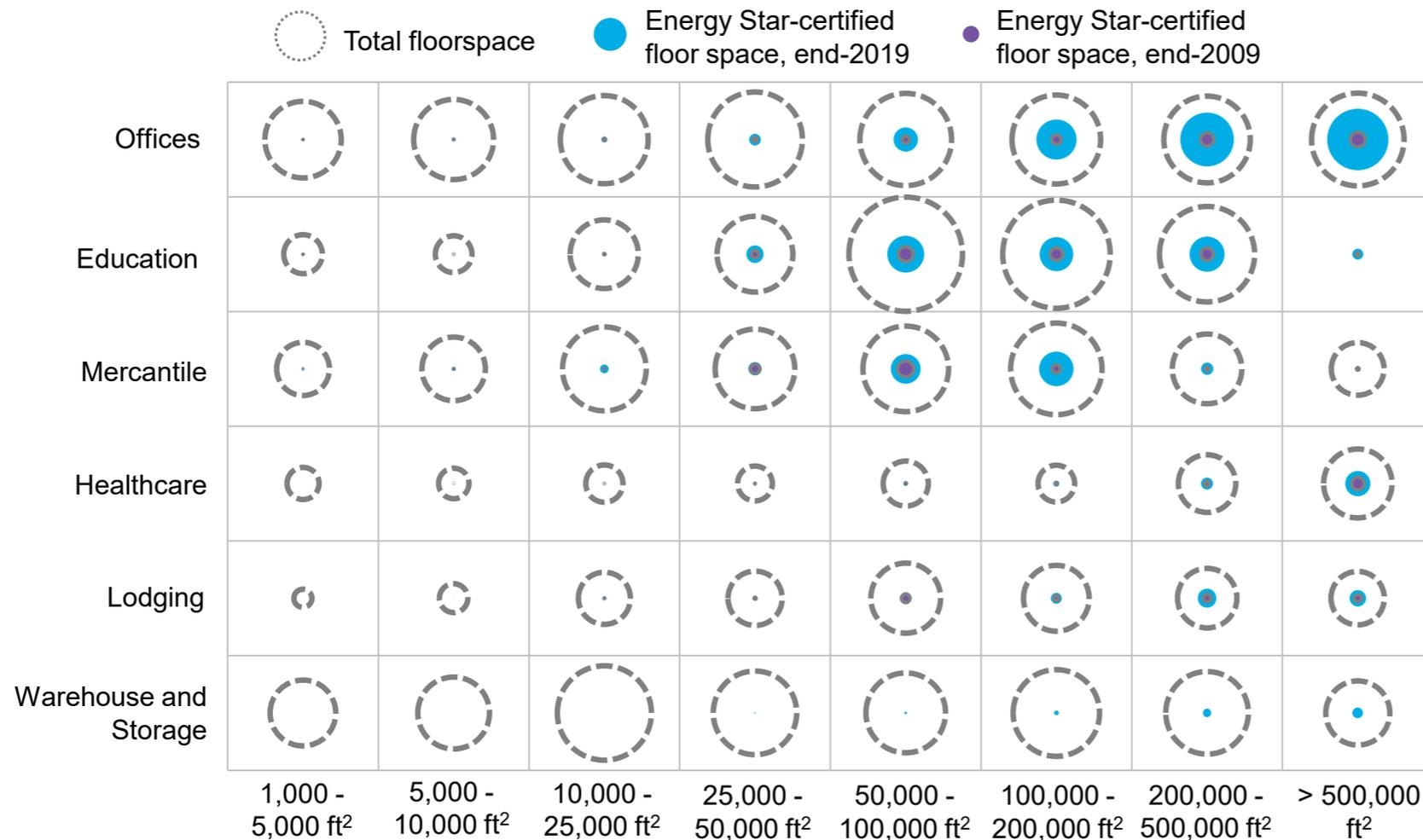
Digitalization could lower labor and overhead costs by 13.4%

Source: BloombergNEF

# There is significant opportunity to make real estate more energy efficient



## U.S. commercial building Energy Star-certified space, by type



Energy efficiency certification is highest in large buildings, in particular office buildings.

In the past decade, educational facilities and retail have emerged as important segments for energy efficiency certification.

Large mixed-use buildings have had the greatest increase in certification since 2009, with a 37% increase in Energy Star-certified floor space since 2018.

Efficiency uptake remains low for buildings smaller than 50,000 square feet.

Source: 2020 Sustainable Energy in America Factbook [link](#)

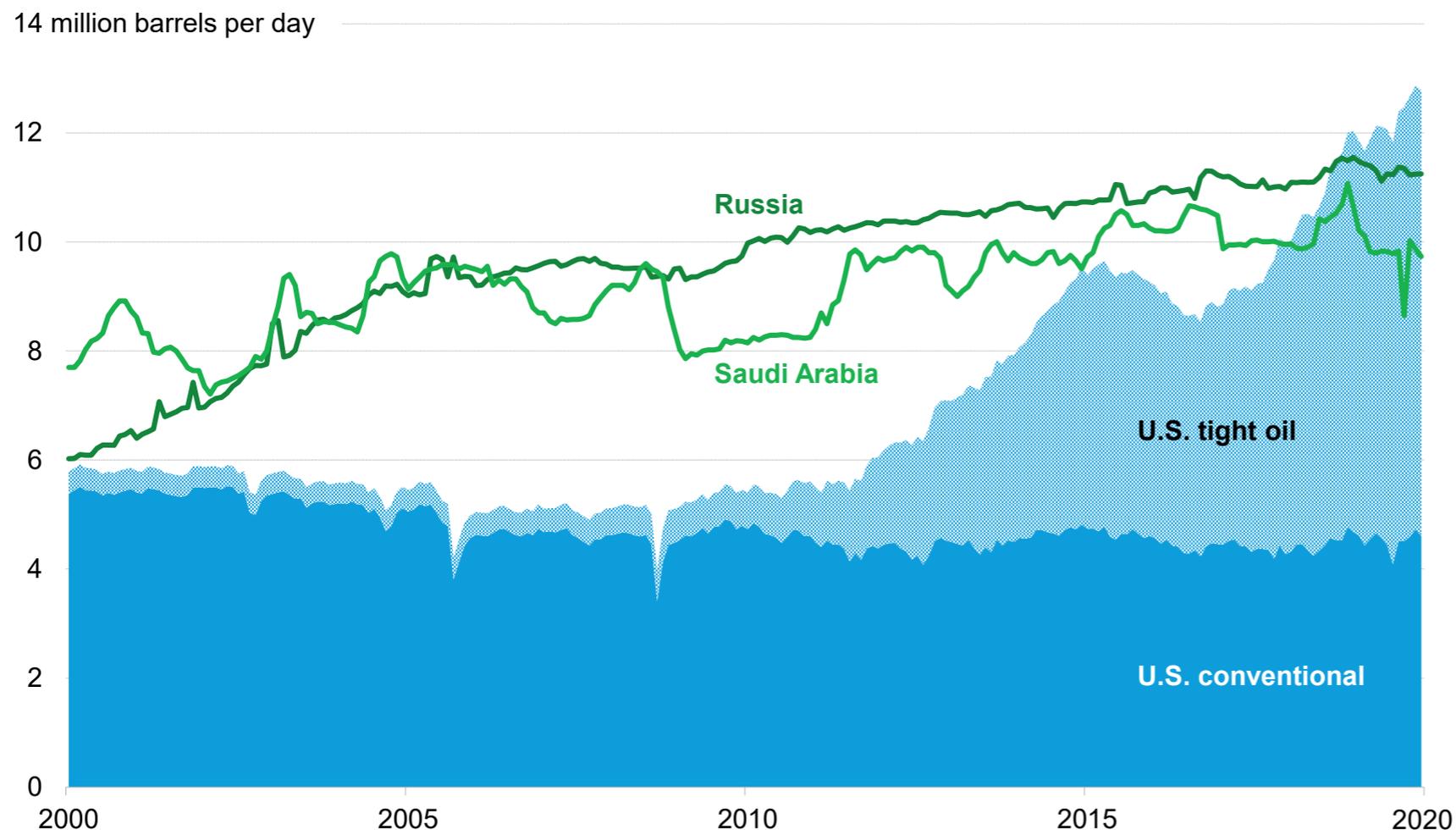
# Table of contents

Introduction: the moment we are in	3
 A cleaner future	12
 Power	21
 Transport	40
 Industry and Buildings	55
 <b>Commodities</b>	<b>70</b>
 Food and Agriculture	87
 Capital	93
BNEF Summit series / About BNEF	102

# The U.S. became the world's largest oil producer in 2019



## Oil production by country



Thanks to a boom in shale production, the U.S. became the world's largest oil producer in 2019.

U.S. conventional oil production has been in slow decline since the beginning of the century.

Saudi Arabia has sufficient spare capacity to act as swing producer, or flood the market with supply.

While Russia has higher oil production costs than Saudi Arabia, it also has a greater fiscal cushion to withstand lower oil prices.

Source: EIA, Bloomberg

# The U.S. became a net exporter of crude oil and products in 2019



## U.S. net imports of crude oil and petroleum products



From the early 1980s to the mid-2000s, U.S. oil imports rose steadily, to reach more than 13 million barrels per day.

The U.S. shale boom, combined with relatively flat domestic consumption, steadily lowered U.S. net imports for the next decade.

The U.S. became a net exporter of crude oil and petroleum products in 2019.

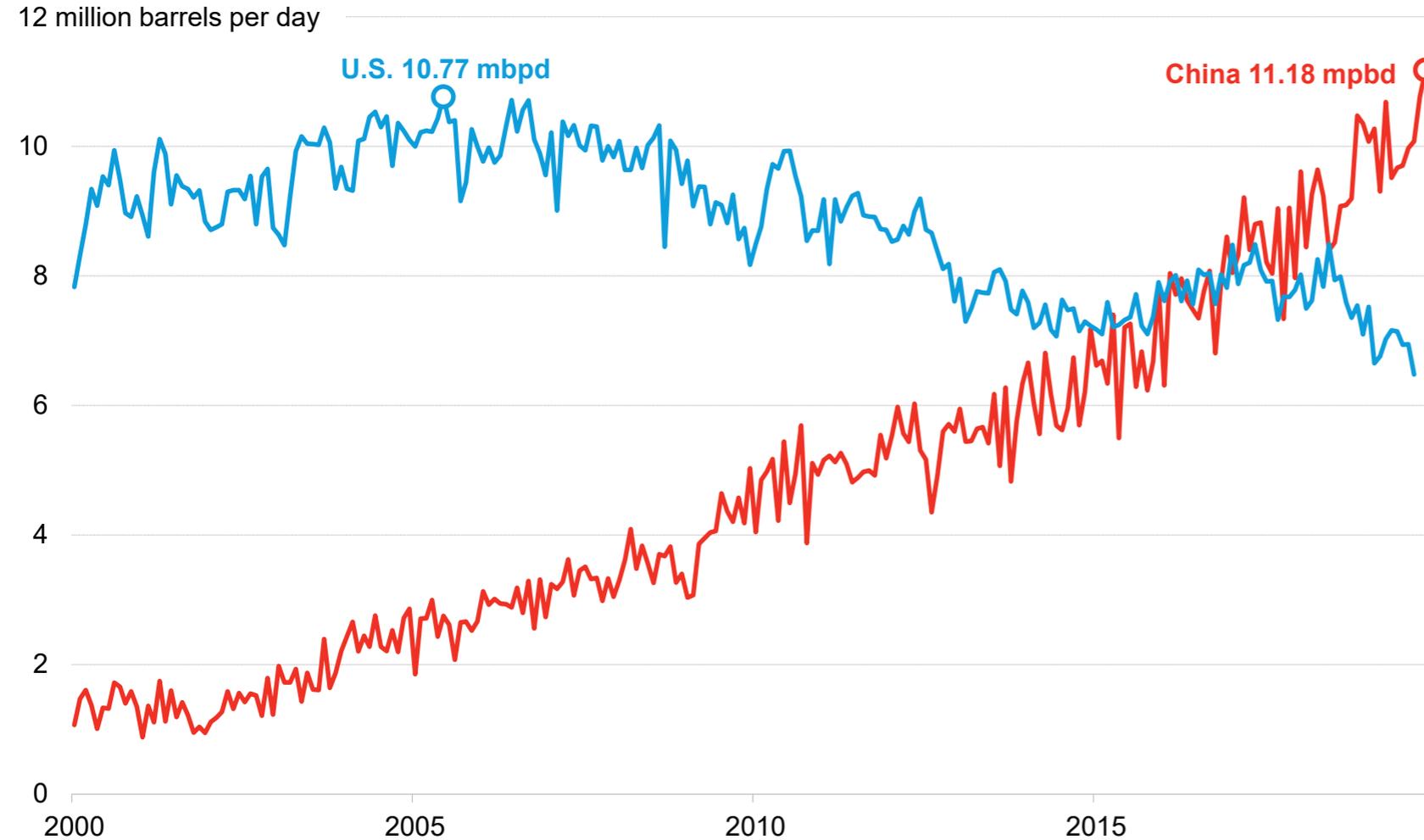
The U.S. is only a *net* exporter – it still imports a significant volume of oil every day.

Source: EIA

# China now imports more oil than the United States imported at its peak



## Crude oil imports



China imported 11.8 million barrels of oil per day in November 2019, surpassing the U.S. peak imports of 10.77mbpd in June 2005.

China is opening new refineries and if production ramps up, will likely continue to increase imports.

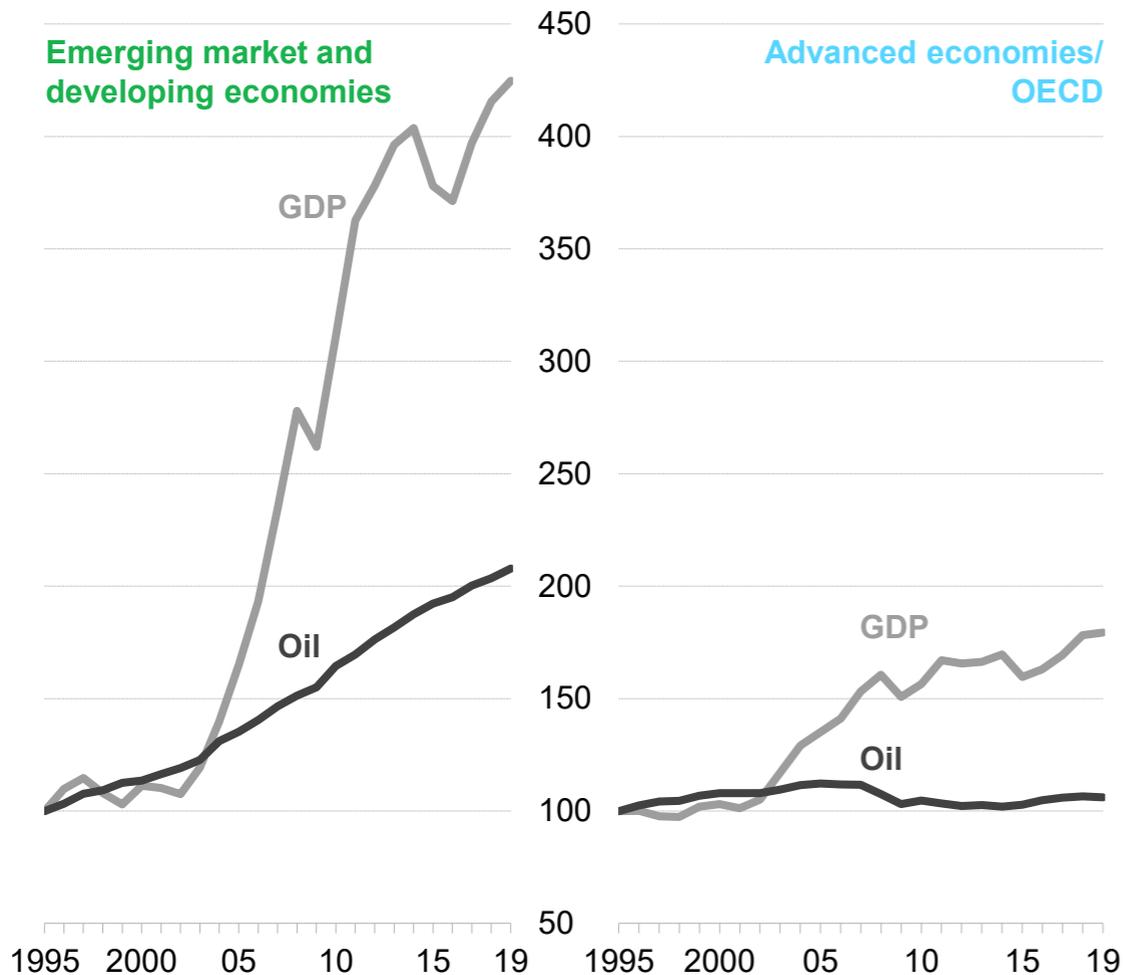
China is also urging its state-owned oil and gas companies to boost domestic output.

