



Sustainable Energy in America **2024 Factbook**

Tracking Market & Policy Trends

BloombergNEF

 **The Business Council
for Sustainable Energy®**

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Table of contents



<u>1. Executive summary</u>			
<u>2. A look across the US energy sector</u>			
<u>3. Policy</u>	<u>3.1 Infrastructure and emissions</u>	<u>6. Deployment</u>	
	<u>3.2 Tax credits and stimulus</u>		
	<u>3.3 Vehicle standards</u>		
<u>4. Finance</u>	<u>4.1 Energy transition investment</u>		<u>7. Transportation</u>
	<u>4.2 Utility investment</u>		
	<u>4.3 Corporate sustainability</u>		
<u>5. Economics</u>	<u>5.1 Levelized costs of electricity</u>	<u>6.1 Energy efficiency</u>	
	<u>5.2 Environmental markets</u>		
			<u>6.3 Solar and wind</u>
		<u>6.4 Storage</u>	
		<u>6.5 Hydrogen</u>	
		<u>7.1 Gasoline</u>	
		<u>7.2 Fuel prices and EV sales</u>	
		<u>7.3 Renewable natural gas</u>	

About the Factbook: 2024 updates



What is it?

- The Factbook **aims to augment existing sources** of information on US energy.
- It **focuses on renewables, efficiency, natural gas, distributed power and storage, and sustainable transportation.**
- It **fills important data gaps** in certain areas, such as clean energy investment flows and contribution of distributed energy.
- Wherever possible, it **contains data through the end of 2023.**
- In most cases, it **employs BloombergNEF data.** This is augmented by data from the Energy Information Administration (EIA), the Environmental Protection Agency (EPA), the Federal Energy Regulatory Commission (FERC), the American Council for an Energy-Efficient Economy (ACEEE), Lawrence Berkeley National Laboratory, and other sources where necessary.
- It **contains the 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 12th edition of the Factbook, which was 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 multiple sectors plus discussion around implications of the Inflation Reduction Act, the landmark climate law Congress passed in August 2022.

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 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: Amazon, American Clean Power Association, American Gas Association, Capital Power, Clean Energy Buyers Association, Copper Development Association, Covanta, CRES Forum, Johnson Controls, JPMorgan Chase & Co., 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.

Table of contents



<u>1. Executive summary</u>			
<u>2. A look across the US energy sector</u>		<u>6. Deployment</u>	<u>6.1 Energy efficiency</u>
<u>3. Policy</u>	<u>3.1 Infrastructure and emissions</u>		<u>6.2 Natural gas</u>
	<u>3.2 Tax credits and stimulus</u>		<u>6.3 Solar and wind</u>
	<u>3.3 Vehicle standards</u>		<u>6.4 Storage</u>
<u>4. Finance</u>	<u>4.1 Energy transition investment</u>		<u>6.5 Hydrogen</u>
	<u>4.2 Utility investment</u>	<u>7. Transportation</u>	<u>7.1 Gasoline</u>
	<u>4.3 Corporate sustainability</u>		<u>7.2 Fuel prices and EV sales</u>
<u>5. Economics</u>	<u>5.1 Levelized costs of electricity</u>		<u>7.3 Renewable natural gas</u>
	<u>5.2 Environmental markets</u>		

Executive summary (1 of 6)

Clean Energy Transition Thrives in 2023, Boosted by Strong Policy Support

Both the pace and scope of the clean energy transition grew in 2023, supported by a suite of federal policies. While many post-pandemic market challenges eased over the course of 2023, the headwinds of high interest rates and disrupted clean energy supply chains remained. However, the market signals created by new policies under the Infrastructure Investment and Jobs Act and the Inflation Reduction Act (IRA) bolstered adoption of renewables and electric vehicles, drove entirely new levels of activity in nascent low- and zero-carbon fuels and processes and spurred a wave of domestic manufacturing announcements.

Mature sectors grew, setting records

The construction of new renewable power grew, and solar set records. In 2023, the US added a record 42GW of new renewable power-generating capacity to its grid, including distributed rooftop generation on homes and businesses. However, the fortunes of solar and wind diverged – both large-scale and rooftop solar set records for new build, while wind additions were the lowest since 2015. New biomass, geothermal, waste-to-energy and small hydro capacity build remained comparatively small in 2023. In all, 35MW of new biomass and waste-to-energy capacity came online in 2023.

Despite higher costs and supply chain uncertainty, the solar market benefitted from a waiver on tariffs imposed on cells and modules imported from Southeast Asia, which supplied 78% of the country's photovoltaic module imports in 2023. This led to a near-doubling of imports, year-on-year, with 50GW of modules imported in 2023. However, legal challenges are not yet over, and it is possible that retroactive tariffs could be applied on imports going back to 2022. The industry absorbed this uncertainty, weighing other factors that led to strong growth, such as high demand and a beneficial tax credit regime.

Renewable energy sources met a record volume of US energy demand in 2023. Specifically, the contribution of wind, solar, biomass, waste-to-energy, geothermal and hydro rose at the fastest pace among major sectors of the economy. In power, renewables contributed 972TWh, or 23% of total US power generation in 2023 – their highest level ever. The growth was driven by an increase in solar generation, which offset declines in hydro and wind production. In 2023, zero-carbon power (renewables generation plus nuclear power) accounted for an all-time high of 41.1% of all output.

Executive summary (2 of 6)

Electric vehicle sales surged

Electric vehicles (EVs) had another record year of sales in 2023. Sales of EVs and fuel-cell vehicles hit nearly 1.46 million, up 50% from 2022. EV sales surged in response to price cuts, IRA incentives and a slew of new models. Tesla, the biggest player in the market, saw its proportion of new sales fall to 46% in 2023 from 52% in 2022. Other carmakers leading sales are Stellantis, Hyundai-Kia, GM, BMW and VW. Battery-electric vehicles (BEVs) dominated: they made up 80% of 2023 sales, with plug-in hybrid electric vehicles (PHEVs) making up the remaining 20% and fuel-cell vehicles accounting for well under 1% of sales.

Energy storage deployment more than doubled

The US commissioned an estimated 7.5 gigawatts (GW) of battery storage in 2023, a 62% rise year-on-year, to bring total installed capacity to 19.6GW. Despite record new additions for the fourth year in a row, the US was eclipsed by China as the largest energy storage market in the world and stood in second place in 2023. Tax credits and other incentives passed through the IRA spurred storage deployments and investment in the sector. Funding to increase the duration, and therefore the grid benefits, of storage also picked up in 2023, with the US Department of Energy (DOE) announcing \$13 million for advanced pumped hydro storage, and \$505 million towards long-duration energy storage, or projects that can deliver electricity for 10 hours or more.

Green shoots from climate package seeds: emerging low-carbon sectors

Interest in “clean” hydrogen takes off with strong policy foundations

As of 2023, developers in the US have announced hydrogen project pipelines totaling 10.4 million metric tons per year. A favorable policy environment was the main driver for these plans, which are a mix of conventional hydrogen production with carbon capture and storage, and electrolysis running on renewable energy. The Biden administration’s regional hydrogen hubs, established under the bipartisan Infrastructure Investment and Jobs Act of 2021, will contribute an additional three million metric tons of hydrogen per year once all four phases of the program are complete. The hubs are currently in award negotiations with the Department of Energy, which are expected to be completed by mid-2024. Pre-rulemaking draft guidance on the IRA’s 45V hydrogen production tax credits in 2023 proposed that qualifying facilities must meet requirements on incrementality, time matching, and deliverability of production to emissions. The strictness of these rules has split opinion among market participants in the near term. The draft rules are expected to be released and finalized over the year.

In 2023, BNEF tracked 437MW of hydrogen-producing electrolyzers shipped to the US, with the largest share from HydrogenPro’s 220MW delivery to the ACES Delta project in Utah, followed by Plug Power shipping 120MW.

Executive summary (3 of 6)

Manufacturing facility plans rise, battery manufacturing grows

The number of manufacturing facilities planned in response to the IRA rose to 104 as of December 2023, representing \$123 billion in announced investments. Battery and solar facilities dominate, with 34 facilities planned in each sector. The majority of battery manufacturing announcements were for cell manufacturing, intended to support the automotive sector.

By the end of 2023, the US had 114GWh of lithium-ion battery manufacturing capacity. Cumulative capacity grew 28% year-on-year, with 25GWh of new capacity additions. Though capacity has grown significantly, this is short of the 178GWh that was anticipated to be commissioned by the end of 2023, based on original company announcements. Slower-than-expected EV market demand has decelerated expansions throughout the year.

New sectors develop interest in carbon capture and storage

The US is the global leader on carbon capture and storage (CCS), with 23 million metric tons per annum (Mtpa) of operational capacity, and the IRA has provided the most generous incentives in the world to capture carbon dioxide that is currently emitted into the atmosphere. The overwhelming majority of carbon capture currently installed in the US is in natural gas processing facilities, but a generous revival of the 45Q tax credit has led to a jump in sectors planning to add CCS. Sectors like ethanol, power generation, ammonia and hydrogen, and chemicals make up most of the demand from the 137Mtpa of new planned projects.

Renewable fuels and Biofuels grow, seeing more supply and demand

Renewable natural gas: The US continues to build out more renewable natural gas (RNG) production capacity, which grew 13% year-on-year in 2023. Investment tax credits included within the IRA can offset the cost of new-build RNG facilities by 6-30% of eligible costs. As of 2023, 17 natural gas utility companies now have regulatory approval to sell RNG to customers using a special tariff mechanism. RNG also saw more adoption in transport, reaching 55% of total natural gas consumed in vehicles in 2023, the first time it has surpassed conventional natural gas.

Liquid biofuels: IRA incentives drove increased production of sustainable aviation fuel, another name for renewable jet fuel. Demand for such fuel is increasing amongst some airlines' corporate customers, especially those looking to reduce their emissions associated with aircraft combustion (Scope 3 carbon emissions). Renewable jet fuel supply rose 81.2% year-on-year. Renewable diesel saw 53% year-on-year growth.

Executive summary (4 of 6)

Growth was uneven, and work remains to be done in some sectors

Both onshore and offshore wind struggled

Interconnection delays and a lack of early-stage development projects were the year's primary complications weighing on US onshore wind build in 2023. While the IRA revived the tax credit mechanism for new wind farms, it will take time for the support offered by the new law to translate into new capacity additions. In addition, the regions where the tax credits have the most value are those where wind already has a high share of generation, meaning transmission congestion can hold back new build. Offshore wind also struggled in 2023, with the year marked by project cancellations and contract renegotiations as developers confronted high costs of capital, inflation, supply chain constraints and uncertainty over tax credit qualification. For 6.7GW, or half of US contracted capacity, these blows to project economics proved fatal. However, efforts to sustain expansion of the offshore wind sector continued last year through state procurements, lease auctions, regulatory decisions, and company investment decisions.

Energy efficiency spending stabilized after a Covid-related drop

After a sharp drop in efficiency spending from 2019 to 2020 due to the pandemic, efficiency spending stabilized in 2021, the last year for which there is complete data. Spending rose 1% year-on-year from 2020 to 2021 to reach \$7.7 billion, according to data compiled by the American Council for an Energy Efficient Economy (ACEEE). Spending on efficiency improvements related to electricity stayed essentially flat at \$6 billion in 2021, while spending on improving the efficiency of natural gas delivery grew from \$1.5 billion to \$1.7 billion. The total impact of all ratepayer-funded electric energy efficiency programs in place in 2021 was a savings of about 290 million MWh – equivalent to approximately 7.63% of 2021 electricity consumption, according to ACEEE.

Executive summary (5 of 6)

Post Covid disruptions and rebound-effects end

US emissions started to fall again, ending post-covid rebound

In 2023, the US emitted 6,229 million metric tons of carbon dioxide equivalent (MMtCO₂e) of greenhouse gases, according to BNEF estimates. This represents a 1.8% drop from the year prior, with emissions falling in every sector except transport. As a result, 2023 was the first year since 2020 (an anomalous year due to the impact of lockdowns) that US emissions have fallen – if there was a post-Covid rebound, it appears to be over. Ignoring 2020, the last time US emissions were this low was 1987. Progress remains concentrated in the power sector, where the annual change in emissions was -95MMtCO₂e, or 83% of the net drop. Power is now the US economy's third-highest emitting sector, having been first as recently as 2016. The majority of emissions reductions in the power sector to date can be attributed to coal being displaced by natural gas. In the long-term natural gas will also need to decarbonize or be replaced by zero- or low-carbon generation sources. This could happen through uptake of renewable energy and renewable fuels, as well as investments in energy efficiency and carbon capture and storage. US emissions are 15.8% lower than 2005 levels, while power emissions are 40% lower than 2005 levels.

Key clean energy cost inputs (mostly) find new equilibrium

Prices for key commodities that underpin the clean power sector finally eased in 2023, with some nearly returning to pre-pandemic levels. The global price of polysilicon – used to manufacture photovoltaic solar – fell steadily over 1H 2023, as new factories ramped up production and tipped the market back toward oversupply. Lithium carbonate and lithium hydroxide, key minerals for batteries, saw their prices fall sharply in 2023, reversing the surge seen in 2022, when supply chain disruptions, including the Russian invasion of Ukraine, significantly disrupted metal supply and pushed prices as high as 10-14 times their pre-pandemic levels. By the end of 2023, lithium commodity indices were trading at just twice their pre-pandemic levels. International freight costs also dropped to pre-pandemic levels. However, this cost easing is not uniform. The price of steel has fluctuated over 2023, ticking back up to twice pre-pandemic costs. This impacts the wind industry, where steel is a substantial part of the material costs. In addition, interest rates are 3.3 times higher than in January 2020, which raises the cost of finance for all clean power plants.

Falling natural gas costs

US natural gas prices fell from highs in 2022, with milder winter weather and higher production from Alaska. The average benchmark Henry Hub wholesale natural gas price for 2023 was 27% below 2022 levels. Retail natural gas prices were down for all segments – residential, commercial and industrial consumers. Residential price adjustments tend to lag index prices by six to 12 months, depending on utility practices. Industrial prices tend to be most correlated to wholesale markets.

Executive summary (6 of 6)

Persistent trends remain at play

US energy productivity rose to record levels in 2023

In 2023, the US economy expanded by 2.4% while primary energy consumption slowed down by 1.4% year-on-year. Taken together, the US “energy productivity” (the ratio of US GDP to total US energy consumption) increased by 3.8% year-on-year. This resulted in the highest economic output achieved per unit of energy consumed: on average, \$240 billion of GDP was generated per quadrillion British thermal units (Btu) of energy consumed. With Covid-19 firmly past, US primary energy consumption dipped, returning to the declining energy consumption trajectory seen since the peak of 2007. Energy consumption in 2023 was 5.8% lower than the 2007 peak.

The highest number of extreme weather events

The impacts of climate change continue to be felt throughout the US, and 2023 saw the highest number of extreme weather events recorded. The country experienced 28 climate-related disasters each causing at least \$1 billion in damage over the 12 months. Although the number of events has increased, the costs associated with them have decreased, as there were fewer expensive tropical cyclones and a higher incidence of severe storms. About 19 severe storms made up 58% of the \$92.9 billion dollars in damage in 2023. In response, citizens and communities are installing a growing number of microgrids powered by solar, storage, natural gas and diesel generation sets.

US natural gas demand reaches record, as the country becomes the world’s largest supplier of LNG

Demand for US natural gas rose 4.3% in 2023 from the year prior to reach another record of 99.9 billion cubic feet per day (Bcf/d). Higher demand was due to more consumption by the power sector, as well as exports – both via pipeline (to Mexico) and liquefied natural gas (LNG) shipments. A warmer-than-normal winter in early 2023 saw lower consumption for heating. This in turn led to higher levels of gas reserves in underground storage, which pushed prices down over the course of the year. The Henry Hub front month contract fell as low as \$2.00 per million BTU. These prices improved gas power plant economics when compared to coal, which also retreated from the market as plants retired, resulting in more gas being burnt to produce power in 2023. About 20% of US gas demand is for exports, whether through pipelines to neighboring countries or shipped as LNG. Following the return of the Freeport terminal to service, LNG feedgas demand from exports was 31% higher than in 2022. In addition, hotter-than-normal temperatures over the summer, particularly in the south, saw demand from Mexico rise.

