



 **Sustainable Energy in**  
 **America 2022 Factbook**  
 **Tracking Market & Policy Trends**

**BloombergNEF**

 **The Business Council**  
for Sustainable Energy®

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# About the Factbook: 2022 updates



## What is it?

- The Factbook **aims to augment existing sources** of information on U.S. energy
- It **focuses on renewables, efficiency, natural gas, distributed power and storage and sustainable transportation**
- It **fills important data gaps** in certain areas (e.g., clean energy investment flows, contribution of distributed energy)
- It **contains data through the end of 2021** wherever possible
- It **employs BloombergNEF data** in most cases, augmented by EIA, FERC, ACEEE, LBNL, and other sources where necessary
- It **contains the very latest information on new energy technology costs**
- It **has been graciously underwritten by the Business Council for Sustainable Energy** with the help of supporting sponsors
- This is the Factbook's 10<sup>th</sup> edition (first published in January 2013)

## What's new?

- This year's report contains annual views of and commentary on driving factors in the energy sector. It includes new data on gasoline demand, hydrolyzer costs, energy efficiency codes and electric vehicles among other things.
- **Format:** This year's Factbook has been streamlined from previous editions to make it easier for readers to find the data and information they seek.

# About the Factbook: Sponsorship



The Business Council for Sustainable Energy (BCSE) is a coalition of companies and trade associations from the energy efficiency, natural gas and renewable energy sectors. It includes independent electric power producers, investor-owned utilities, public power, manufacturers, commercial end users and service providers in energy and environmental markets. Founded in 1992, the coalition's diverse business membership is united around the continued revitalization of the economy and the creation of a secure and reliable energy future in America. The *Sustainable Energy in America Factbook* is commissioned by the BCSE and supported by the generous contributions of the following sponsors: American Clean Power Association, American Gas Association, Capital Power, CRES Forum, Clean Energy Buyers Association, Copper Development Association, Covanta, ITC Holdings, Johnson Controls, JPMorgan Chase, National Grid, National Hydropower Association, Polyisocyanurate Insulation Manufacturers Association, Sacramento Municipal Utility District, Schneider Electric, Sempra, Solar Energy Industries Association, Trane Technologies and Washington Gas.

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# Executive summary (1 of 8)

The massive uncertainty and upheaval that plagued the U.S. in 2020 began to ease in 2021, offering the country's energy sector a chance to take stock of a new reality buffeted by a lingering pandemic, global supply chain bottlenecks and rising inflation, but powered by a strong economic recovery. Despite considerable uncertainty, the clean energy and energy efficiency transition continued, with a record-breaking year for deployment of renewable power, battery storage and sustainable transportation, an unprecedented injection of new capital into companies, technologies and projects, and a wave of supportive new policies.

Here are some of the key findings from this year's Sustainable Energy in America Factbook:

- **U.S. primary energy consumption grew 4.4 percent in 2021 as the economy recovered from COVID-19 business conditions**, but consumption was 3.19% below 2019 (pre-pandemic) levels.
- **Energy productivity improved by 1.3%**. The ratio of GDP growth vs. energy consumption grew again in 2021 suggesting that the long-term trend of the U.S. using energy more efficiently continued – despite two incredibly anomalous years.
- **A record-breaking \$105 billion in new capital went into new U.S. clean energy assets**, an 11% year-on-year jump; the figure has grown 70% in the last five years.
- **Developers built a record 37 gigawatts (GW) of wind and solar power-generating capacity**. Solar enjoyed its best year ever with 24.2GW added while wind had its third-best year at 13GW.
- **Corporate demand for clean energy endured, with a total of 351 companies pledged to procure 100% clean energy**. Companies signed 17GW in clean energy procurement contracts in 2021.
- **U.S. consumers allocated less than 5% of their proportional household spending to energy products**, despite high gasoline prices, supply chain challenges and overall inflation.
- **Renewables made another record contribution to the power grid with production rising 4.1% year-on-year**. Renewable sources accounted for just over one fifth of U.S. power generation in 2021.
- **Demand for U.S.-produced natural gas grew 9.4%**, with liquid natural gas (LNG) exports jumping 64% and industrial, residential and commercial heating demand rising 0.4%, 4.7% and 1.9%, respectively.
- **Power from all zero-carbon sources electricity (renewables plus nuclear power) met 40% of demand**, despite lower hydropower output due to extreme droughts in the Western U.S.

# Executive summary (2 of 8)

- **Natural gas remained the largest source of U.S. power generation at 38%, however the fuel contributed 3.1% less than in 2020,** due primarily to higher gas prices.
- **Coal-fired power's contribution rose year-on-year for the first time since 2014 to provide 22% of generation.** Overall, however, coal's contribution is down nearly 40% from a decade ago due to weak demand, competition from lower-carbon power sources and coal plant retirements.
- **Over 8GW of new hydrogen-fired power-generating capacity projects were announced in 2021 in the U.S.,** positioning the country to potentially lead in developing the fuel for new applications.
- **Nearly 4.2GW of battery storage capacity was added to the U.S. grid in 2021.** Today, 81% of storage is provided by pumped hydropower projects, but batteries account for 89% of build over the last decade.
- **2021 was a breakthrough year for U.S. offshore wind with 8.5GW of new capacity awarded,** stemming from contracts in New York, New Jersey, Massachusetts and Maryland.
- **U.S. electric vehicle (EV) sales hit 657,000 units in 2021,** a doubling from the 325,000 cars sold in 2020.
- **Renewable natural gas (RNG) production capacity grew 12% year-on-year, with \$3 billion earmarked for investment in 2021.** RNG is predominantly used in transportation today, but has potential use in industrial applications and buildings.
- **Total U.S. CO2 emissions rose 5.8% year-on-year.** In the power sector, coal-fired generation rebounded. Transportation sector emissions also jumped as drivers returned to the roads. Economy-wide emissions finished 2021 15% below 2005 levels. Power sector emissions were down 35% vs. 2005.
- **Climate disasters caused \$145 billion in damage,** making 2021 the third most costly year on record after 2005 and 2017.
- **The Biden administration adopted a 2050 economy-wide net zero emissions goal for the U.S. as Congress approved \$80 billion for energy transition investment.** Congress ended 2021 with over \$300 billion in climate and clean energy policies pending in a tightly divided House and Senate.

These trends are discussed at a high level below then in far greater depth graphically in the Factbook itself.

# Executive summary (3 of 8)

## **Investors, large corporates, and consumers poured record-breaking investment into the U.S. energy transition**

Investors became even more bullish about the energy transition in 2021. BloombergNEF tracked a record volume of energy transition capital deployed into virtually every asset class in 2021 -- \$755 billion in all globally.

This included record investment for technology start-ups through venture capital financings (\$53.7bn), for growth companies through offerings on public stock exchanges (\$111bn), and for clean power and storage projects through private loans and tax equity investments (\$366bn). In addition, BNEF tracked \$1.6 trillion in total sustainable finance for a wide range of assets through “green”, “sustainability-linked” and other bonds (\$894bn).

In the U.S. specifically, BNEF counted \$105 billion invested in energy transition assets, predominantly in renewable energy and electric transport. Given that capital invested today has the potential to make impact tomorrow, the private funds raised in 2021 foreshadow new build and progress on key technologies for years to come.

Large energy consumers, namely large corporations, continue to drive the U.S. energy transition by demanding more clean energy. A total of 351 companies have now pledged to procure 100% clean energy, with 65 new companies joining the list in 2021, including nine headquartered in the U.S. This is combined with 127 companies having pledged to increase their energy productivity and 121 companies having pledged to reduce the carbon emissions of their fleets.

## **U.S. CO2 emissions rose, but not to pre-pandemic levels**

With the U.S. economy recovering from the Covid-19 pandemic, there were concerns that CO2 emissions might rebound to pre-pandemic levels. And rebound they did: economy-wide emissions hit 6,263 MtCO2 in 2021, up 5.8% from 2020 but still 4.4% below 2019 levels. Economy-wide emissions are down 15% from 2005 levels.

Power sector emissions also rose. Natural gas generation remained the largest source of power, providing 38% of electricity in 2021. This was a slight decline from the previous year due to higher natural gas prices, making other generating sources more competitive, including coal.

Renewable generation (biomass, geothermal, hydropower, waste to energy, solar, wind) represented 21% of the U.S total in 2021, about the same as in 2020, despite higher gross output. Wind and solar’s growth in output was largely offset by increased coal-fired generation, which rose by 21%.

Nuclear contributed 19% of generation, roughly the same as 2020 and hydropower output dropped 11% due to droughts in the West. Overall, power sector emissions remain 35% below 2005 levels due to a far cleaner and more diverse energy mix. Transportation-related emissions also rose as more Americans hit the roads compared to 2020 and air travel picked up. But transport emissions in 2021 did not return to 2019 levels.

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## **Despite uncertain economic condition, U.S. energy productivity continued to improve**

Over the last three decades, the U.S. economy has consistently improved on how efficiently it uses energy, due primarily to private sector investment and key policies. Given the unprecedented events of the past two years, it was far from clear whether this long-term trend would continue. Remarkably, U.S. energy productivity improved in 2020, when the economy dramatically contracted, and in 2021 when it dramatically expanded. This suggests a trend that is largely immune to short-term swings in economic activity.

## **Energy prices rose sharply, oil and gas production increased more modestly – but energy costs remain relatively low for U.S. consumers**

For energy consumers, 2021 was a year of sharp energy price hikes that contributed to higher overall inflation. Average gasoline prices for 2021 were up 75% vs. 2020, and reached their highest levels since 2014. The price trend for U.S. crude oil was almost identical. The average wholesale price for natural gas across 2021 was 84% higher than in 2020.

Price booms have historically created boons for U.S. oil and gas producers and spurred them to sharply ramp demand. Due to extraordinary circumstances and some fatigue on the part of investors with the sector, however, this did not occur.

Despite the strong economic growth, consumers similarly confronted higher prices for many goods, but particularly energy-related products and most specifically, gasoline. Nevertheless, U.S. households devoted less than 5% of monthly spending to energy goods and services. And Americans felt the energy price squeeze much less acutely than others elsewhere in the world.

## **The impacts and costs of climate change continued to become more evident across the U.S.**

The impacts of climate change continued to proliferate in 2021 across the country. The U.S. experienced 20 separate climate disasters causing at least \$1 billion in damage apiece in 2021, according to the National Oceanic and Atmospheric Administration. The 2021 events, made up of tropical cyclones, severe storms, droughts and wildfires, are estimated to have cost \$145 billion, making 2021 the third most costly year on record after 2005 and 2017.

# Executive summary (5 of 8)



## **Federal policy embraced net zero targets and historic technology investments**

On the policy front, 2021 marked the first year of the Biden administration, which sought quickly to make up for time lost in addressing climate change. The U.S. re-entered the Paris agreement and sought to reassert leadership on the global stage with an extensive presence at the COP26 negotiations in Glasgow in November. The White House set a new target for cutting U.S. CO2 emissions economy-wide 50% by 2030 (vs. a 2005 baseline) and for eliminating them entirely from the power sector by 2035. The administration released new, more aggressive efficiency standards for U.S. cars and light trucks, outlined plans to make the federal government the world's most important clean energy buyer and established targets to kickstart demand for high-performance buildings.

The administration had mixed success pushing its energy transition agenda through a deeply divided Congress. The Infrastructure Investment and Jobs Act was signed into law and allocates an unprecedented \$80 billion for new energy technologies, including those that could prove critical to achieving “deep decarbonization” in the 2030’s and beyond. Meanwhile, the clean energy and energy tax package that was part of the Build Back Better bill, which would support today’s suite of economically-viable clean energy technologies, passed the House of Representatives but stalled in the Senate.

## **Unprecedented financial support for next-generation technologies**

Capital invested today has the potential to make tangible impact tomorrow. In 2021, the U.S. made critical research and development commitments to technologies that could hold the key to “deep decarbonization” in the 2030s and beyond. This included \$80bn in new funding specifically for hydrogen, advanced nuclear and carbon capture and utilization and storage (CCUS) allocated under an infrastructure law passed with bipartisan support. The Biden administration also looked to take advantage of the authority it inherited with renewed efforts to issue loan guarantees through the Department of Energy’s Loan Program Office. Meanwhile, companies around the world developing technologies and demonstration projects that might someday help the U.S. achieve its net-zero CO2 ambitions attracted \$165bn through private investment and IPOs.

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## **Renewable energy made record contributions to power generated and consumed**

The U.S. installed a record volume of renewable power-generating capacity with 37.3GW installed, just over the 35.5GW installed in 2020. Solar led the way with 24.2GW. Wind followed with 13GW. The solar industry beat its own record for installations set in 2020 by a whopping 30%. Wind had its third-best year ever with total build, down from a record 16.6GW in 2020. Wind developers worked to complete projects before the start of a production tax credit (PTC) phase down planned for 2022. The primary difference in the performances of the two sectors was that solar has recently been able to expand into new markets more rapidly throughout the U.S. Solar additions outside California and the Southeast states more than doubled in 2021. By comparison, wind additions outside of MISO and Texas markets declined.

Renewables generated 21% of U.S. power, with wind, hydropower and solar being the largest contributors. Wind and solar each made record contributions to power generated and consumed in 2021, providing a combined 66 terrawatt-hours (TWh) of new generation. The two technologies accounted for record 13% of total U.S. power generated.

Achieving the Biden administration's climate goals will require U.S. renewable capacity additions to double from recent levels. Policies to expand and modernize transmission infrastructure as well as a broad range of federal tax incentives to accelerate deployment of renewable generation are pending enactment. These are some of the policies that will be required to make progress towards meeting this goal.

## **Natural gas demand grew, along with demand for decarbonization**

Total demand for U.S. natural gas jumped 9.4% in 2021, a rebound from the minimal growth seen in 2020 due to the Covid-19 pandemic. Industrial, residential and commercial heating demand increased 0.4%, 4.7% and 1.9%, respectively, driven by weather and the economy. The increase in residential gas customers was the largest since 2006, with 900,000 more customer hook-ups in 2020. The average residential customer efficiency continues to improve, offsetting sectoral demand growth that would result from new customers.

While overall load grew, gas demand for power generation fuel dropped by 1.0 Bcfd (-3.3%) as high year-on-year gas prices led to more coal-fired power plants being online, which contributed to increased power sector emissions in 2021. LNG exports rose very significantly (64%) in 2021, driven mainly by a demand surge in Europe and Asia. In Europe, LNG has backfilled depleted domestic production while in Asia gas has met high demand from economic growth and replaced coal generation.

As the economy seeks to decarbonize, demand for decarbonized natural gas is rising. With the passage the new infrastructure law, the U.S. is poised to provide \$20.5 billion in federal funding for CCS and hydrogen efforts. Demand for RNG rose in 2021, with 33 states taking action to promote the use of the fuel for thermal heating purposes in the residential or commercial sectors, up from 26 in 2020.

# Executive summary (7 of 8)

## **State action on energy efficiency slowed due to Covid, but savings measures continued to deliver**

Energy Efficiency resource standards (EERS) are state-level policies that require utilities to invest in measures that improve end-user efficiency to meet energy-savings goals set by the government. In 2021, 26 states and the District of Columbia had EERS policies – down two states from the prior year as the New Hampshire and Arizona public utility commissions voted to end their efficiency standards.

In 2020 (the last year with complete spending data), the global pandemic significantly depressed total financing for energy efficiency programs. Total utility spending on energy efficiency dropped 9.3% drop from 2019 levels levels.

Despite 2020's challenges, the total annual impact of efficiency programs continued to grow, since most efficiency measures impact savings for years after their installation. The total impact of ratepayer-funded energy efficiency programs was a savings of about 286 million MWh in 2020 – equivalent to approximately 7.69% of 2020 electricity consumption.

In 2021, Hawaii and Virginia adopted updated building energy codes that stand to cut energy use and carbon emissions in future years. Colorado signed HB 1286 to become the second state, after Washington, to adopt a building energy performance standard for large buildings, a critical step forward for addressing energy waste in existing construction. Washington's program goes into effect in 2026, though an early-adopter incentive program started in 2021.

## **Energy storage demand and battery capacity additions surged**

Pumped hydropower storage projects account for around 81% of installed energy storage capacity in the U.S. While pumped hydro will remain the bulk of energy storage capacity in the U.S., other technologies, such as lithium-ion batteries and thermal storage are being built. Close to 4.2GW of battery capacity was added to the U.S. grid in 2021, more than in all preceding years combined. The underlying driver is the growing need for batteries in energy-shifting applications, a need created by the rising penetration of renewables, particularly solar, in certain markets, particularly California. Additionally, regulatory changes in the wake of Federal Energy Regulatory Commission (FERC) Order 841 (2018) – which required regional power markets to revise their rules to allow storage to fully participate in energy markets – have removed barriers that would have otherwise stemmed the tide of batteries to the grid. State targets have also played a role in encouraging uptake.

While 2021 marked the start of an exciting transition as batteries moved into the mainstream in certain markets, it also put the technology under pressure to deliver. Higher penetration rates raise expectations that batteries can make meaningful system-level impacts on the grid and power markets, especially in resolving some of the challenges associated with renewable integration.

# Executive summary (8 of 8)

## **A giant step forward for the U.S. offshore wind**

In September, Vineyard Wind secured \$2.3 billion in financing for its 806MW project planned for the waters south of Massachusetts, making it the first commercial-scale U.S. offshore wind project to reach financial close. Total U.S. offshore wind capacity stands at 42MW, but there is now a pipeline of 17.6GW of projects in very active development. Most are set to be commissioned post-2025. Vineyard Wind, on track to commission in 2024, demonstrates a large-scale project can navigate the complexities of permitting and financing in the U.S. It offers hope to projects further back in the pipeline while allowing the industry to focus on scaling local supply chains and achieving the economies of scale that have driven cost reductions in Europe.

## **U.S. EV sales accelerated but not as fast as elsewhere**

Americans bought 657,000 electric vehicles in 2021, doubling the 325,000 sold the year prior. Lower battery costs, growing consumer acceptance and the roll-out of exciting new models all contributed. Tesla continued to account for by far the largest share of EV sales in 2021 with half. While the overall market expanded 34%, the market for electric cars *not made* by Tesla grew 83%. The ball is now very much in the court of other automakers to match Tesla's success. While signs are encouraging, much remains to be done.

Brisk EV sales in 2021 mask two sobering realities. First, for the U.S. to meet its 2030 nationally determined contribution on emissions EVs must be at least 30% of vehicles *on the road* by that time. For context, EVs were just 4.4% of total U.S. passenger vehicle *sales* in 2021. Second, even with this progress the U.S. EV market is a third the size of the European Union's and one fifth of that in China. The U.S. market is growing, but not nearly fast enough to satisfy either the country's climate ambitions, or to establish the U.S. as an industrial leader in the field.

## **The U.S. affirmed its major hydrogen production ambitions**

The U.S. is a global leader with over 8GW of planned hydrogen-fired power-generating capacity. State-level clean energy targets are clear drivers with nine of 10 planned projects due to provide electricity in states with clean energy mandates. Two-thirds of these projects have hydrogen-natural gas blend targets. Half expect to run on 100% H2 by 2045.



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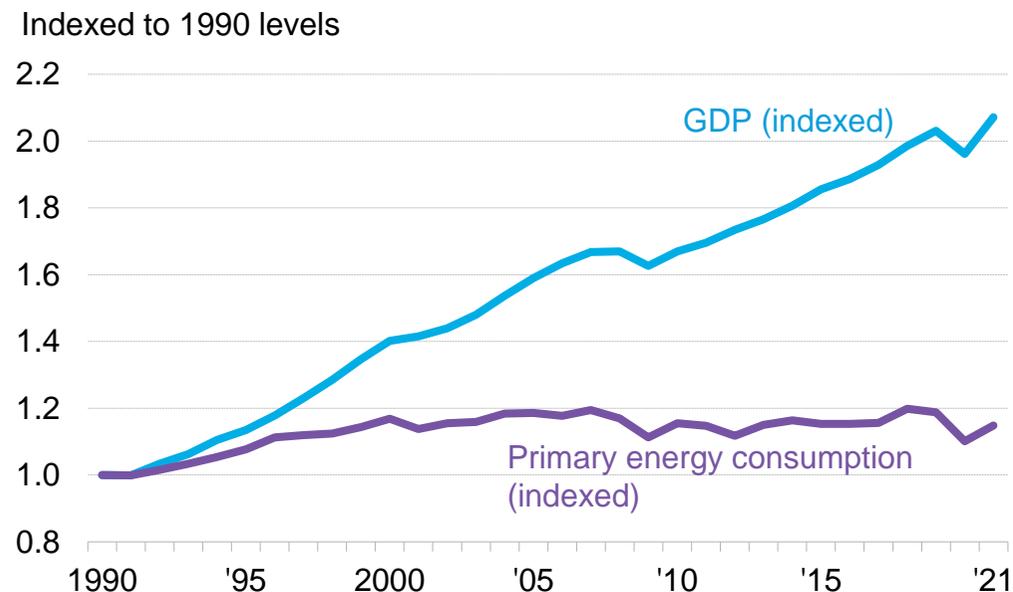
7.1 Gasoline

7.2 Fuel Prices and EV Sales

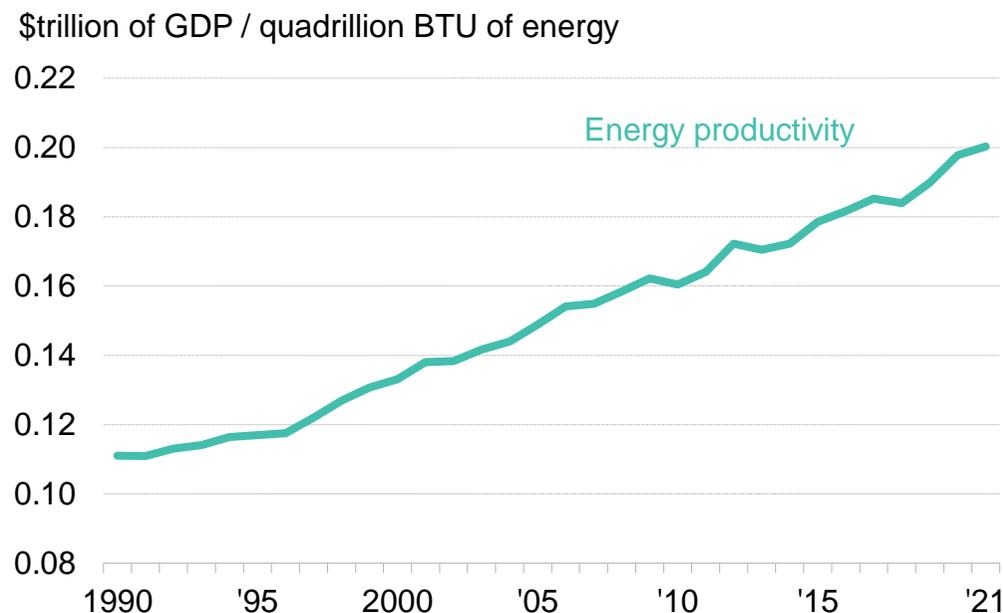
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# U.S. energy overview: Productivity

## U.S. GDP and primary energy consumption



## U.S. energy productivity

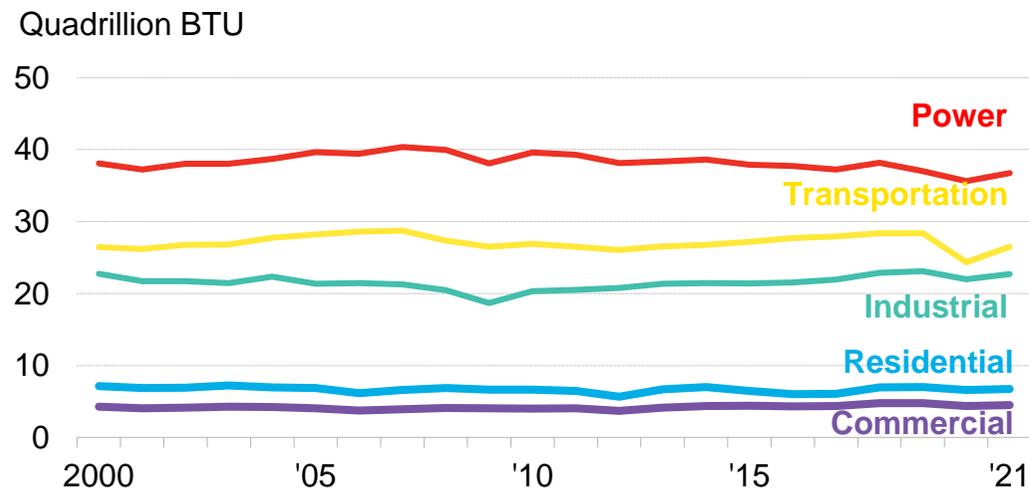


- Leaving the heavy lockdowns of 2020 behind, the U.S. in 2021 posted the largest year-on-year GDP growth since 1983-84. The economy grew 5.6% in 2021 while primary energy consumption rose by 4.4%. Taken together, U.S. "energy productivity" climbed 1.3%. This represented the continuation of a multi-decadal trend of rising economic output accompanied by level energy consumption.
- U.S. economic growth has effectively "decoupled" from energy use, as reflected in improvements to energy productivity driven by efficiency improvements. From 2012-2021, U.S. GDP grew 19.4% while primary energy consumption minimally changed by 2.9%. The result: a 16.1% increase in productivity.
- From 1990-2021, the U.S. economy more than doubled in size, while annual primary energy consumption rose just 15%. This suggests an 80% improvement in U.S. energy productivity over three decades.