Source: Bloomberg, [Bloomberg News link](#)

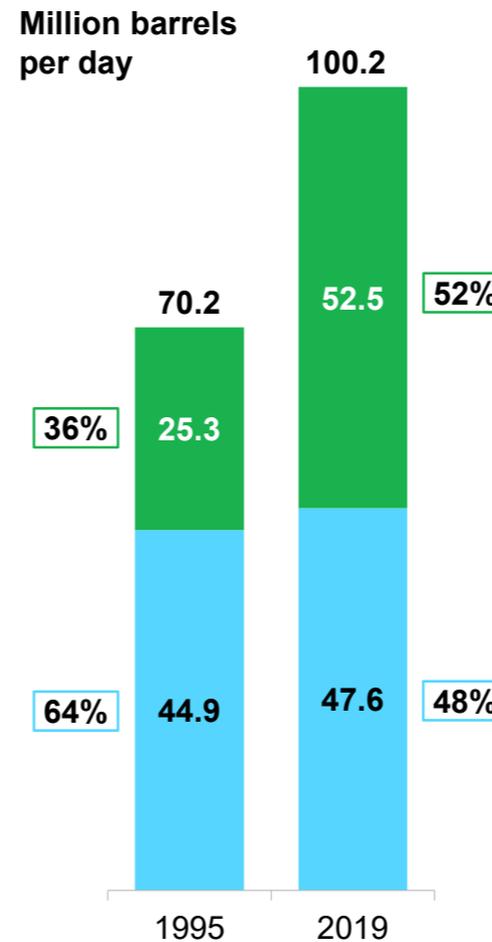
# Global oil demand has shifted to emerging markets and developing economies



GDP per capita and oil demand (Rebased 1995 = 100)



Oil demand



Oil demand growth follows different paths in advanced economies and emerging market/developing economies.

Oil demand in emerging market and developing economies has more than doubled since 1995, while GDP has increased four-fold.

Advanced economy oil consumption has hardly increased, and advanced economies are now less than half of global oil demand.

Source: IMF, IEA, Bloomberg. Note: OECD oil demand for "advanced economies"; World-OECD for "developing economies"

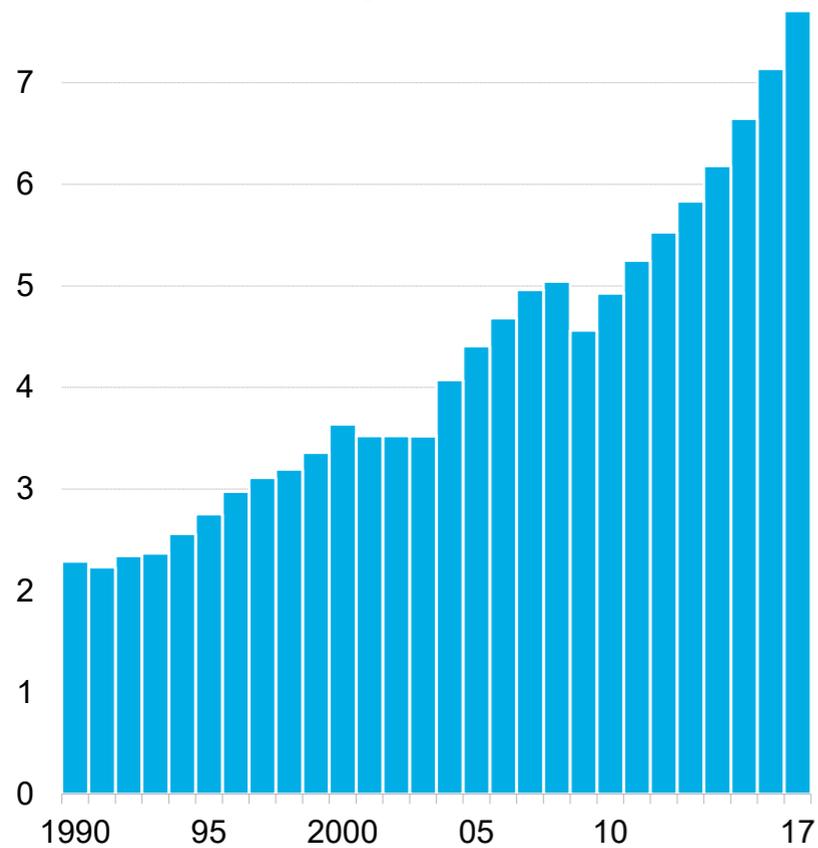
# Airline travel has more than tripled in three decades, while emissions have not quite doubled



## Airline travel

**+237%** since 1990

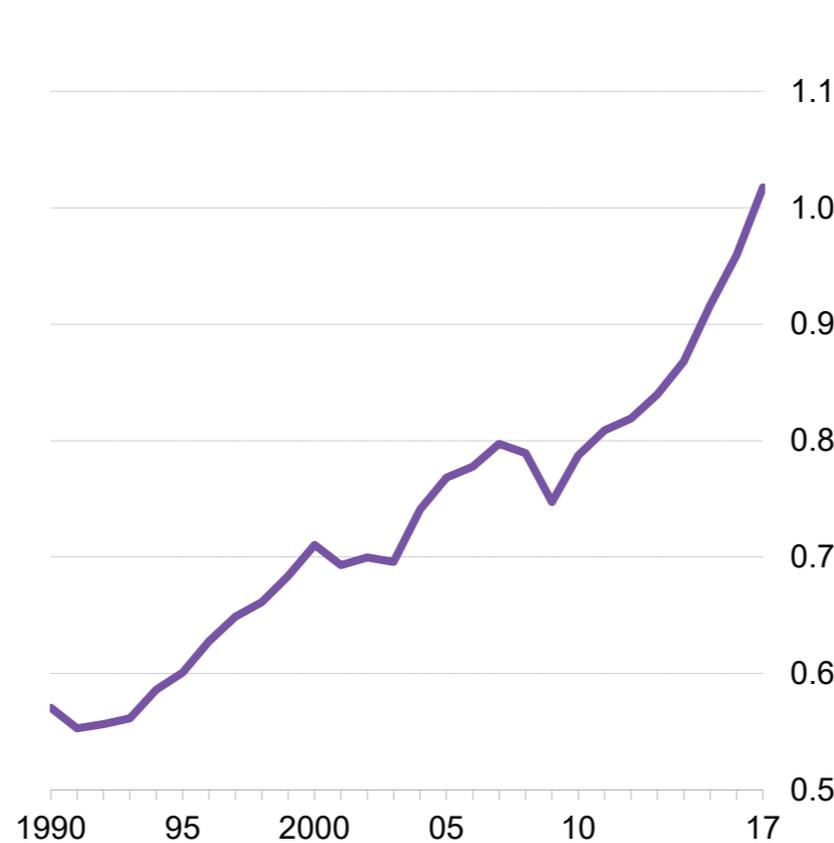
8 trillion revenue passenger kilometers



## Passenger aviation emissions

**+78%** since 1990

1.2 gigatons CO<sub>2</sub>



Both airline travel, and the emissions from passenger airline flights, have increased in the past three decades.

Aviation is becoming more fuel efficient, such that while revenue passenger kilometers have more than tripled, passenger aviation emissions have not quite doubled in that time.

Aviation is a relatively small part of global greenhouse gas emissions, but it is growing at a faster rate than most other forms of transportation.

Source: BloombergNEF, ICAO

# Integrated oil company planning assumes \$58 to \$65 oil prices in 2020



Brent crude price and integrated oil company planning assumptions (2020 \$real)



Oil super-majors assume certain oil prices in their multi-year strategic planning.

2020 super-major planning assumptions range from \$58 to \$65 per barrel.

Due to a flood of supply and an exceptional collapse in demand, current oil prices are around half of what companies had built into their plans.

Substantially lower prices will challenge existing capital expenditure plans and stated dividend distributions.

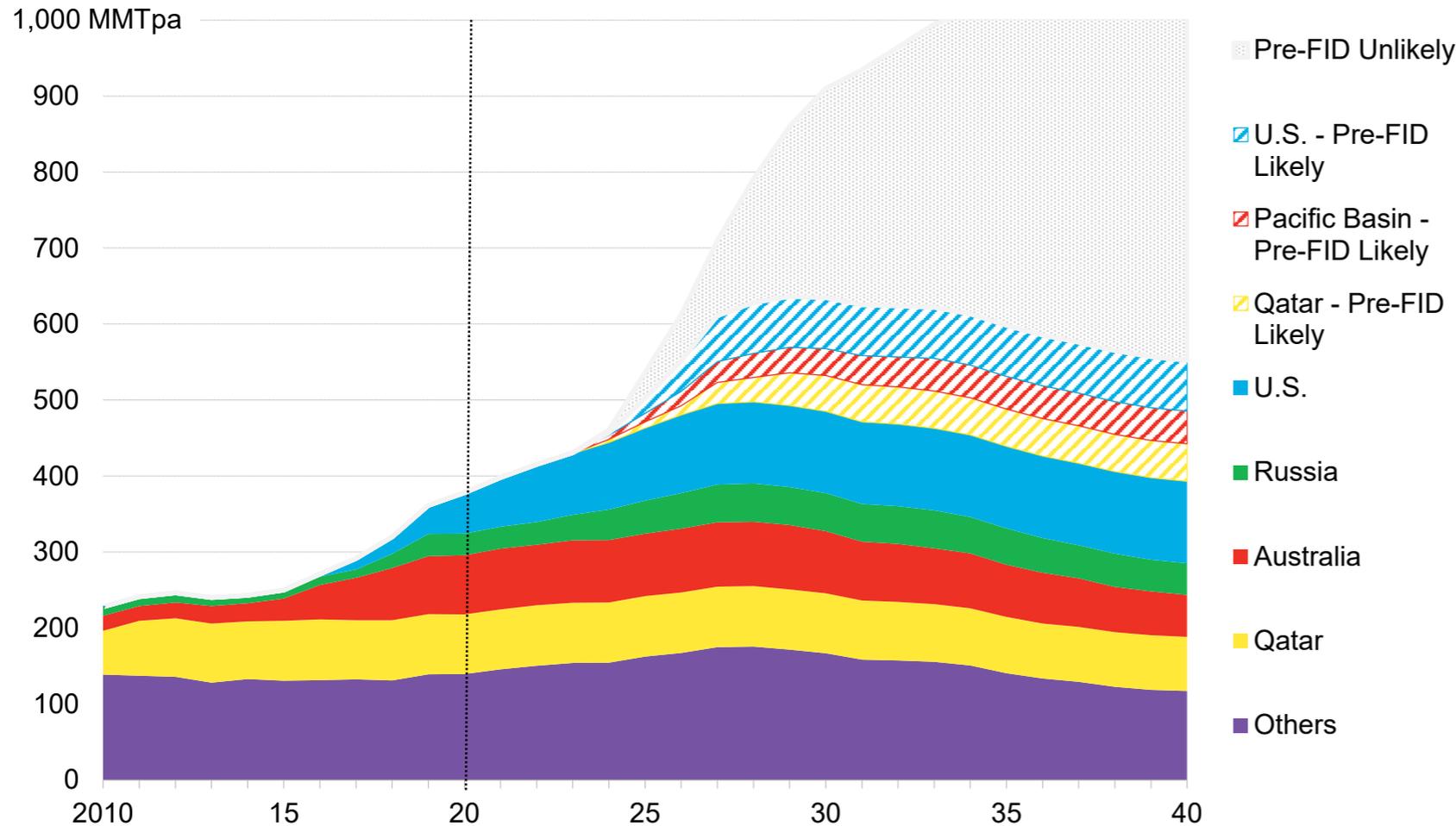
Source: Company presentations. Note: BP assumption converted from real 2017\$



# Global LNG export capacity has nearly doubled in a decade, and will continue to increase



## Global LNG export capacity by country and status



The global liquefied natural gas market is oversupplied, and more supply is on the way.

2019 was a record year for final investment decisions on LNG supply projects, and more projects are expected in 2020.

Currently, 115MMtpa of supply capacity is under construction, including recent FIDs. Likely additions could add 55 million metric tons of annual LNG supply.

Source: BloombergNEF [link](#)

# Asia LNG prices have fallen to their lowest levels ever



## Japan-Korea Marker swap futures



Japan-Korea Marker futures, the standard for contracted LNG in Asia, have fallen to their lowest levels ever. Spot prices are even lower, and are also at record lows.

Falling oil prices impact oil-linked export gas prices. An oversupplied LNG market also contributes to low prices.