Quick facts (1 of 2)

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

Market responses to the IRA

- **A record-shattering \$303.3 billion in energy transition financing was deployed in the US** for clean energy technologies, including renewables, electric vehicles, power grid investment and others.
- **By the end of 2023, the number of manufacturing facilities planned in response to the IRA rose to 104**, representing \$123 billion in announced investments. Battery facilities dominate, with 34 facilities planned
- **42GW of new renewable power-generating capacity was added to the US grid**, primarily driven by robust solar additions. Renewable energy use also set new highs: 8.8% of total US energy demand and 23% of electricity demand.
- **The US is the second-largest energy storage market in the world** and commissioned an estimated 7.5GW of battery storage capacity in 2023, a new US record. China overtook the US to become the largest storage market in 2023.
- **Electric vehicle sales surged 50% to nearly 1.46 million vehicles.** The rise in sales was driven by new EV incentives, Tesla's price cuts and more EV models being released.
- **Interest in "clean" US hydrogen is growing.** About 437MW of new electrolyzers were shipped in 2023, and plans to add nearly three million metric tons of low carbon hydrogen capacity through the regional hydrogen hubs were announced in 2023. The DOE's hydrogen hubs program announced the winners selected for funding and are currently in negotiations. This infrastructure is key to enabling hydrogen adoption and use.
- **Carbon capture plans are surging:** 137Mtpa of new projects are being planned, against an installed base of 23Mtpa in the US in 2023. Most of the new demand for carbon capture and storage (CCS) comes from diverse sectors like ethanol, power generation, ammonia and hydrogen, and chemicals, while current installations are primarily at natural gas processing facilities.
- **Renewable diesel and jet fuel supply rose 52.8% and 81.2% year-on-year, respectively.** Globally, airlines signed a total of 36 agreements to procure sustainable aviation fuel (SAF) from January to early December 2023. To date, US-based airlines lead SAF procurement, which likely stems from government incentives such as investment tax credits under the IRA for SAF producers..

Quick facts (2 of 2)

Energy trends and updates

- **US CO2 emissions were 1.8% lower in 2023 than in 2022, BloombergNEF estimates:** Transport remained the top-emitting sector with industry second and power third.
- **US “energy productivity” set a new record in 2023** as economic growth outpaced energy consumption, and grew 3.8% year-on-year. The trend is even starker over the past 10 years, where GDP has grown by 25.5% while primary energy consumption has decreased 4%. The result: a 30.6% increase in productivity.
- **Total US energy consumption fell 1.4% year-on-year**, ending the rebounding after the Covid-19 pandemic and returning to trends of lower energy consumption. A warmer-than-normal winter also resulted in less fuel consumed for building heat.
- **Energy spending accounted for 4.2% of total US personal consumption expenditures in 2023**, down 0.6 percentage points from 2022 as the cost of motor fuel fell, along with slight drops in the price of natural gas and electricity.
- **Inflation and higher interest rates boosted levelized costs of electricity (LCOEs) for renewable energy technologies** in 2023, but natural gas plants saw costs fall as the underlying price of the fuel fell year-on-year.
- **Demand for US natural gas rose 4.3% to reach 99.9 billion cubic feet per day.** The jump was led by stronger power sector demand and rising LNG exports, which offset modest declines across industrial, commercial and residential sectors.
- **Corporations buying clean power slowed their activity in 2023**, signing up to buy 17.1GW zero-carbon power compared with a record 20GW in 2022. The number of deals signed fell to less than 100 as the prices of power purchase agreements jumped in response to inflationary pressures.
- **Only one new US company joined the RE100, pledging to offset their power consumption with clean power at a future date**, reflecting the growth of broader net zero targets and the fact that the largest players in the market have already committed to the alliance
- **A record number of extreme weather events hit the US in 2023, with 28 events recorded.** This cost the US \$92.9 billion in damages – although this was less than seen in 2022, when a smaller number of events caused more monetary damage.
- **Coal’s contribution to power generation slid to 15.8% in 2023, its lowest level ever.** It was largely replaced by natural gas, which met 43% of US power demand with a record estimated output of 1,809 terawatt-hours (TWh), up 6.5% from the year prior.
- **Energy efficiency spending stabilized in 2021 (the last year with complete data).** Utility spending on power and natural gas improvements rose 1% year-on-year to reach \$7.7 billion.

These trends are discussed in far greater depth, and with graphic illustrations, in the Factbook itself.

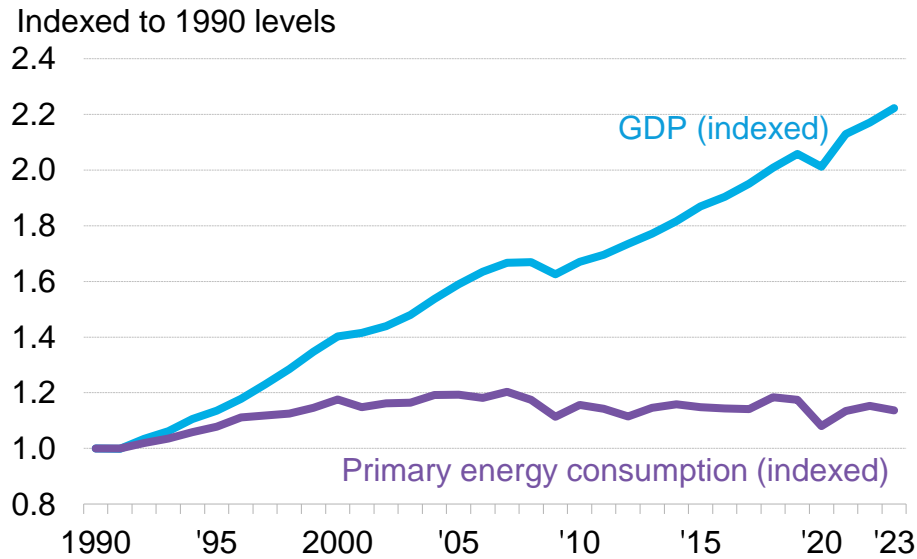
Table of contents



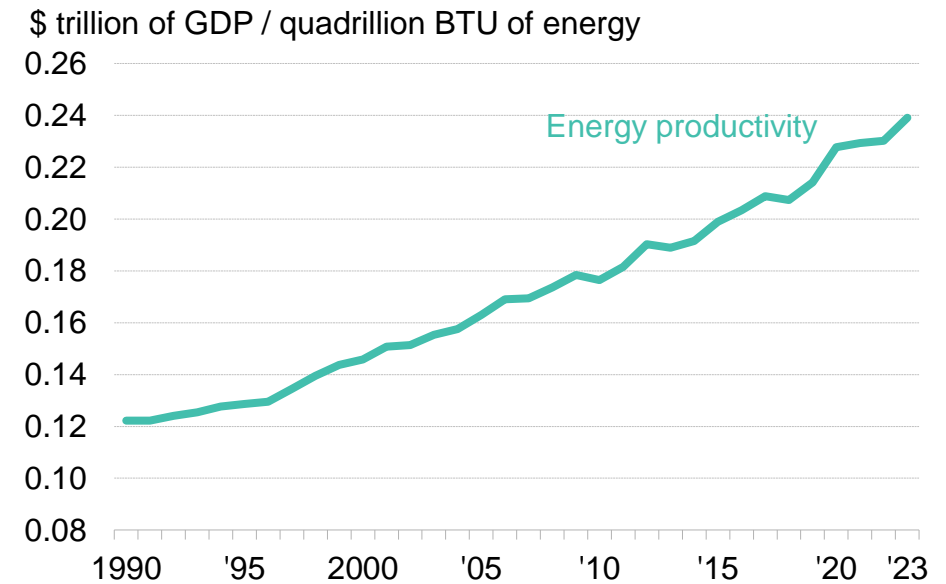
<u>1. Executive summary</u>			
<u>2. A look across the US energy sector</u>			
<u>3. Policy</u>	<u>3.1 Infrastructure and emissions</u>	<u>6. Deployment</u>	
	<u>3.2 Tax credits and stimulus</u>		
	<u>3.3 Vehicle standards</u>		
<u>4. Finance</u>	<u>4.1 Energy transition investment</u>		<u>7. Transportation</u>
	<u>4.2 Utility investment</u>		
	<u>4.3 Corporate sustainability</u>		
<u>5. Economics</u>	<u>5.1 Levelized costs of electricity</u>	<u>6.1 Energy efficiency</u>	
	<u>5.2 Environmental markets</u>		
			<u>6.3 Solar and wind</u>
		<u>6.4 Storage</u>	
		<u>6.5 Hydrogen</u>	
		<u>7.1 Gasoline</u>	
		<u>7.2 Fuel prices and EV sales</u>	
		<u>7.3 Renewable natural gas</u>	

US energy overview: Energy productivity

US GDP (real) and primary energy consumption



US energy productivity

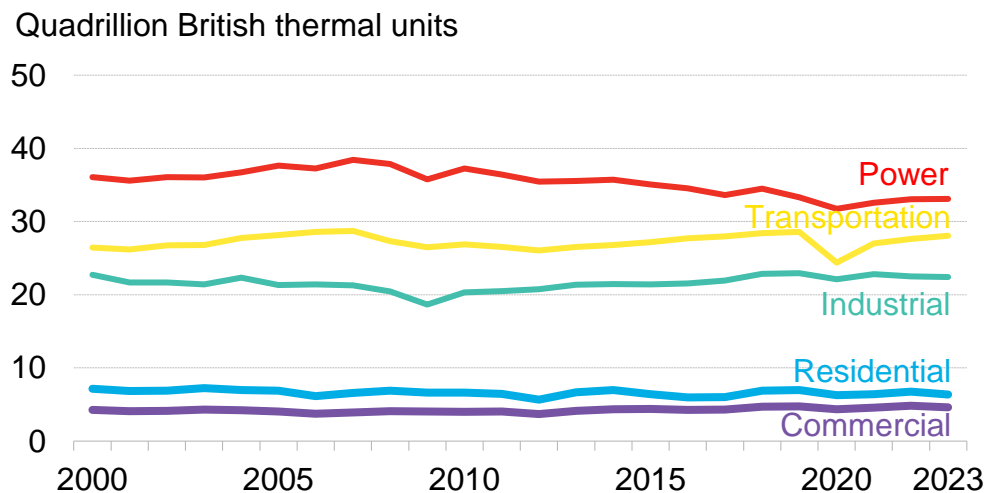


- In 2023, the US economy expanded by 2.4% while primary energy consumption slowed down by 1.4% year-on-year. Taken together, US “energy productivity,” defined as the ratio of US GDP to total US primary energy consumption, increased by roughly 4%.
- The dip in US primary energy consumption was likely caused by a decline in coal consumption and a warmer-than-normal winter that resulted in lower fuel use for heating residential and commercial buildings. Coal consumption reached the lowest level recorded in the past 33 years, at 8.15 quadrillion British thermal units (BTU), and was replaced in the power sector primarily by natural gas, as well as renewable energy.
- Over the past 10 years, US GDP has grown 25.5%, while primary energy consumption has decreased 4%. The result: a 30.6% increase in productivity. Looking even further back, the long-term trend remains clear. From 1990 to 2023, the US logged a 101% improvement in energy productivity.

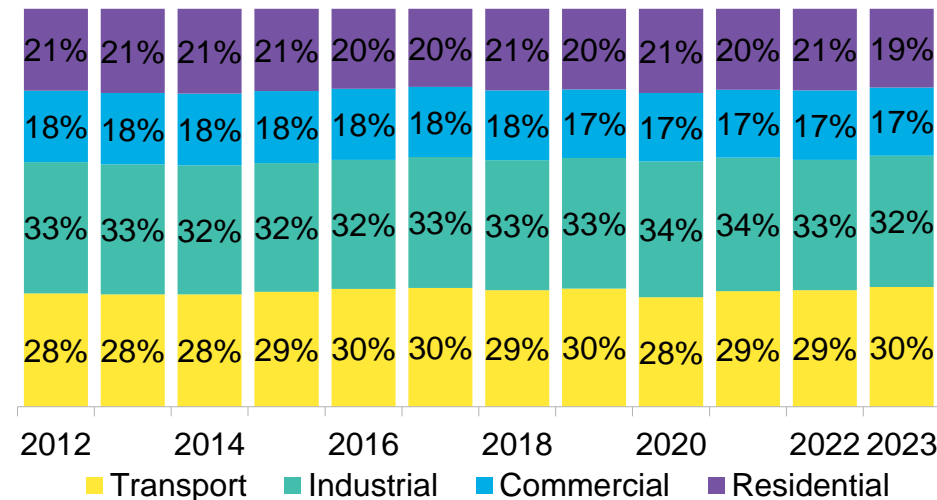
Source: Bureau of Economic Analysis, EIA, BloombergNEF. Note: Values for 2023 are projected, accounting for seasonality, based on latest monthly values from EIA (data available through September 2023). The 2023 GDP estimate is a projection from economists compiled at ECFC <GO> on the Bloomberg Terminal.

US energy overview: Primary energy consumption by sector

US primary energy consumption



US end-use energy consumption

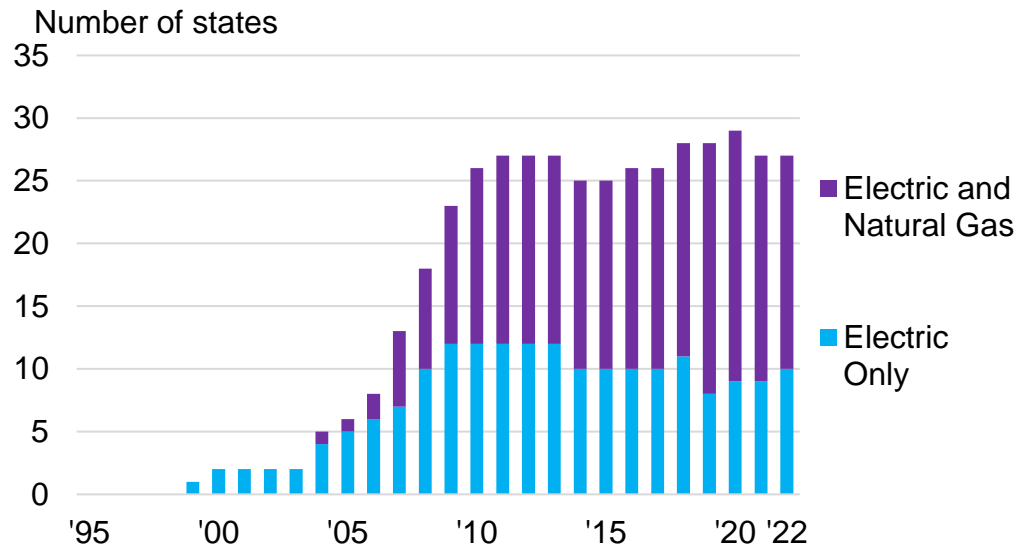


- Residential building, commercial building and industrial energy consumption decreased year-over-year by 6.0%, 3.8% and 0.4%, respectively. Despite increased adoption of electric vehicles that consume less energy, transport energy consumption was 1.5% higher than the year before, although it remained below pre-pandemic levels.
- Sector-level trends as a share of end-use energy consumed only changed slightly year-on-year. Building energy consumption was down by 1.1% , while transport increased by 0.9%. Residential buildings, commercial buildings and industry have steadily reduced their power consumption, while energy consumption through other sources, mostly fuels, is up. This is likely due to power generation itself becoming more efficient and consuming less primary energy per megawatt-hour (MWh) of output. As an example, overall industrial energy use has been trending up and was 11% higher in 2023 than its low point in 2009. However, in that time industry used 11% less power and 16% more energy in the form of direct fuels like gas.