Source: Bureau of Economic Analysis, EIA, BloombergNEF Notes: Values for 2021 are projected, accounting for seasonality, based on latest monthly values from EIA (data available through September 2021). 2021 GDP estimate is a projection from economists compiled at ECFC <GO> on the Bloomberg Terminal.

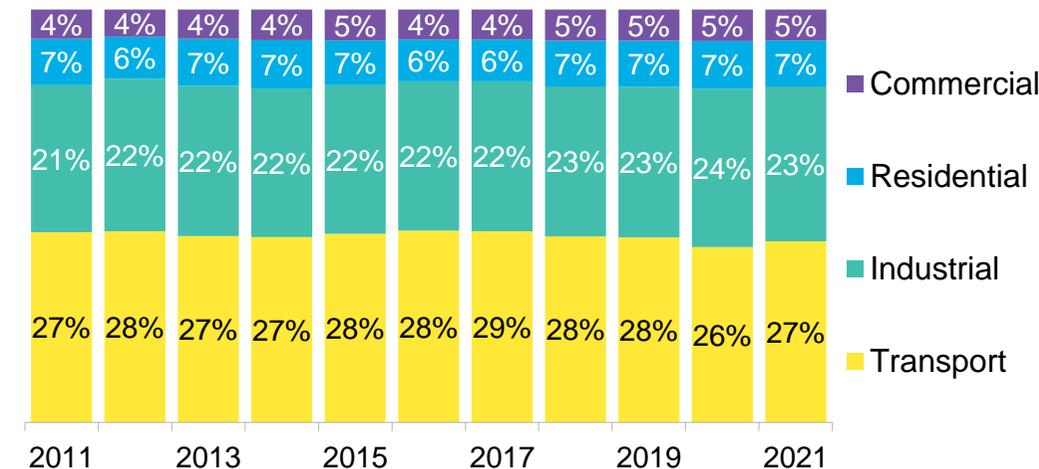
# U.S. energy overview: Primary energy consumption by sector

## U.S. primary energy consumption



Note: Electricity is excluded from Industrial, Residential, Commercial and Transportation sectors and aggregated in "Power"

## U.S. final energy consumption



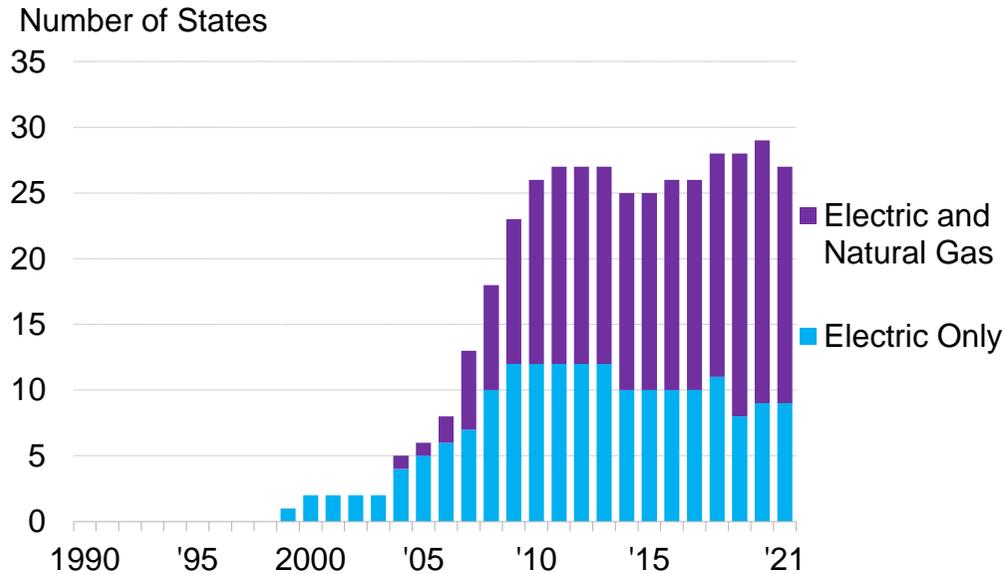
Note: Sector end uses include electricity use

- All sectors used more energy in 2021 as the economy began to recover from the Covid-19 pandemic. Total U.S. primary energy consumption ticked up 4.4% in 2021 but remained 3.13% below 2019 (pre-pandemic) levels.
- Primary energy end-use consumption includes electric power as the industrial, commercial, and residential sector purchase electricity for their sector's activity. Electric power used in these sectors are in total 37 quadrillion BTU, about 38% of the country's primary energy consumption. Meanwhile, transportation is still dominated by fuels (petroleum, natural gas, biofuels) and relies significantly less on electric power.
- States relented on mandated stay-at-home restrictions in 2021, leading to a rebound in professional and personal commuting. As a result, transport energy use grew most at 8.8%, followed by 3.4% growth in commercial, 3.2% in power, 3.1% in industrial and 2.4% in residential. Demand from road transport (gasoline) normalized by the middle of 2021. On the other hand, jet fuel demand still lagged pre-pandemic levels though air travel did rise in 2021 as restrictions loosened.

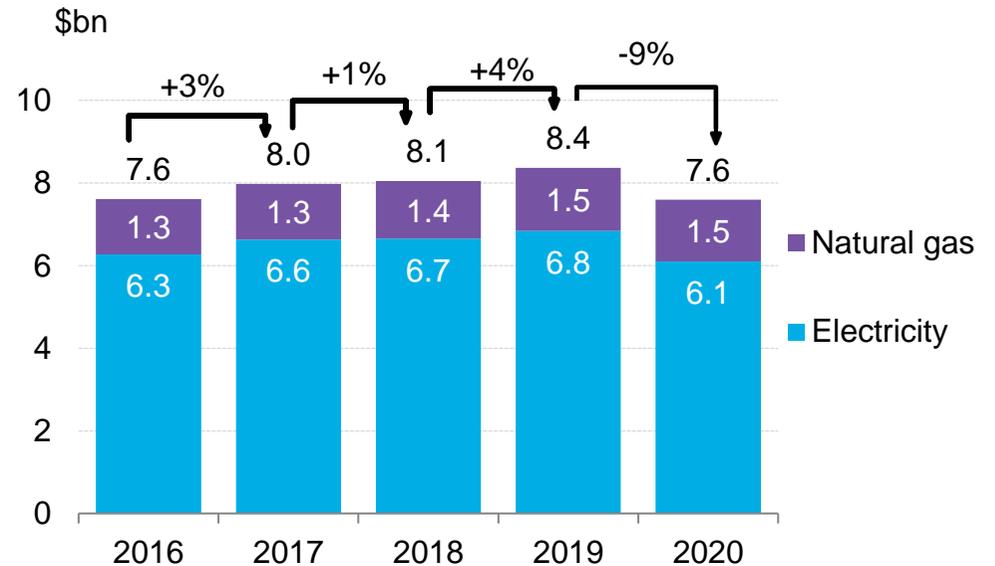
Source: EIA, EPA, BloombergNEF Notes: Values for 2021 are projected, accounting for seasonality, based on latest monthly values from EIA (data available through September 2021)

# U.S. energy overview: Energy Efficiency

## U.S. states with Energy Efficiency Resource Standards (EERS)



## Utility energy efficiency spending

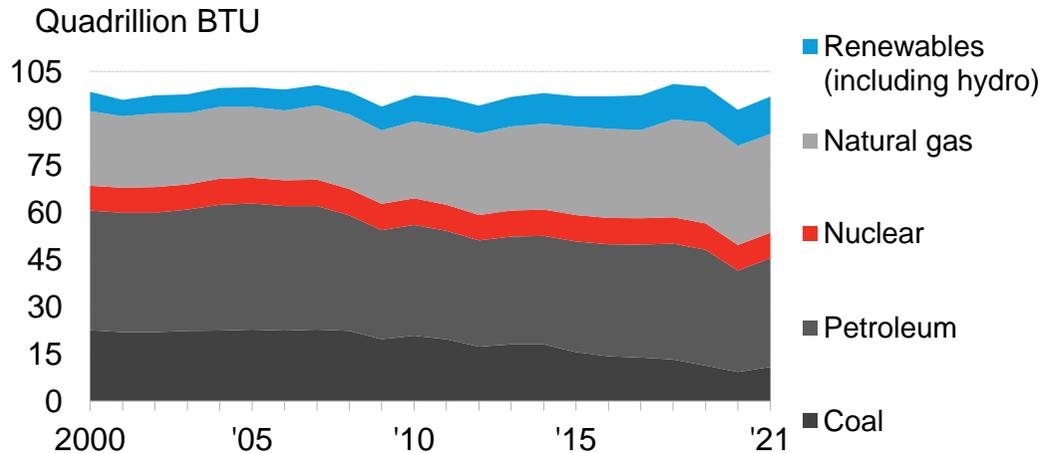


- Energy Efficiency resource standards (EERS) are state-level policies that require utilities to invest in measures that improve end-user efficiency to meet energy-savings goals set by the government. In 2021, 26 states and the District of Columbia had EERS policies.
- In 2020 (the last year with complete spending data), the global pandemic significantly depressed total financing for energy efficiency programs. Total utility spending on energy efficiency dropped 9.3% drop from 2019 levels, with natural gas utility efficiency spending remaining steady at \$1.5 billion.
- Despite 2020's adversity, the total annual impact of efficiency programs continues to grow, since most efficiency measures impact savings for years after their installation. The total impact of ratepayer-funded energy efficiency programs was a savings of about 286 million MWh in 2020 – equivalent to approximately 7.69% of 2020 electricity consumption.

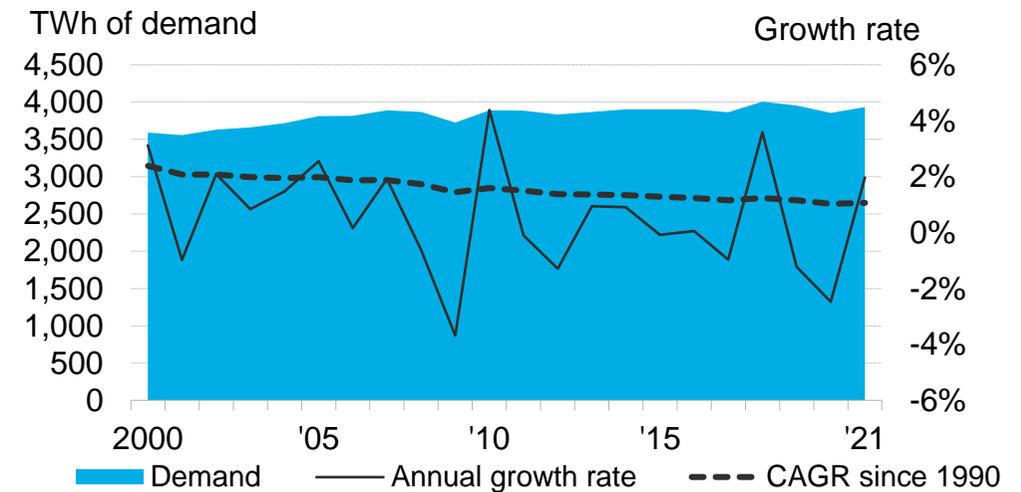
Source: American Council for an Energy Efficient Economy (ACEEE) State Energy Efficiency Scorecard: 2021 Progress Report

# U.S. energy overview: Energy and electricity consumption

## U.S. primary energy consumption, by fuel type



## U.S. electricity demand

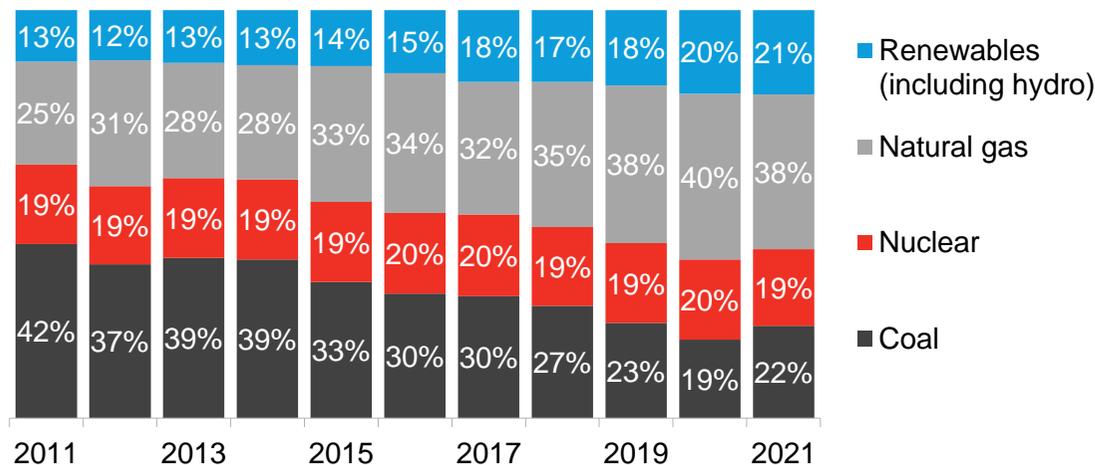


- U.S. total energy consumption grew 4.3% to 97 quadrillion British Thermal Units (BTU) in 2021 from the year prior. Coal consumption increased by 18.8% to 10.9 quadrillion BTU in the wake of high gas prices but is still half of its 22.8 quadrillion BTU peak in 2005.
- Contributions from non-hydro renewables (wind and solar, primarily but also biomass, waste-to-energy and geothermal) rose 8.6% in the wake of strong capacity additions in 2021. Natural gas consumption minimally fell by 0.4% as natural gas-fired power generation dropped by 3.9% due to high natural gas prices. Nuclear's contribution declined by 1.1% in 2021. Hydro declined by 12.3% in 2021.
- Petroleum use grew by 7.5% year-over-year. Oil is rarely used in U.S. power generation but accounts for the vast majority of transportation fuel, the sector that saw the largest rebound in consumption following Covid-19 in 2020.
- Total retail electricity demand rebounded, increasing 2% year-on-year. Electricity demand had risen just 5% between 2010-2019 (excluding contributions from distributed, small-scale facilities).

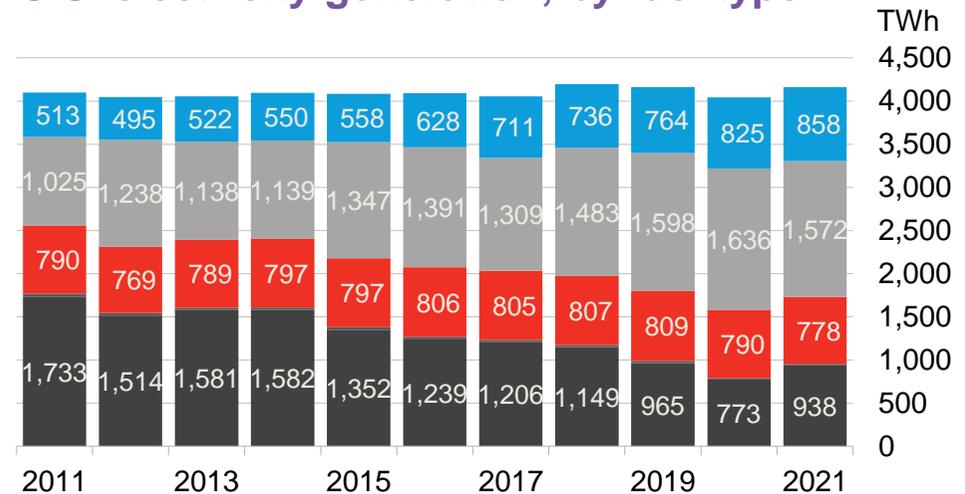
Source: EIA, BloombergNEF Notes: "CAGR" on the right hand side graph is compound annual growth rate. Values for 2021 are projected, accounting for seasonality, based on the latest monthly values from EIA (data available through September 2021). BTU stands for British thermal units.

# U.S. energy overview: Electricity generation mix

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



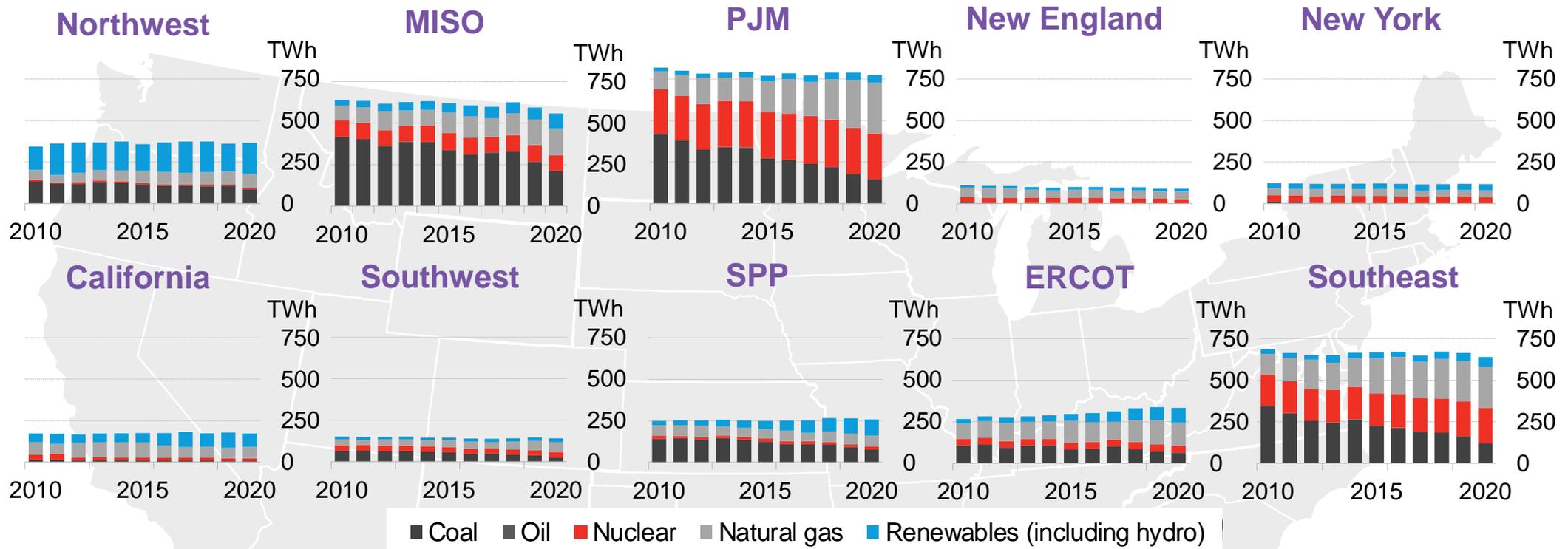
## U.S. electricity generation, by fuel type



- Total U.S. power generation rose 3.1% 2020-2021 largely due to a rebound in the economy and extreme weather throughout the west.
- Natural gas remains the largest source of U.S. power though its contribution fell year-on-year for the first time in a decade. Gas made up 38% of generation, or 1,572TWh, in 2021. That's a 3.9% decline in its contribution from 2020 despite overall electricity demand growth.
- Renewable power generation's contribution grew 4.1% year-on-year in 2021. The share from wind and solar rose to an impressive 13%. Hydropower's contribution slipped 11% due to exceptional drought conditions in California and the Northwest. In absolute terms, renewables generation rose 33TWh to land at 858TWh, or 21% of total power supply.
- Renewables and natural gas grew from a combined 38% to 59% of total power generation over the past decade.
- Coal-fired generation posted its first year-on-year rise since 2014 to 22% of the 2021 total. This was the result of significantly higher natural gas prices (coal prices also saw a rise in the second half of the year but to a lesser extent). This uptick in coal generation is likely to be short-lived, however. No new coal-fired plant has come online in the U.S. since 2013 and 30% of the U.S. coal plant fleet has retired since 2010.
- Nuclear power held its position supplying just under one fifth of U.S. power with only one plant closing in 2021 (Indian Point in New York). After years of actual and rumored plant closures, the outlook for nuclear has improved on the back of higher gas prices and government support.

Source: EIA, BloombergNEF Note: Values for 2021 are projected, accounting for seasonality, based on latest monthly values from EIA (data available through October 2021)

# U.S. energy overview: Electricity generation mix by U.S. power market

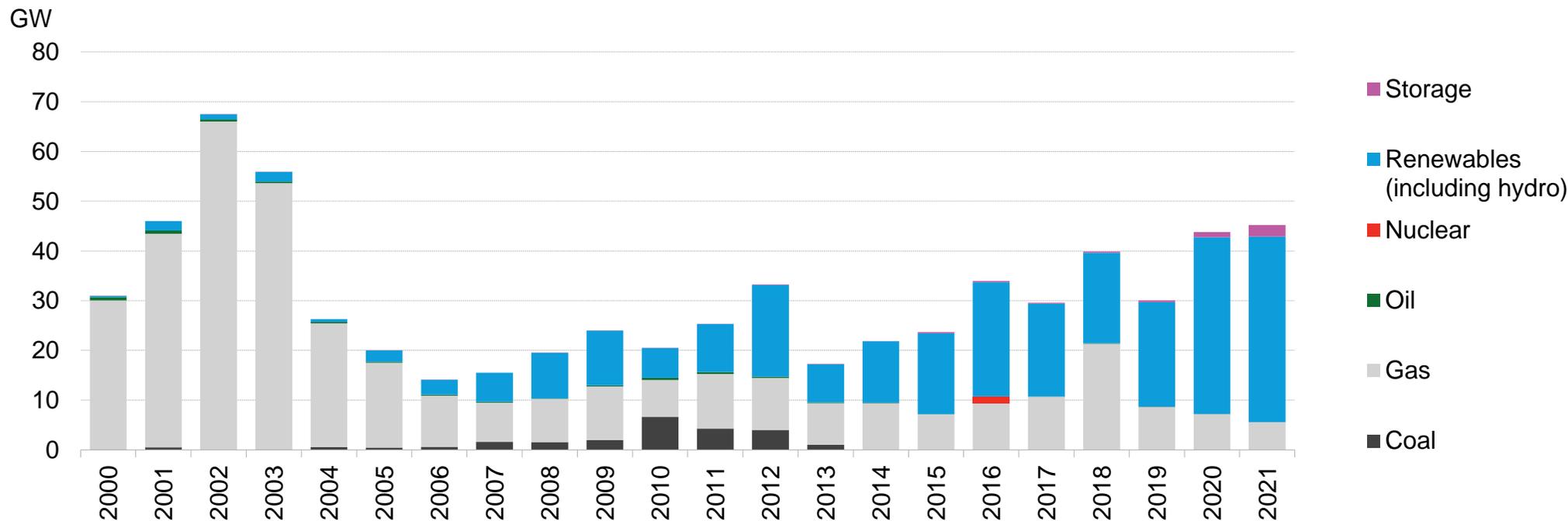


- The energy generation mix varies throughout the U.S. with different power-generating technologies contributing various amounts in different power markets. The top-line volume of generation also varies, with higher demand in some regions. Energy can also be sold between regions, incentivizing areas with lower prices to generate more. About two thirds of U.S. power sales are in competitive wholesale markets, with the largest markets being PJM, MISO, and Ercot.
- Major trends over the last 10 years have included the rise of natural gas-fired and the fall of coal-fired generation in the Southeast and PJM (which encompasses Midwestern and mid-Atlantic states) and the growth of renewables – particularly wind and solar – in ERCOT (Texas) and California. Load in most regions has been flat or falling but Ercot stands out with load growth between 1-2% each year until the Covid-19 pandemic stunted all regions in 2020. The Southeast and MISO saw the steepest declines in demand.
- In 2021 a rare winter storm hit Texas, producing power demand levels in Ercot normally only ever seen in the summer. Abnormal weather is expected to continue to shake up grid planning in many parts of the country like Texas and the west coast.