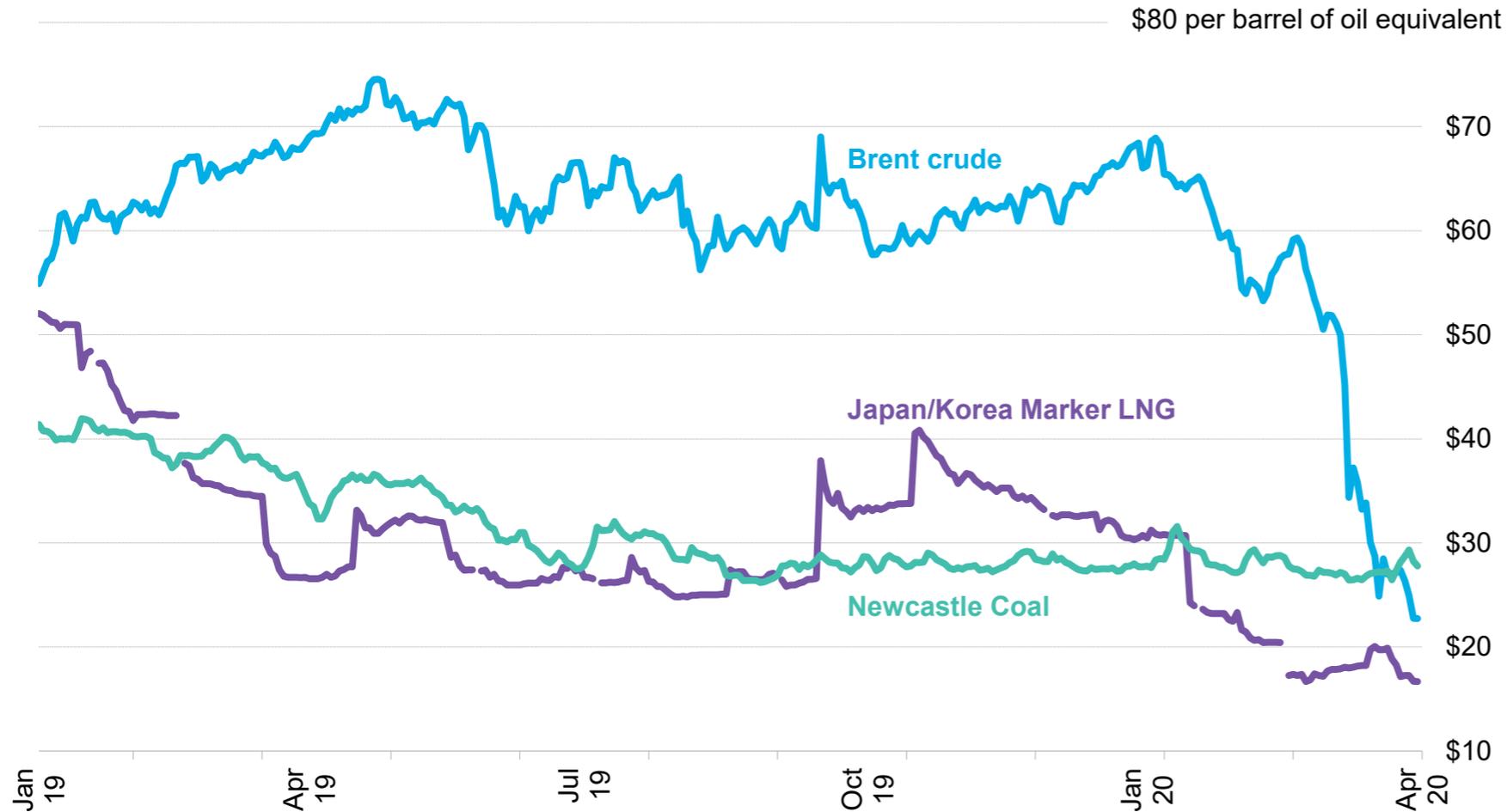
Current prices are below breakeven costs for many producers.

Source: Bloomberg, S&P Global Platts

# Oil's price collapse has made Brent crude cheaper than Newcastle coal



## Spot prices in barrels of oil equivalent



Coal has long been viewed as the cheapest fossil fuel, particularly in Asia.

However, its price collapse since early 2020 meant that by late March, spot export coal prices were higher, on an energy basis, than oil.

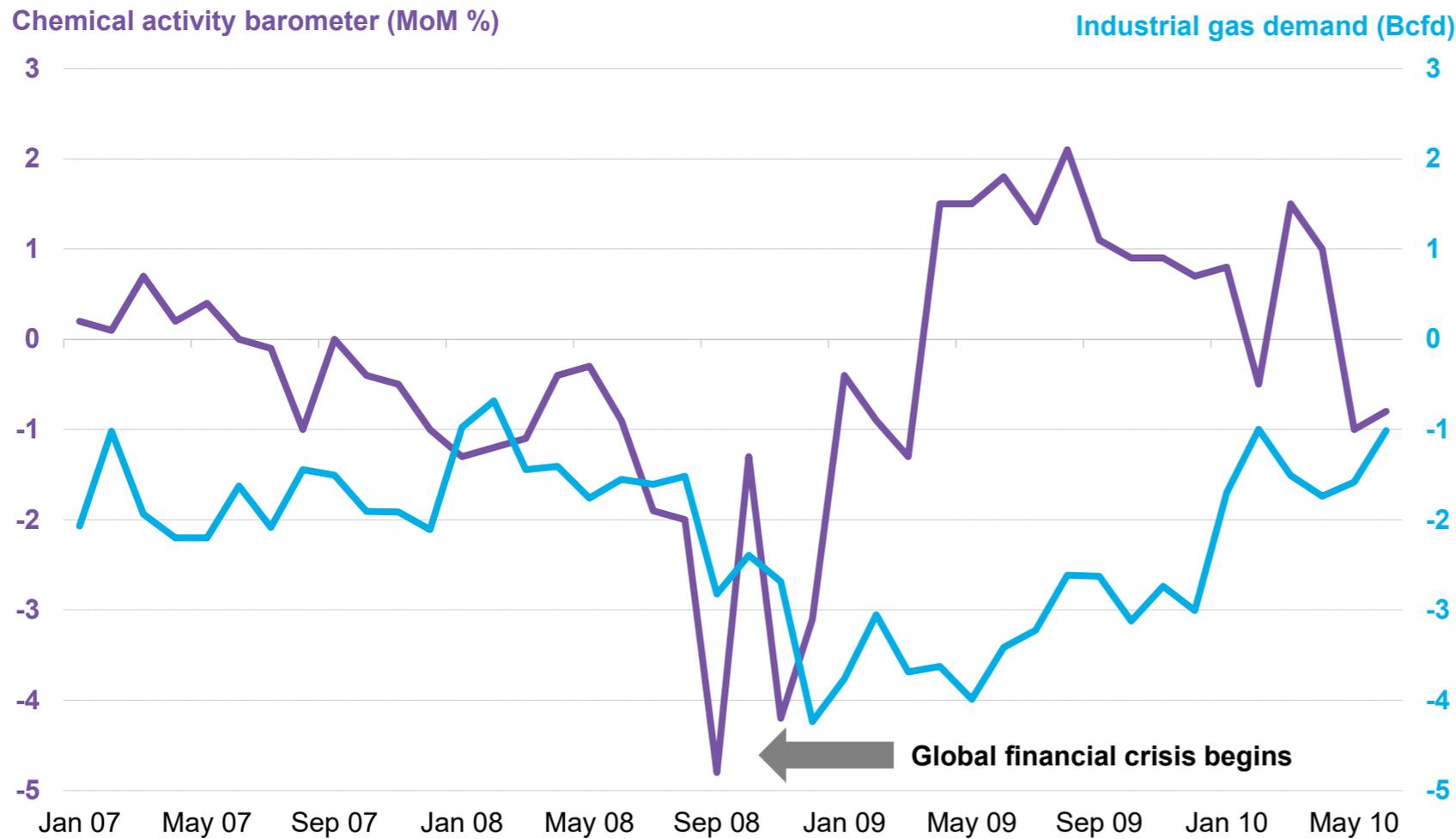
Liquefied natural gas, the cleanest but for years the most expensive fossil fuel, was the least expensive on an energy basis at the end of March 2020.

Source: [Bloomberg link](#)

# Industrial gas demand recovers from economic downturns more slowly than the broader economy



## Weather-adjusted industrial gas demand and chemical activity barometer



Prior to the global financial crisis, industrial gas demand began to fall prior to other industrial demand softening.

Gas demand also rebounded more slowly than chemical activity and than labor productivity.

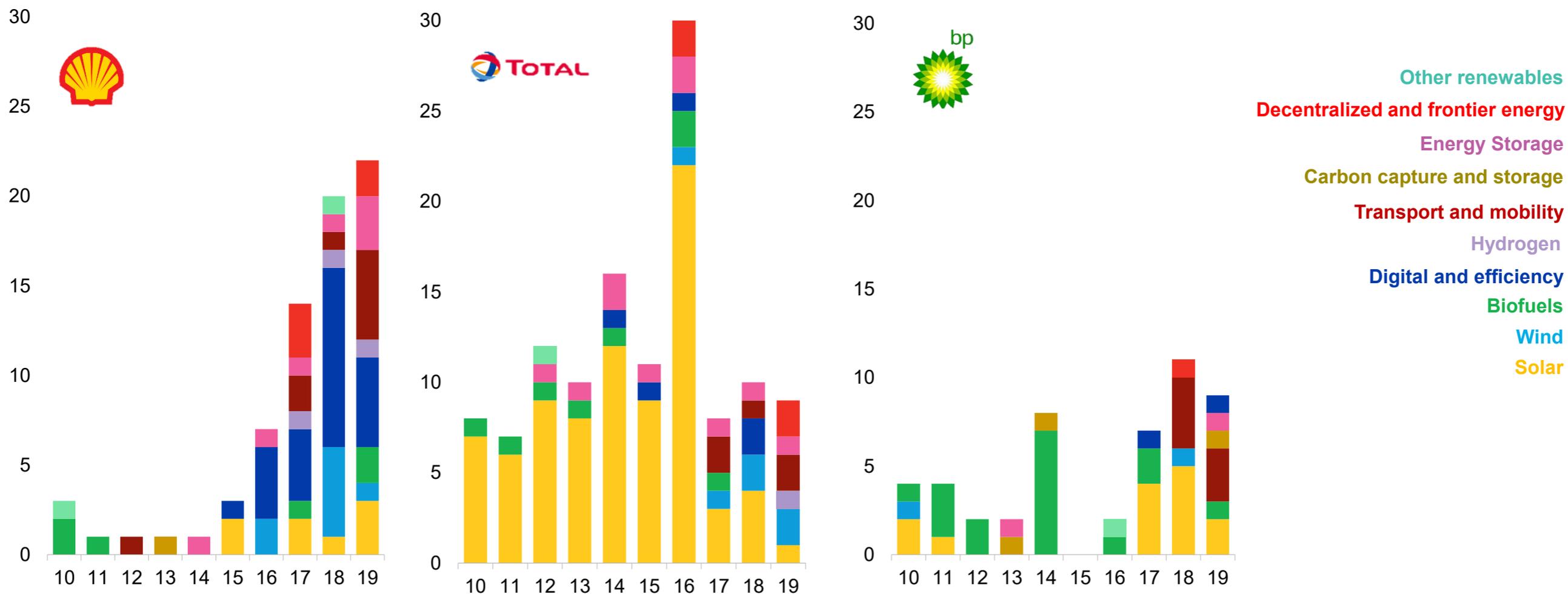
Industrial gas demand remained below prior levels well after chemical activity had returned to growth.

Source: BloombergNEF [link](#)

# Oil majors are pursuing diverse approaches to clean energy



Annual oil supermajor clean energy deals, by technology

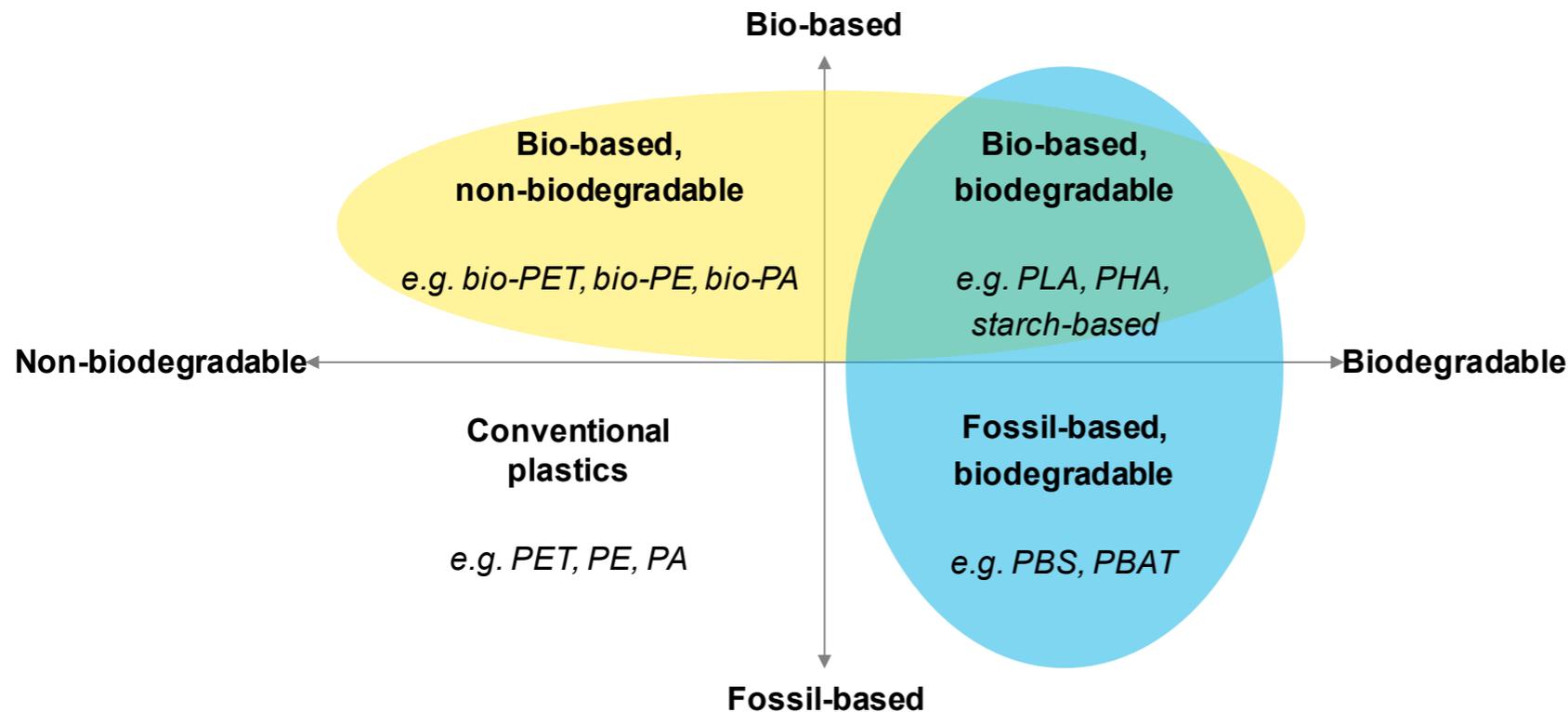


Source: BloombergNEF

# Sustainability, environmental concerns, and climate change drive interest in bioplastics



## Types of bioplastics



Drop-ins are bio-based versions of non-biodegradable petrochemical plastics currently in use.

Drop-ins are derived from biomass but are chemically identical to their fossil-based counterparts and show the same physical properties, offer the same performance, and can be processed with existing equipment.

Substitutes are new biodegradable plastics that have different chemical and physical properties compared to conventional plastics.

Substitutes have novel and sometimes superior properties and are used for an increasing number of applications as their capabilities are better known.