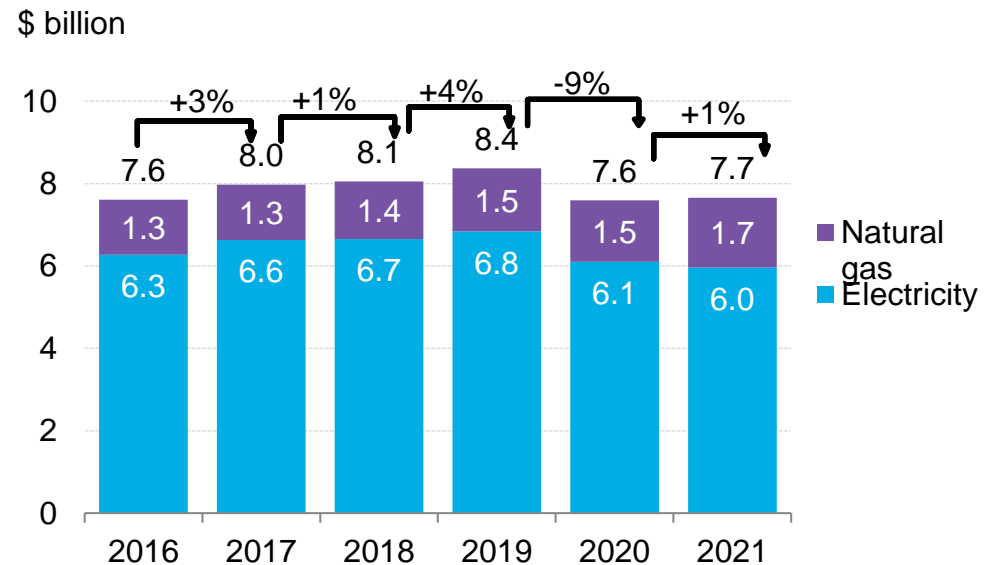
Source: EIA, EPA, BloombergNEF. Note: Values for 2023 are projected, accounting for seasonality, based on latest monthly values from the EIA (data available through September 2023). Electricity is excluded from industrial, residential, commercial and transportation sectors and aggregated in “power” in the left-hand chart. In the right-hand chart, sector end uses include electricity use.

US energy overview: Energy efficiency

US states with Energy Efficiency Resource Standards (EERS)



Utility energy efficiency spending

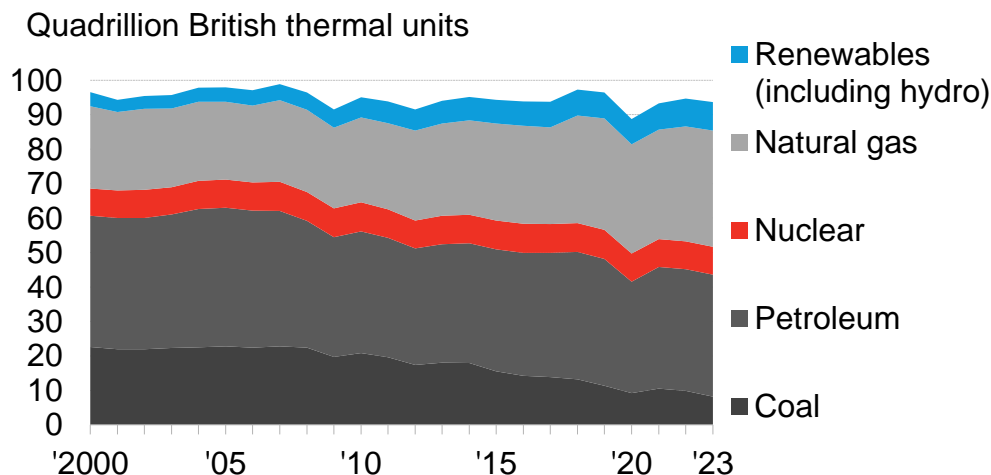


- Energy Efficiency resource standards (EERS) are state-level policies that require utilities to invest in measures that improve end-user efficiency to meet energy-savings goals set by the government. In 2022, 26 states and the District of Columbia had EERS policies.
- After a sharp drop in efficiency spending from 2019 to 2020 due to the pandemic, efficiency spending stabilized in 2021, the last year for which there is complete data. Spending rose 1% year-on-year from 2020 to 2021 to reach \$7.7 billion, according to data compiled by the American Council for an Energy Efficient Economy (ACEEE).
- Spending on efficiency improvements related to electricity stayed essentially flat at \$6 billion in 2021, while spending on improving the efficiency of natural gas delivery grew from \$1.5 billion to \$1.7 billion.
- The total impact of ratepayer-funded energy efficiency programs was a savings of about 290 million MWh in 2021 – equivalent to approximately 7.63% of 2021 electricity consumption, according to ACEEE.

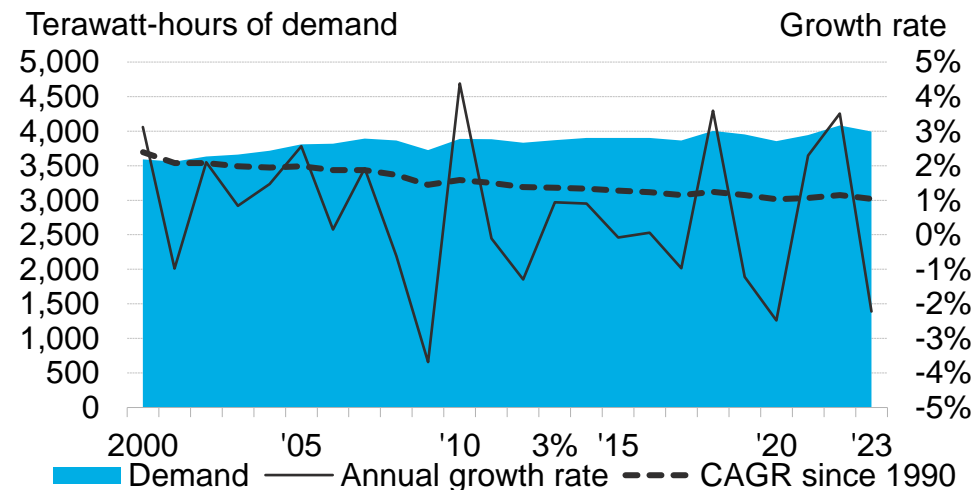
Source: American Council for an Energy Efficient Economy (ACEEE) State Energy Efficiency Scorecard: 2022 Progress Report

US energy overview: Energy and electricity consumption

US primary energy consumption, by fuel type



US electricity demand

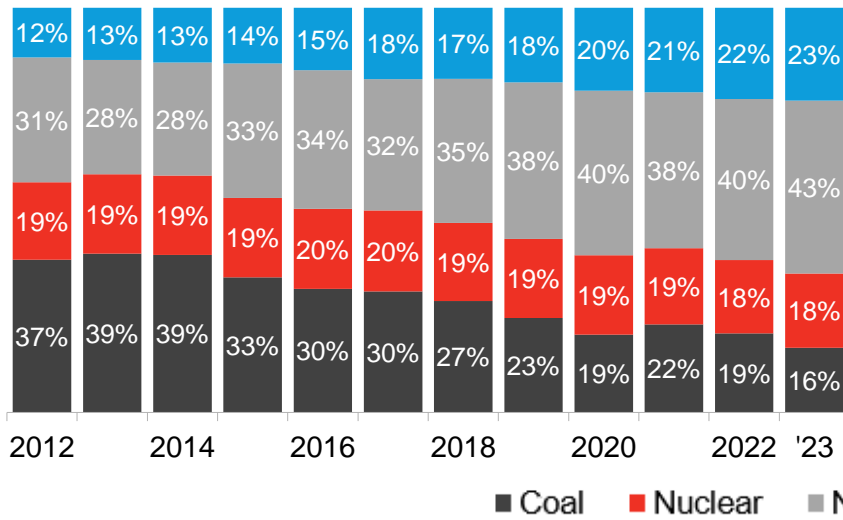


- US total energy consumption decreased 1.4% from 2022 to 2023 to an estimated 93.48 quadrillion BTU. It has now decreased by 6% since its peak of 98.97 quadrillion BTU in 2007. Contributions from non-hydro renewables (primarily wind and solar, but also biomass, waste-to-energy and geothermal) rose roughly 3.5% from the prior year to account for 8% of total US energy consumption.
- The role of natural gas in 2023 continued to grow, rising 1.2% year-on-year. Natural gas now accounts for more than one-third of all US energy consumption. Natural gas consumption is up in tandem with the decrease in coal consumption, as the former replaces the latter in electricity production. Nuclear's contribution remained essentially level in 2023 compared to prior year.
- Coal consumption slipped 17.5% year-on-year to 8.15 quadrillion BTU, less than half its all-time peak of 22.8 quadrillion BTU in 2005. Petroleum use shrank by 0.2% year-over-year, but at 35.3 quadrillion BTU was still solidly within the narrow consumption range of the past 10 years of 34-36 quadrillion BTU (excluding 2020, when consumption fell to 32.3 quadrillion BTU).
- Total retail demand for electricity decreased 2.2% year-on-year, after two years of growth. Electricity demand has risen by 3% in the last decade. The compound annual growth rate (CAGR) for electricity between 1990 and the present day has been slowly decreasing, from 1.4% in 2013 to 1.0% in 2023, as the US economy uses power more efficiently.

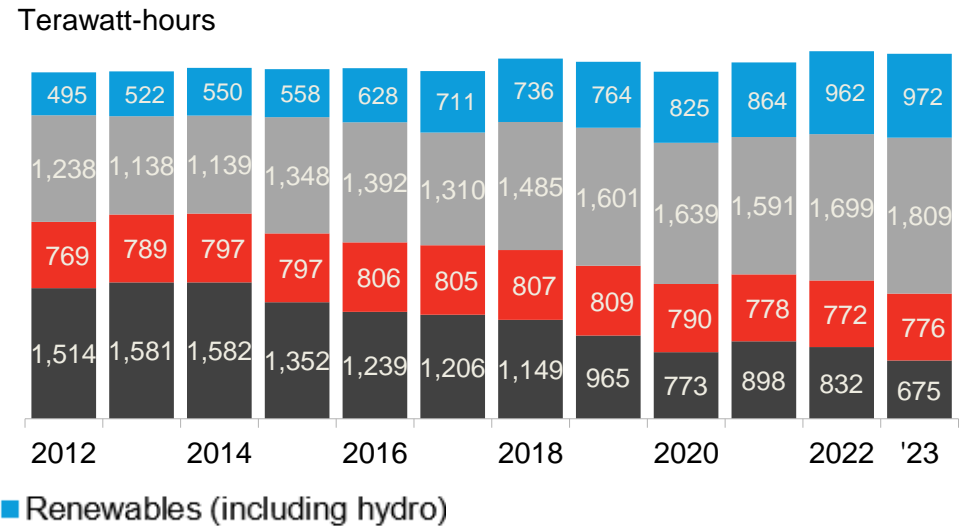
Source: EIA, BloombergNEF. Notes: "CAGR" in the right-hand chart is compound annual growth rate. Values for 2023 are projected, accounting for seasonality, based on the latest monthly values from EIA (data available through September 2023). BTU stands for British thermal units.

US energy overview: Electricity generation mix

Share of US electricity generation, by fuel type



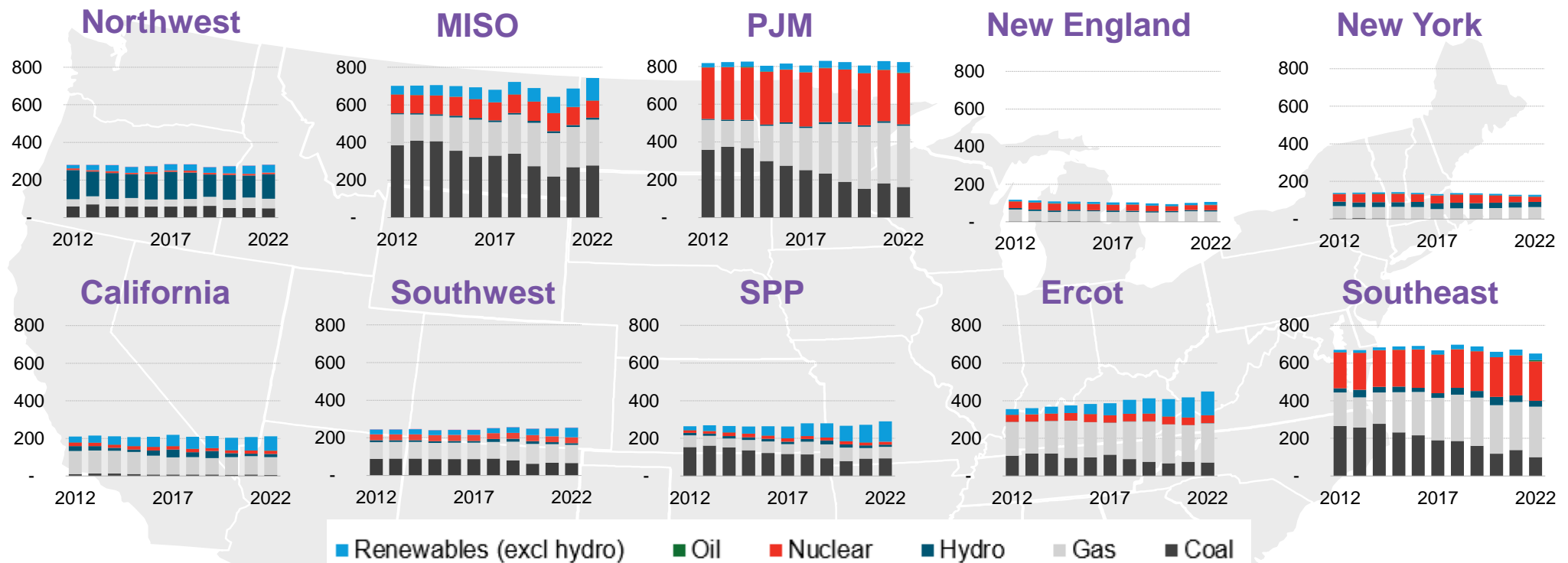
US electricity generation, by fuel type



- Total US power generation decreased by an estimated 0.9% year-on-year to 4,252 terawatt hours (TWh) in 2023. Nevertheless, 2023 had the second-highest volume of power generation of any year over the past two decades, with output 8% higher than in 2010. In 2023, zero-carbon power (renewables plus nuclear power) accounted for 41% of all output, an all-time high.
- Natural gas remained the largest source of US power and set another record with 1,809TWh of production in 2023, up 6.5% from the year prior. In 2013, coal accounted for about 39% of electricity generation and natural gas for 28%; now the roles are beyond reversed, with natural gas accounting for approximately 43% and coal 16% of power generation.
- The collective contribution of renewables, including wind, solar, biomass, waste-to-energy, geothermal and hydro, rose by 1% year-on-year, reaching 972TWh from 962TWh in 2022. A drop in hydro and wind output was offset by strong solar generation.
- Renewables and natural gas are the two generation sources seeing steady growth, rising from a combined 41% of total power generation to 65% in just a decade. Coal-fired and nuclear generation are seeing a steady decline, dropping from 56% of the generation mix to 34% in the same time period.

Source: EIA, BloombergNEF. Note: Values for 2023 are projected, accounting for seasonality, based on latest monthly values from EIA (data available through October 2023).

US energy overview: Electricity generation mix by power market (TWh)

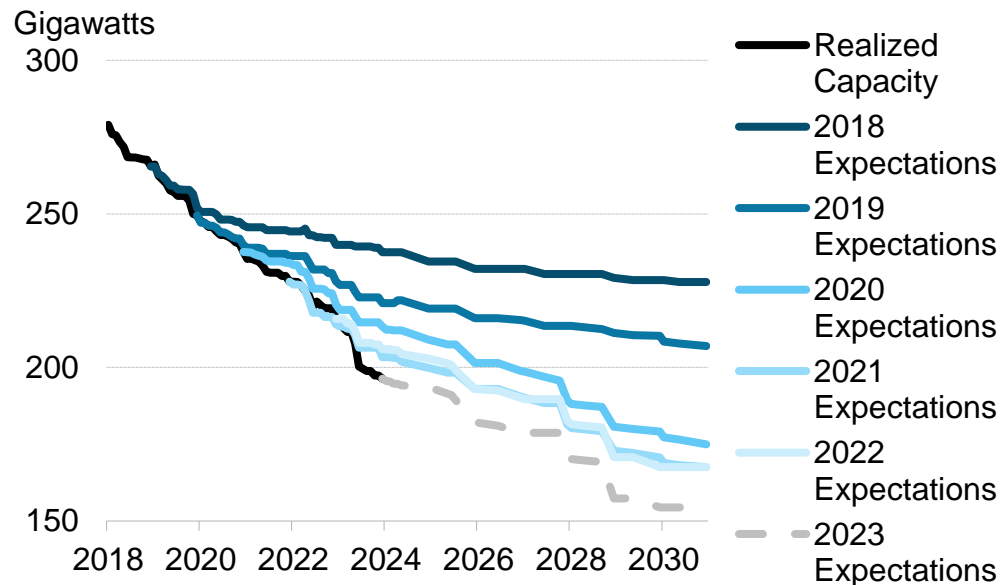


- The power generation mix varies throughout the US, with the share of fuels varying by market. The top-line volume of generation also varies, with some power regions being larger than others. Power can also be sold between regions, incentivizing areas with lower prices to generate more. About two-thirds of US power generation occurs in competitive wholesale markets, with the largest markets being PJM, MISO, and Ercot.
- Major trends over the last decade have included the rise of natural-gas-fired generation and the fall of coal-fired generation in the Southeast and PJM. For 2022, the last year for which there is sufficiently complete regional data, coal generation dropped in most regions, falling 7% compared with 2021. Renewables use also grew across most markets between 2021 and 2022.