Source: EIA, BloombergNEF Notes: MISO is the Midwest region; PJM is the Mid-Atlantic region; SPP (Southwest Power Pool) covers the central southern U.S.; Ercot covers most of Texas.

# U.S. energy overview: Electric generating capacity build by fuel type

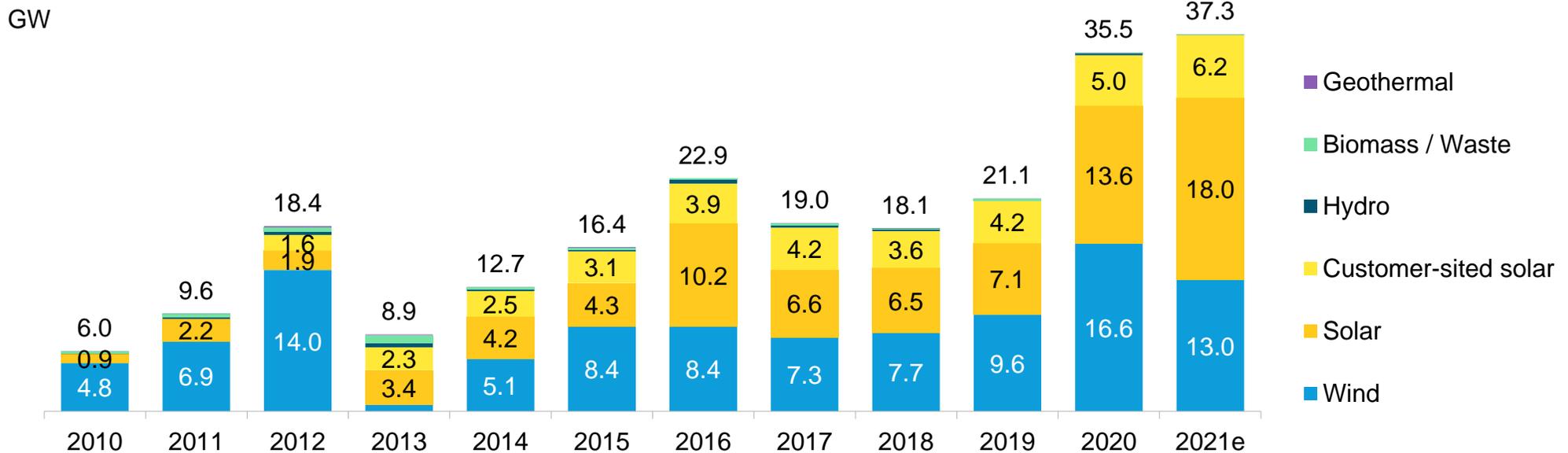
## U.S. electric generating capacity build, by fuel type



- Over 45GW of new generation capacity was commissioned, making 2021 the biggest overall build year in nearly two decades.
- Non-hydro renewable energy accounted for 82.5% of total additions, also the highest percentage of all time. These technologies (wind, solar, biomass, geothermal, waste to energy, others) broke records for the second year in a row, while accounting for 60% of total additions in the last decade. Demand for these generation sources has remained steady, despite supply chain uncertainty and rising prices that defined 2021.
- Natural gas-fired power new builds fell to 5.6GW of new capacity commissioned, a 22.5% drop from 2020. Most new build was in the Northeast and Florida.
- Natural gas and renewables have accounted for 95% of all build in the last decade.

Source: EIA, BloombergNEF Note: All values are shown in AC except solar, which is included as DC capacity. "All capacity figures represent summer generating capacity. Includes installations or planned installations reported to the EIA through October 2021, as well as BloombergNEF projections.

# U.S. energy overview: Renewable energy capacity build by technology



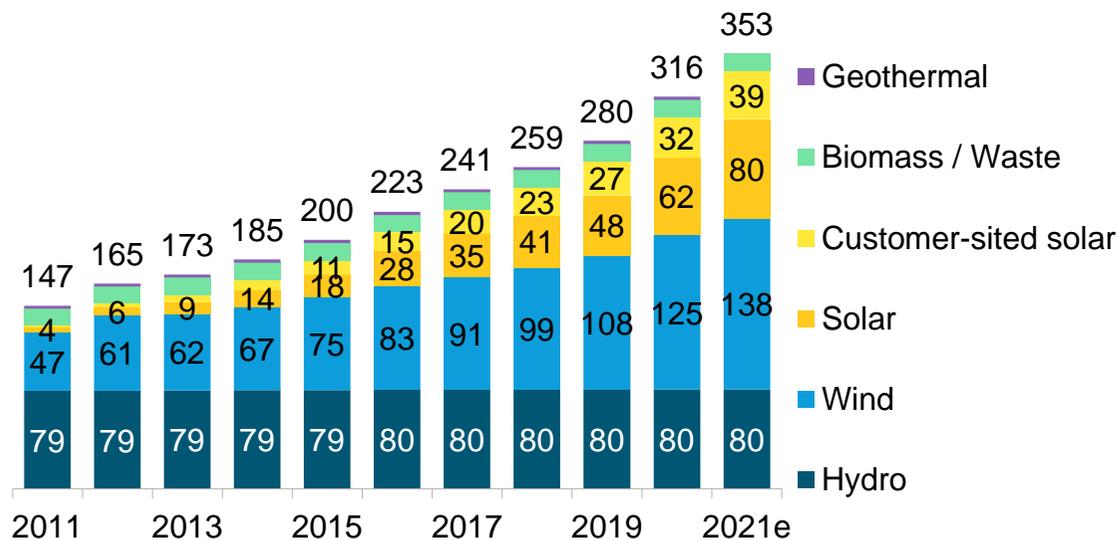
- Renewable energy capacity additions in the U.S. continued their steady upward march and set another new record in 2021, with 37GW completed. Wind and solar powered the growth as biomass, geothermal and new hydro capacity added totaled just under 80MW.
- Solar in 2021 posted another tremendous year with 24.2GW of new capacity added, up from 18.7GW in 2020. For a third straight year, solar accounted for the largest share of new capacity added to the U.S. grid.
- The events of 2020 influenced wind build in 2021. Some projects that had previously planned to be completed in 2020 were pushed into the following year due to Covid-19 related delays or tight supply chains. Thankfully for developers, the IRS showed leniency in allowing projects to receive tax credits even if they did not achieve commissioning until 2021. Ultimately, 2021 was the 3rd biggest year ever for wind build.
- 2021 was also defined by supply chain headaches. Global shipping channels were disrupted following worldwide lockdowns, with several parts unable to reach destinations because of shipping unavailability, port lockdowns, or labor shortages and delays. For projects aiming to come online in 2021, this meant working longer lead times into their operations, and in some cases, cancelling projects.
- Workers were also often in short supply in 2021, raising the cost of engineering, procurement and construction (EPC) contracts. Were it not for these disruptions, new renewable build could have been marginally higher in 2021.

Source: BloombergNEF, EIA Notes: All values are shown in AC except solar, which is included as DC capacity. Numbers include utility-scale (>1MW) projects of all types, rooftop solar, and small- and medium-sized wind. Includes installations or planned installations reported to the EIA through October 2021, as well as BloombergNEF projections.

# U.S. energy overview: Cumulative renewable energy

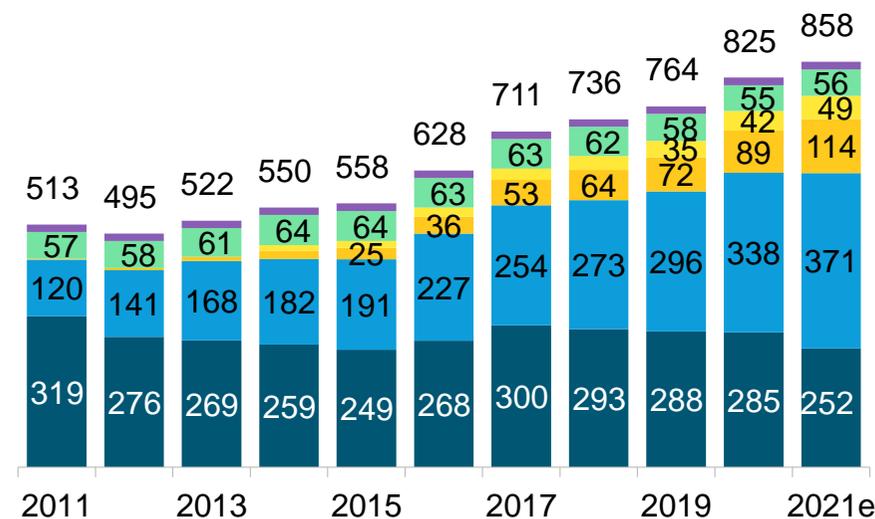
## U.S. cumulative renewable capacity

GW



## U.S. renewable generation by technology

TWh

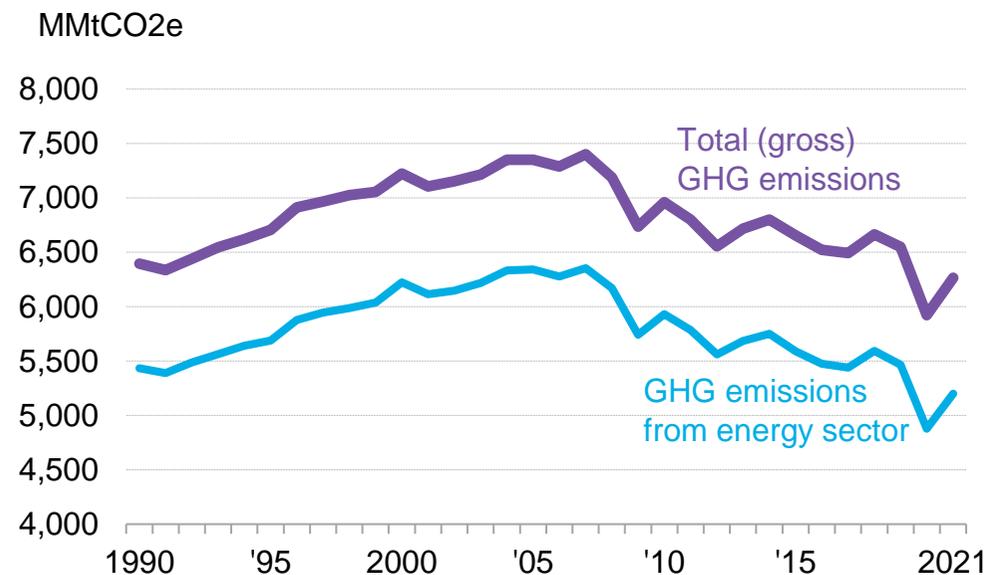


- Total renewable energy capacity, excluding pumped hydro facilities, stands at 353GW. Wind and solar have accounted for nearly all new additions, aided by policy support, rapidly falling equipment costs, and steadily increasing demand from the private sector. The installed wind and solar fleet at the end of 2021 was 17% larger than at the end of 2020
- U.S. wind capacity reached 138GW in 2021 and was the largest source of U.S. renewable power generation for the third year in a row, at nearly 370TWh. While annual capacity additions of solar have surpassed wind since 2020, the cumulative installed fleet in the country remains second to wind, at 119GW.
- As wind and solar additions remained steady, generation from all renewable sources in 2021 rose by 4% to 858TWh. Solar from all sources is estimated to have produced over 160TWh, making it the third-largest renewable source of generation, following wind and hydro.
- While hydro generation accounted for 29% of total renewable output, it experienced a slight dip from the previous year's 35% due to drought conditions in California and the Northwest. However, during critical evening peak times in California, hydropower's output rose to 10% of total generation.

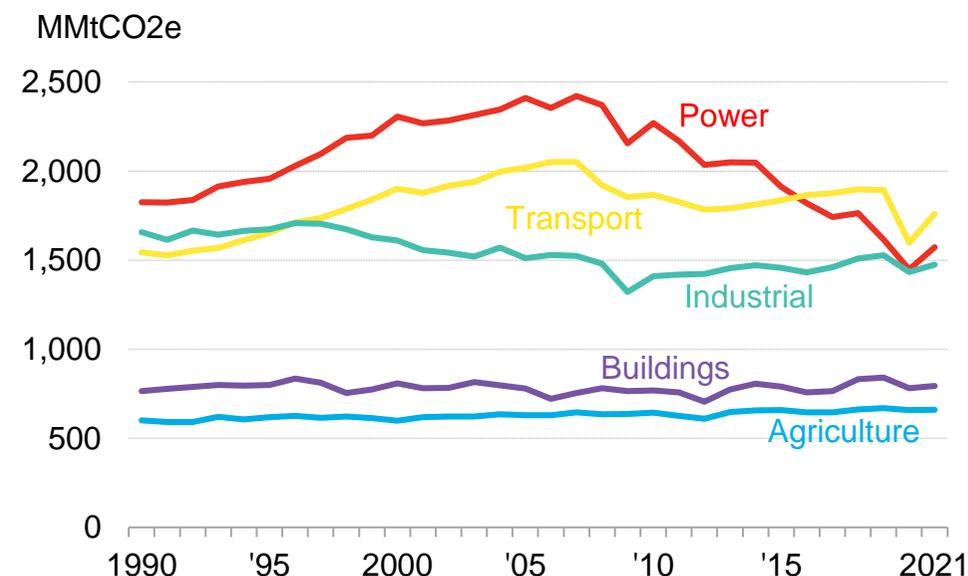
Source: BloombergNEF, EIA Notes: All values are shown in AC except solar, which is included as DC capacity. Hydropower capacity and generation exclude pumped storage facilities (unlike in past Factbooks). Totals may not sum due to rounding. Values for 2021 are projected, accounting for seasonality, based on latest monthly values from EIA (data available through October 2021)

# U.S. energy overview: Greenhouse gas (GHG) emissions

## Economy-wide and energy sector emissions



## Emissions by sector

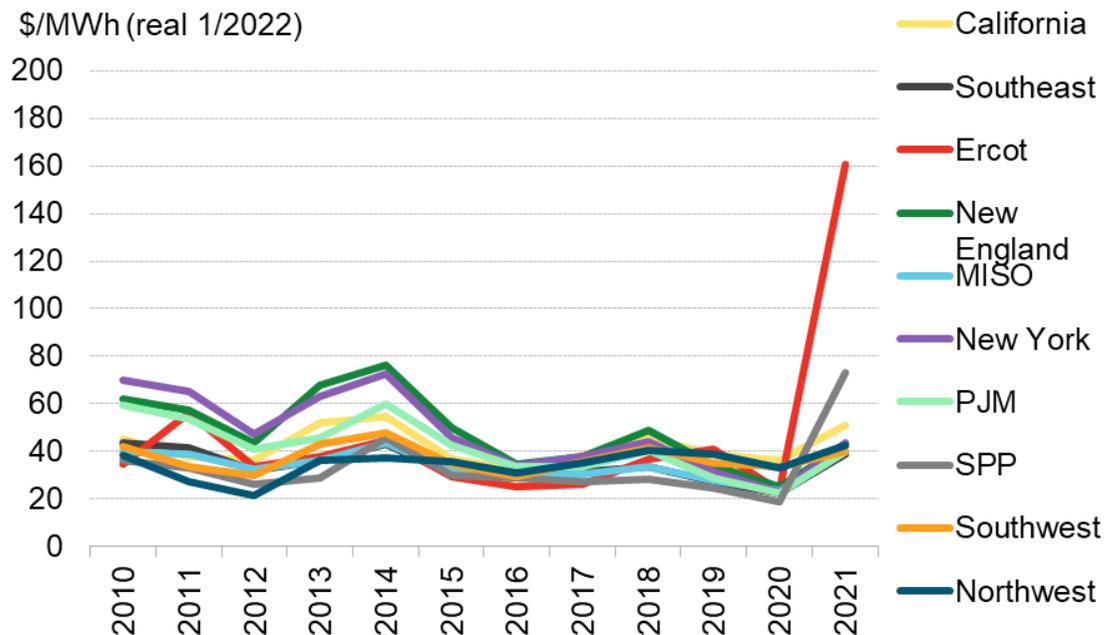


- After collapsing by 9.6% in 2020, U.S. GHG emissions rebounded 5.8% in 2021, but were still 4.4% below 2019 levels. The 2021 bounce-back was largely expected, as the economy recovered from Covid-related lockdowns, and was concentrated in two sectors: power and transport.
- Power sector emissions rose 8.6%, a significant reversal on the 10.4% drop in 2020. However, this was due in part to short-term impacts as high natural gas prices drove increased coal usage. 2021 power sector emissions were still 2.7% lower in 2021 than in 2019, and with renewables being added to the grid at record rates, power sector emissions should resume their downward trajectory.
- Transport-related emissions have proven most sensitive to the U.S. economy. Having fallen 14% in 2020, they rose a staggering 10% in 2021, as lockdowns ended and Americans took to the roads again. Aviation-related emissions rose sharply, up 27% on 2020 levels. However, this was from a low level as air travel was most acutely impacted by Covid-19 in 2020. Aviation emissions in 2021 were still 22% below 2019 levels.
- In the long term, U.S. emissions are declining: in 2021 they were 15% lower than in 2005. However, this is not evenly spread across the economy. Power sector emissions have fallen 35% during that period, but transport and industry only declined 13% and 3% respectively. Emissions from buildings were 2% higher in 2021 than they were in 2005.

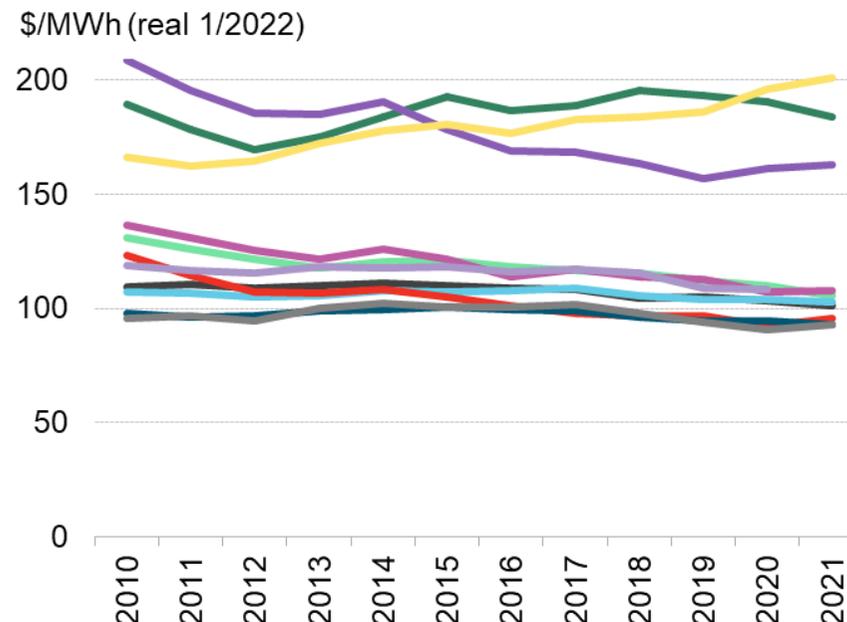
Source: BloombergNEF, EIA, EPA.

# U.S. energy overview: Retail and wholesale power prices

## Wholesale power prices



## Retail power prices

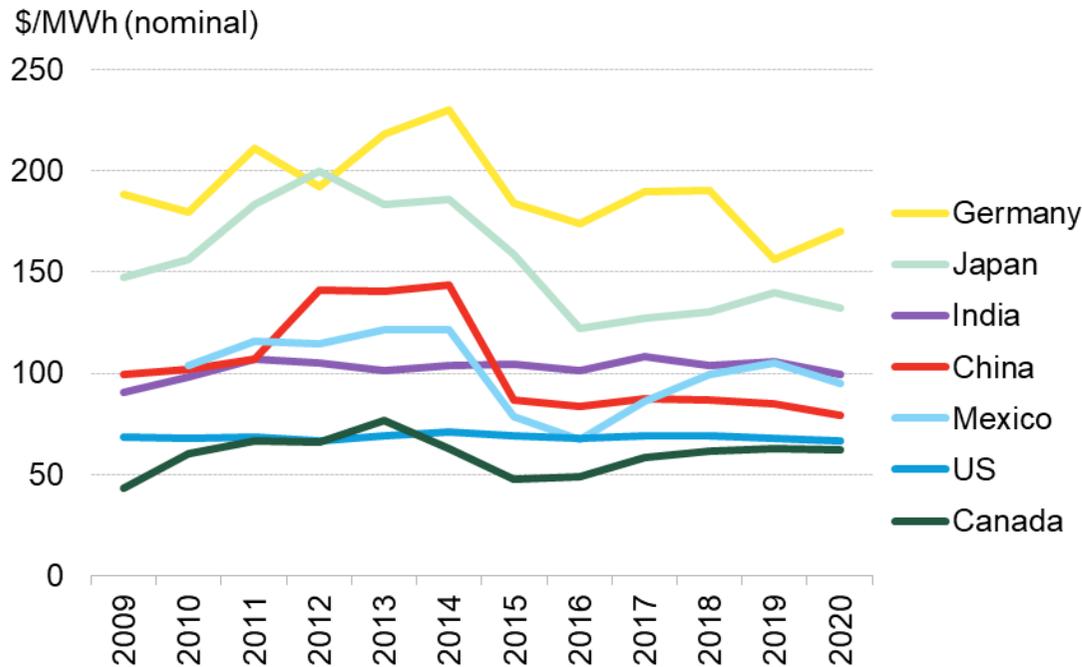


- Wholesale power prices in 2021 were unusually volatile across most of the country. In 2020 power prices reached record lows due to steep declines in demand and large supplies of natural gas. By summer 2021 a gas price rally caused power prices to surge upward from the 2020 lows. Year-over-year natural gas prices rose 84% and power prices nearly doubled at many benchmark hubs.
- In early 2021 a brutal winter storm froze over most of Texas and parts of the Midwest, damaging power and gas supplies, and launching power prices to \$9,000/MWh in the Ercot power market. The impact was felt by all power markets as gas production stalled for days in Texas.
- Retail prices rose slightly across most U.S. regions, but they did not increase nearly as much as wholesale power prices. The uptick in wholesale prices foreshadows a future increase in rates if utilities can get approval in the next general rate cases to follow the rising wholesale power and gas prices.