### Drop-ins:

- Bio-PE (polyethylene)
- Bio-PET (polyethylene terephthalate)
- Bio-PA (polyamides)

### Substitutes:

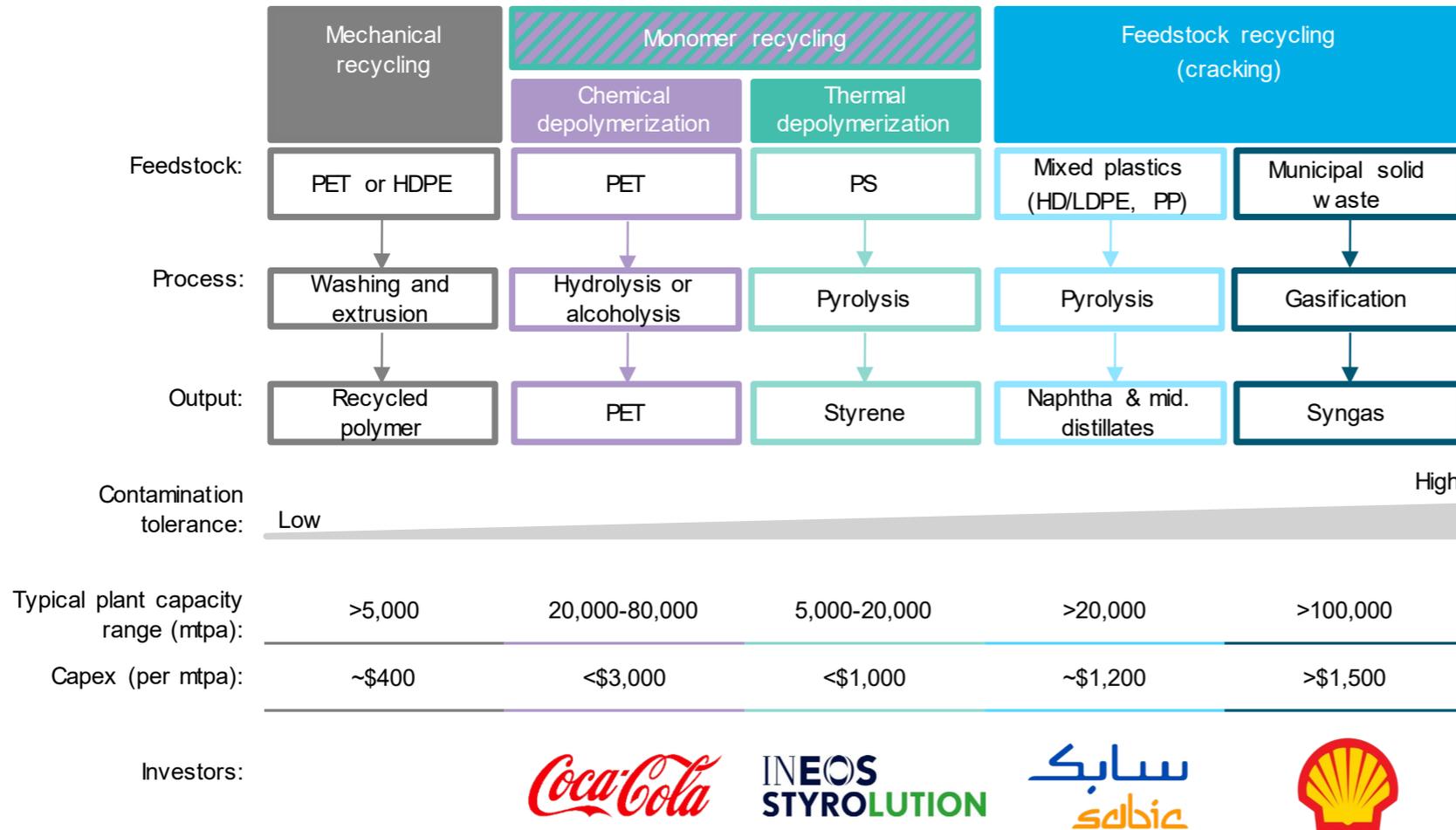
- Bio-PLA (polylactic acid)
- PHA (polyhydroxylalkoanates)
- Bio-PBS (polybutylene succinate)
- PBAT (polybutylene adipate terephthalate)

Source: BloombergNEF [link](#)

# Chemical plastics recycling converts waste products into like-new materials



## Overview of plastics recycling technologies



Chemical recycling is a new class of technologies that recycle waste plastics into virgin-grade material.

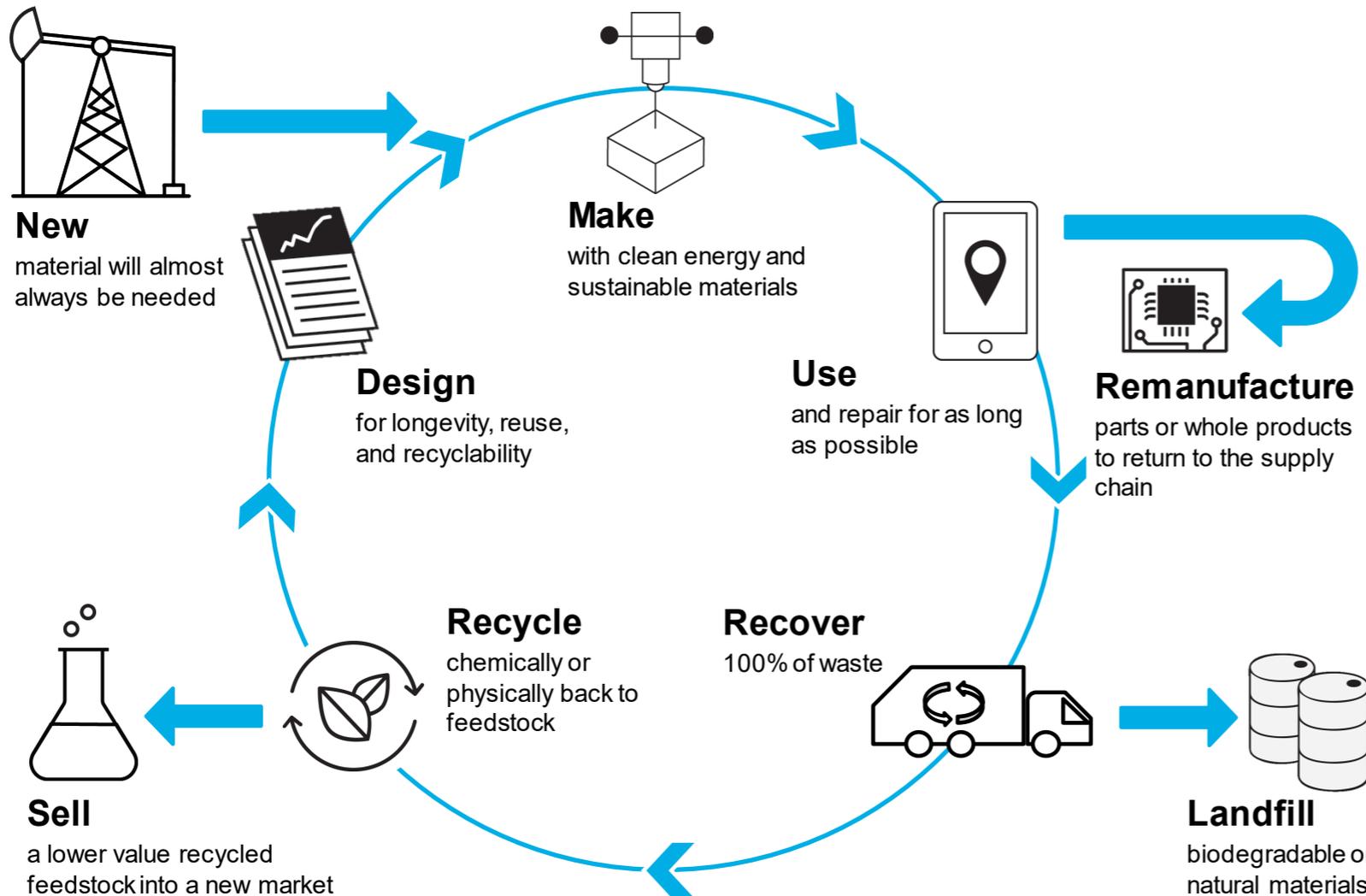
Companies across the plastics supply chain, and in particular resin producers, seek to speed up and commercialize these innovative recycling processes and deploy large-scale capacity over the next decade.

Chemical recycling feedstock costs are low, and processes have a high contamination tolerance.

Chemical recycling can be profitable because it does not require high precision in sorting, can recycle contaminated plastic waste, and produce virgin-quality material.

Source: BloombergNEF [link](#)

# The circular economy can transform supply chains and materials demand



Plastics have radically changed our economy and society and become an integral part of daily life.

However, large amounts of plastic wastes and lack of proper waste management also negatively impacted our land, water, and air.

The circular economy represents a more sustainable solution over the traditional linear model of "extract-make-use-dispose".

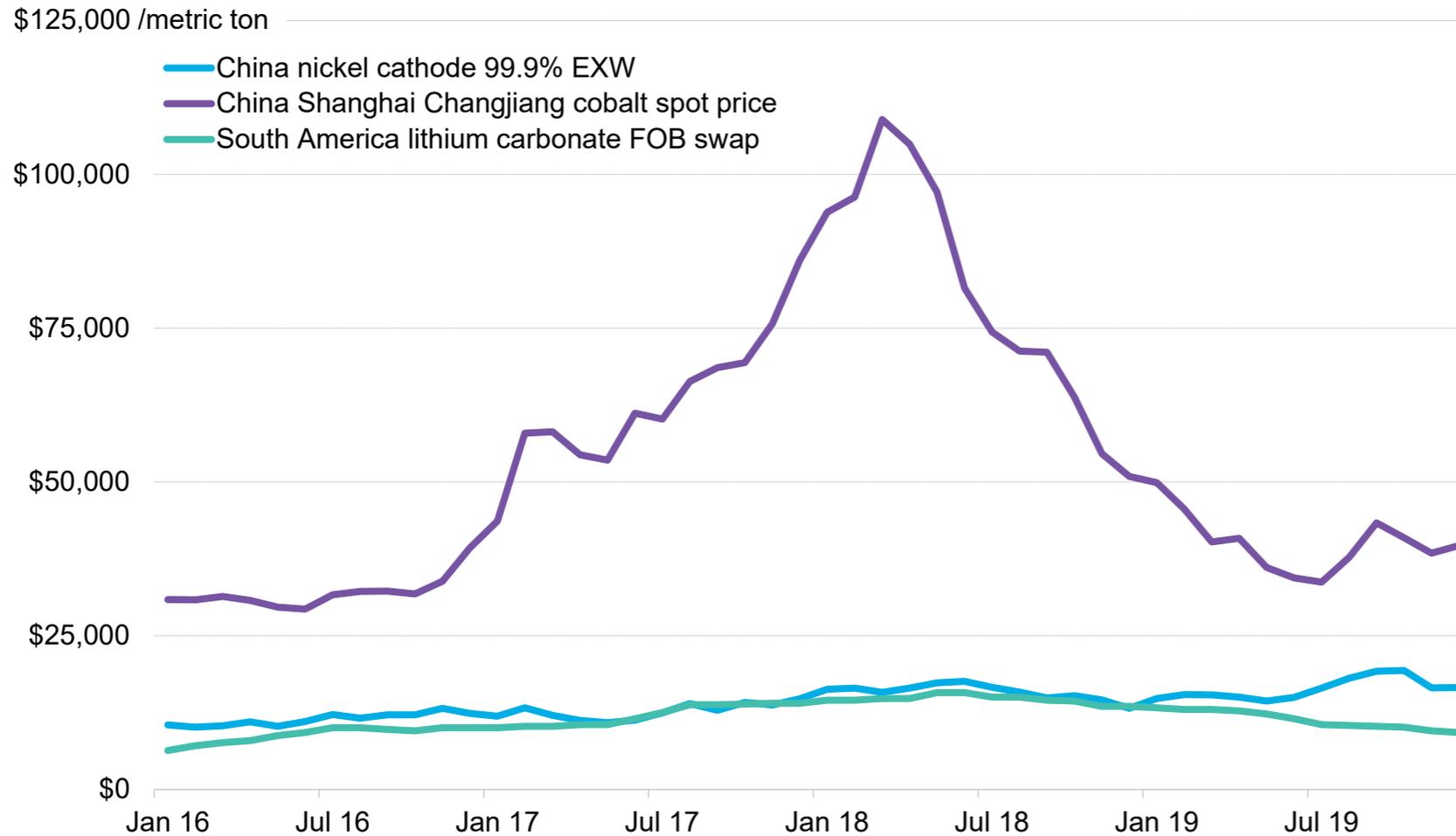
The changes along the entire value chain promote more recycling, novel product design and new business models.

Source: BloombergNEF

# Battery metals prices have spiked and now settled



## Lithium-ion battery metals prices



Battery metals have had volatile prices as demand from electric vehicles increased significantly.

Cobalt prices, which spiked in 2017 to more than \$100,000 per metric ton, are now back to similar levels as in 2016.

Nickel cathode and lithium carbonate trade at similar prices to four years ago.

Source: [BloombergNEF link](#)

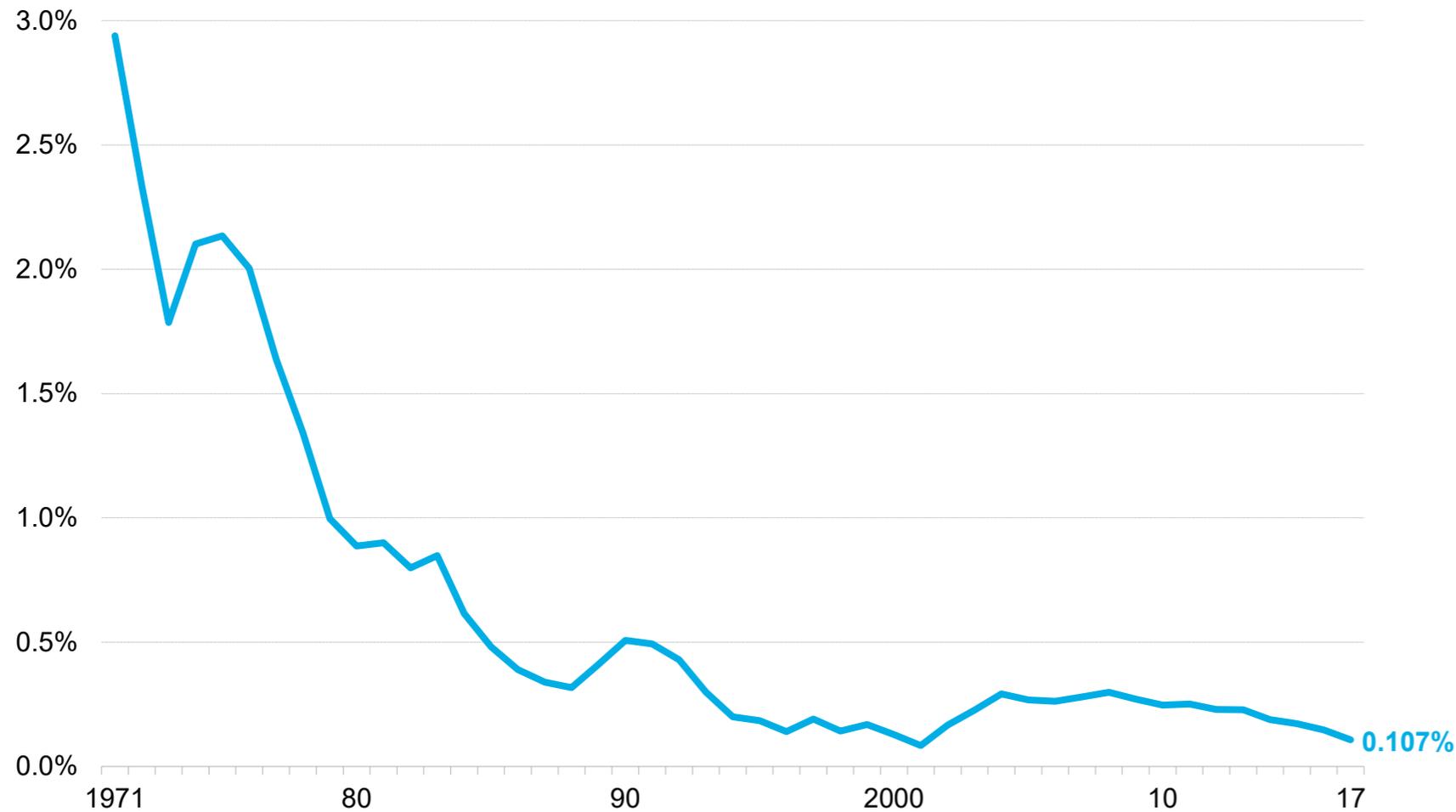
# Table of contents

Introduction: the moment we are in	3
 A cleaner future	12
 Power	21
 Transport	40
 Industry and Buildings	55
 Commodities	70
 <b>Food and Agriculture</b>	<b>87</b>
 Capital	93
BNEF Summit series / About BNEF	102

# Global beef consumption is very close to peaking



## 10-year compound growth rate in global beef production



Grazing cattle uses 60% of global agricultural land

At the same time, all of that grazing land provides just 2% of the world's calories.