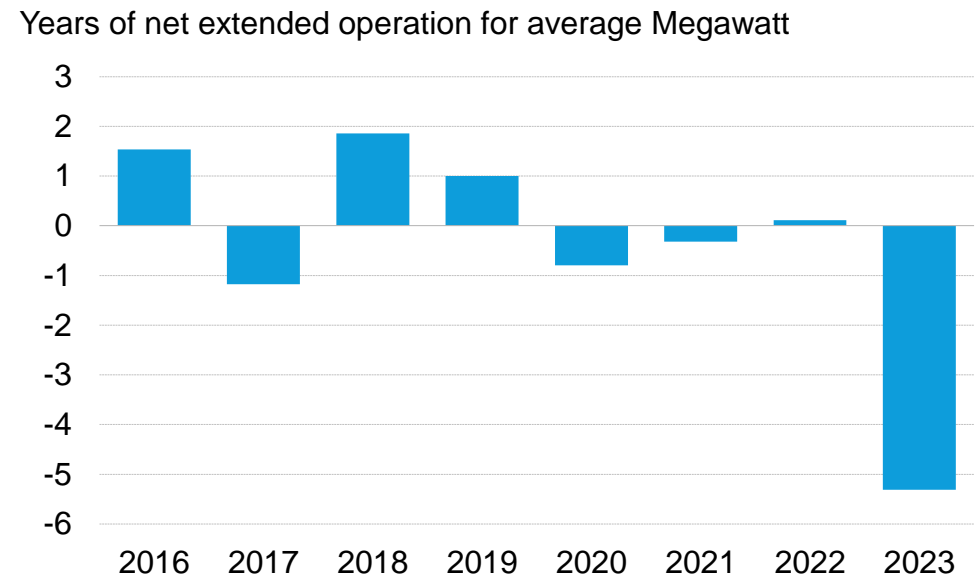
Source: EIA, BloombergNEF. Notes: MISO is the Midwest region; PJM is the Mid-Atlantic region; SPP (Southwest Power Pool) covers the central southern US; Ercot covers most of Texas.

US energy overview: Trends in coal retirement expectations

Realized and planned coal fleet expectations



Change in planned coal retirement expectations

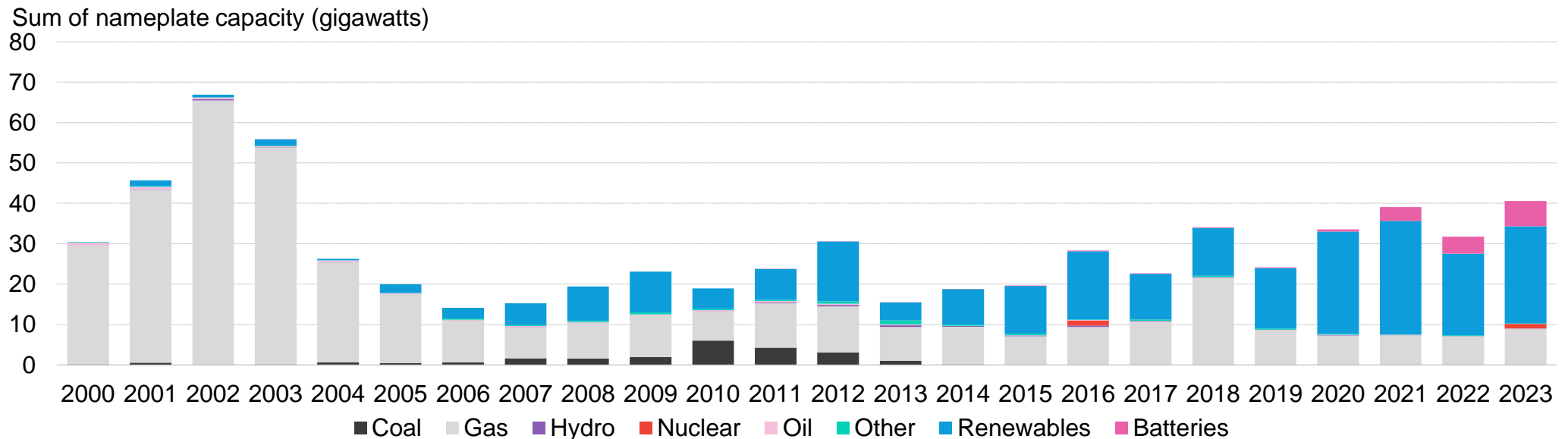


- Operational US coal capacity has been steadily declining over the last few years. From January 2018 to December 2023, operational coal capacity decreased by a total of 81.5 gigawatts (GW). The current fleet stands at 196GW as of 2023, or some 15.3% of the country's capacity.
- Current plans by plant owners to retire facilities, reported by the Energy Information Administration (EIA), show another 43GW lined up to retire by 2030, which would shrink the US coal fleet to 154.5GW by the end of 2030. However, the historic trend suggests more coal retires than owners project – for example, in 2018, EIA data suggested that from January 2018 to December 2023 only 37.7GW would retire, compared with the 81.5GW that did retire during that period.
- Additionally, retirement plans are subject to change, based on the economic outlook for coal plants and other factors. In 2023 there was a strong trend among coal plant operators to bring forward the retirement date of their assets. The life expectancy of the average megawatt (MW) of coal capacity dropped by 5.3 years in 2023. Most of this change comes from the Midcontinent Independent System Operator (MISO) region, which is expecting to see 7.7GW retired by the end of 2025.

Source: EIA, BloombergNEF. Note: 2023 expectations use November EIA data. Prior year expectations use December EIA data.

US energy overview: Electric generating capacity build, by fuel type

US electric generating capacity build, by fuel type

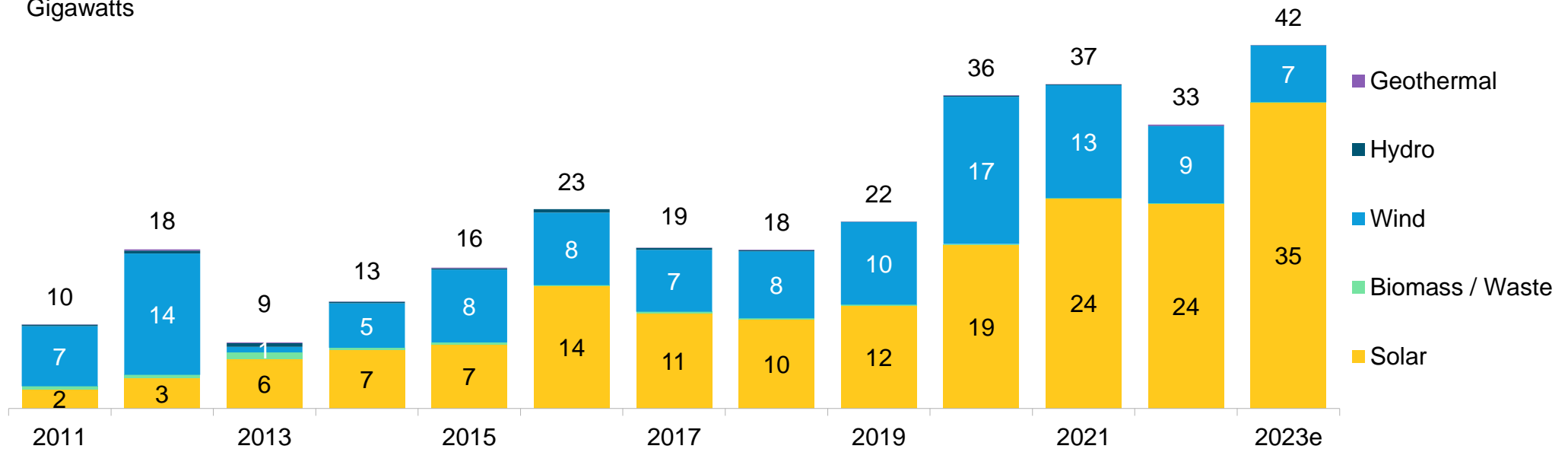


- The US commissioned an estimated 40.5GW of new utility-scale power-generating and power-storage capacity in 2023 – the most since 2003. Renewables accounted for approximately 59% of this, at 24.1GW. The buildout of new wind, solar, biomass, geothermal, waste-to-energy and other zero-carbon technologies rose above 2022 levels, reaching its third-highest year ever, after 2020 and 2021.
- The addition of new natural-gas-fired power generating capacity rose slightly, with 9GW commissioned in 2023 compared with 7.1GW the year prior. This marked the largest annual volume of new gas added to the US grid since 2018.
- The rising contribution of variable renewable generation to the grid has created greater demand for energy storage capacity. In 2023, the US set a record for the fourth year in a row for storage build, with 6.2GW added, up from the prior record build of 4.2GW, achieved the year before.
- Unit 3 of the Vogtle nuclear plant came online in 2023, marking the first nuclear capacity brought online since 2016.

Source: EIA, BloombergNEF. Note: Solar capacity counted in alternating current (AC) terms to enable a comparison to other grid-facing technology. Distributed rooftop solar not included.

US energy overview: Renewable energy capacity build by technology

Gigawatts

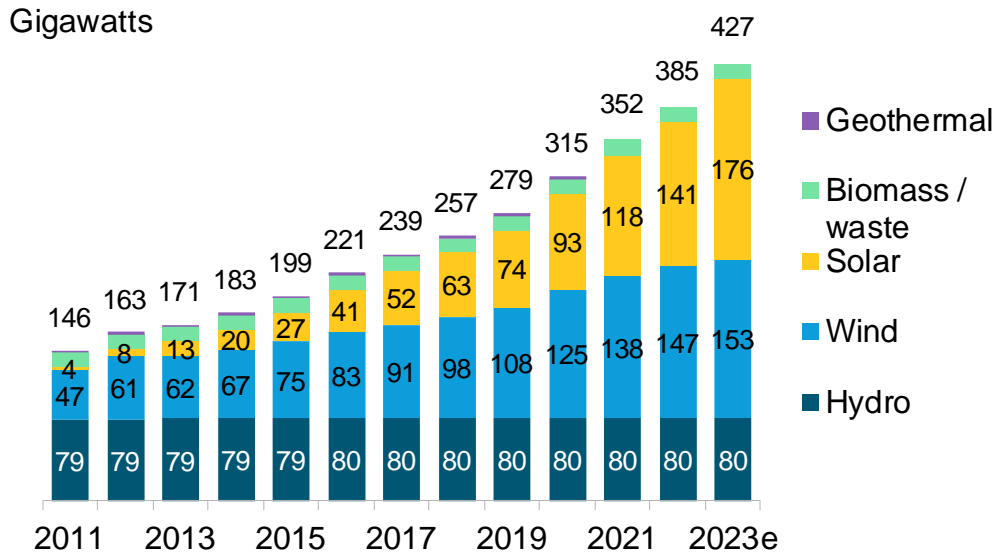


- A total 42GW of renewable capacity came online in 2023, dominated by solar and wind. This set a new record for renewable energy of all types. The higher cost of debt and constraints in permitting and grid connections were outweighed by the tailwinds of steady demand for renewables for corporate buyers and utilities, and a stabler tax credit regime. These factors affected wind and solar differently.
- In 2023, a record 23.7GW of large-scale solar came online, as projects that had been delayed from the past year due to supply chain issues moved forward. Utility-driven build in the US Southeast and Southwest, as well as explosive growth in Texas, drove most of the activity. Nearly 11.6GW of rooftop solar on homes and businesses were added as well.
- Onshore wind installations declined for a third year in a row in 2023, as development activity in past years had slowed in anticipation of pre-IRA tax credits being phased out. In addition, transmission and permitting constraints have hit wind harder than solar, given its high levels of penetration in markets where the wind resource is strong.
- New biomass, geothermal and small hydro build remained comparatively small in 2023. In all, 35MW of new biomass and waste-to-energy (WTE) capacity came online in 2023. In 2023, Pasco County, Florida began construction of an 18MW expansion of new WTE capacity.

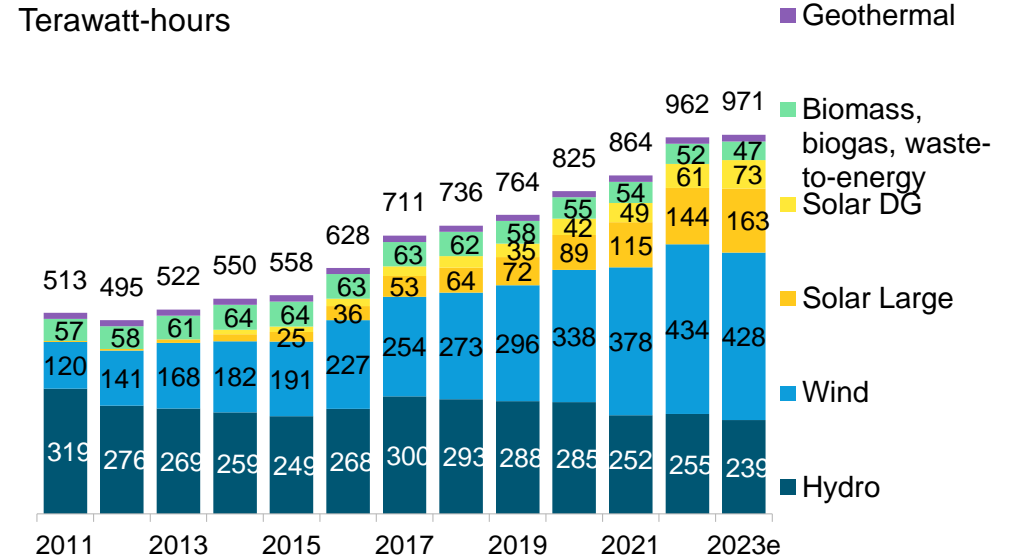
Source: BloombergNEF. Note: All values are shown in alternating current (AC) except solar, which is included as direct current (DC) capacity using a 1.34 conversion factor. Numbers include utility-scale (>1MW) projects of all types, rooftop solar, and small- and medium-sized wind. Includes installations or planned installations reported to the EIA through November 2023, as well as BloombergNEF projections.

US energy overview: Cumulative renewable energy

US cumulative renewable power capacity



US renewable generation, by technology

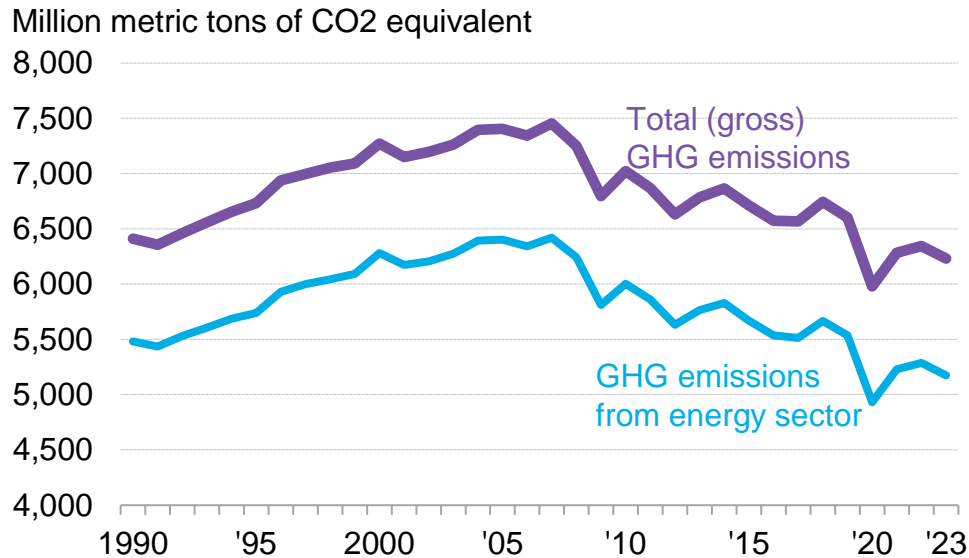


- Total US renewable energy capacity, excluding pumped hydro facilities, stands at 425GW. Despite lingering concerns around supply chains, a higher interest rate environment, and trade policy worries, the installed fleet of wind and solar grew 13.5% year-on-year in 2023.
- Total renewable electricity generation in the US rose a mere 0.9%, reflecting lower output from hydro and wind generation, both of which declined year-on-year compared with 2022. Hydro declined by 6.1%, and wind generation fell by 1.4%
- Although solar generation collectively increased by 15.4%, wind remains the largest generating source, accounting for 44.1% of total renewable generation. The nearly 153GW wind fleet produced 428TWh of electricity in 2023. That was followed by hydroelectric generation at 239TWh, down from 255TWh in 2022.
- Production from all types of solar generating projects reached 237TWh in 2023, making it the third-largest renewable generating source, only 2TWh behind hydro.