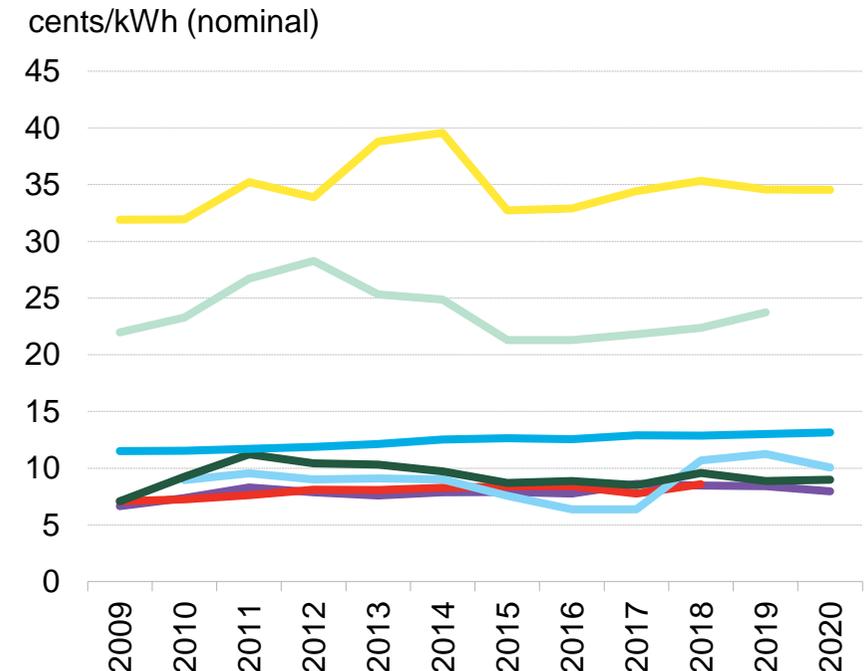
Source: BloombergNEF, EIA, Bloomberg Terminal Notes: Wholesale prices are taken from proxy power hubs in each ISO and are updated through end-2021. All prices are in real Jan 2022 USD. Retail power prices shown here are not exact retail rates but weighted averages across all rate classes by state, as published by EIA 861. Retail prices are updated through October 2021.

# U.S. energy overview: Average electricity rates by country

## Industrial power prices



## Residential power prices

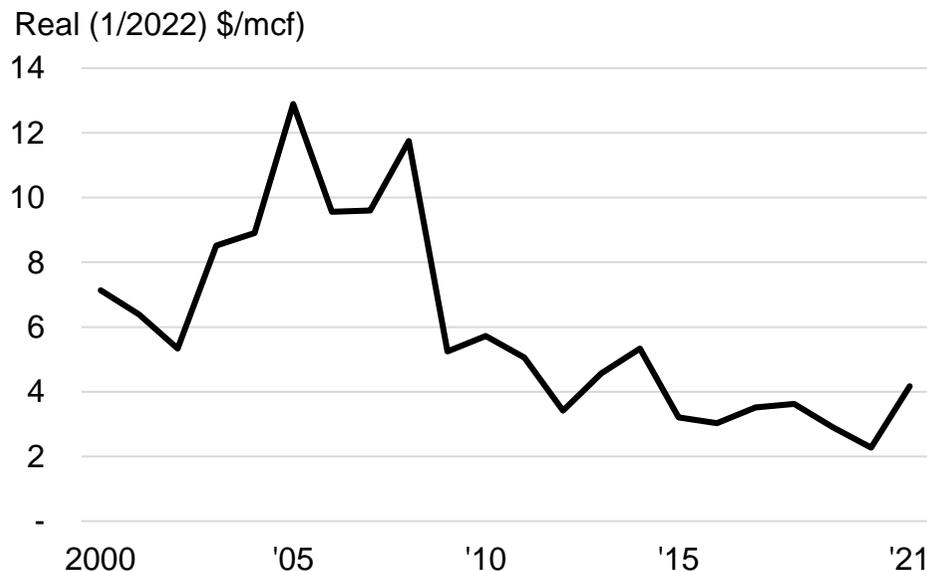


- The U.S. – and North America in general – offer industrial customers some of the least expensive electricity in the world. Among the G-7 nations, the U.S is second only to hydro-rich Canada and offered an average price for industrial customers of 6.7¢/kWh in 2020.
- Prices in Mexico rose sharply over the 2016-19 period but found some relief in 2020. Mexico introduced energy market deregulation and wholesale power pricing in 2016. Since then, the country’s oil-fired power plants have played a heavy role in dictating marginal power prices. Specifically, the 2018 power price hike came in the wake of a national oil price spike.
- Canada has a hydropower-heavy energy mix that produces affordable electricity, most notably in the provinces of Quebec, British Columbia, and Manitoba. Prices tends to fluctuate with rainfall levels in a given year.

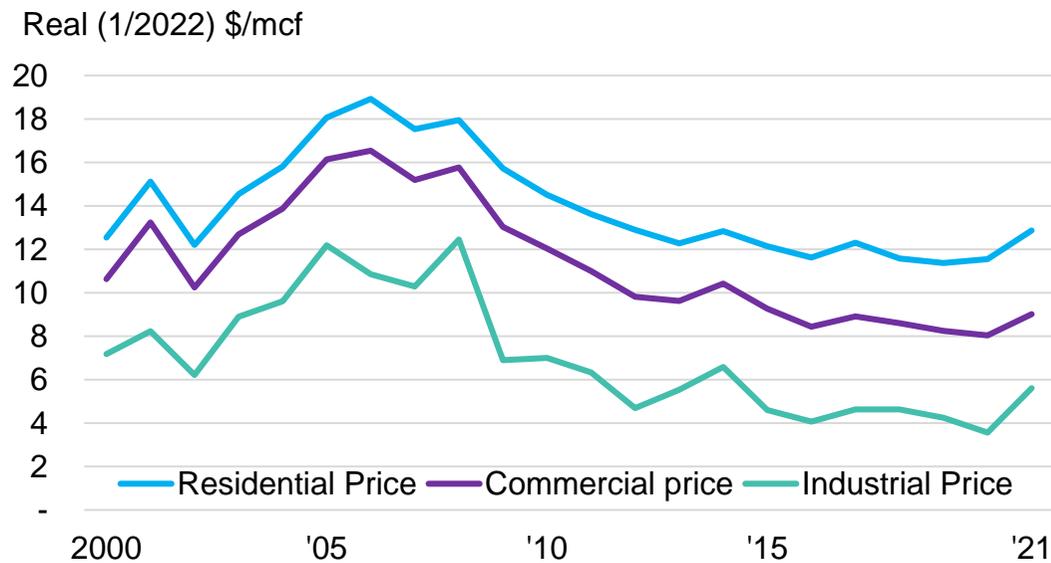
Source: BloombergNEF, government sources (EIA for the U.S.) Notes: Prices are averages (and in most cases, weighted averages) across all regions within the country. Japanese data are for the C&I segment and 2016 figures come from a different source than preceding years.

# U.S. energy overview: U.S. natural gas pricing, wholesale and by end use

## Natural gas wholesale prices at Henry Hub, LA



## Natural gas prices to end users, U.S. average

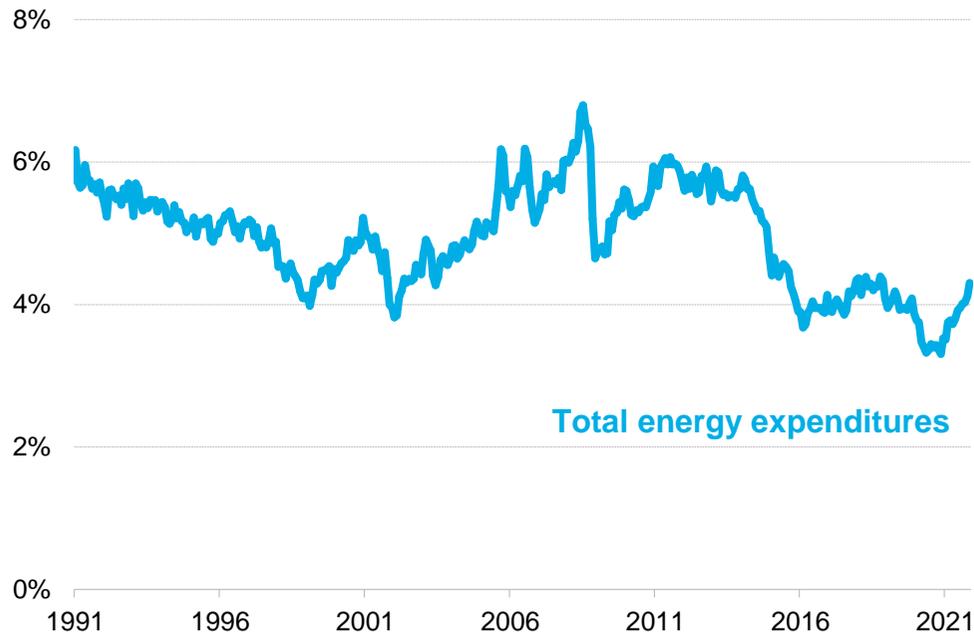


- U.S. natural gas prices increased in 2021 due to tightening market conditions caused by lack of production growth and strong domestic and international gas demand from LNG exports. After collapsing by 22% in 2020, wholesale prices rebounded 83.9% in 2021.
- Natural gas prices increased 11.4% and 12% for residential and commercial consumers in 2021, respectively. Industrial users saw the biggest year-on-year change, with prices jumping 57.2%. Even with the hikes, prices today are still below where they were 10 years ago; residential deliveries cost 5.6% less, commercial delivery prices are down 18.1% and the industrial sector saw a price decline of 11.6% versus 2011.
- Residential price adjustments tend to lag behind index prices 6-12 months, depending on utility practices. Industrial prices tend to be most correlated to wholesale markets.

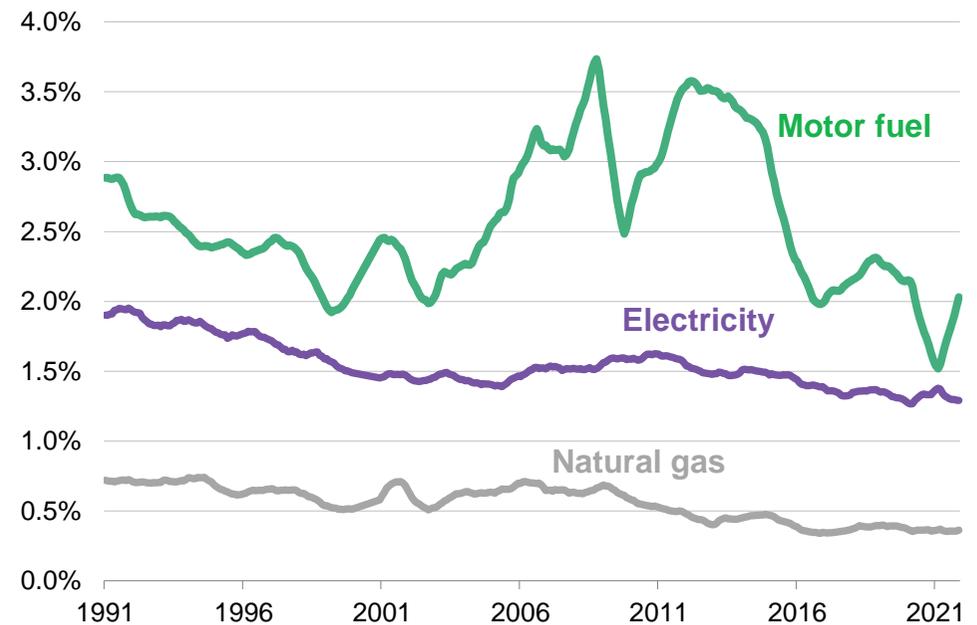
Source: BloombergNEF, EIA Short Term Energy Outlook, CPI where 1982-84 = 1

# U.S. energy overview: Energy as a share of personal consumption expenditures

## Total energy goods and services as share of total consumption expenditure



## Components of total consumption expenditure, 12-month rolling avg.

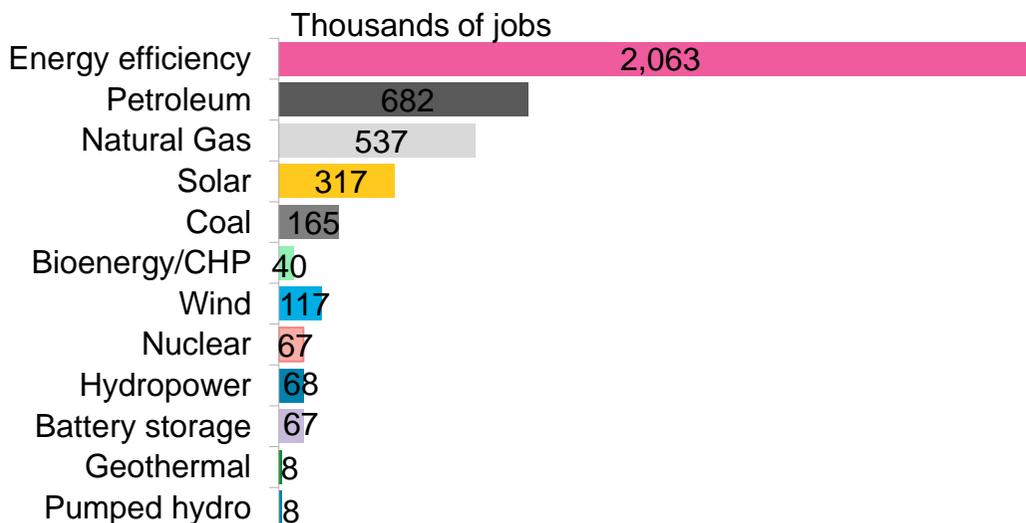


- Total consumer spending, including energy goods and services, increased significantly in 2021. But consumers still devoted relatively smaller shares of their total spending to energy compared to historical levels, helped along by low-cost renewables, energy efficiency measures, and relatively inexpensive natural gas. Energy spending accounted for 3.9% of total U.S. personal consumption expenditures in 2021, up 0.4 percentage points from 2020 levels as overall energy consumption increased.
- The 1.65% share of household expenditures that went to electricity and natural gas in 2021 is only slightly below 2020 levels of 1.71%. This slight downtick contrasted the steep incline in motor fuel spend, which reflects the rebound in transportation energy consumption from 1.6% of spend in 2020 to 2.1% in 2021. Consumers may feel more of the recent rise in wholesale natural gas and power prices as utilities update rates, subject to utility commission approvals.

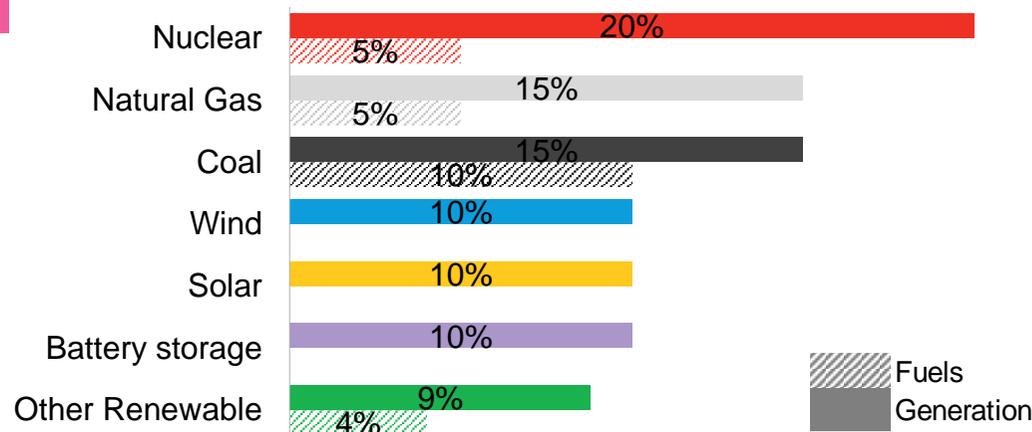
Source: Bureau of Economic Analysis, BloombergNEF

# U.S. energy overview: Jobs in select segments of the energy sector

## Jobs in select energy segments, 2020



## Unionization rates in select energy segments, 2020



- In 2020 (the last year for which complete data is available), the sustainable, nuclear and storage energy sectors employed an estimated 3.5 million Americans, according to the U.S. Energy and Employment Report. This is almost a 10% drop from 2019 pre-pandemic levels, which amplifies the impact of COVID-19 and its economic effects on the energy sector. The losses were concentrated in California and Texas, with over 100,000 job losses from 2019 to 2020 in each state.
- Energy efficiency was still the largest employment sector, supporting close to 2.1 million jobs, while natural gas supported 319,512 jobs (down 10%) and solar 316,675 jobs (down 8%). Solar PV firms saw the greatest overall decline, shedding a net 25,700 workers through 2020. Although the energy industry experienced widespread job losses, continued investment prevented declines in some areas. Notably, the wind sector had the strongest growth in jobs – 2,000 employees (up 2%), followed by battery storage by 800 jobs (up 1%).
- Union membership for solar, wind and battery storage sits close to 10%, significantly higher than the national private-sector union membership rate of 6.3% in 2020. Natural gas generation, coal generation and nuclear generation had the highest unionization rates. Historical data also demonstrates that energy jobs pay 34% higher than the national median - \$25.60 compared to the median of \$19.14.

Source: The U.S. Energy Employment Report, NASEO and EFI. Notes: This data relies on thousands of data points provided via survey. Fuel employment encompasses all work related to fuel extraction, mining and processing, as well as workers in the forestry and agriculture sectors who support biofuel production. Generation includes all utility and non-utility employment related to electric generation technologies, including firms that engage in construction, operations, maintenance, and generation equipment manufacturing.



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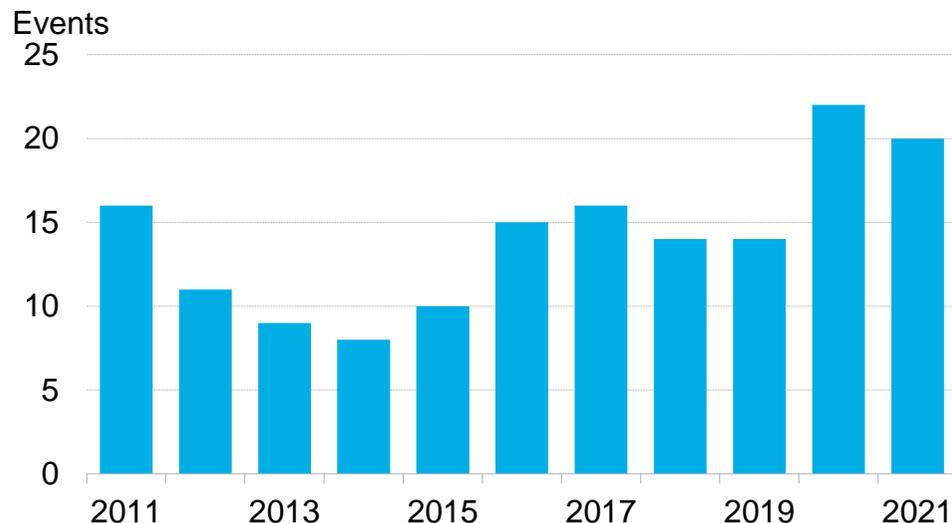
7.1 Gasoline

7.2 Fuel Prices and EV Sales

7.3 Renewable Natural Gas

# Policy: Infrastructure and resilience

## U.S. billion-dollar weather and climate disasters



## Quarterly residential energy storage systems installed in California

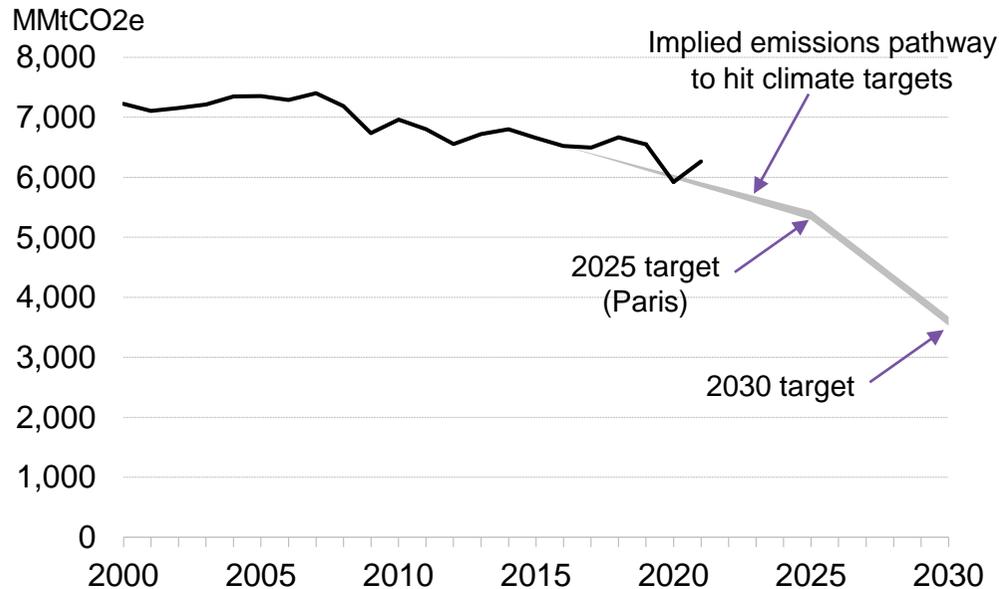


- The U.S. in 2021 experienced 20 climate disasters causing at least \$1 billion in damage. The 2021 events, made up of tropical cyclones, severe storms, droughts and wildfires, are estimated to have cost \$145 billion, the third most costly year on record after 2005 and 2017.
- California last year recorded the 2<sup>nd</sup> largest wildfire in its history. The Dixie fire, started by a tree falling onto a power line owned by PG&E, burned through almost 1 million acres of land. In total, California experienced 4.3 million acres burned in 2021, compared to the 5-year average of 1.6 million acres.
- Motivated by policy incentives and concerns about grid reliability, California utility customers installed more than 19,607 residential energy storage systems Q1-Q3 2021 (the latest quarter for which there is complete data). This number is 66% greater than for the similar three quarters of 2020 and 152% higher than in 2019.
- Microgrids, primarily comprised of batteries, solar, and combined heat and power (CHP) systems, are growing primarily in Texas, California and New York. In 2020, 35 new microgrids came online, with 108MW of new capacity installed.

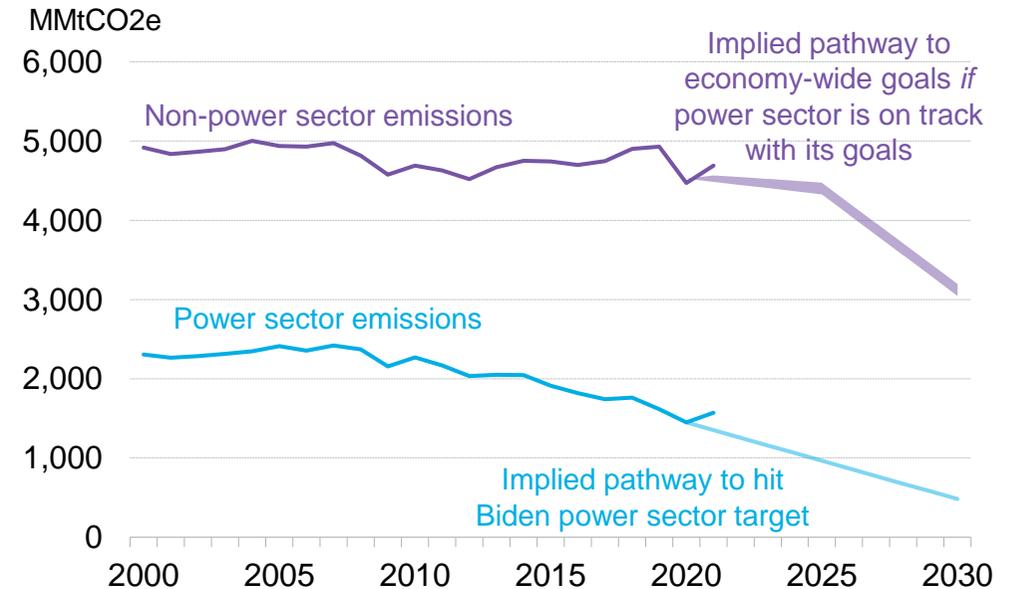
Source: National Oceanic and Atmospheric Administration, BloombergNEF. Note: Portrays annual counts of drought, flooding, freeze, severe storm, tropical cyclone, wildfire and winter storm events in the U.S. with losses of more than \$1 billion each.