Domesticated cows and buffalo emit about 5 billion tons of CO<sub>2</sub>e annually

That volume is equivalent to about 14% of all emissions from fossil fuel combustion.

Other proteins have overtaken beef in the U.S. and beef has peaked in rich Asia

Among affluent East Asian countries, only South Korea is still showing a rising trend of beef consumption.

The compound annual growth rate over the past decade was just 0.11%

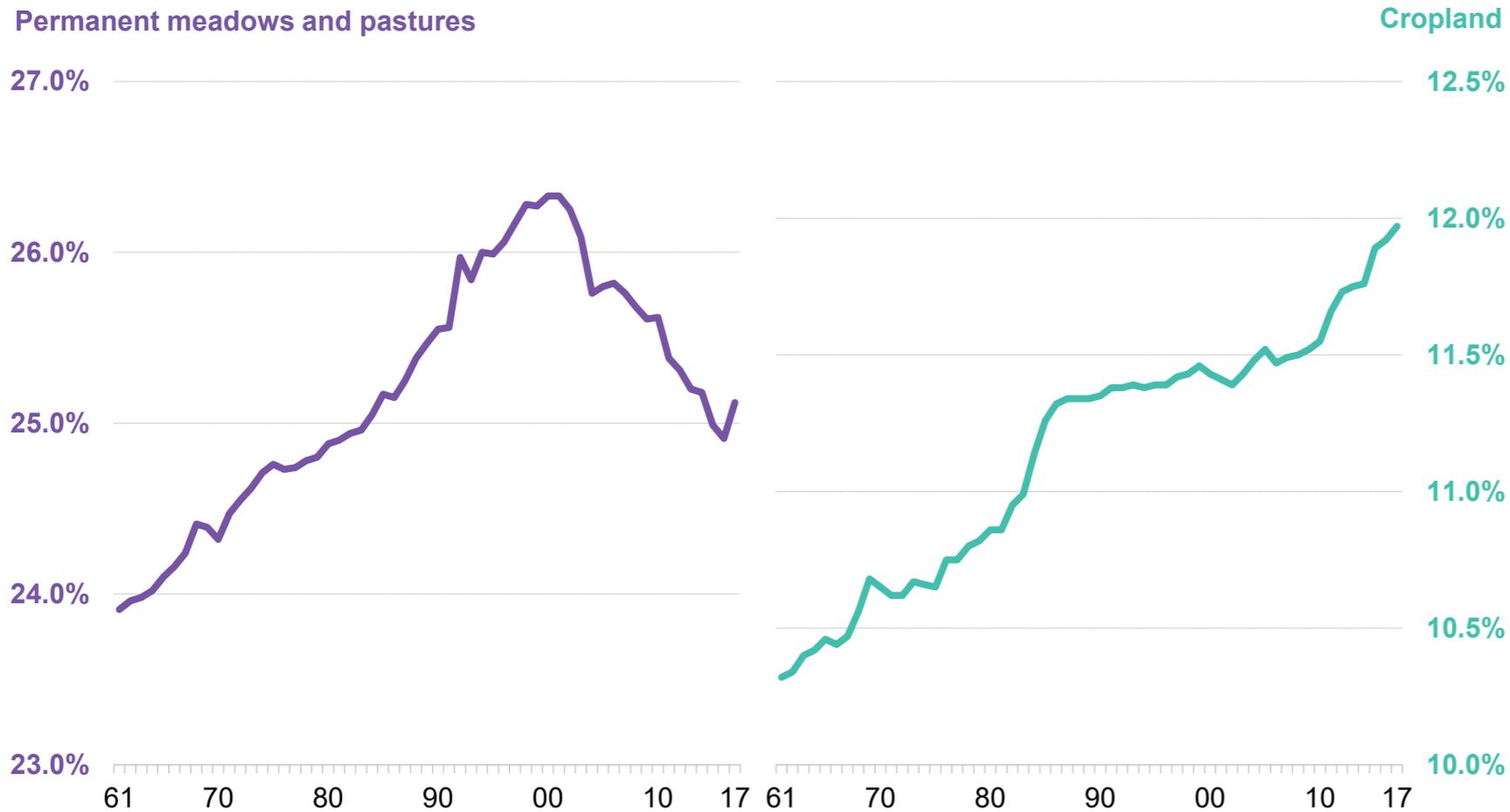
That is the slowest rate since the decade to 2001, when many countries were deeply concerned about "mad cow" disease.

Source: Bloomberg, Food and Agriculture Organization (FAO)

# Land used for livestock has peaked, while cropland is still increasing



% of total land area



The percentage of total land area used for grazing livestock peaked earlier this century, and has been declining since.

The percentage of land area used for growing crops, however, has continued to increase.

“Peak pasture” does not mean peak meat, however – poultry and pork are much more likely to be housed and industrial farmed than grazed on open land.

Source: BloombergNEF [link](#), Food and Agriculture Organization of the United Nations

# Meat calories grew faster than vegetable calories, but vegetable calories still dominate in volume



## Change in calories per capita, year-on-year average per decade

Meat product kcal per person

**+54.4%**

1961 – 2017

Vegetal product kcal per person

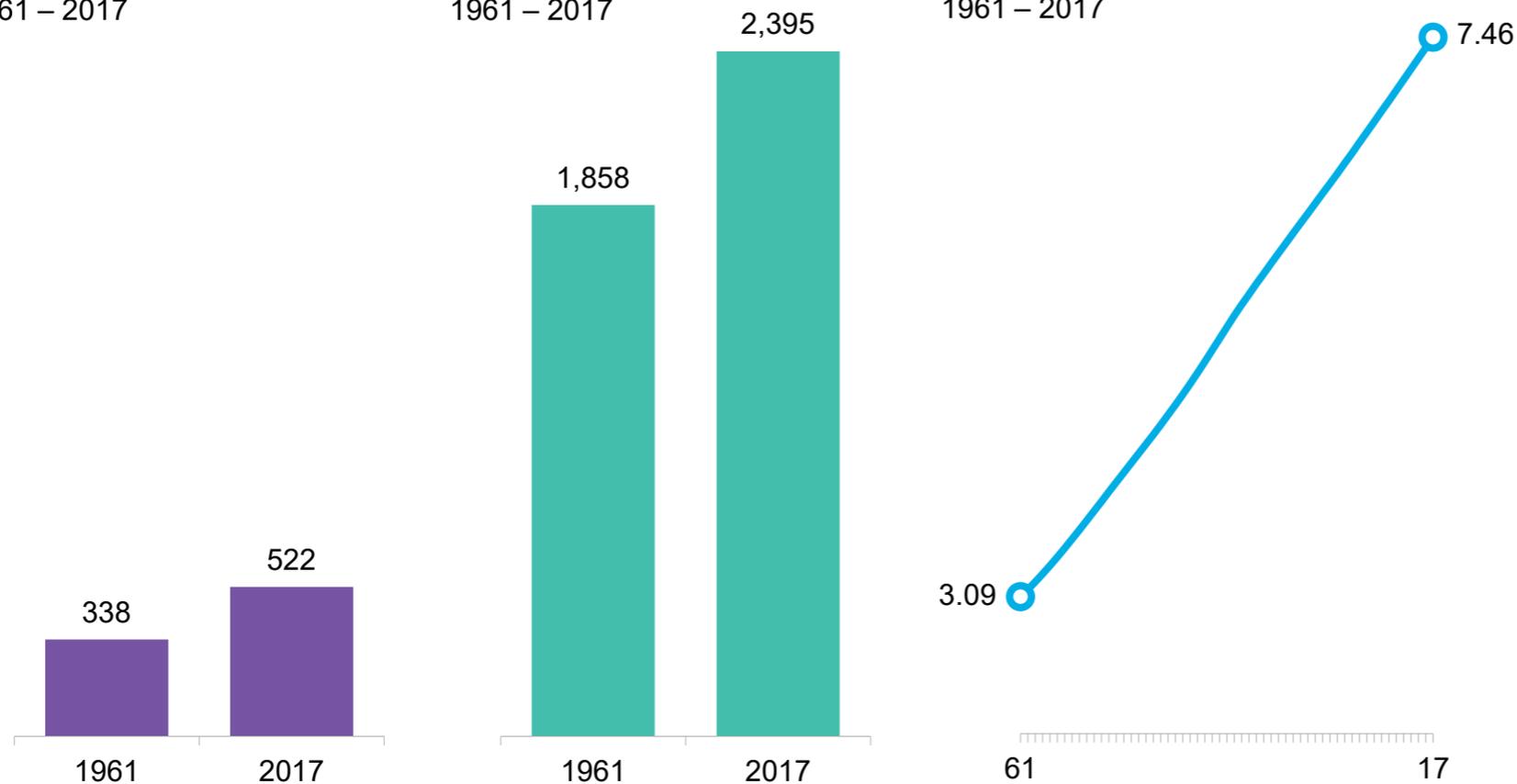
**+28.9%**

1961 – 2017

Global population (billions)

**+144%**

1961 – 2017



Total meat product calories have increased almost four-fold since 1961.

Meat product calories per person have increased almost twice as much as vegetal product calories per person in the past 60 years.

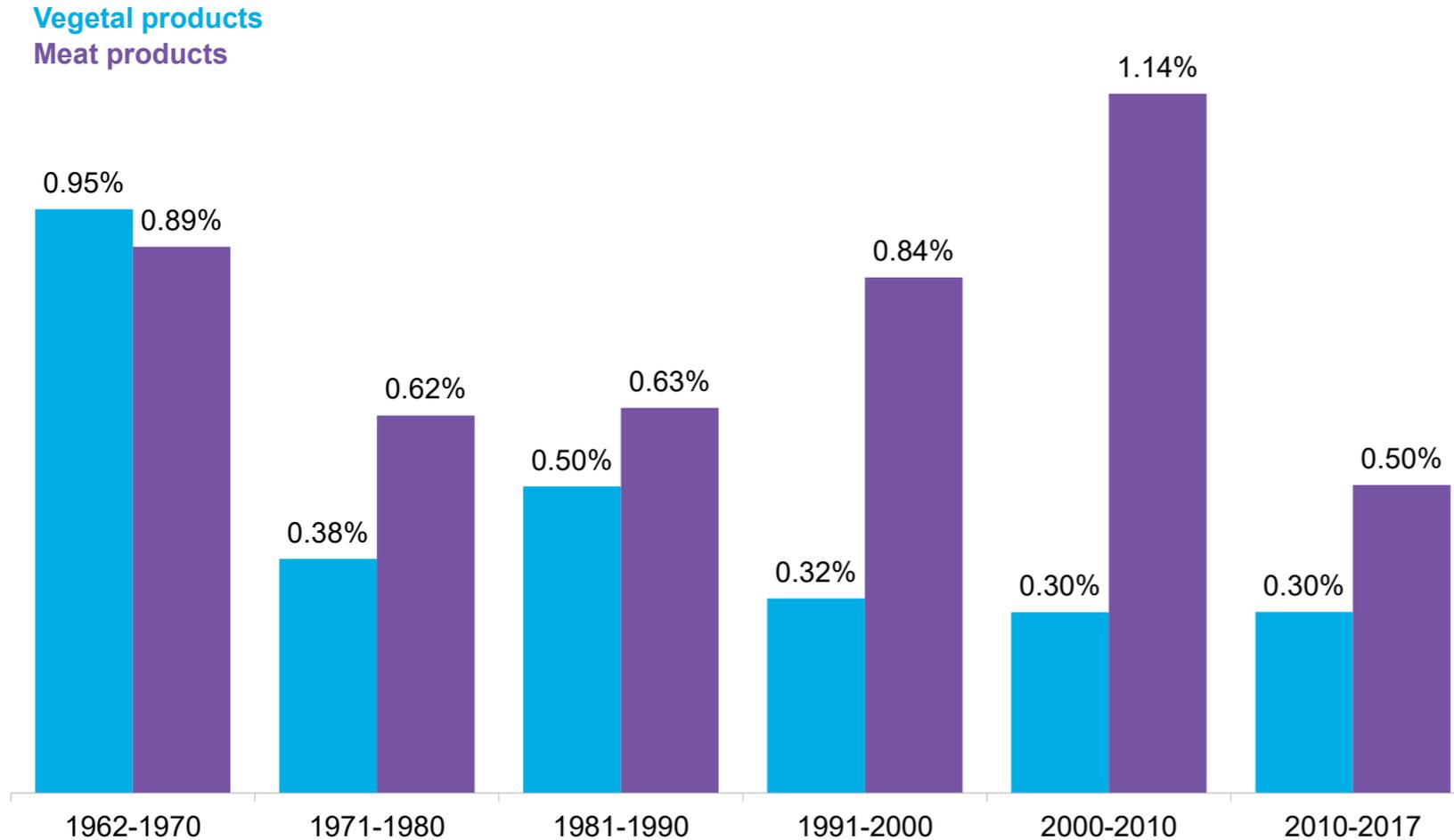
This per capita and absolute growth in meat and vegetable calories comes as the human population has more than doubled, and land used for production has decreased.

Source: BloombergNEF [link](#), Food and Agriculture Organization of the United Nations

# The rate of increase in meat calories is re-aligning with growth in vegetable calories



## Change in calories per capita, year-on-year average per decade



Meat product calories have increased more, on average, than vegetable product calories since the 1970s.

By the 2000s, the difference in growth rate between meat the vegetable calories per capita was more than 0.8% per year.

Since the early 2000s, however, the meat calorie increase rate has fallen back to about the same as it was in the 1970s.