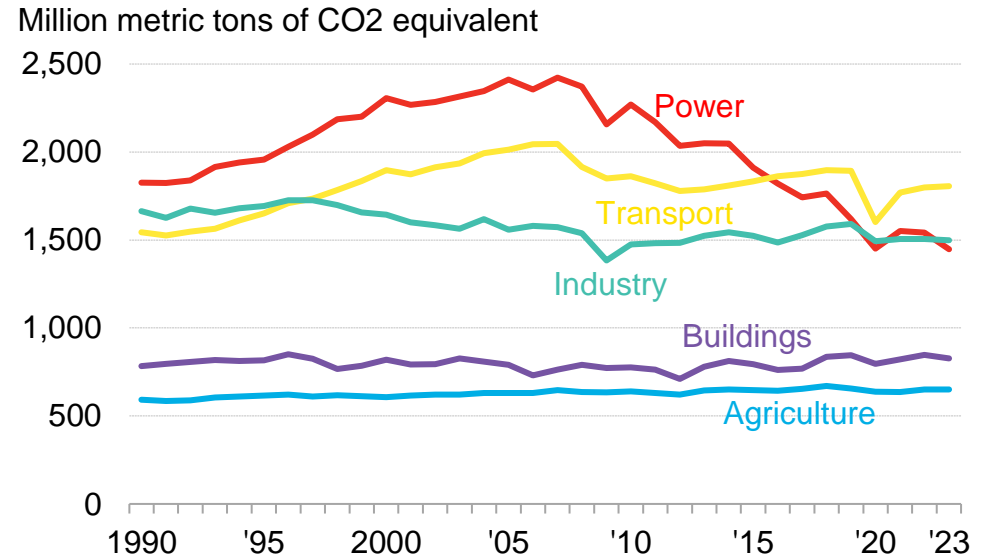
Source: BloombergNEF, EIA. Note: All values are shown in alternating current (AC) except solar, which is in direct current (DC) capacity using a 1.34 conversion factor. Totals may not sum due to rounding. Values for 2023 are projected, accounting for seasonality, based on latest monthly values from EIA (data available through October 2023).

US energy overview: Greenhouse gas (GHG) emissions

Economy-wide and energy sector emissions



Emissions by sector

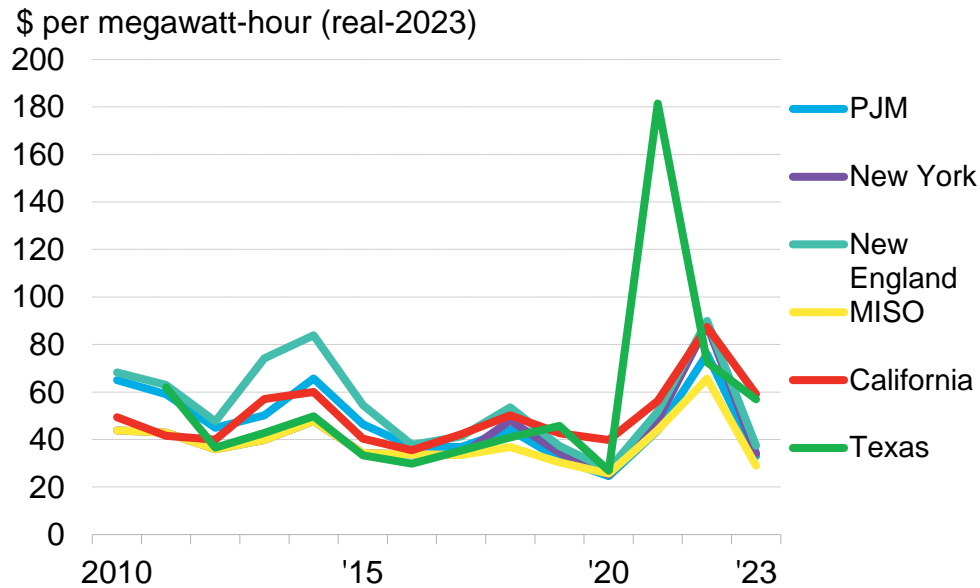


- In 2023, the US emitted 6,229 million metric tons of carbon dioxide equivalent (MMtCO₂e) of greenhouse gases, according to BNEF estimates. This represents a 1.8% drop from the year prior, with emissions falling in every sector except transport. As a result, 2023 was the first year since 2020 (an anomalous year due to the impact of lockdowns) that US emissions have fallen – if there was a post-Covid rebound, it appears to be over. Ignoring 2020, the last time US emissions were this low was 1987. Emissions have fallen in 8.2% in the last 10 years.
- Progress remains concentrated in the power sector, where the annual change in emissions was -95MMtCO₂e, 83% of the net drop. Power is now the US economy's third-highest emitting sector, having been first as recently as 2016. The bulk of emissions reductions in the power sector to date can be attributed to coal being displaced by natural gas. In the long term, natural gas will also need to be displaced by renewable energy if emissions reductions are to continue.
- To meet its emissions goals, the US must make more progress in transport and industry. Although transport emissions increased by 0.5% in 2023, they are still 4.5% below pre-pandemic (specifically, 2019) levels, as some of the reductions made in transport in 2020 persist.

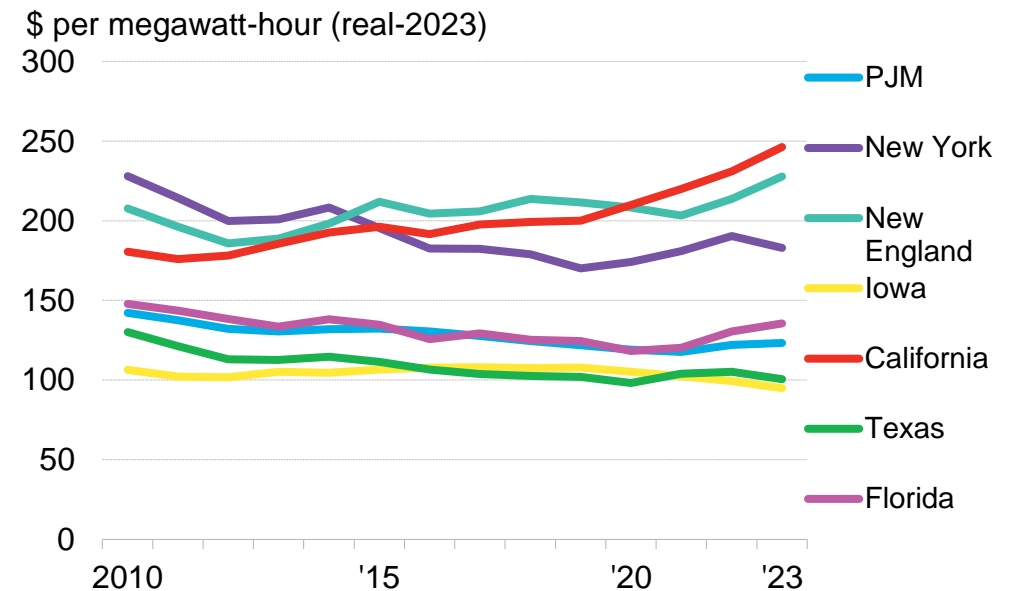
Source: BloombergNEF, EIA, EPA. Note: GHG stands for greenhouse gas.

US energy overview: Retail and wholesale power prices

Wholesale power prices



Retail power prices

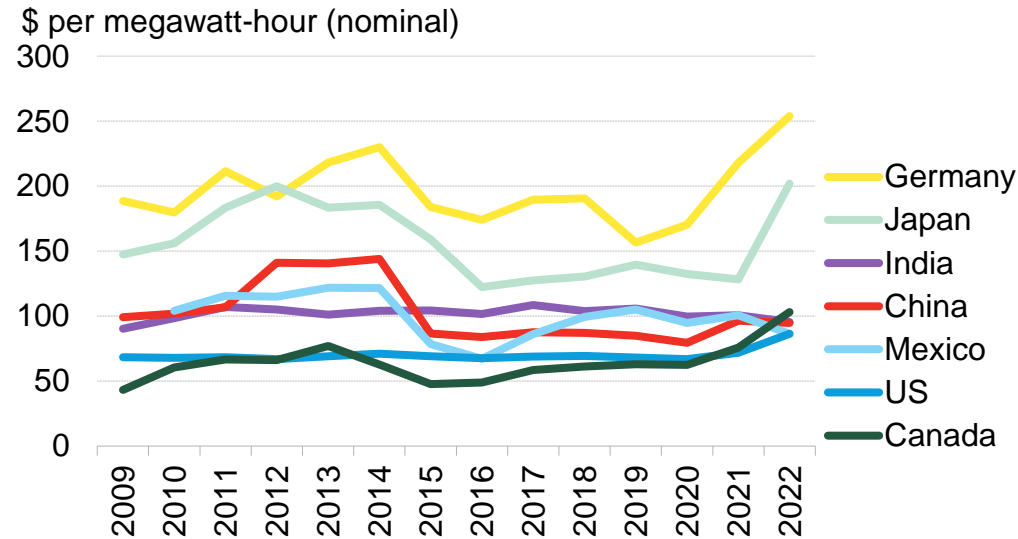


- On average, wholesale power prices fell 48% (in real terms) in 2023, reflecting the decline in the price of natural gas around the country. In most wholesale markets, prices were on par with or lower than power prices in 2021.
- The drastic drop in wholesale prices has not yet filtered through to retail prices. The average US retail price (in real terms) dropped by just 0.68% in 2023. Retail electricity prices show smaller fluctuations year-on-year since they include components other than the cost of wholesale energy, such as capital expenditure returns and the cost of infrastructure for electric delivery, and reflect a longer-term outlook.
- State-level retail prices highlight the fragmentation in the trend. Electricity consumers in Texas, Iowa and New York saw a drop of nearly 4% in retail power prices. Meanwhile, consumers in New England and California experienced a 6% rise in their average power bill.

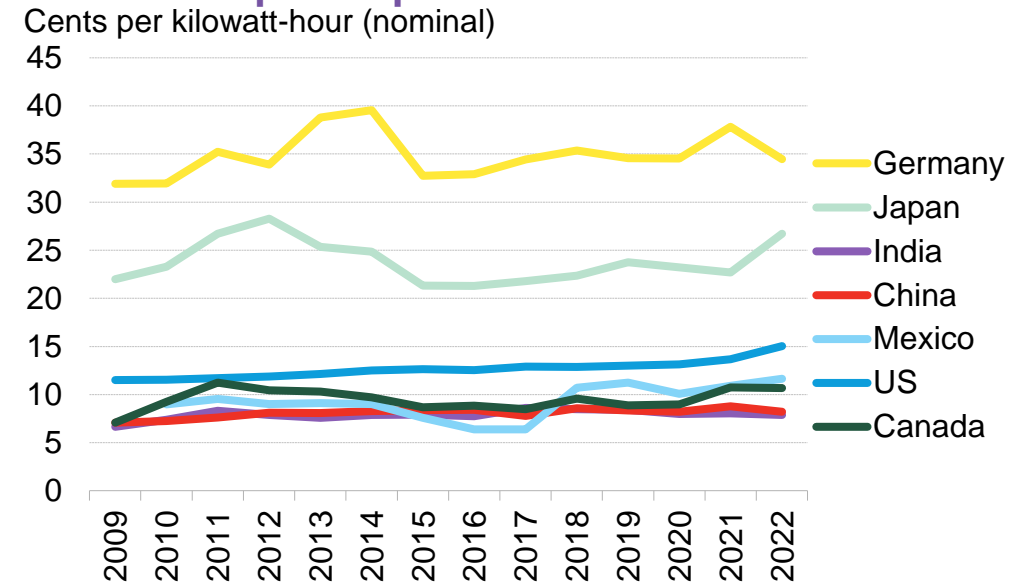
Source: BloombergNEF, EIA, Bloomberg Terminal. Note: Wholesale prices are taken from proxy power hubs in each independent system operator (ISO). All prices are in real 2023 USD. Retail power prices shown here are not exact retail rates but weighted averages across all rate classes by state, as published by the EIA. Retail prices are updated through November 2023. MISO is the Midwest region; PJM is the Mid-Atlantic region.

US energy overview: Average electricity rates by country

Industrial power prices



Residential power prices

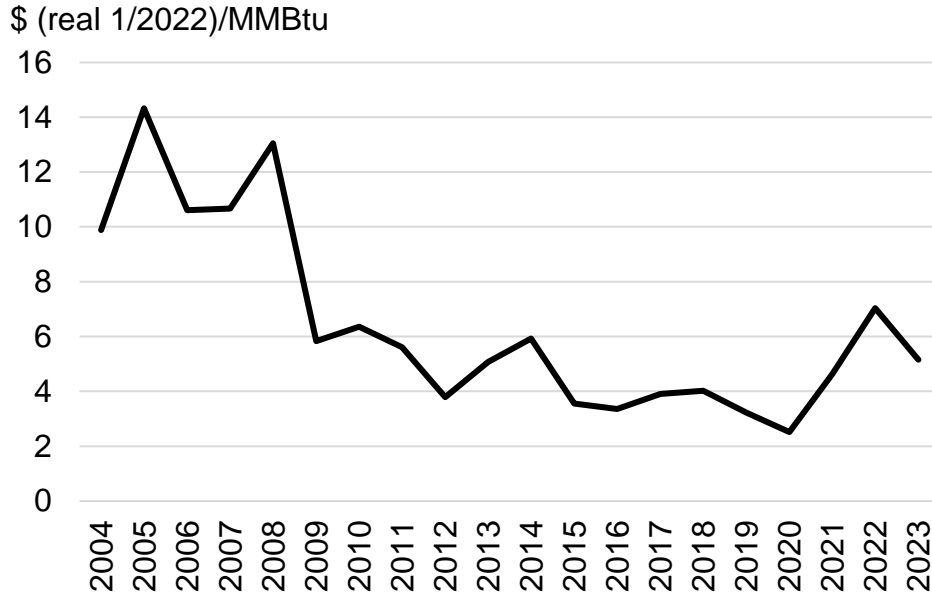


- The US – and North America in general – offers industrial customers some of the least expensive electricity in the world. Among the G-7 nations, the US and Mexico offered the lowest average industrial power price of 8.6 cents per kilowatt-hour (cents/kWh) in 2022, the last year for which there is complete data.
- Residential power prices in the US have been relatively stable over the past decade but surged from 13.66 cents /kWh in 2021 to 15.04 c/kWh in 2022.
- In Germany, 2022 residential power prices decreased to 34.47 cents /kWh from 37.81 cents /kWh in 2021, matching prices prior to the war in Ukraine, while industrial prices rose by 17%.
- Japan saw higher electricity costs in 2022 for all segments, including a whopping 58% increase year-on-year for industrial prices. India, China and Mexico saw lower costs in all segments.