# Policy: U.S. progress toward emissions goals

## U.S. economy-wide emissions



## U.S. power emissions

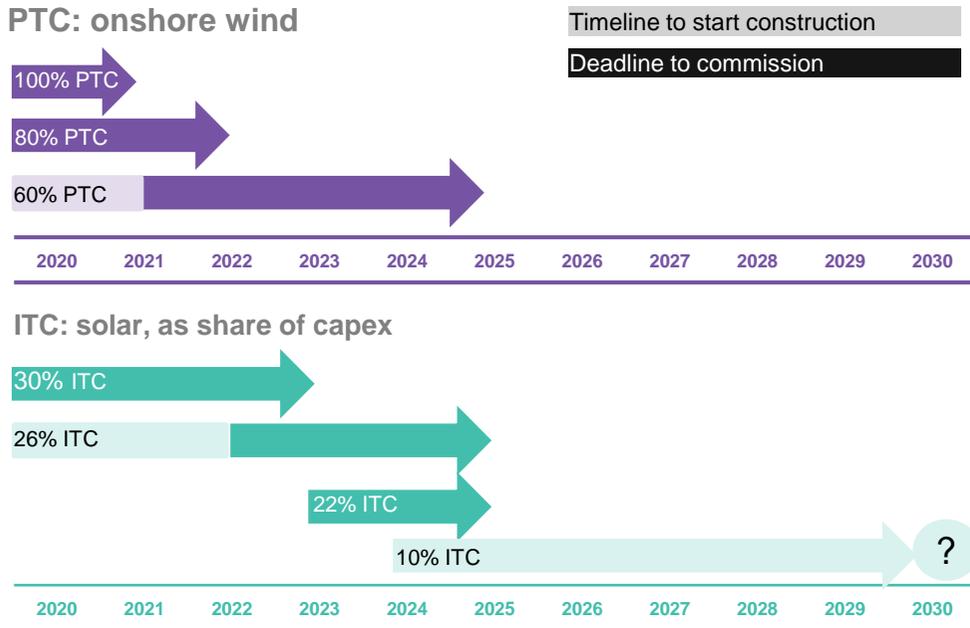


- After taking office, President Biden re-entered the Paris pledge of reducing emissions 26-28% below 2005 levels by 2025. Then, in April the administration announced a new Nationally Determined Contribution (NDC) pledge under the same framework to reduce U.S. emissions by 50-52% by 2030. However, with 2021's uptick, U.S. emissions went from being 19% below 2005 levels to 14%, leaving a greater gap to goal.
- The administration has also pledged to set the power sector on a track to being "carbon free" by 2035. At present 39% of U.S. electricity is generated from carbon-free sources. U.S. power has reduced its emissions by 35% since 2005. This is mostly due to the substitution of coal generation by natural gas. To achieve lower emissions reduction goals, the power sector will need to decarbonize the fossil fleet.
- So far, power is the only sector the Biden administration has set an explicit emissions-reduction target for. However, goals for all other sectors can be derived by *subtracting* power sector emissions from economy-wide emissions. Under that calculation, the U.S. must cut such emissions 32-35% from current levels, by 2030. Non-power emissions have dropped just 5% since 2005, however, emphasizing the need for far stronger measures to decarbonize sectors such as industry and transport.

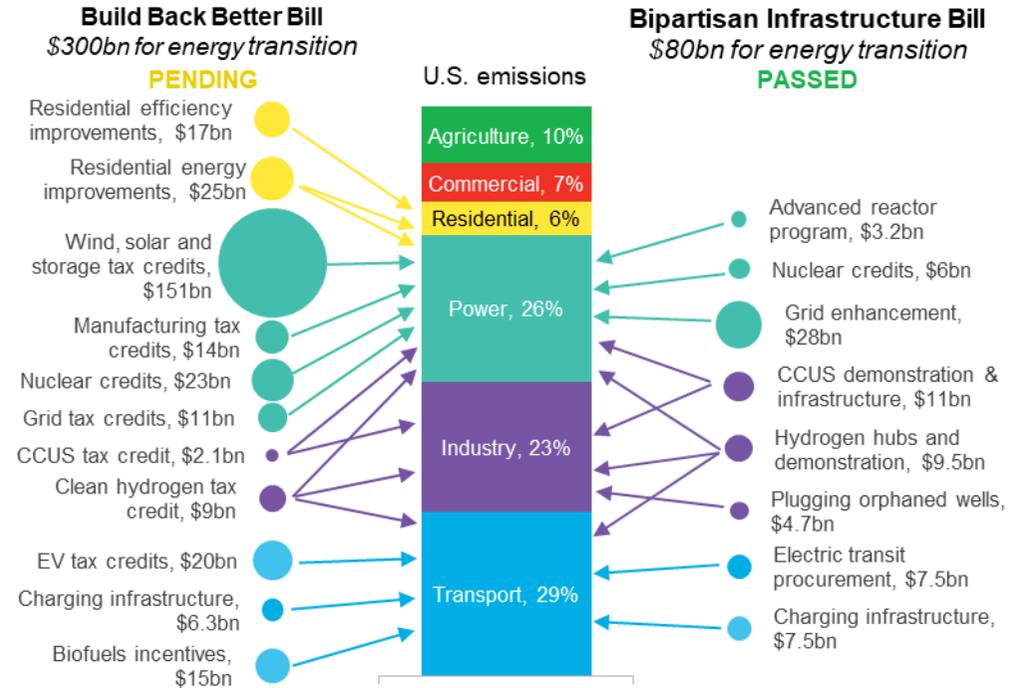
Source: EIA, EPA, BloombergNEF

# Policy: Tax credits and clean energy investment

## Current renewables tax credits schedule



## Energy RD&D spending in U.S. stimulus bill

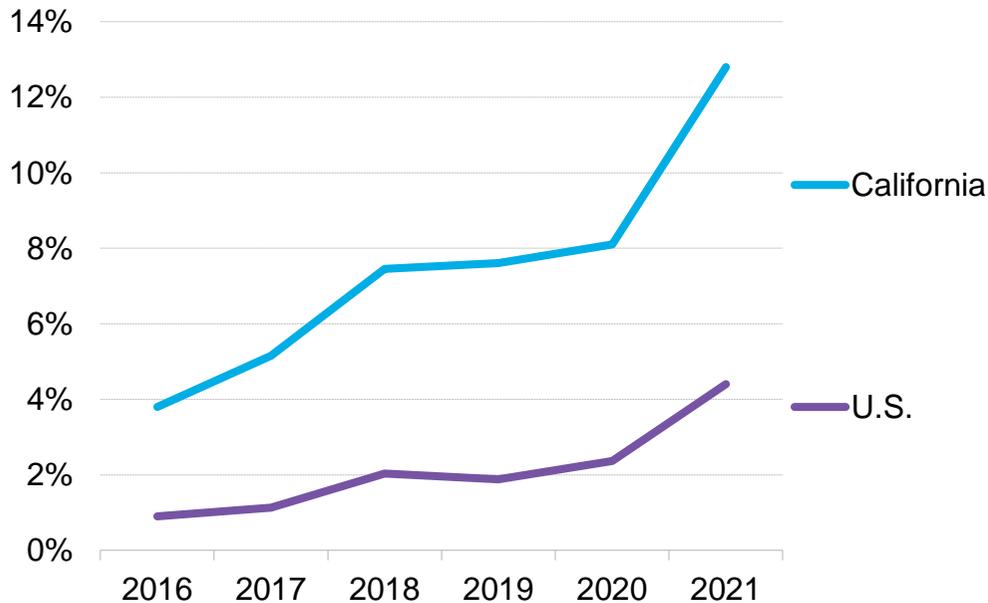


- The \$1.2 trillion Bipartisan Infrastructure law passed in November 2021 and could inject at least \$80 billion in new spending to promote decarbonization into the country’s economy over the next decade.
- The bill contains more than \$37 billion in support of developing grid infrastructure and nuclear energy, as well as almost \$20 billion for developing technologies such as CCUS and hydrogen.
- Tax credits such as the investment tax credit (ITC) and production tax credit (PTC) have a significant impact on renewable energy project economics. In some regions these incentives tip economic balance in favor of renewables. The impact of the investment tax credit on solar economics is fairly even between regions, whereas the PTC impacts wind more in those regions where it is already cheap.
- The ITC and PTC are due to phase down over the next few years. Extending both is currently under discussion in Congress.

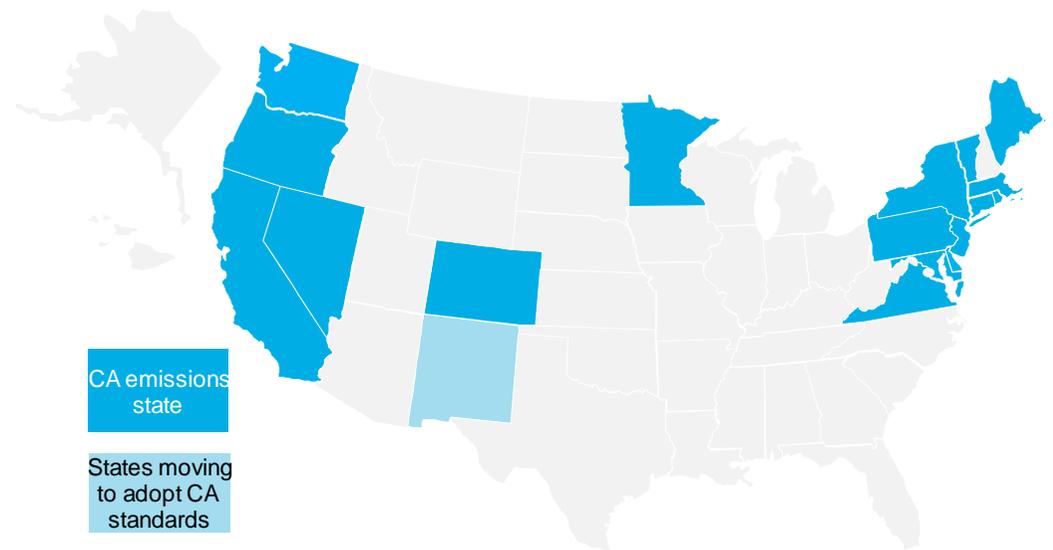
Source: EPA, EIA, BloombergNEF

# Policy: Vehicle fuel economy standards

## EV share of light duty vehicle sales in California and nationwide



## States that have adopted California's vehicle emissions standards



- The transportation sector is the largest source of greenhouse gas emissions in the U.S. Meanwhile, electric vehicle sales are growing. Nationally, EVs accounted for nearly 4.4% of 2021 passenger vehicle sales, up from 2.4% in 2020. In California, EV adoption is much further ahead with sales of the cars reaching 11% in the first half of 2021 from 8.1% in 2020.
- U.S. federal agencies have drafted revised fuel economy standards and are currently in the process of finalizing them. The Department of Transportation's revised Corporate Average Fuel Economy (CAFE) standards would put increased pressure on automakers to have more fuel-efficient fleets. This will require many to sell more EVs in coming years.
- Since last year, three more states have finalized policies to ensure they follow California's emissions standards -- Minnesota, Nevada and Virginia. This brings the total to 17 jurisdictions representing approximately 47% of the US economy.

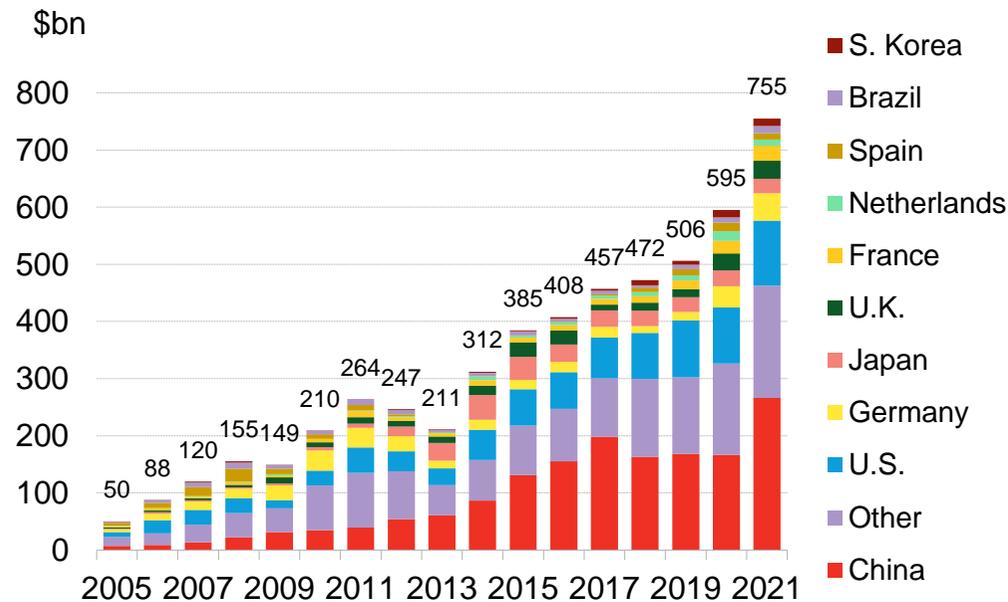
Source: BloombergNEF, California New Car Dealers Association, Auto Outlook, . Note: The 17 jurisdictions that follow the California GHG standard are Colorado, Connecticut, Delaware, District of Columbia, Maine, Maryland, Massachusetts, Minnesota, New Jersey, Nevada, New York, Oregon, Pennsylvania, Rhode Island, Vermont, Virginia and Washington.



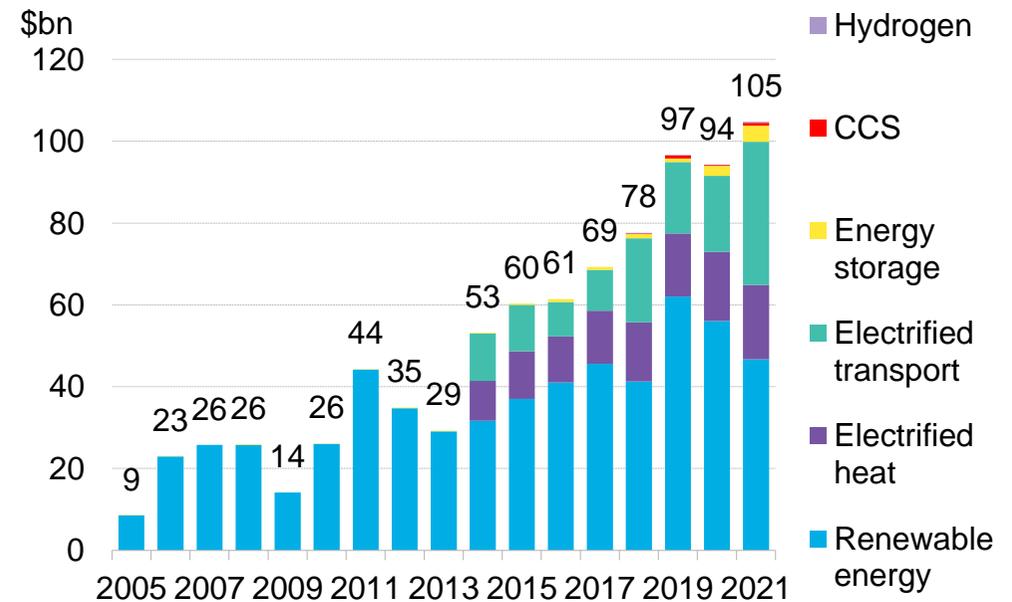
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# Finance: Energy transition investment

## Energy transition investment, by country



## U.S. energy transition investment, by sector

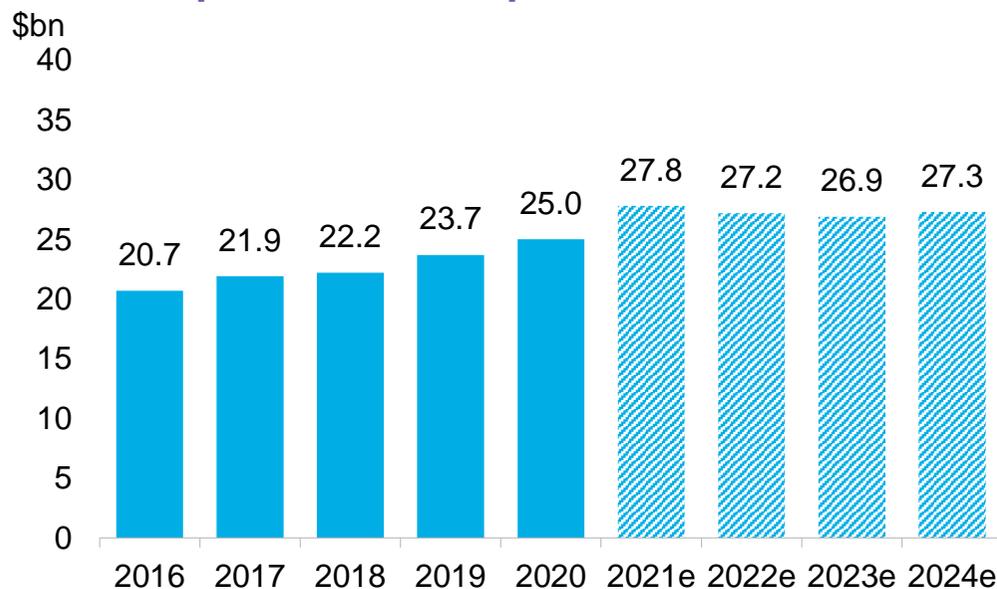


- BloombergNEF tracks investment into the technologies accelerating the trend toward decarbonization of the global economy. In 2021, this "energy transition" investment surged past \$700 billion for the first time. The jump from 2020 marked the largest year-on-year change ever, in dollar terms. The U.S. accounted for roughly one-seventh of the total at \$105 billion. This was up 11% year-on-year and the U.S. annual tally has grown 70% in the last five years.
- Within the country, the lion's share of energy transition capital continues to go to renewables (45% of total spend), but investment in electrified transport is close behind at \$35 billion (34%). Capital spent on transport almost doubled, primarily due to \$33 billion in EV sales.
- Notably, the U.S. now invests roughly \$200 million/year in hydrogen, double the \$100 million spent in 2020 -- the vast majority of which is tied to fuel cell vehicle sales.

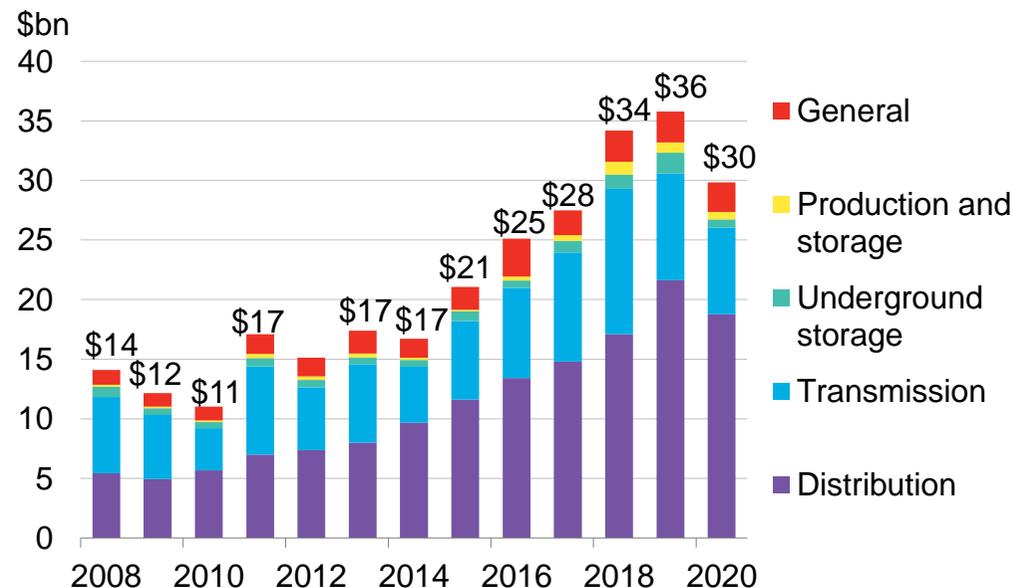
Source: BloombergNEF, "Energy Transition Investment Trends, 2022". Note: BNEF has updated and expanded its coverage of energy transition investment and slightly modified its methodology. For more see <https://www.bnef.com/flagships/clean-energy-investment>.

# Finance: U.S. midstream infrastructure investment

## U.S. electric transmission investment by IOUs and independent developers



## U.S. gas utility construction expenditures

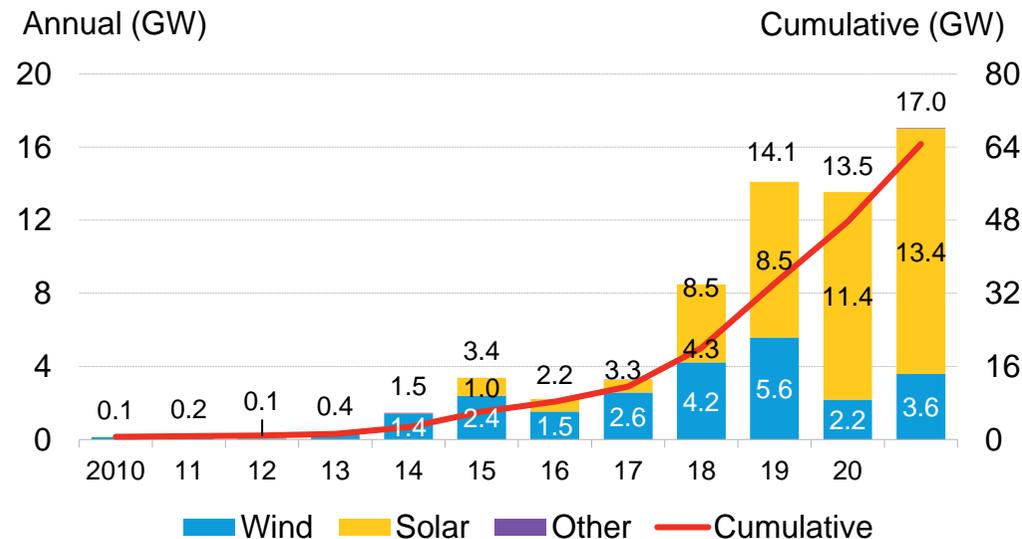


- Investor-owned utilities (IOUs) and independent transmission developers spent a record \$25 billion on electric transmission in 2020, according to the Edison Electric Institute (EEI). This was up 5.5% from 2019 and up 21% from 2016. Based on company reports, investor presentations and a survey, EEI estimates transmission investment in 2021 likely jumped 11% to \$27.8 billion. Current capex plans suggest investment will peak in 2021 then slow. However, future-year budgets are not yet finalized, and these numbers may be revised upward.
- The transmission upswing has been driven by the need to replace and upgrade aging power lines, resiliency planning in response to potential threats (both natural and man-made), the integration of renewable resources, and congestion reduction.
- Midstream gas utility construction expenditures fell by \$5.9 billion in 2020 from the prior year, to \$29.9 billion, according to the American Gas Association. This marked the deepest drop in annual construction expenditures since at least 2008. However, distribution and transmission miles of natural gas pipelines experienced a year-over-year growth by 0.8%.