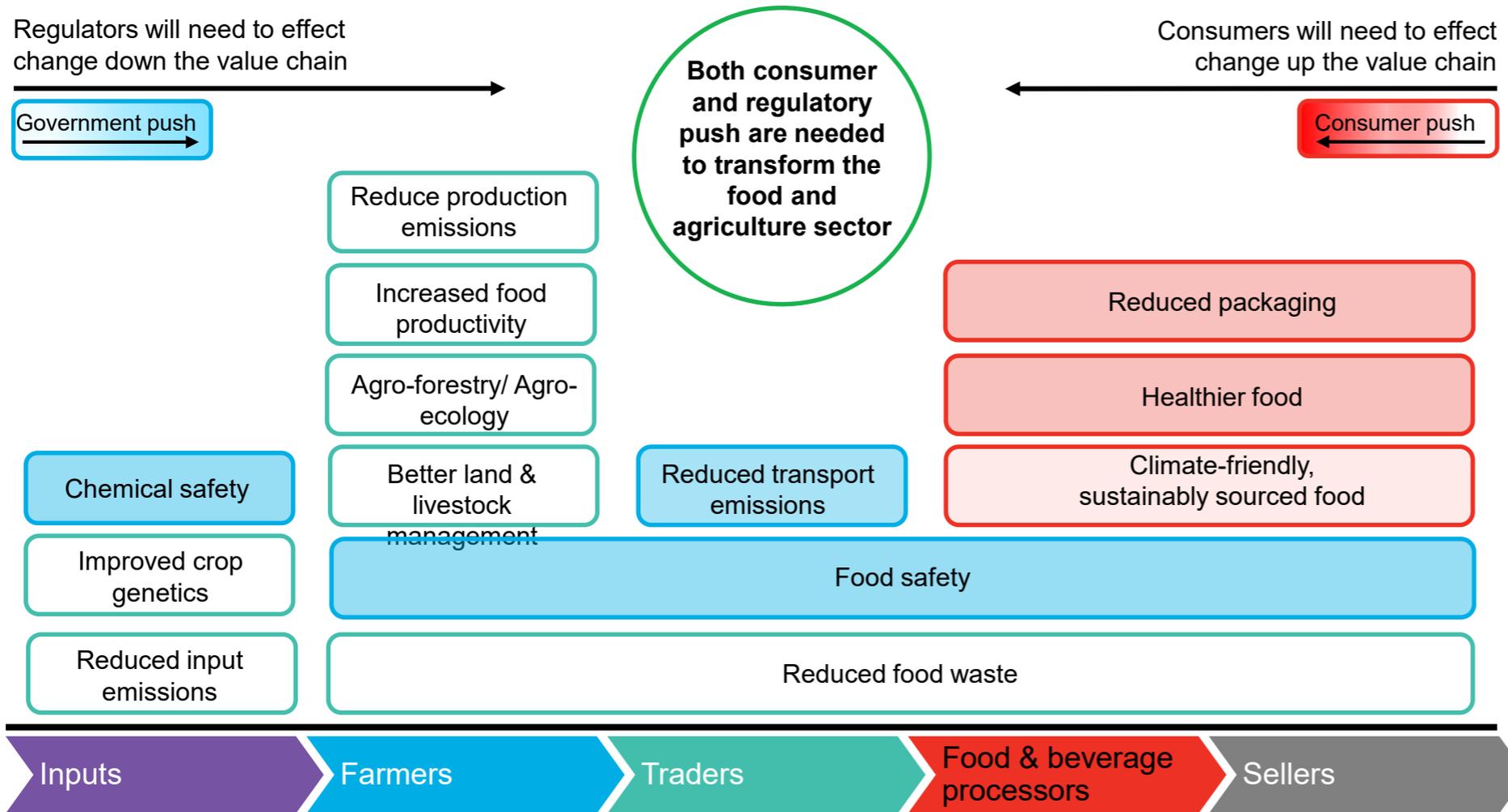
From 2010 to 2017, the average annual increase in meat calories was 0.5% per year, just a bit more than the 0.3% annual increase for vegetables.

Plant-based meat substitutes are in demand, and will need cropland to expand production.

Pea crop plantings in the U.S. and Canada increased 20% in 2019 thanks to demand for pea isolates from plant-based meat substitute producers.

Source: BloombergNEF [link](#), Food and Agriculture Organization of the United Nations

# Decarbonization is not the only driver of food and agriculture innovation



Consumer pressure and reputational action are driving agriculture's sustainability push, in the absence of policy action.

This sustainability push is a contrast to the energy transition, which is heavily policy-driven.

It is not yet clear whether (or how) regulators will implement policies that incentivize low-carbon agricultural practices.

Source: BloombergNEF. This list omits policy for reforestation and conservation because it is outside the scope of the value chain.

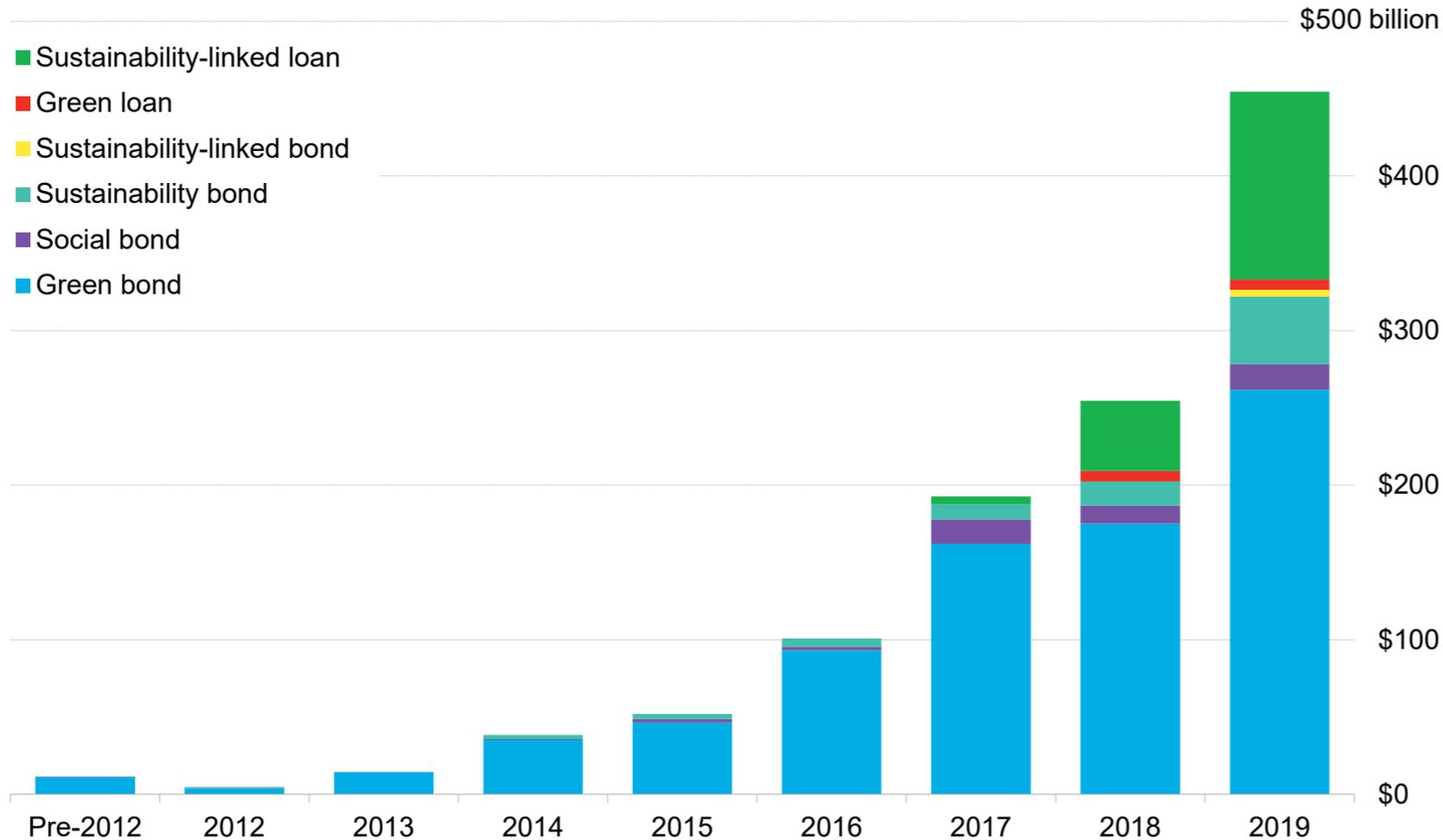
# Table of contents

Introduction: the moment we are in	3
 A cleaner future	12
 Power	21
 Transport	40
 Industry and Buildings	55
 Commodities	70
 Food and Agriculture	87
 <b>Capital</b>	<b>93</b>
BNEF Summit series / About BNEF	102

# Companies and institutions have raised more than \$1 trillion of sustainable debt in the last decade



## Sustainable debt issued by instrument type (nominal)



\$465 billion of labeled sustainable debt instruments were issued in 2019, a nearly 100-fold increase from \$5 billion in 2012.

Green bonds, for long the most significant component of sustainable finance, are now joined by other instrument classes with tens of billions of dollars of issuance.

Sustainability bonds (which emerged two years ago) and social bonds are the fastest growing instrument classes.

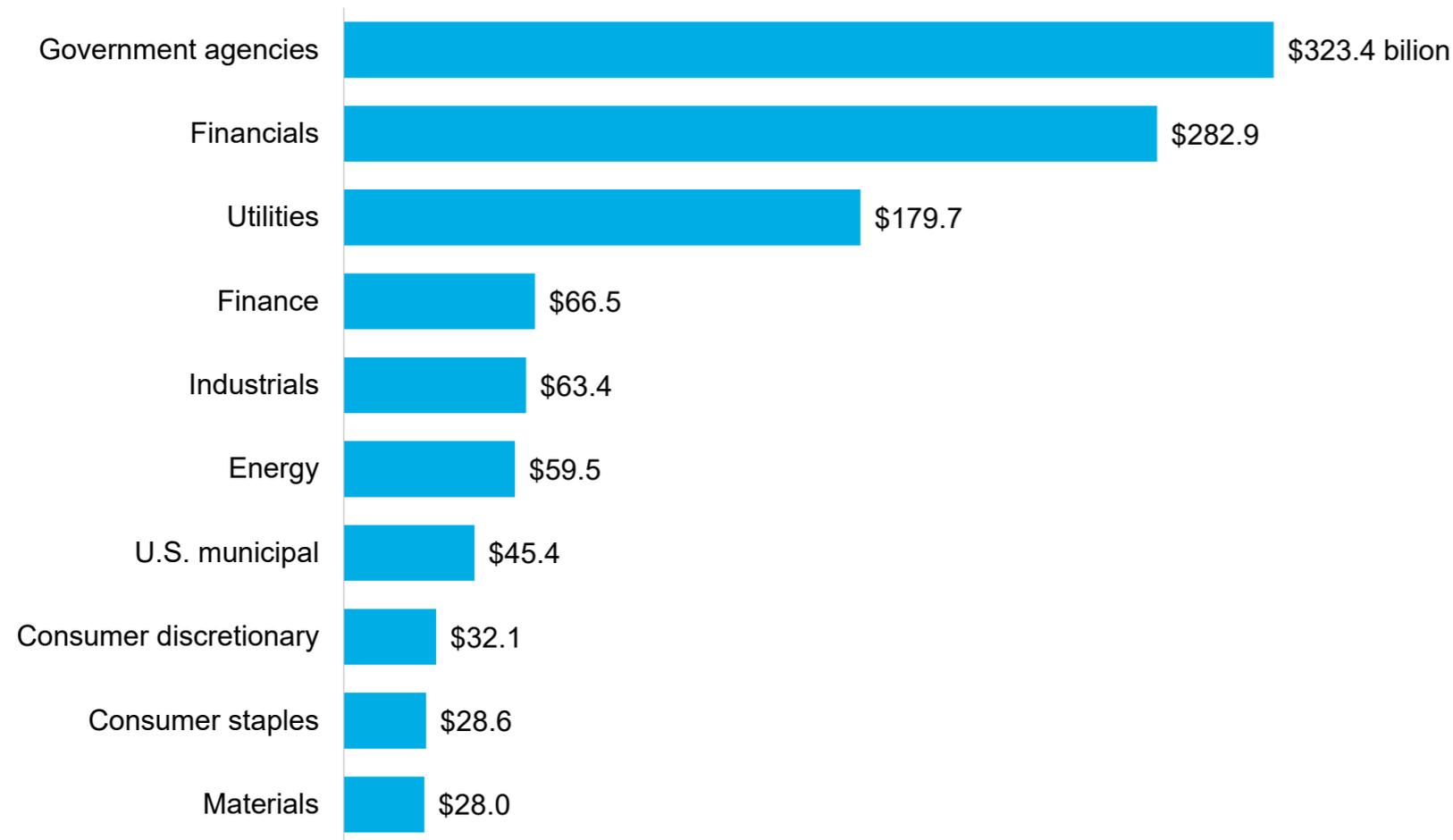
These new securities create options for using debt for general corporate purposes while also labeling it 'sustainable.'

Source: BloombergNEF

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



## Sustainable debt issued by issuer industry, pre-2012 – 2019



Government agencies and financials have each issued more than \$250 billion of sustainable debt since 2012.

Financials were the largest issuers in 2019, issuing \$115 billion.

Governments were the next-largest issuer in 2019, issuing \$110 billion.

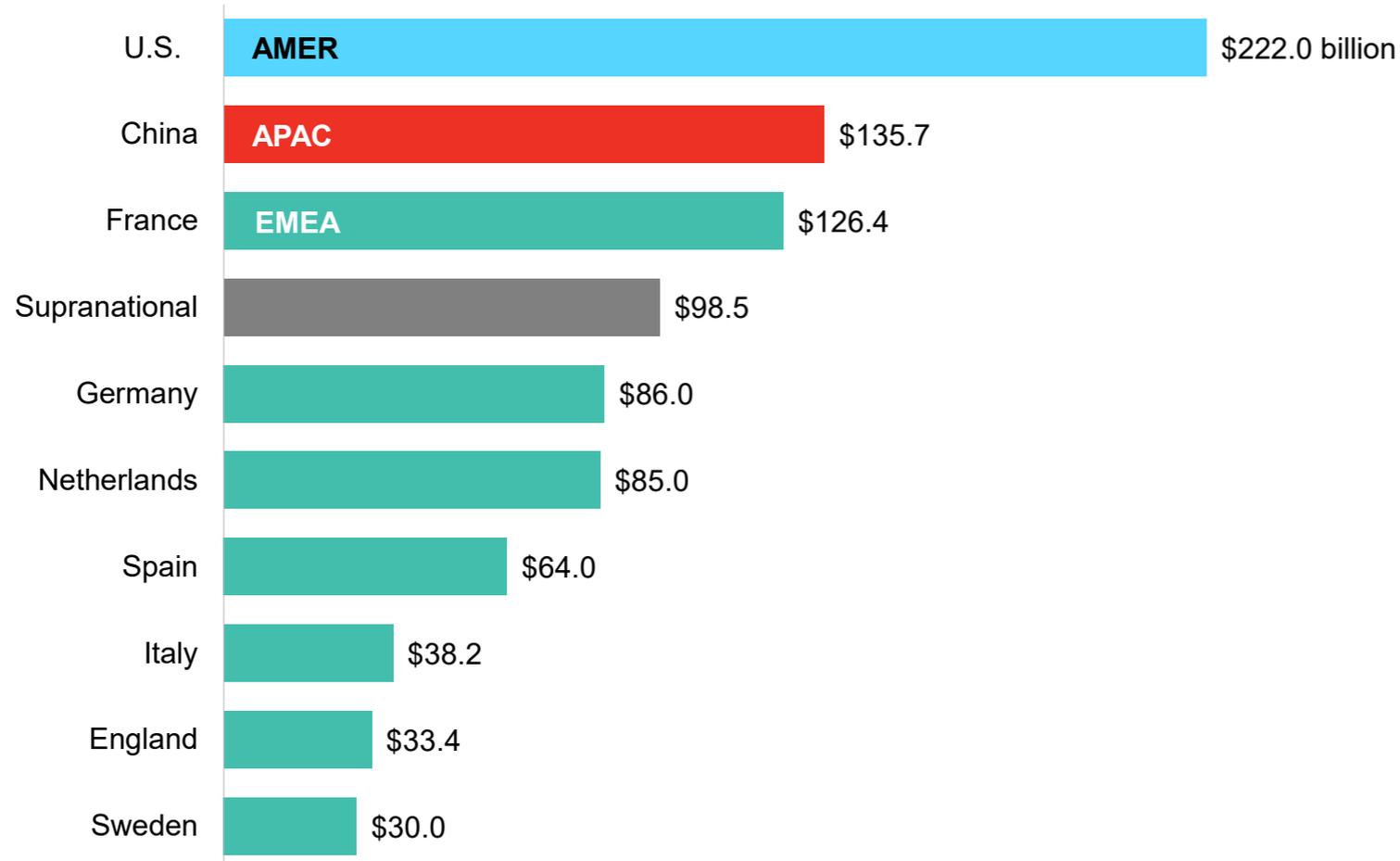
Utilities issued \$65 billion, while energy companies issued \$22.6 billion, not much more than the \$19.8 billion issued by consumer discretionary companies.