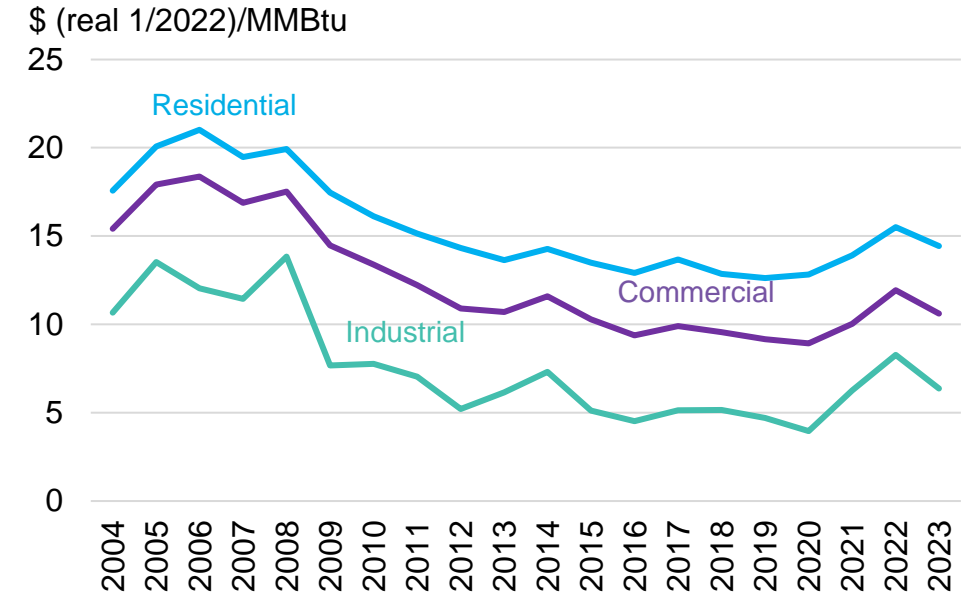
Source: BloombergNEF, government sources (EIA for the US). Note: Prices are averages (and in most cases, weighted averages) across all regions within the country. Japanese data are for the commercial and industrial (C&I) segment, and 2016 figures come from a different source than preceding years.

US energy overview: US natural gas pricing, wholesale and by end use

Natural gas wholesale prices at Henry Hub, LA



Natural gas prices to end users, US average

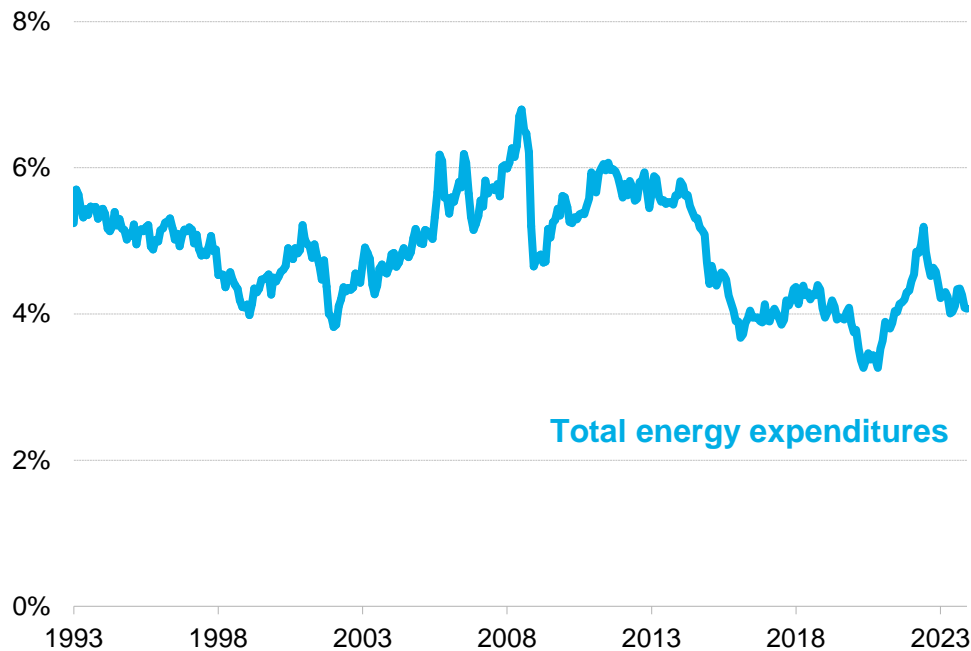


- After two years of rising prices, US natural gas saw a considerable drop of \$1.9 per million British thermal units (MMBtu) driven by warmer-than-normal winter weather and strong US gas production growth.
- The average benchmark Henry Hub wholesale natural gas price for the year fell 27%, and was down 6.9% and 11.1% for residential and commercial consumers, respectively. Industrial users saw the biggest year-on-year change, with prices decreasing by 23%. Despite the drop, 2023 prices were still above pre-pandemic levels.
- Residential price adjustments tend to lag index prices by six to 12 months, depending on utility practices, while industrial prices tend to be most correlated to wholesale markets. This dynamic is part of the reason for a significantly lower decline observed in residential prices than in industrial prices.

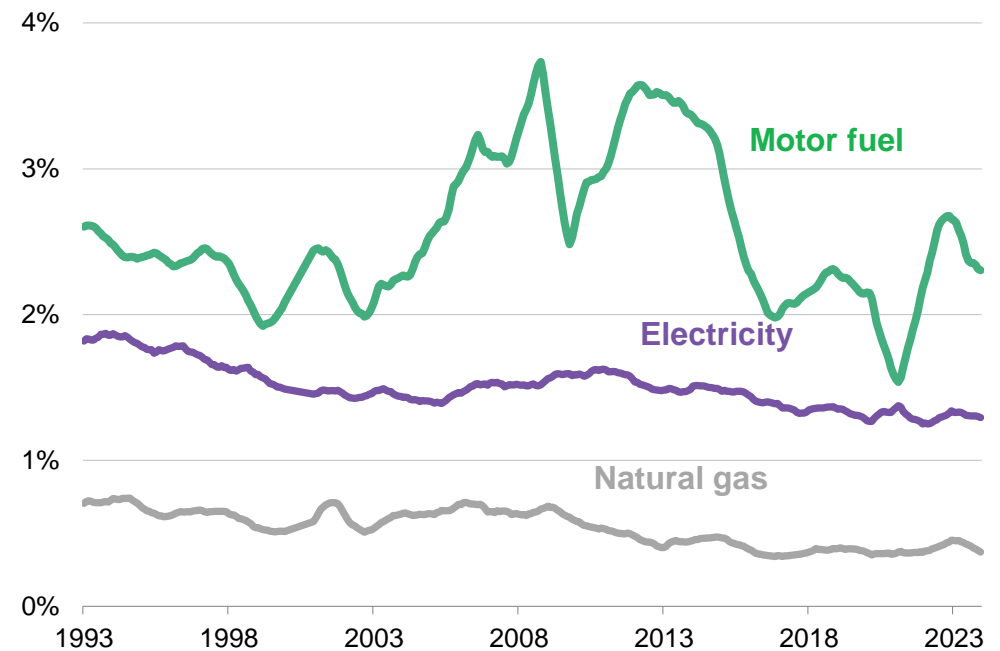
Source: BloombergNEF, EIA Short Term Energy Outlook. LA is Louisiana

US 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 average

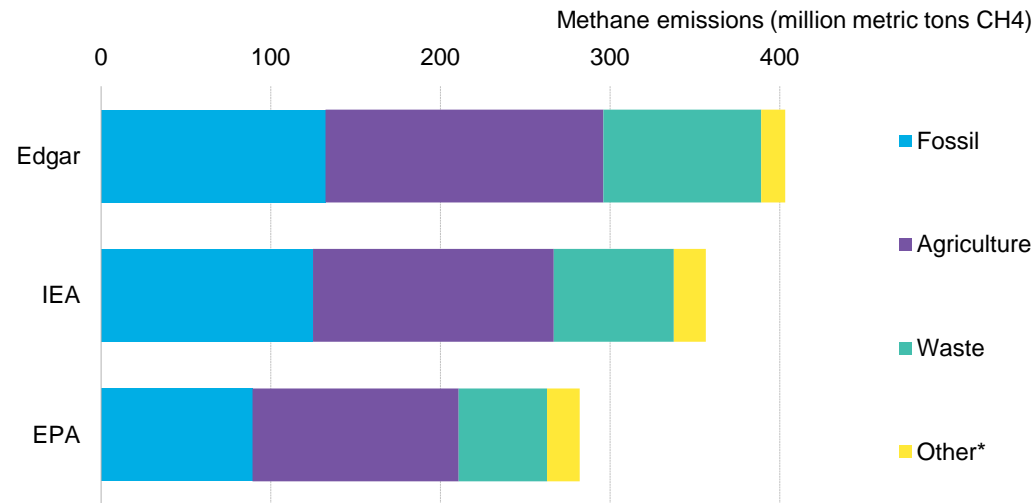


- Total energy expenditure as a share of total consumption expenditure, including all energy goods and services, decreased slightly in 2023. Energy spending accounted for 4.19% of total US personal consumption expenditures in 2023, down 0.52 percentage points from 2022.
- The largest drop was driven by the falling share of motor fuel in personal expenditure, reflecting lower gasoline prices. In addition, the 1.67% share of household expenditures that went to electricity and gas in 2023 was lower than the 2022 levels of 1.79%. Similarly, natural gas spend fell from 0.45% to approximately 0.37%.

Source: Bureau of Economic Analysis "Table 2.4.5U. Personal Consumption Expenditures by Type of Product", BloombergNEF.

US energy overview: Methane emissions

Global 2022 methane emissions by sector



Markets participating in the Global Methane Pledge

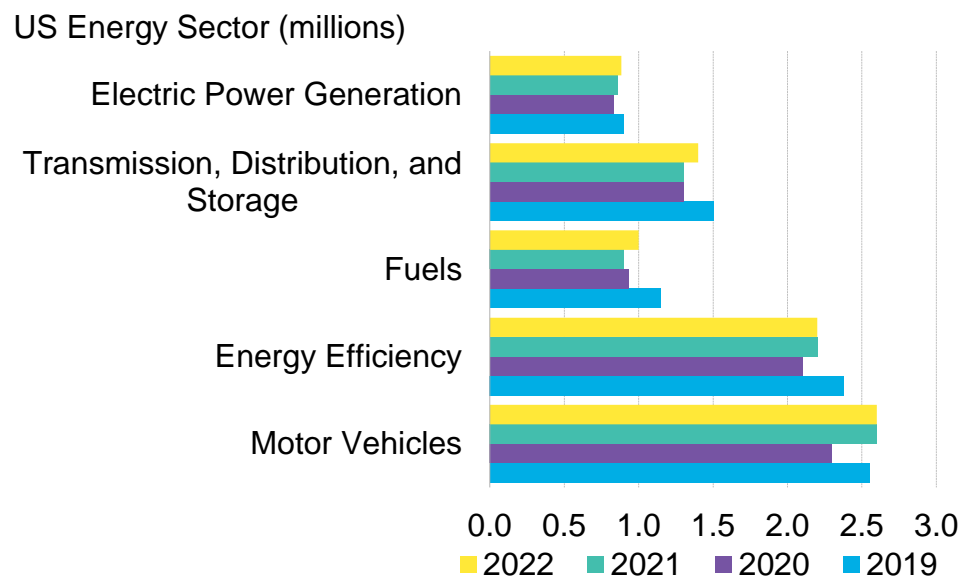


- Methane (CH₄) is the main component of natural gas and accounts for 11.5% of all greenhouse gases, second only to CO₂. Over a 100-year time horizon, it is 29.8 times more potent than CO₂ according to the IPCC. Methane concentrations have been increasing globally over the past four decades, with the largest year-on-year increases between 2018 and 2022.
- Tracking methodologies vary, such that the three most-referenced global inventories differ on the overall quantity of emissions. However, they agree on the major sectoral sources. Agriculture leads, followed by the fossil-fuel value chain and waste processing. Inventories can undercount emissions significantly, partially because they miss random events that release large methane plumes, known as super-emitters.
- Agriculture (primarily cattle) and natural gas systems are the two largest sources of US emissions. Low production wells in the US account for 25-45% of US methane emissions from the oil and gas sector, depending on the inventory. Retiring small wells has been difficult due to fiscal rules that support production, but abatement efforts have restarted the debate. The IRA allocated \$350 million to plug small wells.
- A total of 155 markets are participating in the global methane pledge, which involves committing to take actions to help reduce global methane emissions at least 30% from 2020 levels by 2030. Participants include major markets such as the US, the UK, Brazil and Japan. About 50 oil and gas companies have signed a separate methane pledge to reduce methane emissions to near zero by 2030.

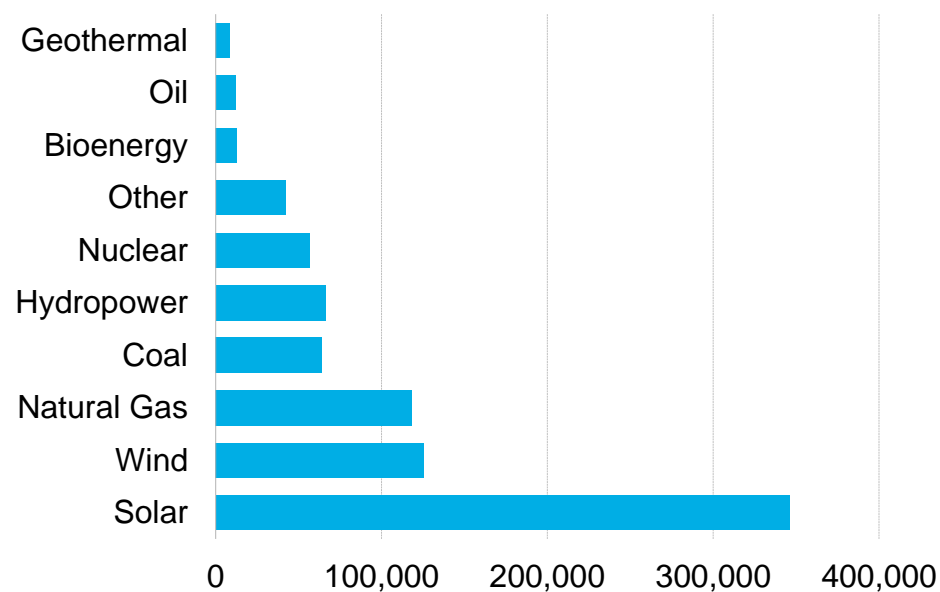
Source: BloombergNEF, International Energy Agency (IEA), Environmental Protection Agency (EPA), Emissions Database for Global Atmospheric Research (Edgar), Global Methane Pledge, S&P Global. Note: Green-shaded markets in the map above are participating in the Global Methane Pledge; white-shaded markets are not.

US energy overview: Jobs in select segments of the energy sector

Jobs in select energy segments, 2019-22



Jobs by power-generating technology, 2022



- The total number of workers employed in the energy sector grew by 2.9% to roughly 8.1 million in 2022, the last year for which there is complete data, according to an annual US Department of Energy report.
- Employment in the motor vehicle and energy efficiency segments remained stable, while the fuels segment saw the biggest year-on-year increase, at 11%. The electric power generation sector increased by 3% from the year prior.
- Among power-generating technologies, solar continues to represent the largest share of total jobs, accounting for nearly 41% of power-sector employment. Coal decreased by 10% year-on-year, following the trend of decommissioned coal plants.