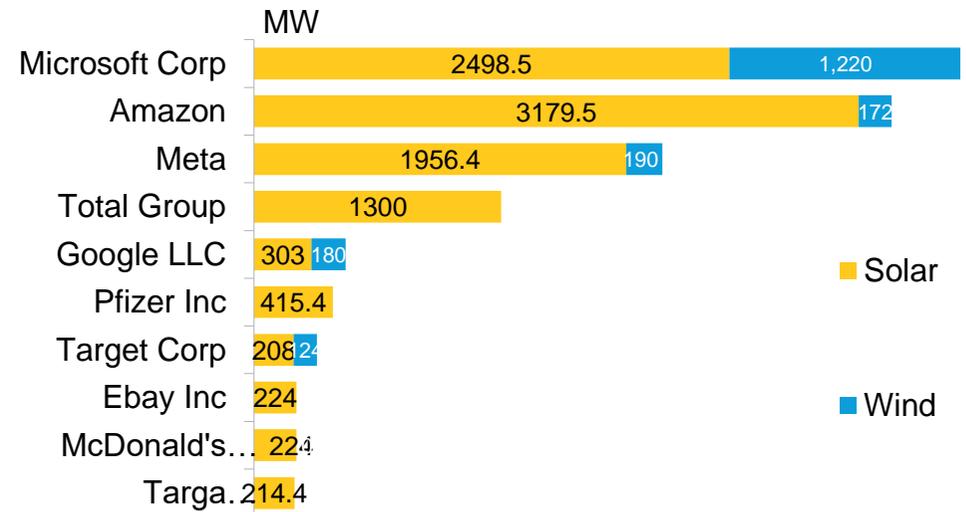
Source: Edison Electric Institute, American Gas Association, BloombergNEF Note: IOU means investor-owned utility. Gas expenditure values reflect figures reported to the AGA by companies across the supply chain, including transmission companies, investor-owned local distribution companies, and municipal gas utilities. "General" includes miscellaneous expenditures such as construction of administrative buildings.

# Finance: Corporate procurement of clean energy in the U.S.

## Renewable capacity contracted by corporations, by technology



## Largest corporate offtakers, 2021

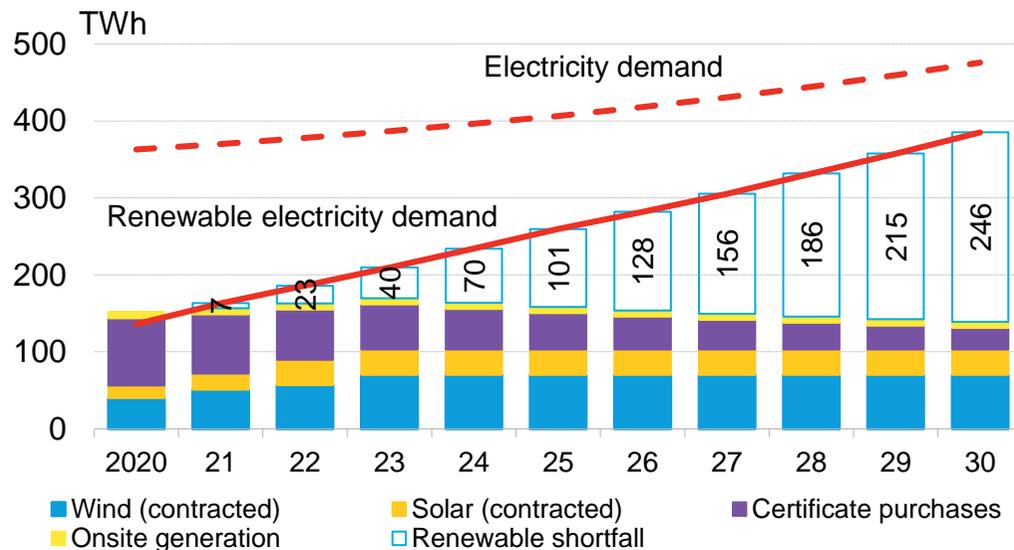


- Corporate power purchase agreements (PPAs) for clean energy totaled a record 17GW in 2021. This is up from 13.5GW in 2020 and the previous record of 14.1GW in 2019. The virtual PPA model has been mastered across the country, allowing companies to sign a portfolio of large deals in short succession, leading to single announcements sometimes exceeding 1GW in contracted capacity. Despite the record volumes, the market failed to diversify, with 40 different publicly-disclosed companies announcing deals – down from 67 different companies in 2020.
- Solar is the overwhelming technology of choice for corporations buying clean energy in the U.S., with contracted capacity growing for the fourth straight year to 13.4GW. Solar’s generation profile lines up more with peak demand in the middle of the day, meaning it captures higher realized prices. In addition to realized prices, a growing number of companies are utilizing green tariff programs with utilities in regulated markets across the U.S. like the Southeast and Southwest. These regions tend to have stronger solar resources.
- Big tech completely dominated clean energy buying in the U.S., with Microsoft (3.7GW), Amazon (3.4GW), Meta (formerly Facebook, 2.2GW) and Google (0.5GW) making up over half of activity. These companies are at or close to 100% renewable today but need to keep signing PPAs to maintain pace with their growing electricity consumption.

Source: BloombergNEF Note: Charts show offsite PPAs only

# Finance: Corporate sustainability targets

## RE100 Members need more clean energy to meet targets



## New U.S. RE100 members in 2021



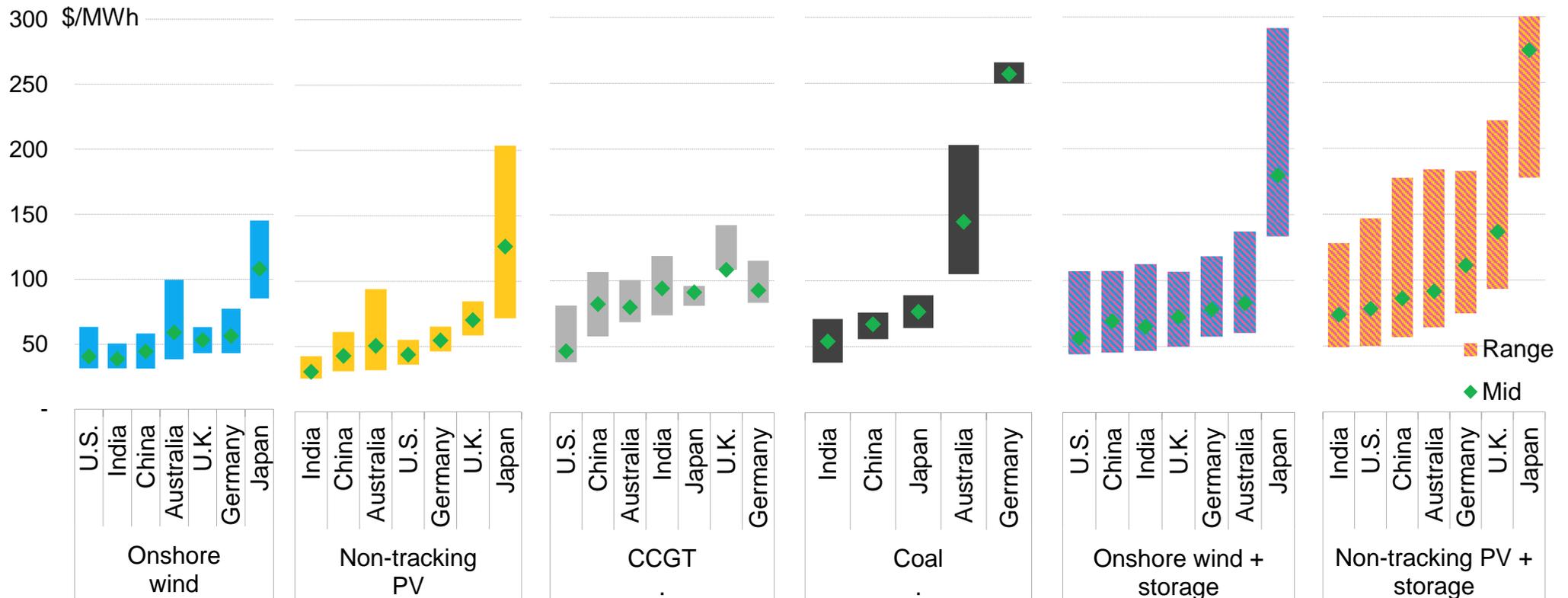
- BNEF projects that the current 351 Renewable Energy 100 (RE100) members who have committed to offset 100% of their electricity demand with renewables will need to purchase an additional 246TWh in 2030 to achieve their targets. Some 99TWh of this demand will come from the Americas region, almost entirely the U.S. This suggests a bullish outlook for more corporate PPAs in the U.S. over the next decade.
- The incumbent RE100 members purchased a record 21TWh of clean electricity through PPAs in the second half of 2021 alone. Some 13TWh, or 62%, of these purchases came from Microsoft, while an additional 4TWh came from Meta (the company formerly known as Facebook).
- Nine new U.S. companies joined the RE100 in 2021. Notable joiners included: The Home Depot, AirBnB, Under Armour and Dupont. In total, 90 U.S. companies have joined the RE100 to date, far ahead of the second largest market for commitments in Japan, at 63. The collective annual electricity demand from the new U.S. companies is 146TWh, based on their latest filings.

Source: BloombergNEF, The Climate Group, company announcements Note: Chart is a list of companies that have either joined a respective campaign or made other efforts in these sectors.



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# Economics: Select country levelized costs of electricity (unsubsidized, 2H 2021)

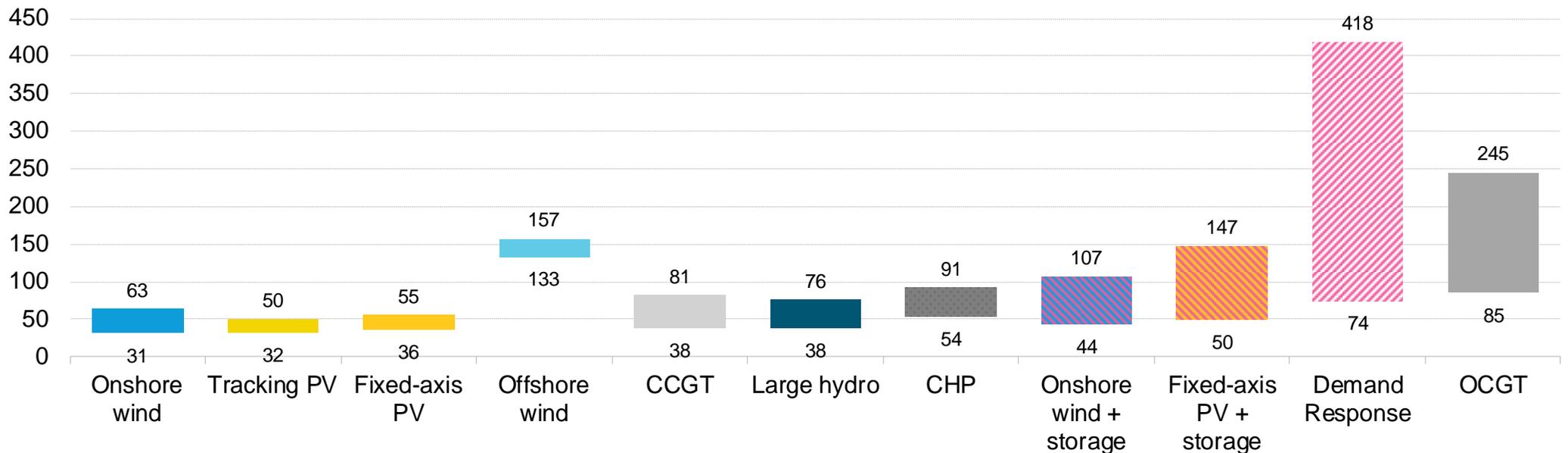


- Levelized cost of electricity (LCOE) is a metric for comparing the relative costs of different generating technologies. It measures the all-in, lifetime costs of operating a plant, accounting for upfront costs as well as anticipated ongoing expenses.
- Today, at least 91% of electricity generation occurs in a country where either onshore wind or utility-scale PV (or both) is the cheapest new bulk electricity generation. Globally, India features the world's lowest-cost solar, at \$25/MWh for non-tracking photovoltaic (PV). Japan has high wind and solar costs as steep capex and O&M more than offset ample access to cheap debt.
- The U.S. sees the least expensive combined-cycle gas turbines (CCGTs) due to cheap, abundant gas resources and no nationwide price on CO2 emissions. Carbon pricing and relatively poor resources in the U.K. and Germany push up the costs for both gas and coal generation.

Source: BloombergNEF. Note: The LCOE range represents a range of costs and capacity factors. In countries where a carbon pricing scheme exists, our coal and gas LCOEs include a carbon price. Battery storage systems (co-located and stand-alone) presented here have four-hour storage. In the case of solar- and wind-plus-battery systems, the range is a combination of capacity factors and size of the battery relative to the power generating asset (25% to 100% of total installed capacity). All LCOE calculations are unsubsidized. Germany CCGT figure is for 2020.

# Economics: U.S. levelized costs of electricity (unsubsidized for new build, 2H 2021)

\$/MWh (nominal)

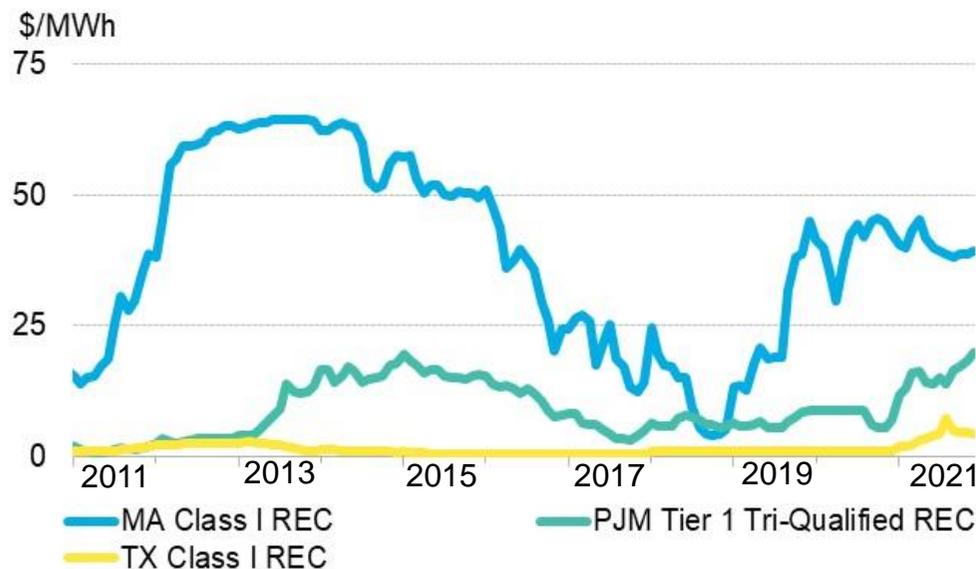


- The U.S. levelized cost of energy for most power-generating technologies rose in 2021 due to rising material, freight and fuel costs. The capex of a large scale solar project with trackers had a year-over-year rise of 4%, while onshore wind experienced a 13% rise in its average LCOE.
- Despite climbing costs, new-build renewables remain cheaper than new gas-fired plants for bulk generation in many areas of the U.S. Onshore-wind and tracking PV projects have a LCOE of \$31-\$63/MWh and \$32-\$50/MWh without accounting for tax credits. Combined-cycle gas turbines (CCGTs) represent the cheapest source of dispatchable power on an unsubsidized basis, with an LCOE of \$38-\$81/MWh.
- The levelized cost of paired onshore wind-plus-battery (four-hour) systems ranges from \$44-\$107/MWh, while solar-plus-battery (four-hour) is at \$50-\$147/MWh. PV projects without tracking are still getting less expensive each year with LCOEs of \$36-\$55/MWh.

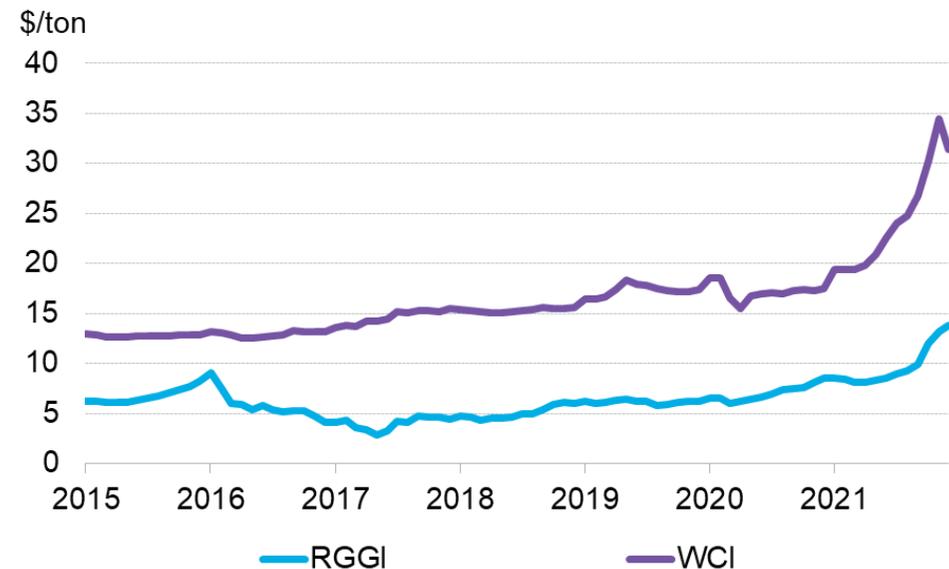
Source: BloombergNEF. Note: The LCOE range represents a range of costs and capacity factors. Battery storage systems (co-located and stand-alone) presented here have four-hour storage. In the case of solar- and wind-plus-battery systems, the range is a combination of capacity factors and size of the battery relative to the power generating asset (25% to 100% of total installed capacity). OCGTs are open cycle gas turbines. All LCOE calculations are unsubsidized. Categorization of technologies is based on their primary use case.

# Economics: U.S. environmental markets

## Class I REC prices in select U.S. markets



## U.S. carbon allowance auction prices



- In states with Renewable Portfolio Standards (RPS), eligible renewable generators receive Renewable Energy Credits (RECs) for each megawatt-hour of electricity they supply to the grid. REC prices typically rise when policy-makers raise overall goals for clean energy generation, increasing demand for credits. The U.S. also has two carbon cap-and-trade markets. In participating states, emission allowances are won by bidding entities in auctions held each quarter. Those allowances can then be traded in the secondary markets between auctions.
- REC markets have been bolstered as policymakers have set increasingly ambitious clean energy targets in recent years. In 2021, long dormant Texas REC prices rose from near-zero to about \$4/MWh; the credits are becoming increasingly valuable to corporate buyers.
- In the two regional carbon markets, auction and trade prices have historically followed the administrative price floors. In 2021, multiple factors finally tightened the supply-demand balance and lifted allowances: inflation and a natural gas price rally; lower emissions caps combined with stronger economic activity; and new speculators entering the market looking for clean energy exposure. Both markets may also have gotten a boost from growing global momentum behind carbon markets highlighted during COP26 climate talks in Glasgow.

Source: BloombergNEF, Bloomberg Terminal, CARB, RGGI NOTE: RGGI is the Regional Greenhouse Gas Initiative in short tons. WCI is the Western Climate Initiative in metric tons