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

# The U.S. and China are the largest issuers of sustainable debt



## Sustainable debt issued by issuer country, pre-2012 – 2019



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

China, which was the largest issuer in 2016, was the second-largest issuer in 2017 and 2018.

Every other major sustainable debt-issuing country is European, with the exception of supranational issuers.

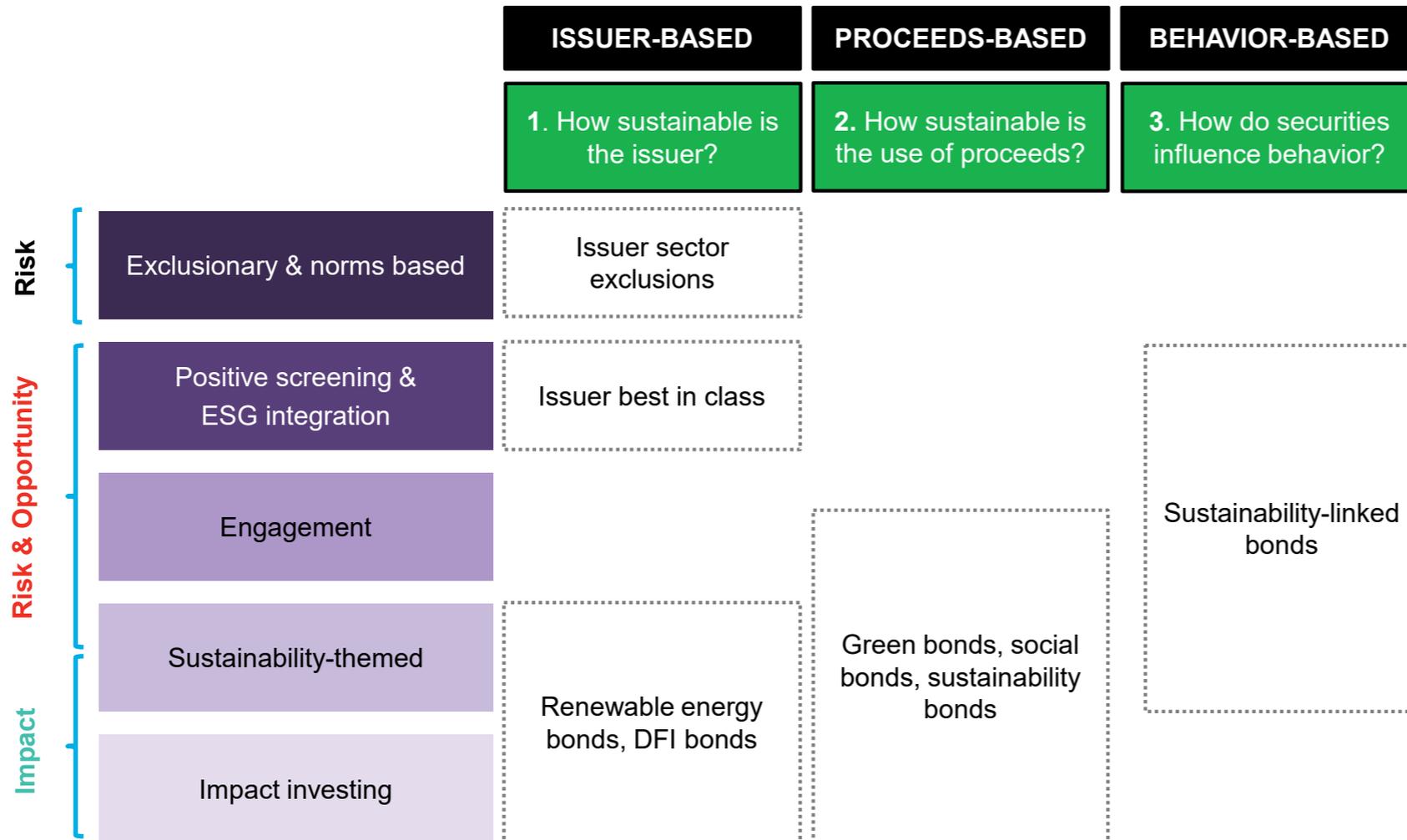
Japan (\$25.6 billion) and South Korea (\$18.5 billion) are the other major issuers in Asia, though far behind China to date.

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

# Sustainable fixed income is expanding, and so are its instruments



## Defining sustainable fixed income



Prior to 2019, most sustainable finance took the form of issuer-based green bonds or loans and their social equivalents, mostly raised by the energy sector.

As new sectors raise sustainable debt, they do so through proceeds-based and behavior-based instruments.

Newer issuers like industrials and transport only issue behavior-based instruments.

Energy and financial firms issue both proceeds- and behavior-based instruments.

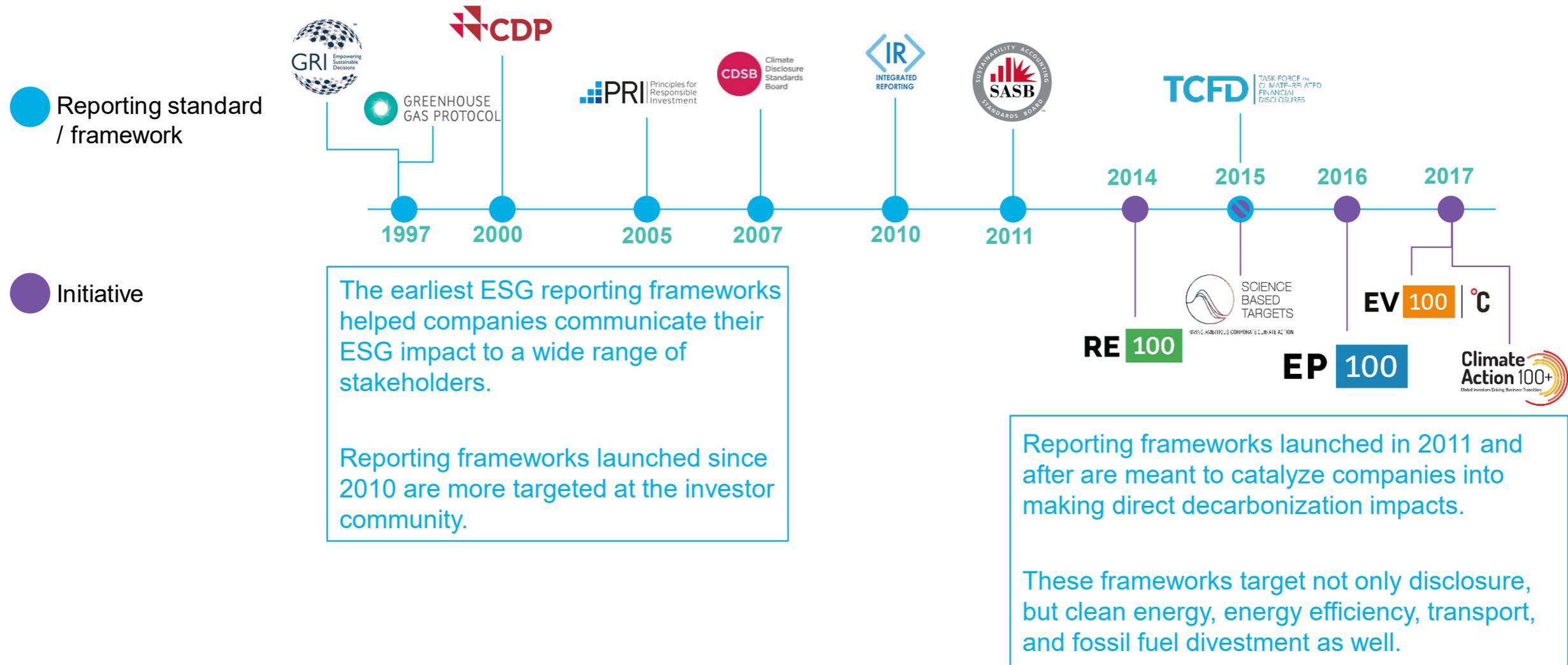
Governments issue only proceeds-based instruments.

Source: BloombergNEF [link](#)

# Early ESG reporting frameworks communicated impact; recent frameworks target investors



## Timeline of major sustainability commitment announcements

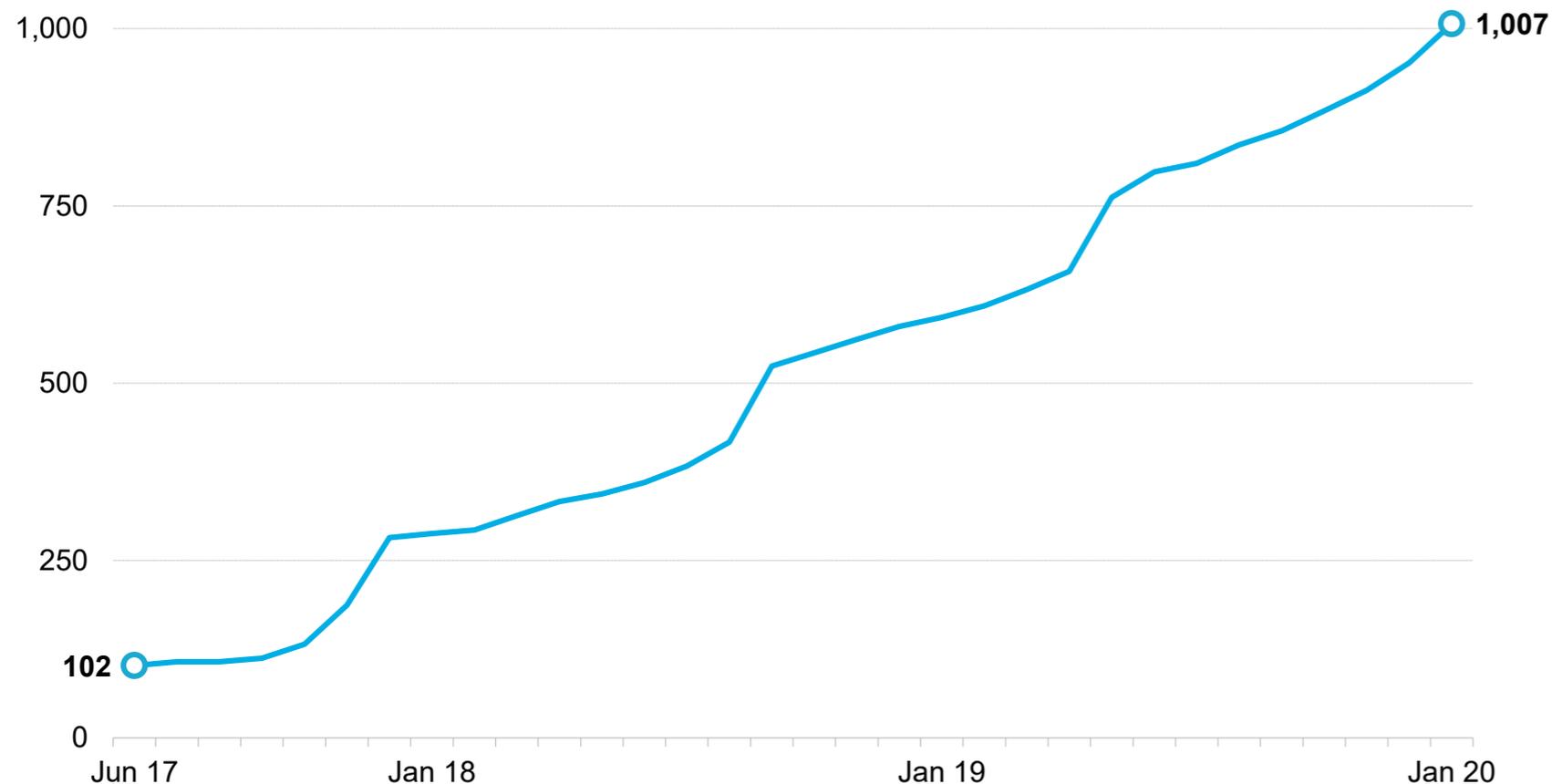


Source: BloombergNEF [link](#)

# The Taskforce on Climate-related Financial Disclosures now has more than 1,000 member companies



**TCFD** | TASK FORCE ON CLIMATE-RELATED FINANCIAL DISCLOSURES  
**Member companies**



The Task Force on Climate-related Financial Disclosures, or TCFD, has developed recommendations on how companies should report on the opportunities and risks that they face.

TCFD's goal is to have greater reporting lead to easier investor decisionmaking on climate-related risks.