Source: US Department of Energy's 2023 Energy & Employment Report

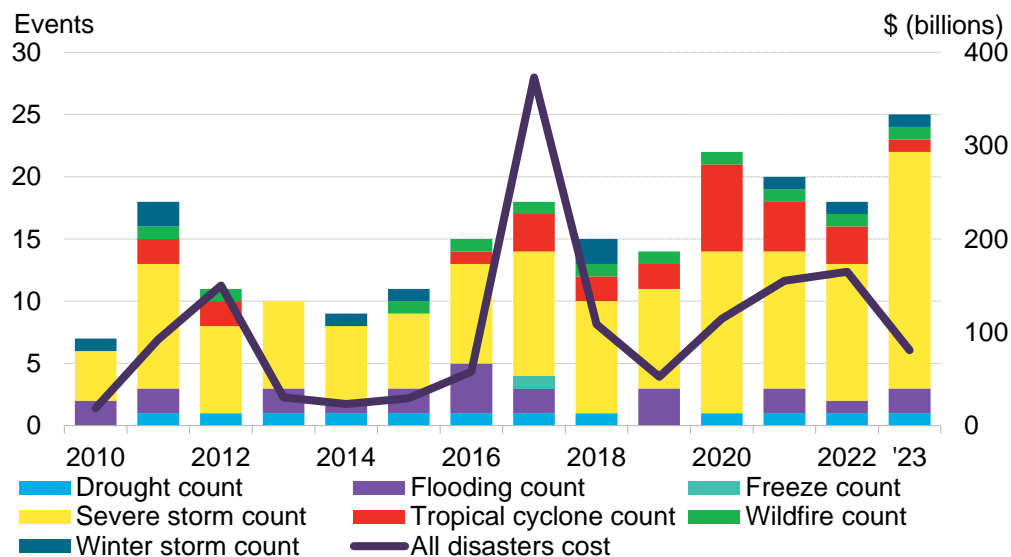
Table of contents



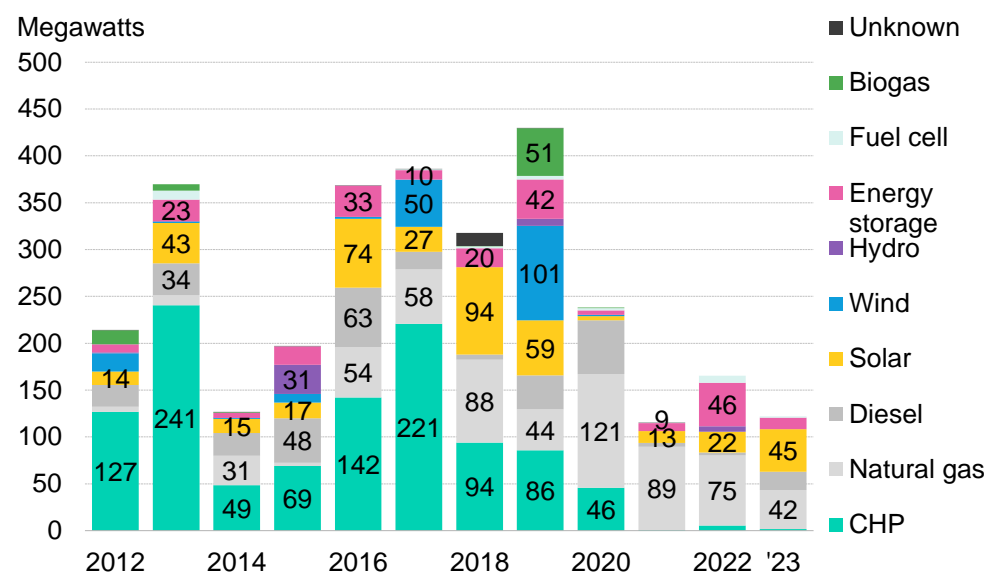
<u>1. Executive summary</u>			
<u>2. A look across the US energy sector</u>			
<u>3. Policy</u>	<u>3.1 Infrastructure and emissions</u>	<u>6. Deployment</u>	
	<u>3.2 Tax credits and stimulus</u>		
	<u>3.3 Vehicle standards</u>		
<u>4. Finance</u>	<u>4.1 Energy transition investment</u>		<u>7. Transportation</u>
	<u>4.2 Utility investment</u>		
	<u>4.3 Corporate sustainability</u>		
<u>5. Economics</u>	<u>5.1 Levelized costs of electricity</u>	<u>6.1 Energy efficiency</u>	
	<u>5.2 Environmental markets</u>		
			<u>6.3 Solar and wind</u>
		<u>6.4 Storage</u>	
		<u>6.5 Hydrogen</u>	
		<u>7.1 Gasoline</u>	
		<u>7.2 Fuel prices and EV sales</u>	
		<u>7.3 Renewable natural gas</u>	

Policy: Infrastructure and resilience

US billion-dollar weather and climate disasters



US microgrid installed capacity, by technology

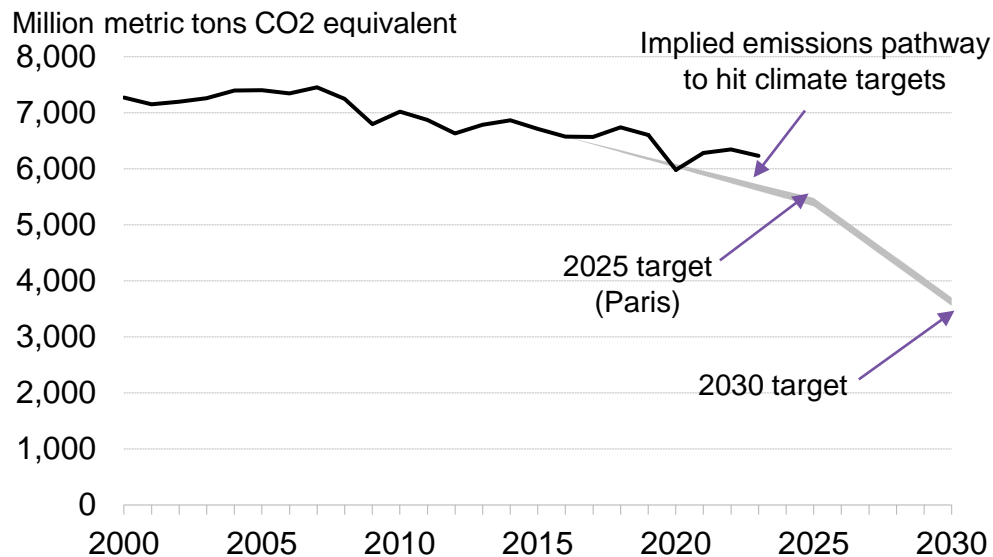


- In 2023, the US experienced 28 climate disasters that together caused \$92.9 billion in damages. Of this monetary impact, 58.1% was associated with 19 severe storms. That said, while the total number of events increased from 2022 to 2023, total costs associated with these events dropped year-on-year, as each storm caused, on average, less monetary damage than the year before.
- Since 2012, roughly 2,800MW of microgrids with roughly 5,000MWh of energy storage have been brought online in the US, where entire cities and communities are actively building microgrids to protect residents' energy supply needs from potential blackouts in the regional grid network. However, new microgrid installations were down year-over-year in 2023, as long negotiation timelines and technical challenges prolonged development and construction.
- In 2023, 48 microgrids representing about 110MW of generation paired with 12.2MW/16.9MWh of storage capacity were brought online. Solar was the preferred source of generation, followed by natural gas. Propane is also used in combined heat and power (CHP) systems and microgrids to support critical infrastructure. Renewable propane is available on a limited basis, with early capacity expansions geared toward serving the western US.

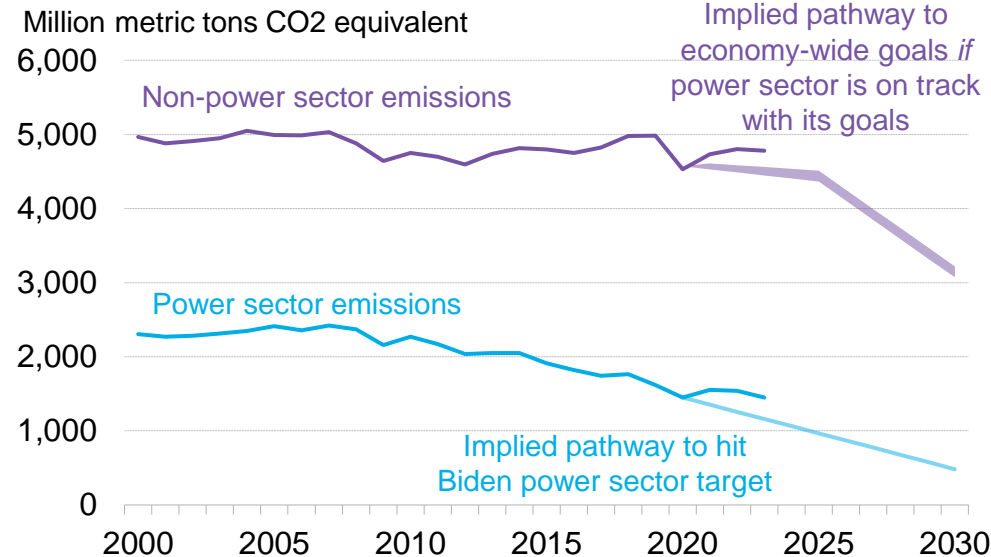
Source: National Oceanic and Atmospheric Administration, BloombergNEF, US Department of Energy, ICF. Note: Chart portrays annual counts of drought, flooding, freeze, severe storm, tropical cyclone, wildfire and winter storm events in the US with losses of more than \$1 billion each. CHP stands for combined heat and power.

Policy: US progress toward emissions goals

US economy-wide emissions



US power emissions

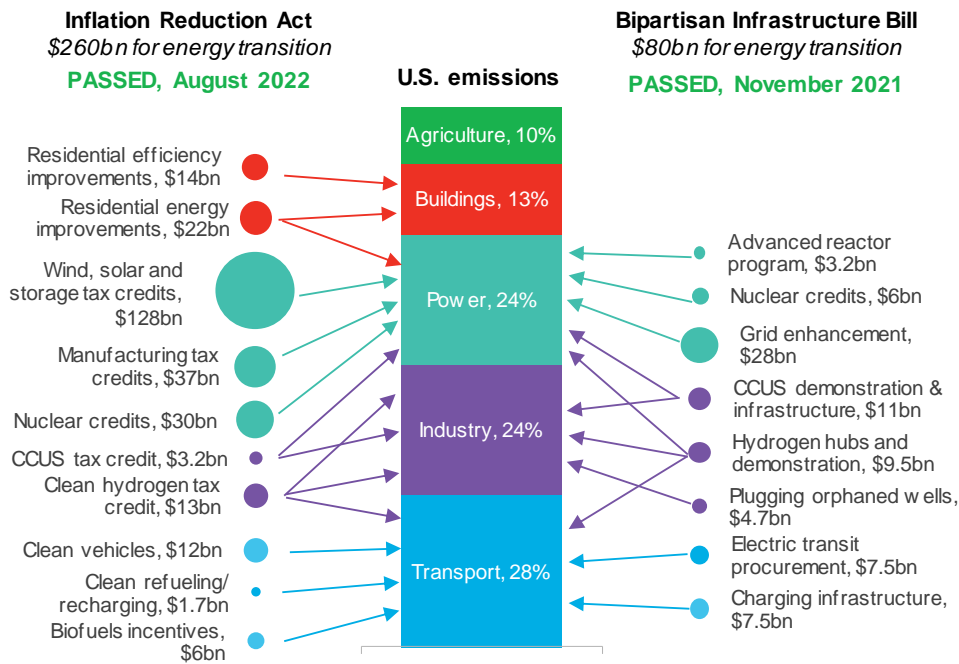


- The Biden administration has pledged the US to a nationally determined contribution (NDC) of cutting emissions by 50-52% from 2005 levels by 2030, under the framework of the Paris Agreement. This follows the original Paris pledge made under the Obama administration of reducing emissions by 26-28% below 2005 levels by 2025.
- US emissions for 2023 were 16% below 2005 levels. For the US to hit its 2025 Paris target, year-on-year emissions would need to fall by more than 6% in both 2024 and 2025. This has only happened twice since 1990 – in 2009, when emissions fell 6.3% in the wake of the financial crisis, and in 2020, when emissions fell 9.4% in the wake of Covid-19 lockdowns.
- Power is the only sector for which the administration has explicitly set an emissions reduction target, with 2023 emissions being 40% lower than 2005 levels. Netting out the power goal from the overall US emissions goal offers an implicit pathway non-power sectors must follow for the US to hit its general target. For the US to remain on track for its post-2025 goals, 2023 power sector emissions needed to fall by at least 7.7% year-on-year, while emissions across all other sectors needed to fall by 0.9%. The actual 2023 reductions were 6.1% and 0.4%, respectively. Thus, while progress is being made, more is needed – particularly outside of the power sector.

Source: EIA, EPA, BloombergNEF.

Policy: Inflation Reduction Act key details

Estimated 2022-2031 energy transition spend in Inflation Reduction Act, Bipartisan Infrastructure Law



Inflation Reduction Act key dates

- January 1:** Clean vehicle Foreign Entity of Concern battery exclusion, clean vehicle tax transfer provisions, and 45U clean nuclear tax credits take effect. Clean vehicle China/Russia battery component exclusion, clean vehicle tax transfer provisions, and 45U clean nuclear tax credits take effect.
- August 16:** Lifecycle emissions methodology for alternative fuels to be released. Unspent state energy office home rebate funds to be distributed to states.
- September 30:** EPA greenhouse gas reduction fund spend deadline. Defense Production Act spend deadline.
- November 5:** US general election.
- December 31:** Energy storage and microgrid controller construction initiation deadline. 45V hydrogen tax credit guidance to be finalized.
- Unspecified:** 45Q tax credit's 75% capture requirement (against baseline CO₂ emissions) for electricity generation facilities goes into effect.
- January 1:** Clean fuel production credit and clean electricity investment and production credits to take effect. Ban on car batteries using critical minerals from sanctioned countries to take effect.
- January 20:** Presidential inauguration.
- January 1:** 2017 Tax Cuts and Jobs Act expires; substantial negotiations on US business and energy taxes likely to take place beforehand.

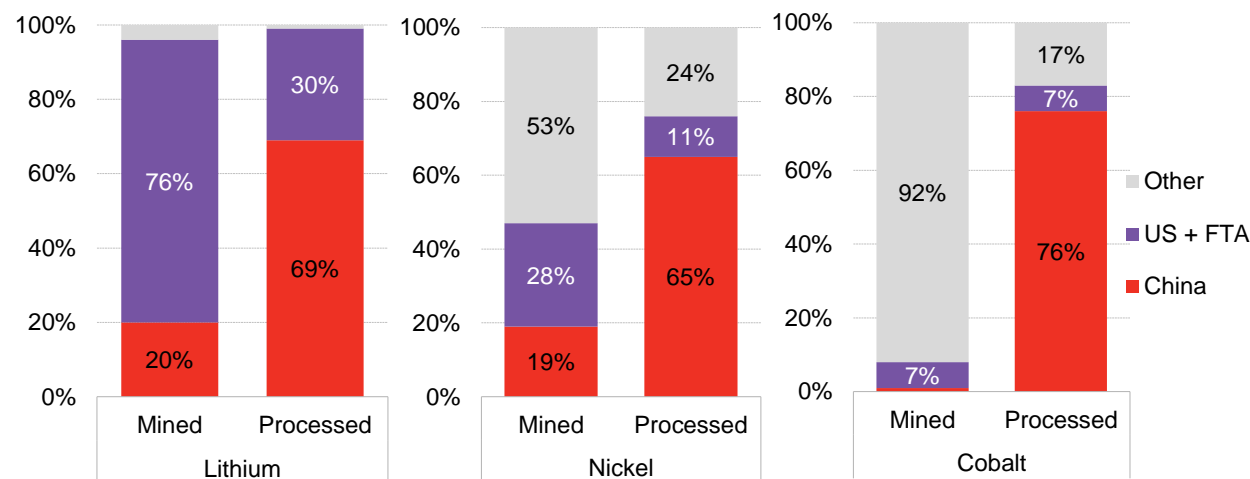
*Note: Gray text indicates guidance was first expected in 2023.

- The effectiveness of US decarbonization policy is tied to final guidance on the IRA tax credits. Key credits for which final guidance is yet to be released include the 45U nuclear credit, the revised 45Q carbon capture credit, the final version of the 45V clean hydrogen credit, and the technology-neutral renewables and storage credits (plus their associated domestic content bonuses).
- Some credit guidance has been pushed back from 2023 to 2024. Other measures, like FERC's regulatory actions to clear transmission bottlenecks and the EPA's regulations on fossil-fuel power plants, will also come at uncertain times in 2024.

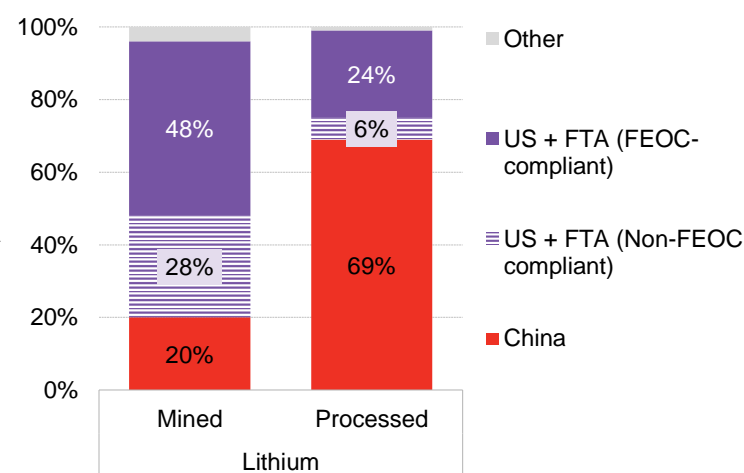
Source: EIA, EPA, Joint Committee on Taxation, Inflation Reduction Act, BloombergNEF. Note: Left-hand chart only captures tax credits and incentives, not grant programs or loans. CCUS is carbon capture, utilization and storage.