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5.2 Environmental Markets

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6.1 Energy Efficiency

6.2 Natural Gas

6.3 Solar and Wind

6.4 Storage

6.5 Hydrogen

7. Transportation

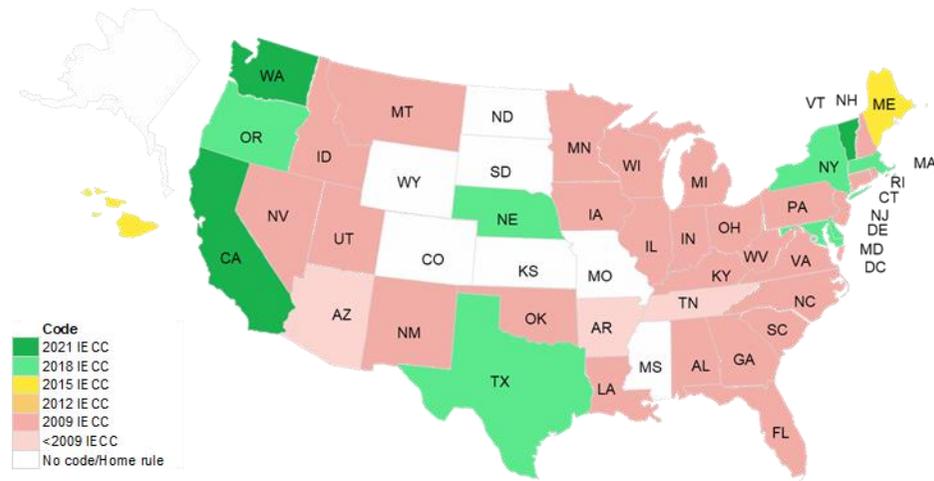
7.1 Gasoline

7.2 Fuel Prices and EV Sales

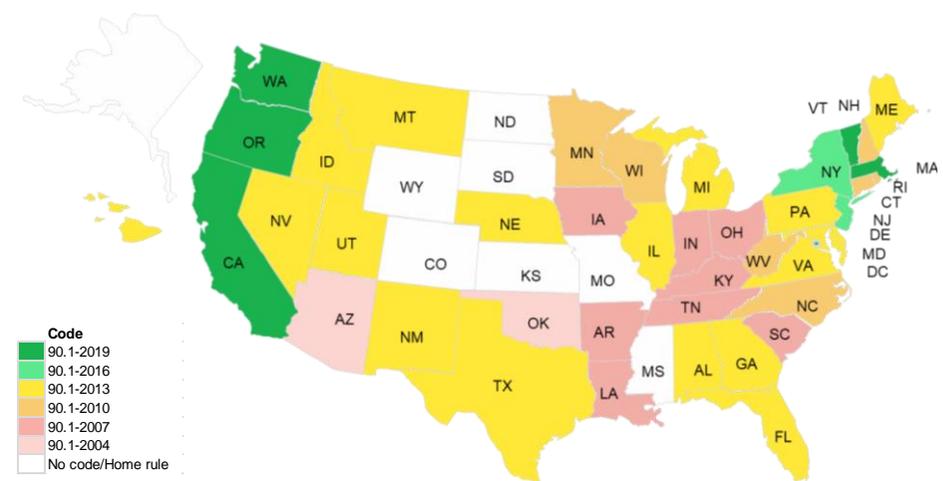
7.3 Renewable Natural Gas

# Deployment: Statewide energy code adoption

## Residential



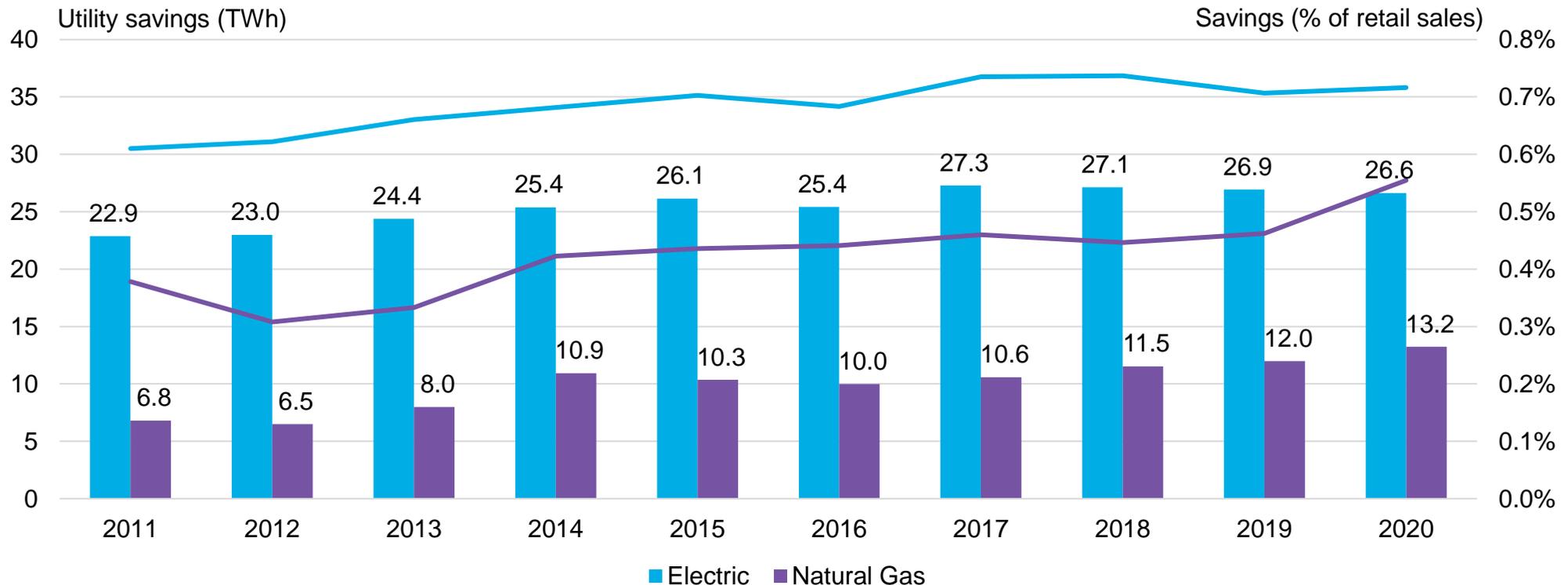
## Commercial



- Building energy codes set minimum standards for both new buildings and renovations. The International Energy Conservation Code (IECC) sets standards for both residential and commercial buildings. The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Standard 90.1 is an alternative standard to IECC provisions for commercial buildings (and is an alternative pathway to meet IECC).
- Building energy codes can be mandated at a state level, but in some states local governments can and often do set more stringent requirements. Thus, building performance in some states exceeds the state-level standard. For example, Arizona's two largest cities, Phoenix and Tucson, which represent around 30% of the state's population, have adopted the 2018 IECC – despite the lack of a statewide code.
- The most recent editions of IECC and Standard 90.1 are considerably more ambitious than their predecessors. Analysis by the DOE estimates that the 2021 IECC leads to efficiency gains of 9.4% over the 2018 edition. Similarly, the most recent 90.1 edition, released in October 2019, is 5% more energy efficient than the 2016 version and 12% more efficient than the 2013 version.
- The Zero Energy Performance Index (zEPI) score, calculated by the New Buildings Institute, assesses the stringency of state-level building codes, incorporating factors such as local climate. State codes are awarded score between 100 (representing an average 2000 building) and 0 (representing a net-zero energy building). There is a wide gap between leaders and laggards. In residential buildings Vermont has a score of 43.2, compared to 72.5 for Arkansas. In commercial buildings Massachusetts and Vermont achieved 46.5, compared to 79.5 in Oklahoma.

Source: EERE, ACEEE, BloombergNEF. Note: The maps represent EERE analysis of energy savings impacts from state code adoptions. Any code for which the Energy Index is not more than 1% higher than that of an IECC or Standard 90.1 edition is considered equivalent to that code edition. For more on the EERE methodology see [link](#).

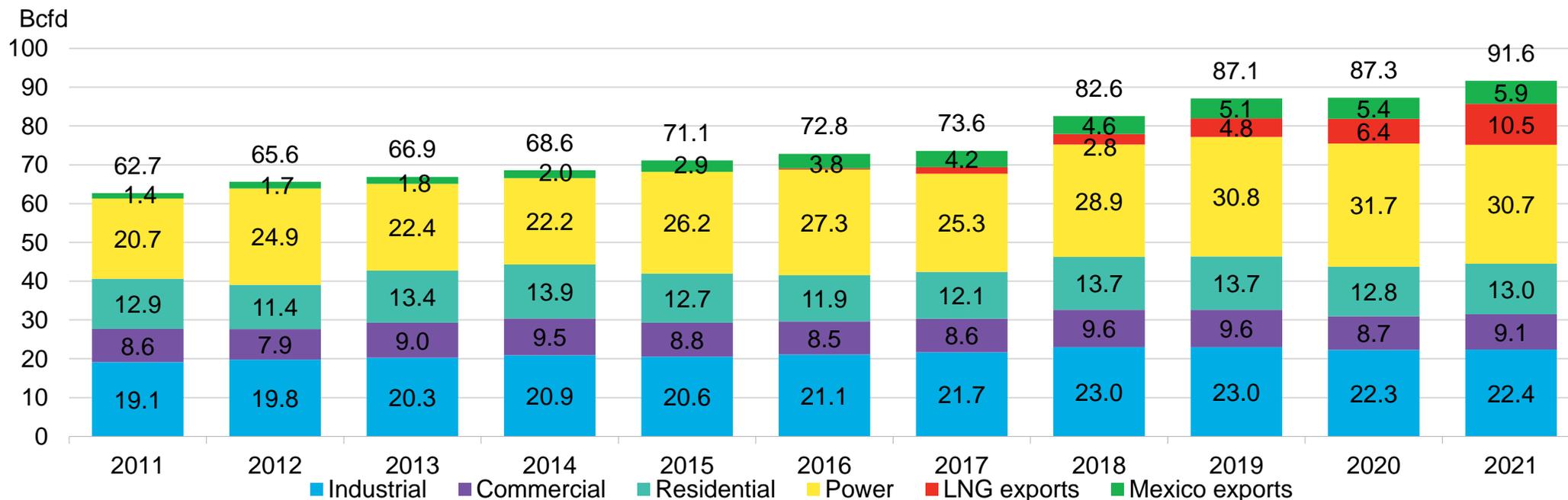
# Deployment: Incremental annual energy efficiency achievements by utilities



- The years leading up to 2011 saw a growing number of states introducing Energy Efficiency Resource Standards (EERS) mandating utilities to invest in energy savings among their customer-base. There was a corresponding increase in investment in utility energy efficiency programs.
- Since 2011, the number of states and jurisdictions with EERS policies in place has leveled off at 27 as investment growth has slowed. 2020 utility electric energy efficiency savings slipped 1% from the previous year to total 26.6TWh of energy and 0.7% of retail sales. 2020 utility gas energy efficiency savings grew by 10% to total 13.2TWh (451 MMTherms) and 0.55% of retail sales.
- The ACEEE, which collects this data, attributes the difference to adjustments in its qualifying criteria for utility energy efficiency savings, rather than a decrease in energy efficiency activity.

Source: ACEEE Note: The ACEEE Scorecard points to caveats in the energy efficiency savings data reported by states. ACEEE uses a standard factor of 0.825 to convert gross savings to net savings for those states that report in gross rather than net terms. The ACEEE currently reports electric and natural gas savings separately in their report but a handful of states have been considering savings in a fuel-neutral basis, which is appropriate when electrification brings net positive effect on emissions, ACEEE may adjust methodology if practice becomes commonplace.

# Deployment: U.S. natural gas demand by end use

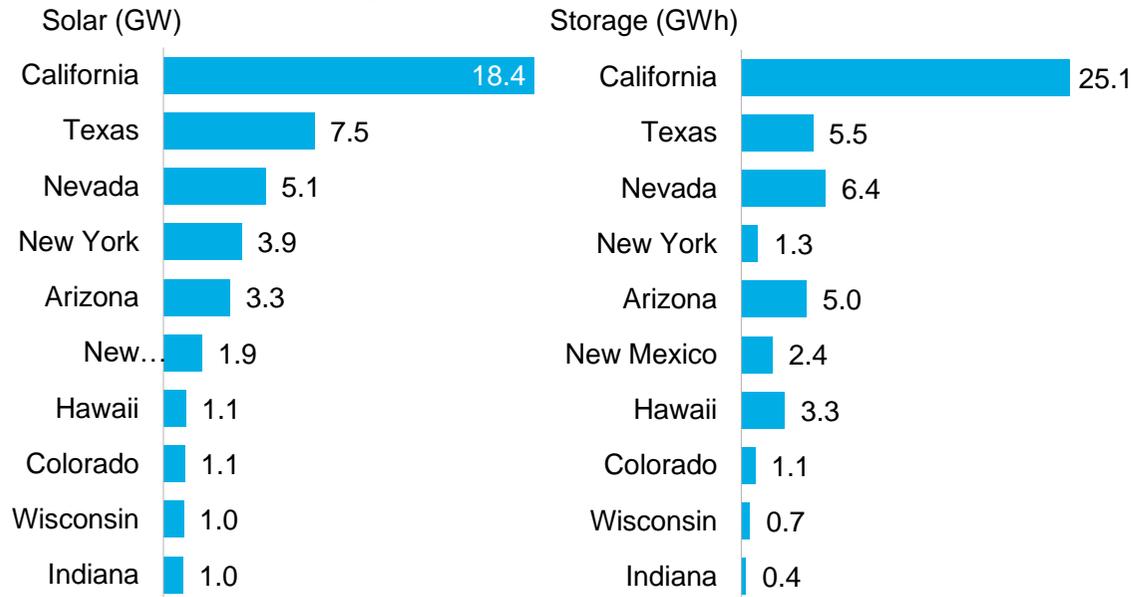


- Total demand for U.S. gas increased by 9.4% in 2021, a rebound from the minimal growth in 2020 due to the Covid-19 pandemic. While overall load grew, gas demand for power generation fuel dropped by 1.0 Bcfd (-3.3%) as high year-on-year gas prices lead to more coal-fired power plants being online.
- LNG exports rose very significantly (64%) in 2021, driven mainly by a demand surge in Europe and Asia. In Europe, LNG has backfilled depleted domestic production while in Asia LNG meets high demand from economic growth and replaces coal generation.
- Industrial, residential and commercial heating demand increased 0.4%, 4.7% and 1.9% respectively. The increase in residential gas customers was the largest since 2006, with 900,000 more customer hook-ups in 2020.
- The average residential customer efficiency continues to improve. Gas utility energy efficiency investments from 2011 to 2019 alone saved an estimated over 319 trillion BTU, the American Gas Association estimates.
- The next market for RNG is set to be utilities who use the molecules for reducing carbon footprints. Utilities are aiming to displace around 20% of existing fossil gas use with RNG by 2040. Approximately \$3 billion has been earmarked for RNG investment in 2021.

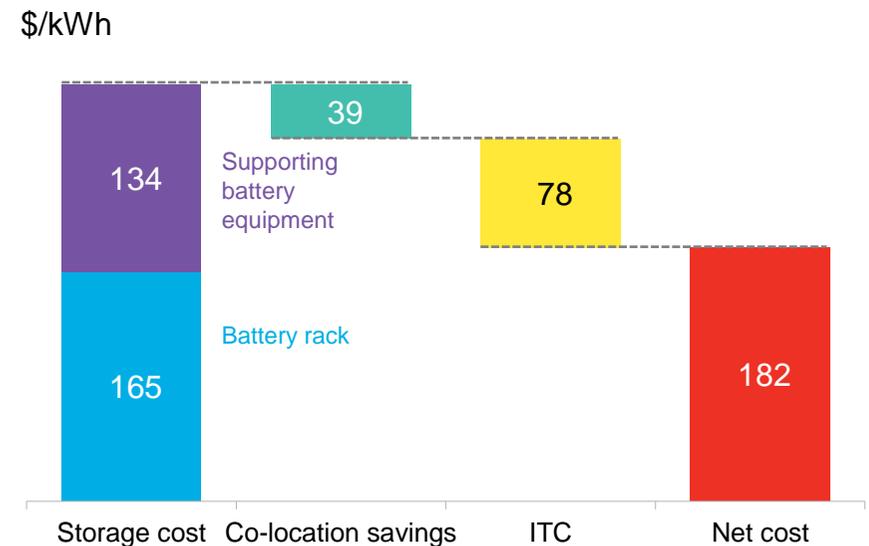
Source: BloombergNEF, EIA, DOE

# Deployment: Solar + storage

## Co-located solar and storage projects announced and commissioned, by state



## Cost advantage to co-locating storage with solar

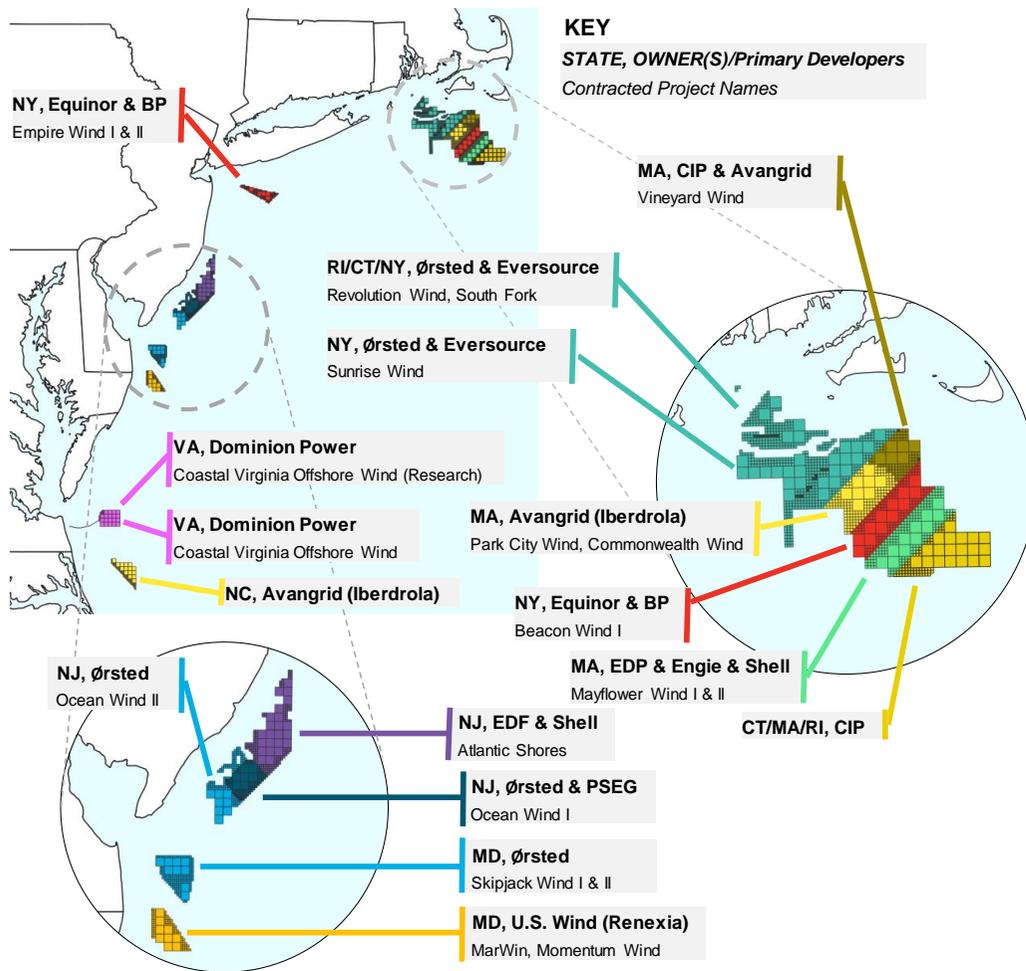


- Co-located solar and storage project pipelines continued to grow in 2021. While sunny markets like the Southwest, California, and Hawaii remain most active, large projects are also being planned in Texas and parts of the Midwest. Wisconsin and Indiana are now among the top ten states in terms of solar-plus-storage projects planned.
- Drivers of co-location remain the same: in regions with a high solar penetration, co-located projects enable energy shifting. In regions without high solar penetration, such as Texas, co-location offers lower costs, and opportunities for batteries to discharge during high-demand hours. In the Midwest, regulated utilities are adding demand for projects they can acquire and own.
- Should Congress pass the Build Back Better Act, standalone storage projects would for the first time be able to exploit Investment Tax Credits (ITC), eliminating the need to pair with solar to tap the capex-based subsidy. In markets where energy shifting is a system need, this will not slow the addition of storage-plus-solar projects. However, in such cases, the two are likely to be listed as separate legal entities to exploit the credits fully.

Source: BloombergNEF. Note: Storage capacity uses two metrics: MW which signifies power output (based on the inverter capacity) and the MWh which specifies the energy storage capacity and relates to the duration the input/output can be sustained for (ie, a 10MW/40MWh system can sustain 10MW for 4 hours). The ITC is the federal investment tax credit.

# Deployment: Offshore wind and federal support

## Location and owners of U.S. offshore wind leases issued by BOEM

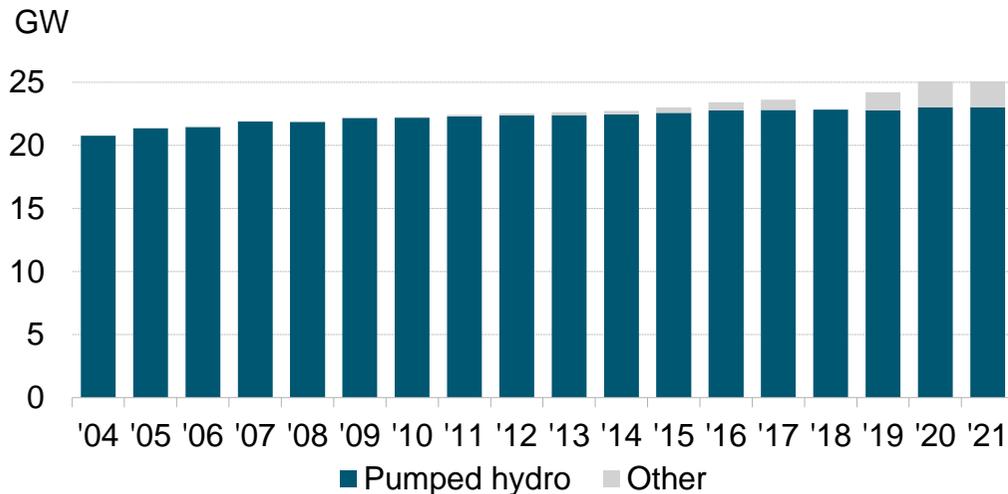


- The U.S. offshore wind sector is set to boom with a supportive federal government driving progress. In 2021, the Biden administration announced a target for 30GW of offshore wind by 2030. It also set goals to approve 16 project plans and hold seven seabed lease auctions by 2025, a major uptick in permitting and leasing activity.
- The Bureau of Ocean Energy Management (BOEM), gave final federal approval to the 806MW Vineyard Wind project and the 132MW South Fork Wind. Vineyard has already started construction after securing \$2.3 billion in debt. The project is set to fully commission in 2024. South Fork is anticipated online in 2023.
- New York, New Jersey, Massachusetts and Maryland all awarded offshore wind contracts in 2021. Totalling almost 8.5GW of capacity, the winning projects across these four states are being developed by Equinor and BP, Orsted, EDF and Shell, Avangrid, Shell and Ocean Winds (Engie and EDP joint venture) and U.S. Wind. New York is preparing to open its third offshore wind solicitation for 2GW in early 2022.
- Activity is starting to pick up away from the east coast. BOEM plans to host seabed lease auctions in California and the Gulf of Mexico as soon as this year. In 2021, Oregon and California passed bills supporting offshore wind development.

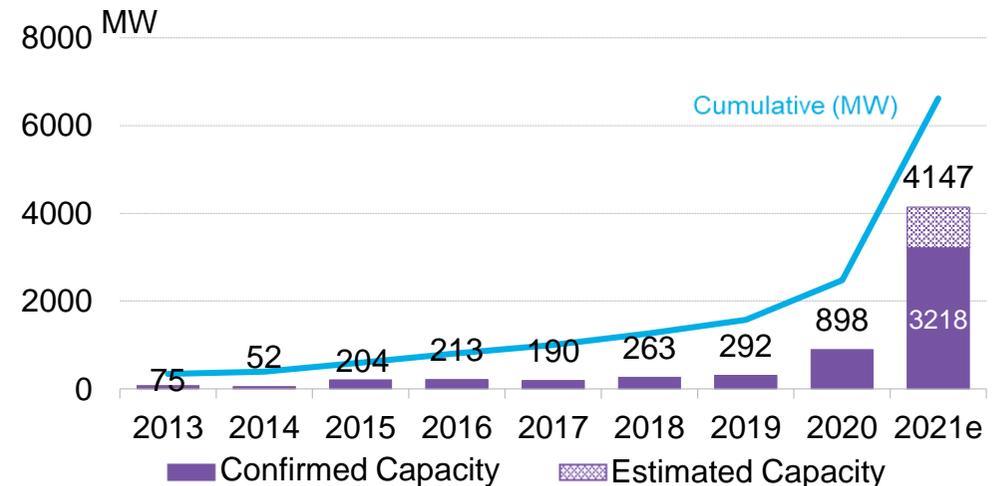
Source: BloombergNEF, Bureau of Ocean Energy Management

# Deployment: U.S. cumulative energy storage

## Commissioned capacity



## Non-hydropower commissioned energy storage capacity



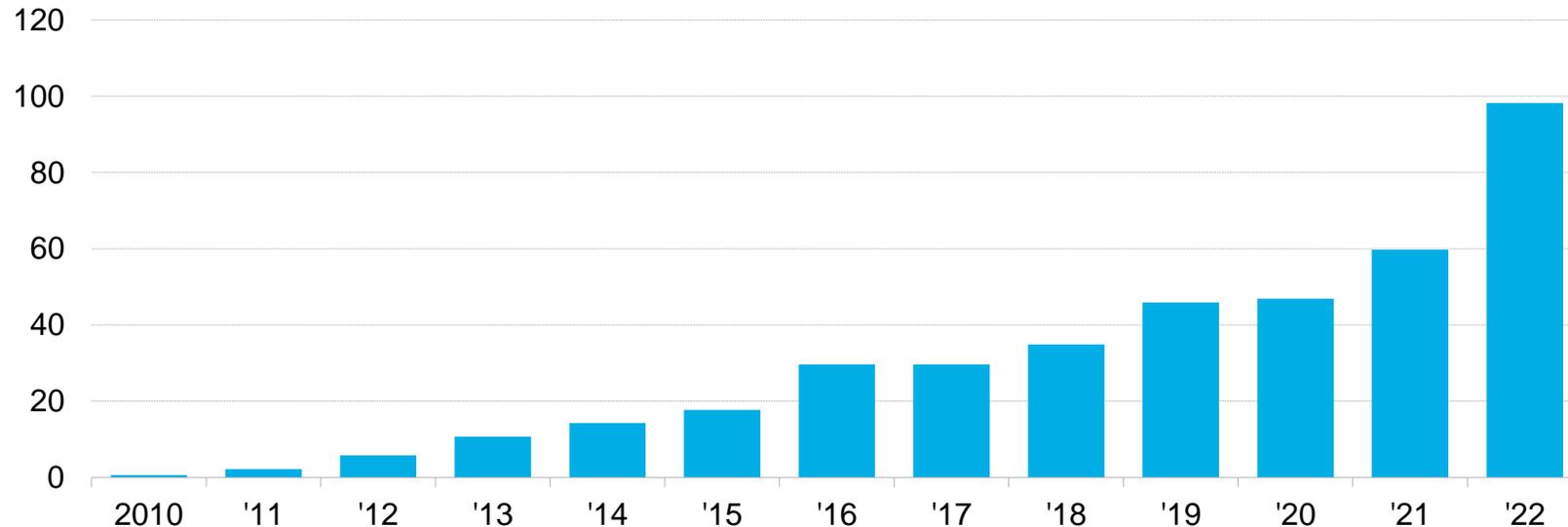
- Pumped hydropower storage projects account for around 81% of installed energy storage capacity in the U.S. Three new pumped storage projects with a combined capacity of 2.1 GW have received licenses. However, other technologies, mainly lithium-ion batteries, have dominated new energy storage build since 2011. State-level storage targets and utility solicitations generally exclude pumped storage.
- In 2021, the U.S. commissioned an estimated 4.1GW in utility-scale non-hydropower storage capacity to bring total capacity to 6.6GW. Energy shifting is the dominant use case for new batteries as pairing renewables with storage is becoming a common cost-effective option to displace fossil fuel projects. Utilities across the nation are beginning to cite energy-storage technologies in their long-term resource planning and as solutions to their power system flexibility needs.
- Utility scale lithium-ion battery deployment remains strong in California. Due to high penetrations of solar, California's greatest power market challenge is meeting peak demand in late afternoon. Texas is the second largest market in the U.S. and had a record year in 2021. High penetrations of wind (and expected deployments of solar) have made Texas an attractive market for larger batteries.
- While lithium-ion holds the majority of the remaining market share, thermal energy storage in the form of ice-based systems are starting to be used in select areas as well.