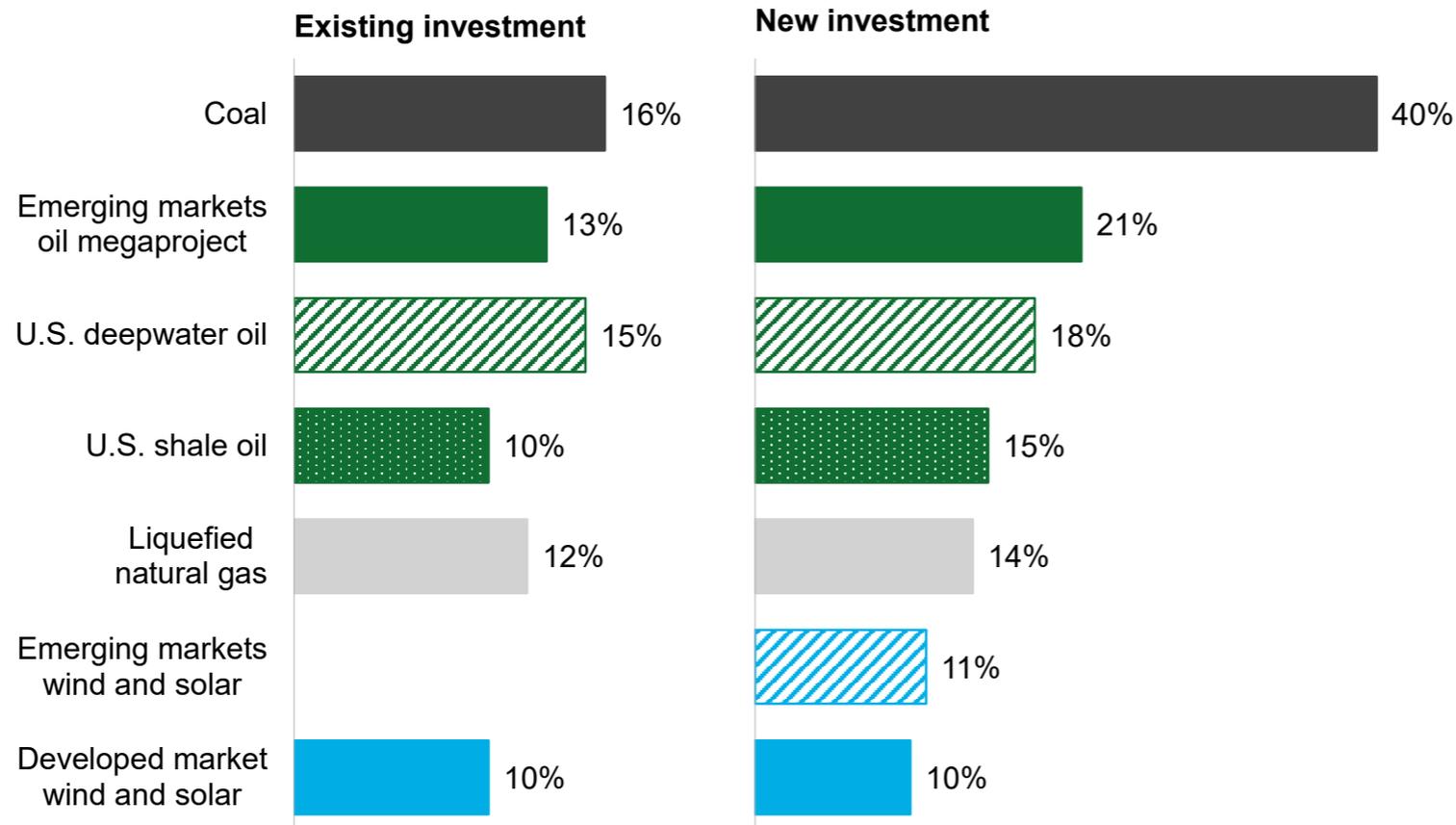
TCFD's use of scenarios for forward-looking disclosure is unique, but also challenging for companies.

Source: BloombergNEF. Note: 2019 data through 3Q.

# Institutional investors already prefer lower-carbon assets



## Base case internal rates of return (IRR) required for a new energy investment to be preferable to dividends or buybacks



Institutional investors are demanding much higher hurdle rates from long-cycle high-carbon coal and oil projects than from natural gas or renewable energy.

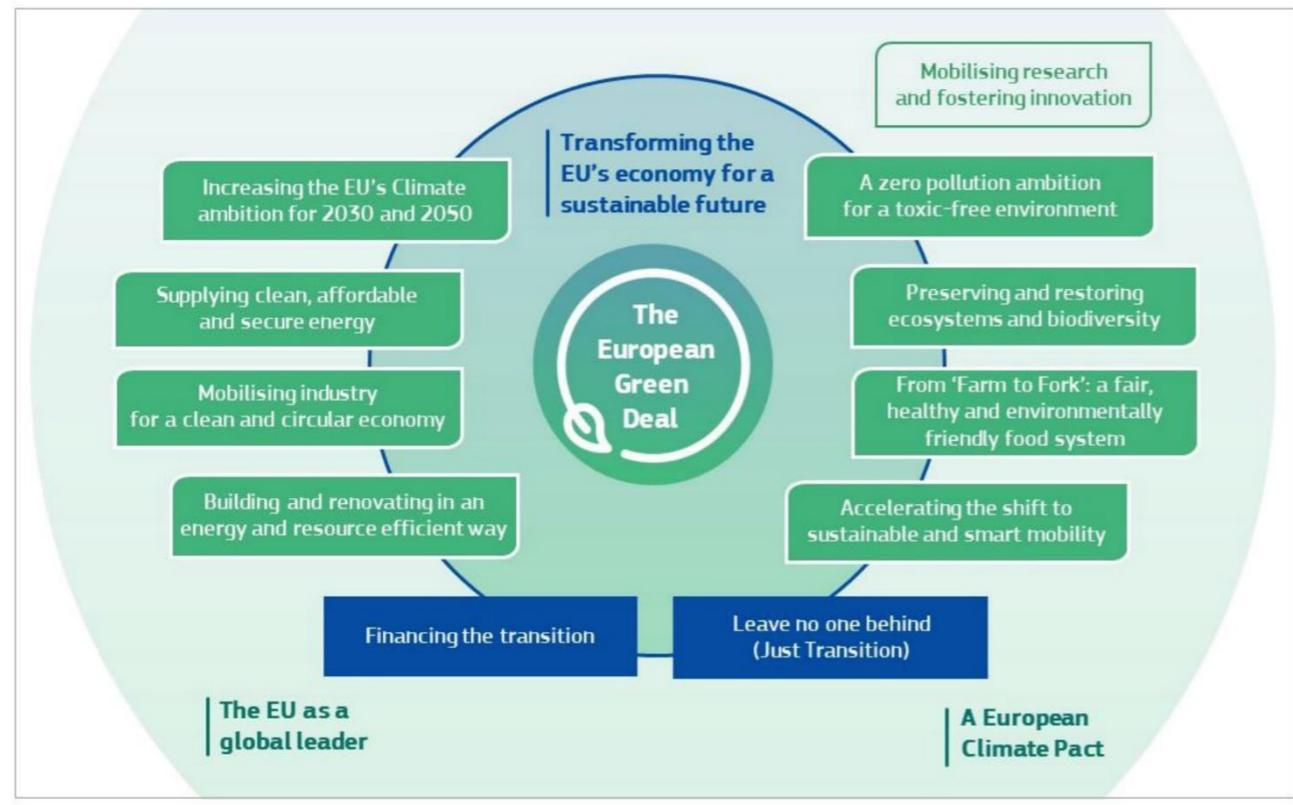
These preferences were evident in 2018, before current oil market conditions.



If this is a true representation of the change in risk perception, then the entire landscape of fossil fuel investment needs to be reconsidered.

Source: Oxford Energy [link](#) Note: The survey of institutional investors was conducted from July to October of 2018. There were 26 participants in the survey. These included investors based in the United States and in Europe, from 'long only' asset managers, hedge funds and private equity investors. Each interview focused on the hurdle rates that were seen to be desirable for different types of energy investment.

# Economy-wide net-zero emissions targets will reshape capital flows



Press release | 4 March 2020 | Brussels

## Committing to climate-neutrality by 2050: Commission proposes European Climate Law and consults on the European Climate Pact



We are turning words into action today, to show our European citizens that we are serious about reaching net-zero greenhouse gas emissions by 2050...The Climate Law will ensure we stay focused and disciplined, remain on the right track and are accountable for delivery.

European Commission Executive Vice-President for the European Green Deal Frans Timmermans

Source: European Commission

# Table of contents

Introduction: the moment we are in	3
 A cleaner future	12
 Power	21
 Transport	40
 Industry and Buildings	55
 Commodities	70
 Food and Agriculture	87
 Capital	93
<b>BNEF Summit series / About BNEF</b>	<b>102</b>



The BNEF Summit has been convening leaders in energy, industry, transport, technology, finance and government since 2008, generating ideas, delivering insight, and making the connections that help them formulate successful strategies, capitalize on technological change and shape a cleaner, more competitive future.

## BNEF Summit

### London

Energy | Finance | Technology

### Munich

Automotive | Manufacturing | Energy

### New Delhi

Energy | Transport | Government

### New York

Energy | Finance | Technology

### San Francisco

Automotive | Energy | Technology

### Shanghai

Energy | Industry | Transport

**Whilst physical convening is constrained during COVID-19, the BNEF Summit will be delivered virtually as the BNEF Summit: Strategic Briefing and Dialogue for each location.**

# 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

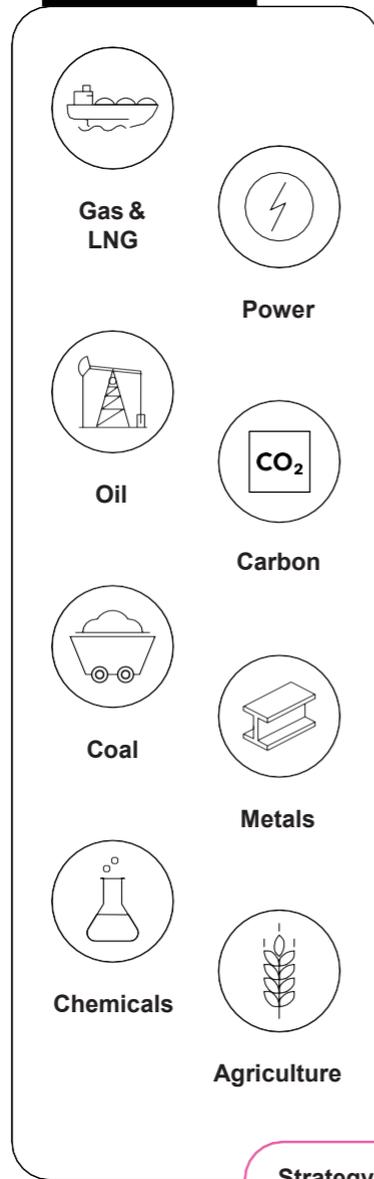
## Data, models, tools

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

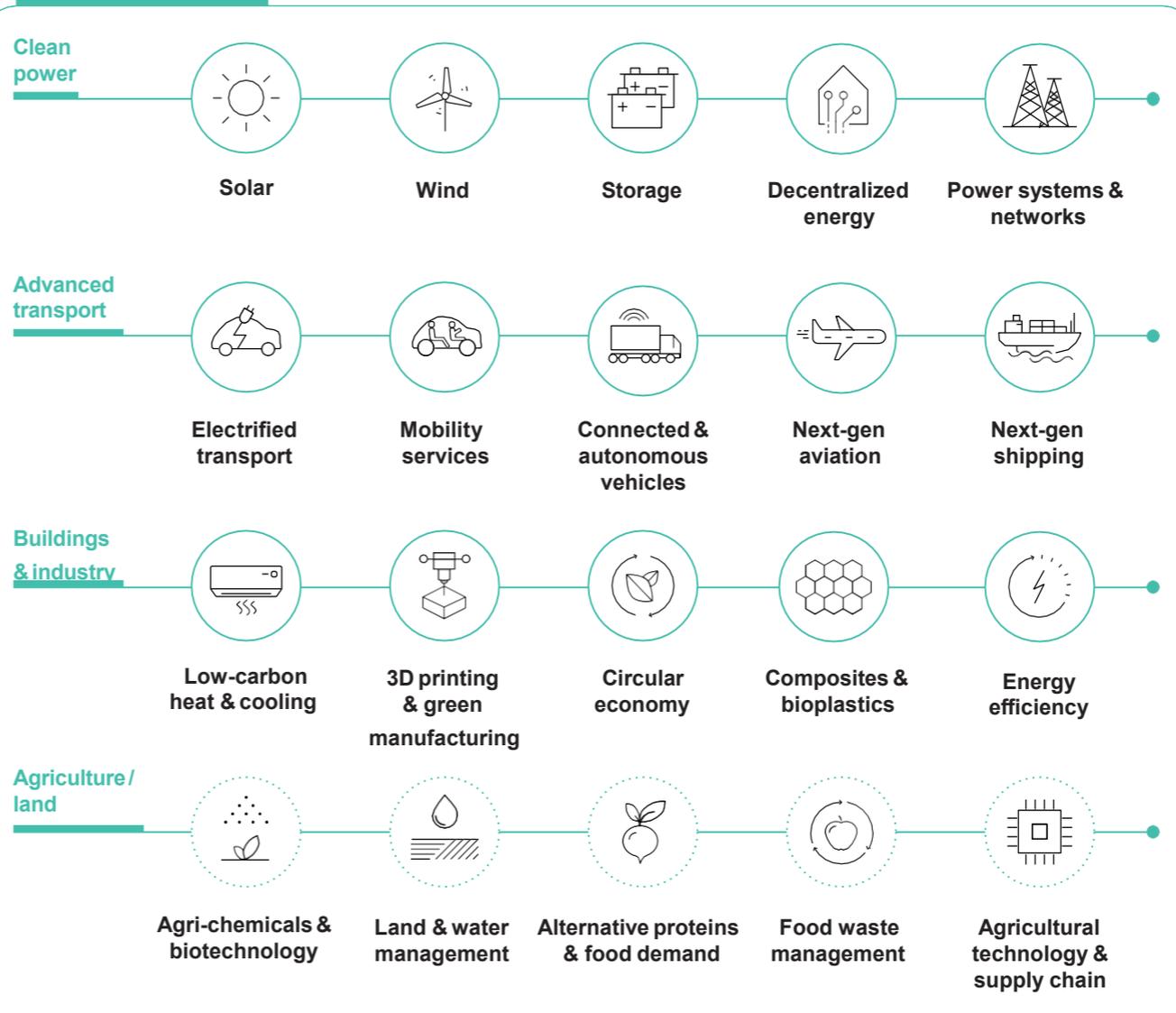
## Briefings and webinars

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

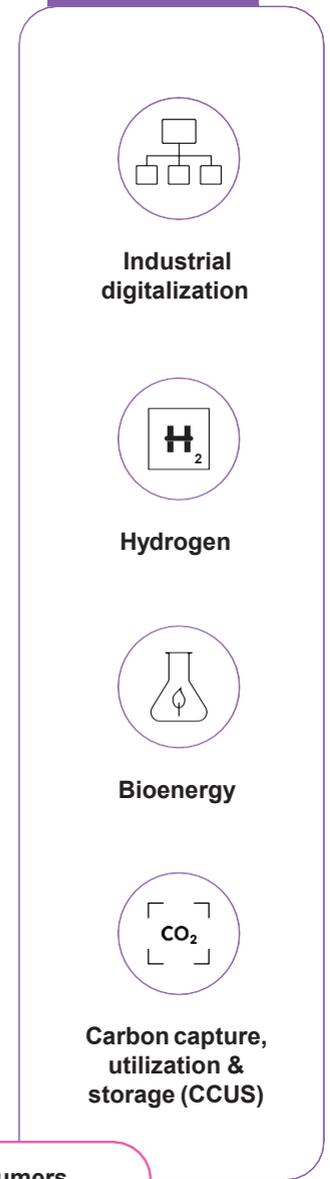
## Commodities



## 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. © 2020 Bloomberg.

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

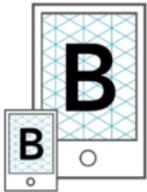
BNEF's global team leverages the world's most sophisticated data sets to create clear perspectives and in-depth forecasts that frame the financial, economic and policy implications of industry-transforming trends and technologies.

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](http://about.bnef.com/mobile)

# BloombergNEF

### Contact:

Nat Bullard [nbullard@bloomberg.net](mailto:nbullard@bloomberg.net)

### Client enquiries:

Bloomberg Terminal: press <Help> key twice

Email: [support.bnef@bloomberg.net](mailto:support.bnef@bloomberg.net)

### Learn more:

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