Source: EIA, FERC, BloombergNEF. Note: "Other" includes projects where the technology is unknown, which is frequently lithium-ion batteries. Confirmed capacity refers to projects that have secured financing.

# Deployment: Current and planned manufacturing capacity

## U.S. lithium-ion battery manufacturing capacity

Manufacturing capacity (GWh/year)

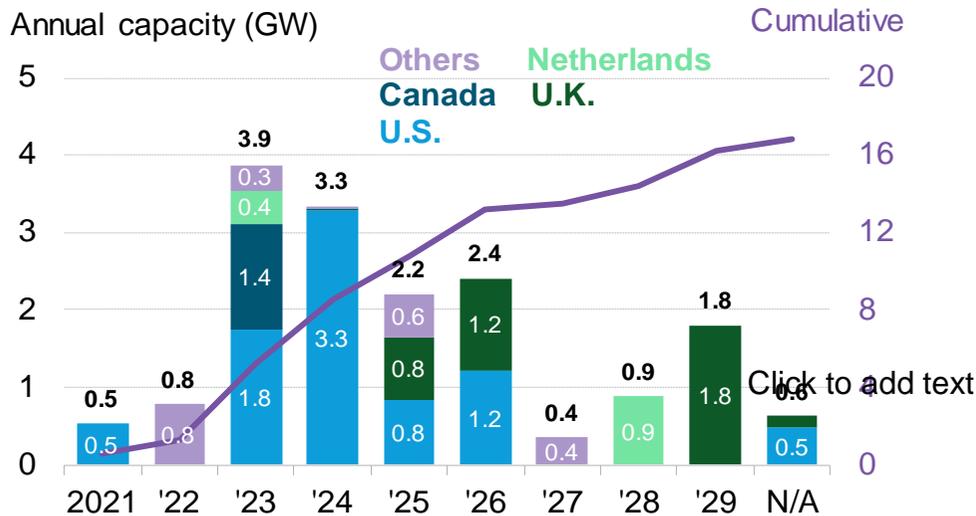


- As of the end of 2021, the U.S. has 59GWh of lithium-ion battery manufacturing capacity commissioned. Capacity expansions were not significant in 2021, but there were major announcements that will lead to a significant ramp-up manufacturing capacity through to 2025:
  - South Korean SK Innovation and Ford announced a joint venture, BlueOvalSK, to invest \$11.4 billion in two battery manufacturing facilities in Tennessee and Kentucky totaling 129GWh by 2027. The plants are expected to supply batteries to Ford’s electric vehicle models.
  - Stellantis announced two separate joint ventures, one with Samsung SDI and the other with LG Energy Solution, to manufacture lithium-ion batteries in North America, which could come on-line in 2024 and 2025, respectively, and could each reach 40GWh capacity.
  - GM and LG Energy Solution announced that its joint venture, Ultium Cells, would invest \$4.9 billion to build a second and third battery manufacturing facility in Spring Hill, Tennessee and in Lansing, Michigan coming on-line in 2023 and 2024, respectively.
- The U.S. is expected to reach almost 98GWh of battery manufacturing by the end of 2022. Growth will be led by a number of companies including Tesla, SK, GM, LG Energy Solution and their respective partnerships. Most of this scaling up will be for the EV industry.

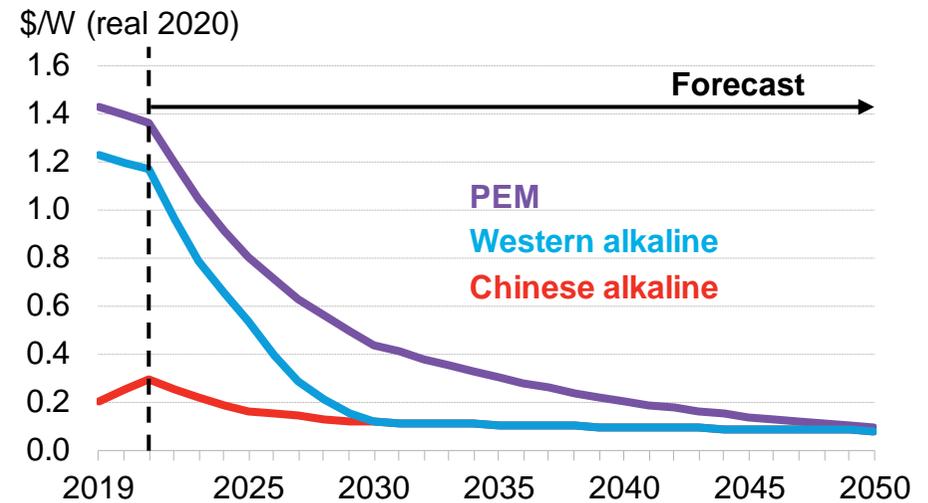
Source: BloombergNEF. Note: manufacturing capacity is based on nameplate capacity and includes manufacturing for multiple segments such as electric vehicles, stationary storage and others.

# Deployment: Hydrogen-fired power plants and electrolyzer costs

## Planned and projected cumulative capacity of H2-ready power projects



## Projected electrolyzer system costs



- The U.S. is a global leader with over 8GW of announced hydrogen-compatible power turbines, mostly at brownfield sites. State-level clean energy targets are clear drivers with nine of 10 planned projects due to provide electricity in states with clean energy mandates. Two-thirds of these projects have hydrogen-natural gas blend targets. Half expect to run on 100% H2 by 2045.
- The U.S. currently produces 15-16 million metric tons of hydrogen, of which 65% is through dedicated plants. The vast majority of this is "gray", from unabated natural gas. However, the U.S. is seeing activity to develop cleaner hydrogen sources. Air Products has announced the largest "blue" hydrogen facility with natural gas and CCS in Louisiana. The Department of Energy estimates more than 120MW of electrolyzers were installed as of June 2021. The U.S is expected to install 262-336MW of electrolyzers for green hydrogen production during 2022. The vast majority will be from Plug Power, a fully integrated hydrogen company which opened a Gigafactory in New York last year.
- BNEF expects sharp decline in the dollar-per-Watt cost of electrolyzer systems. The price of a western-made alkaline electrolyzer system will converge with Chinese-made alkaline electrolyzes by 2030, dropping 90% from 2021. Polymer electrolyte membrane electrolysis (PEM) system costs will also fall, albeit at a slightly slower pace.

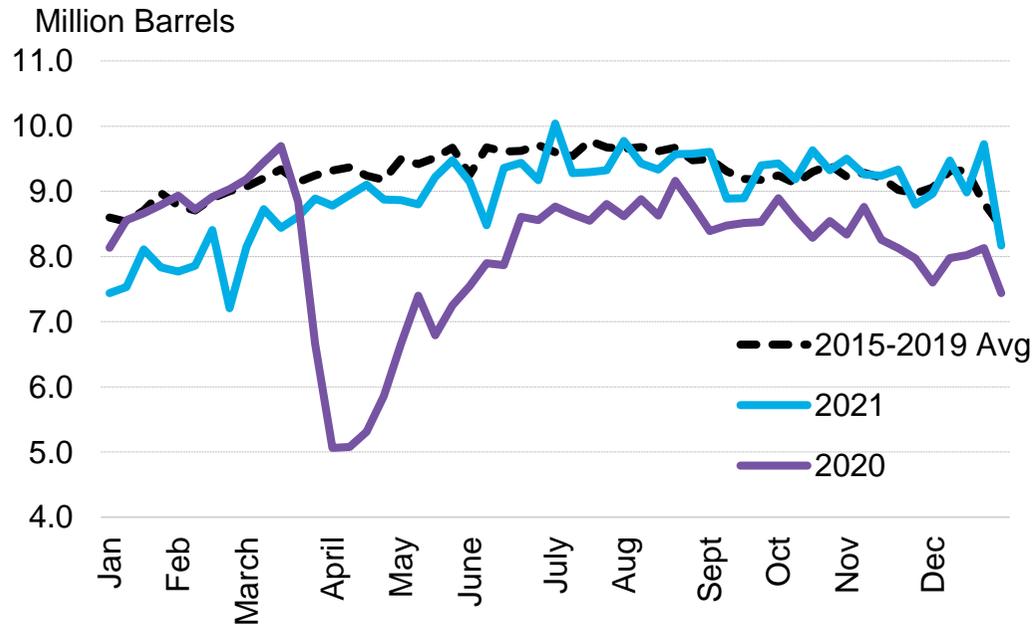
Source: BloombergNEF. Note: Left chart reflects announced and financed commercial projects. Bars begin at expected commercial operation date. 30-year asset lifetime assumed. "N/A" indicates projects that are planned but have not announced target dates. State mandate means there is a state-level clean energy target. Right chart: PEM means Polymer electrolyte membrane electrolysis system. Western-made represents alkaline systems made by a manufacturer outside of China. Chinese-made represents alkaline systems made by a manufacturer inside of China.



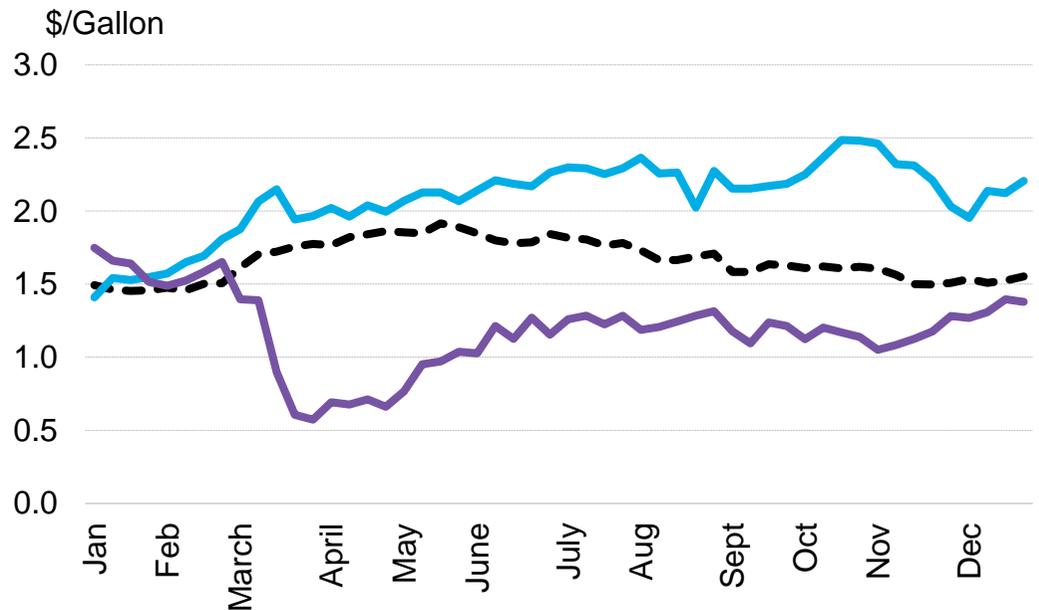
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# Transportation: Gasoline demand and prices

## U.S. gasoline demand



## U.S. wholesale gasoline prices



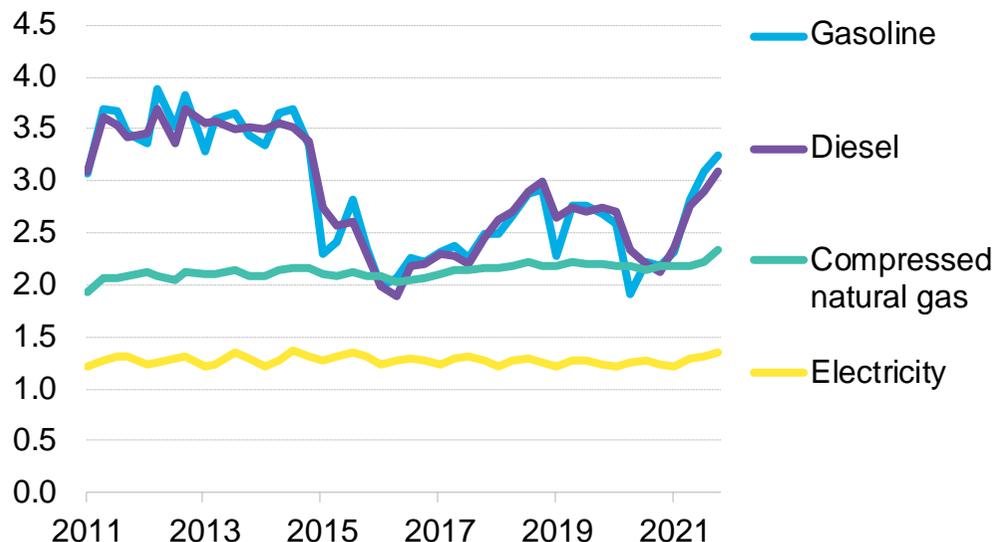
- Demand for gasoline in the U.S. appeared to finally return to pre-pandemic levels in late 2021. Gasoline demand recovered far more quickly than that of other products like jet fuel, which still remains 10-20% below pre-pandemic levels.
- The four-week moving average of product supplied, the most commonly used indicator for U.S. gasoline demand, entered the year more than 1 million barrels a day below 5-year average levels. More drivers began to hit the roads and return to their commutes as concerns over the Delta variant waned through 1H 2021, although demand still held below 5-year levels (outside of 2020) until the fall.
- U.S. wholesale gasoline prices were on average 75% higher than prices in 2020 and 21% higher than 2019. Increased crude oil prices, greater demand for gasoline, and lower gasoline inventories contributed to higher gasoline prices. Demand surpassed 5-year average levels in October 2021, leading to the largest recorded year-over-year increase in prices.

Source: BloombergNEF

# Transportation: Fuel prices and EV sales

## Average vehicle fuel prices

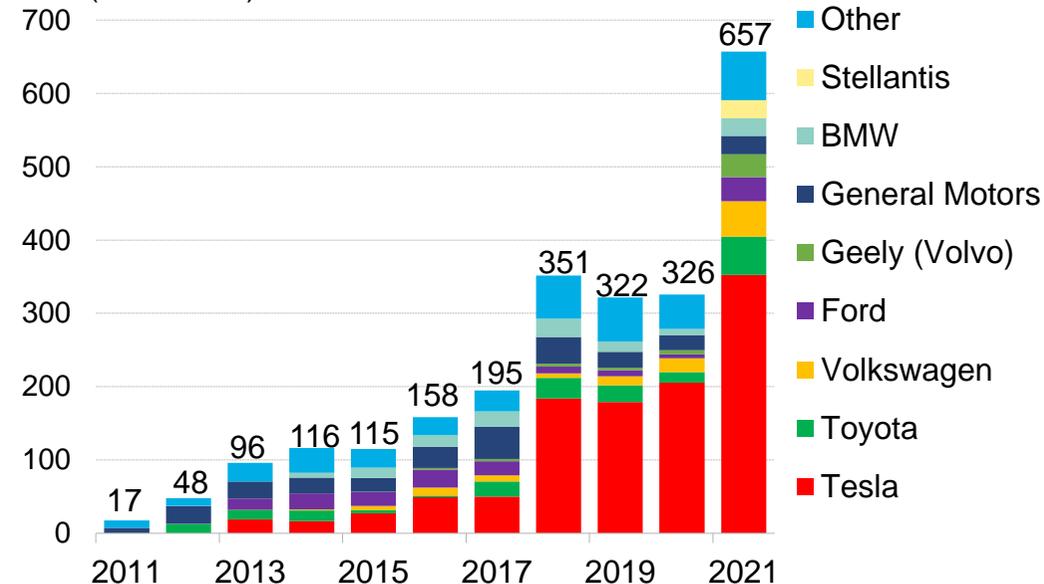
\$/gasoline gallon equivalent (GGE)



- Electricity has been the most competitive fuel for transportation in the U.S. for over a decade, remaining well below gasoline prices. In 2021, the U.S. saw gasoline prices spike to an average of \$2.87 per gallon as the economy rebounded. As a result, the gap between electricity and gasoline costs widened
- The cheaper cost of electricity makes the total cost of ownership of a battery-electric vehicle more appealing, though EV's upfront cost are still a few years away from their gasoline counterpart. BNEF expects to reach price parity by mid-decade in the U.S.
- If sections of the Build Back Better Bill passes in 2022 then there would be an additional \$20 billion investment in EVs.

## Electric vehicle sales

Units (thousands)

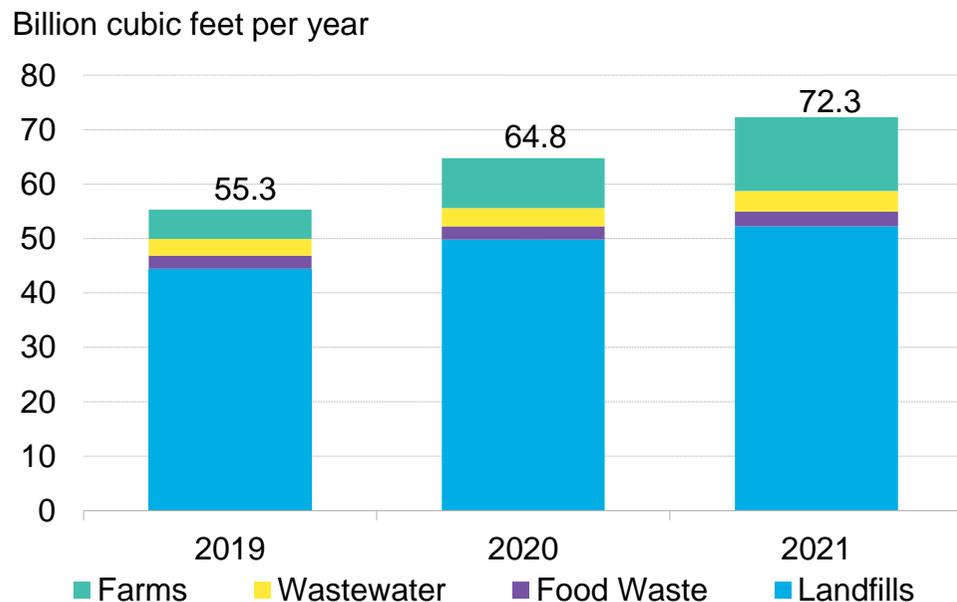


- In 2021, U.S. EV sales hit 657,000 units, a doubling from the 325,000 cars sold in 2020. While the auto industry continues to bounce back from the pandemic, a new challenger emerged for the broader industry – supply chain shortages due to a lack of semiconductor chips.
- Tesla continued to be the highest selling automaker in the U.S. – hitting 50% of all EVs sold. The highest sellers were Tesla's Model Y, which hit 190,000 units and the Model 3, which hit over 121,000 units.
- Battery electric vehicles composed of 75% of 2021 sales, while plug-in hybrid electric vehicles made up close to the remaining 25%. Fuel cell passenger vehicles remain a small part of the overall market with 3,341 units being sold in 2021, totaling 12,272 units.

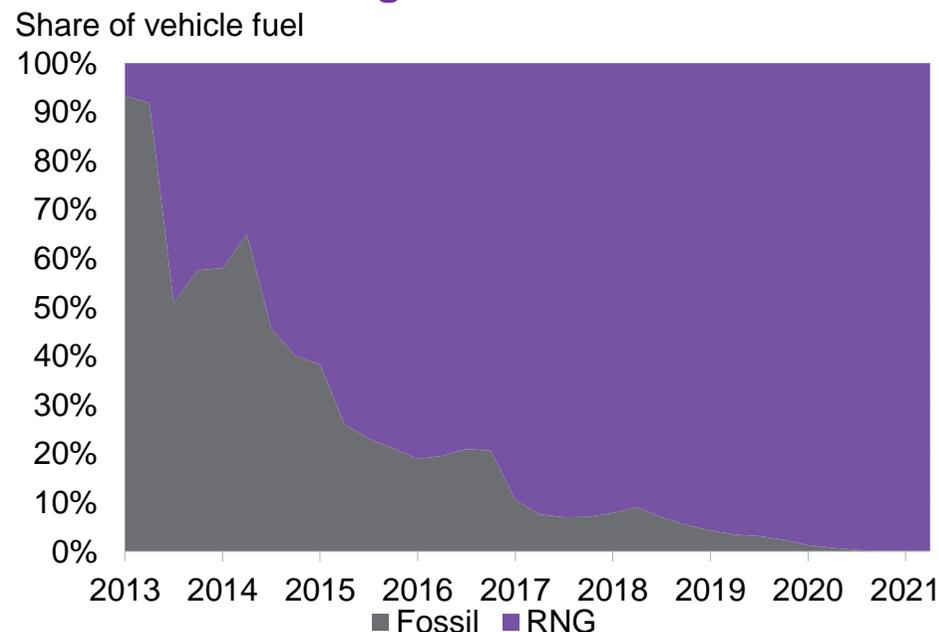
Source: BloombergNEF, Marklines, U.S. Department of Energy.

# Transportation: Renewable natural gas production and vehicle demand

## RNG production capacity, by source



## California natural gas vehicle demand



- To date, the vast majority of renewable natural gas (RNG) by volume has been produced at landfill sites. On the demand side, nearly all has been used in transportation. Both of these dynamics are set to shift in the coming years as more non-landfill/anaerobic digestion projects are developed and large natural gas customers choose to buy RNG. Already, of the 230 operational RNG projects, only 75 (33%) are at landfills. The rest are anaerobic digesters which process their biogas into pipeline-quality RNG.
- Manure-based anaerobic digesters have become the leader in new project growth; current incentives under the federal Renewable Fuel Standard and California's Low Carbon Fuel Standard (LCFS) allow swine or dairy manure biogas to be worth over \$100/MMBtu.
- In terms of demand, the California vehicle fuel market became fully saturated in 2021. Industry interest is shifting to utilities who want to use RNG to lower their carbon footprint and that of their customers, with 33 states taking action to promote the use of the fuel for thermal heating purposes in the residential or commercial sectors, up from 26 in 2020.
- RNG production capacity grew 12% year-on-year and biogas and RNG investments are growing quickly, with \$3 billion earmarked for RNG investment in 2021. This is an increase of 88% from the \$1.6 billion in new investments announced in 2020.

Source: BNEF, Argonne National Labs, RNG Coalition, Company announcements, California Air Resources Board, ICF

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