Policy: EVs now qualifying for new tax credits

Share of battery metal supply in 2023 by location



Share of lithium supply in 2023 by location and FEOC and non-FEOC ownership



- In December 2023, the US proposed new rules rendering materials from “Foreign Entities of Concern” (FEOC) ineligible for federal subsidies. Under the guidance, entities that have 25 percent or more of their board seats, voting rights or equity held by a FEOC – including China’s government – are considered FEOCs. These rules go into effect in 2024 for battery components, and in 2025 for critical minerals.
- Securing critical materials for electrical vehicle batteries outside of China will be difficult. Given that over 65% of *processed* lithium, nickel, and cobalt come from China, manufacturers may choose to go for *mined* critical materials sourced from non-FEOC countries to qualify for tax credits, as these are available in larger supply. The new guidance offers the US and free-trade agreement (FTA) countries an opportunity to increase their share in the critical materials space for battery production.
- BNEF analysis indicates that up to 37% of mined lithium supply and up to 20% of refined lithium supply of lithium from US and FTA countries could be considered non-compliant with the FEOC rules as a result of China’s overseas investments in upstream projects.

Source: BloombergNEF. Note: 2023 data is an estimate from BNEF’s de-risked supply database. Battery metal supply shares are by weight. FTA stands for free-trade agreement; FEOC stands for foreign entities of concern. Non-FEOC compliance is a result of China’s overseas investments in upstream projects, based on BNEF’s current interpretation of the guidance.

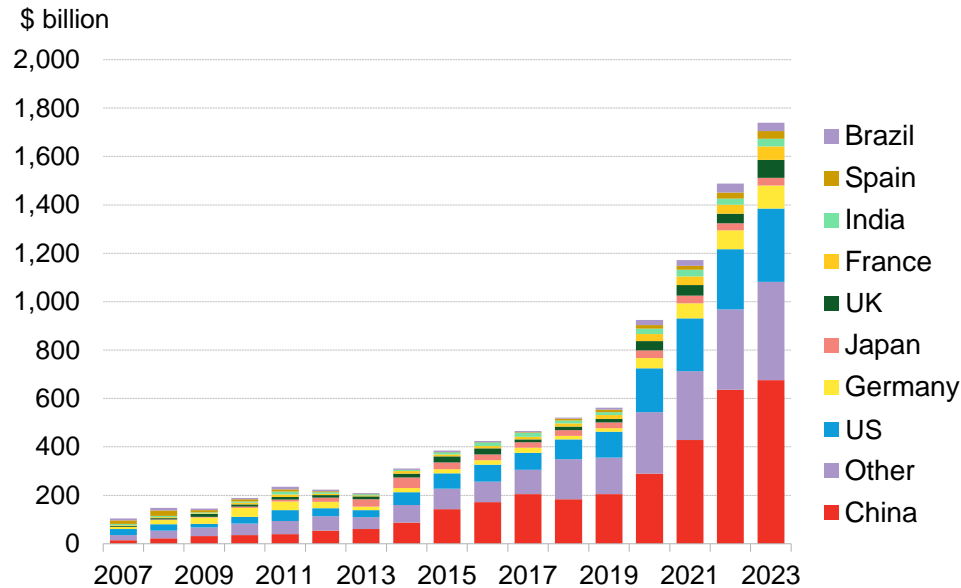
Table of contents



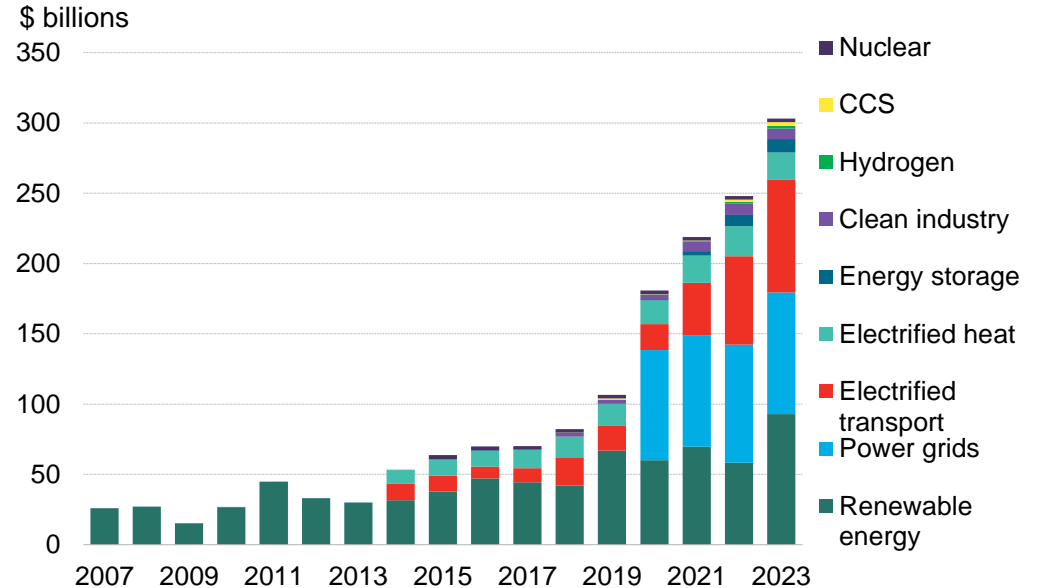
<u>1. Executive summary</u>		
<u>2. A look across the US energy sector</u>		
<u>3. Policy</u>	<u>3.1 Infrastructure and emissions</u>	<u>6. Deployment</u>
	<u>3.2 Tax credits and stimulus</u>	
	<u>3.3 Vehicle standards</u>	
<u>4.1 Energy transition investment</u>	<u>7. Transportation</u>	
<u>4.2 Utility investment</u>		
<u>4.3 Corporate sustainability</u>		
<u>5. Economics</u>	<u>5.1 Levelized costs of electricity</u>	<u>6.1 Energy efficiency</u>
	<u>5.2 Environmental markets</u>	<u>6.2 Natural gas</u>
		<u>6.3 Solar and wind</u>
		<u>6.4 Storage</u>
		<u>6.5 Hydrogen</u>
		<u>7.1 Gasoline</u>
		<u>7.2 Fuel prices and EV sales</u>
		<u>7.3 Renewable natural gas</u>

Finance: Energy transition investment

Energy transition investment, by market



US energy transition investment, by sector

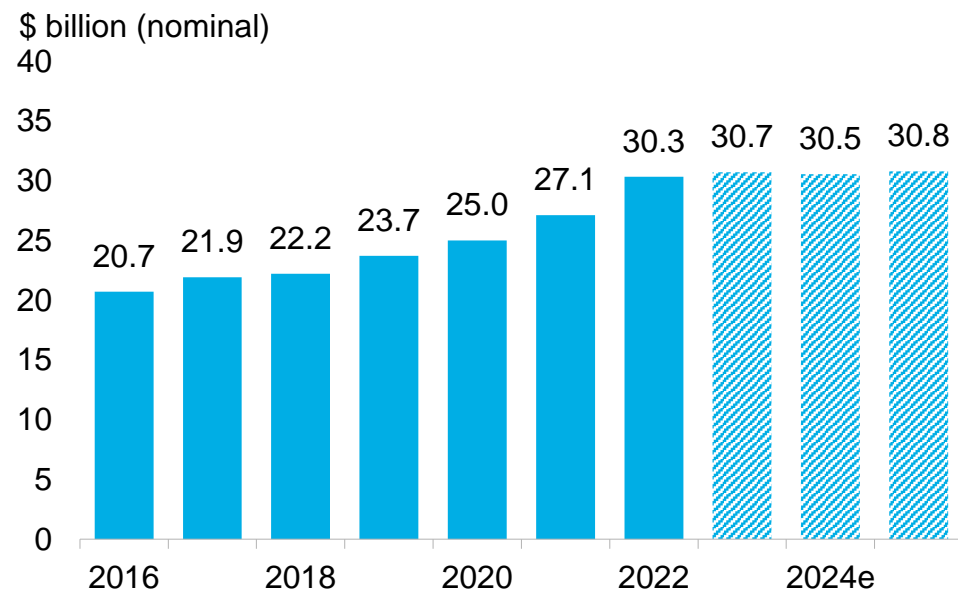


- BloombergNEF tracks investment in technologies that are accelerating the decarbonization of the global economy. In 2023, just over \$1.7 trillion went toward supporting the global energy transition. China continues to spend more than any other market, accounting for \$676 billion of the funds deployed, which is 3.8% of its estimated 2023 GDP.
- The US is the world's second-largest investor in the energy transition, with 2023 investment rising 22% year-on-year to hit \$303 billion, or (1.3% of the year's estimated GDP). That jump is largely thanks to growth in the renewable energy and electrified transport sectors. Renewables accounted for 31% of total investment, a 60% increase year-on-year. Overall, energy transition investments were up 68% from 2020.
- Following the passage of the Inflation Reduction Act, investments in CCS and hydrogen have soared. About \$2.8 billion and \$1.9 billion were invested in CCS and hydrogen-producing projects, respectively, in the US in 2023 – representing respective year-on-year jumps of 68% and 82%. Tax credits, which have also given energy storage a significant boost, are likely behind the surge in investment in these sectors.

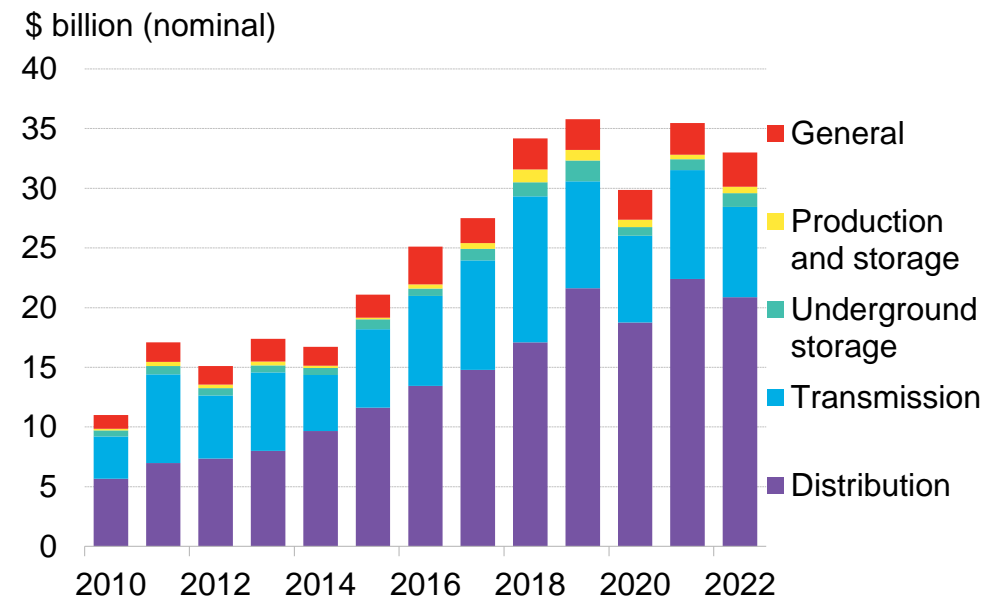
Source: BloombergNEF, Energy Transition Investment Trends database, World Bank. Note: Start years differ by sector, but all sectors are present from 2020 onwards. Most notably, nuclear figures start in 2015 and power grids in 2020. CCS refers to carbon capture and storage.

Finance: US midstream infrastructure investment

US electric transmission investment by investor-owned utilities and independent developers



US natural gas utility construction expenditures

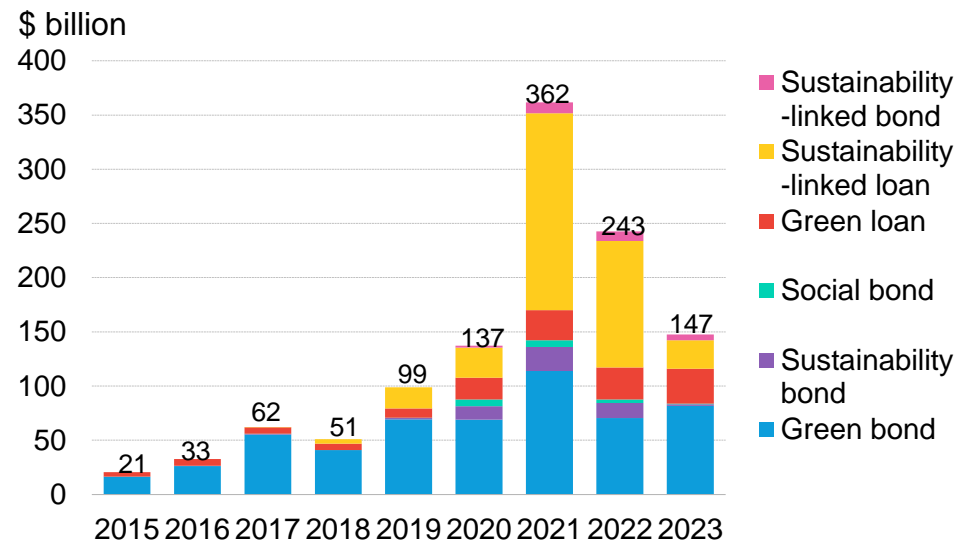


- Investor-owned utilities (IOUs) and independent transmission developers spent a record \$30.3 billion on electric transmission in 2022, according to the Edison Electric Institute (EEI). This was up 12% from 2021 and 38% from 2017. EEI estimates of current capex plans suggest investments will remain at this level through 2025. However, future-year budgets are not yet finalized, and these numbers may be revised upward.
- Midstream gas utility construction expenditures decreased by \$2.5 billion in 2022 from the year prior, to \$33 billion, according to the American Gas Association. A 17% decrease in transmission investment and 7.7% decrease in distribution investment led to the overall decline in natural gas utility expenditure.

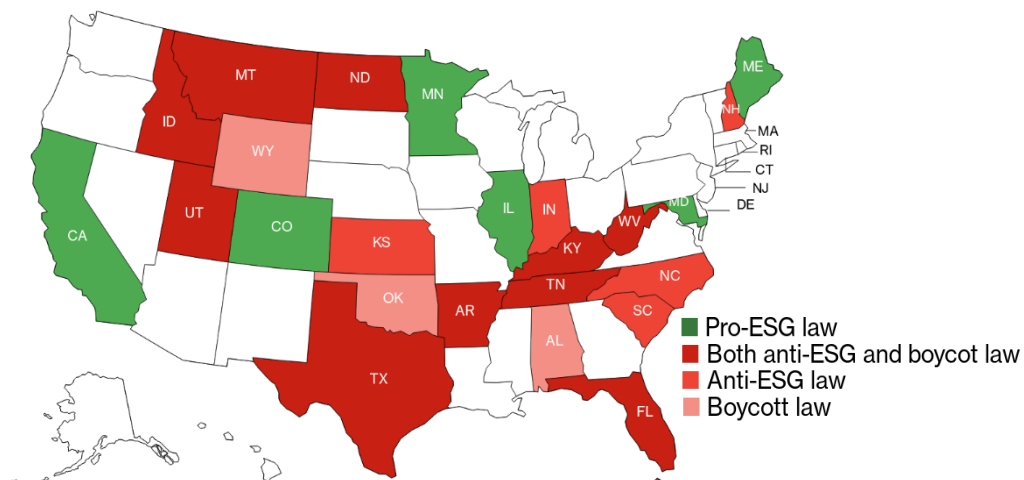
Source: Edison Electric Institute, American Gas Association (AGA), BloombergNEF. Note: Gas expenditure values reflect figures reported to the AGA by companies across the supply chain, including transmission companies, investor-owned local distribution companies and municipal gas utilities. "General"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

Finance: US sustainable debt and sustainable finance policy

Annual US sustainable debt issuance



ESG laws by US state

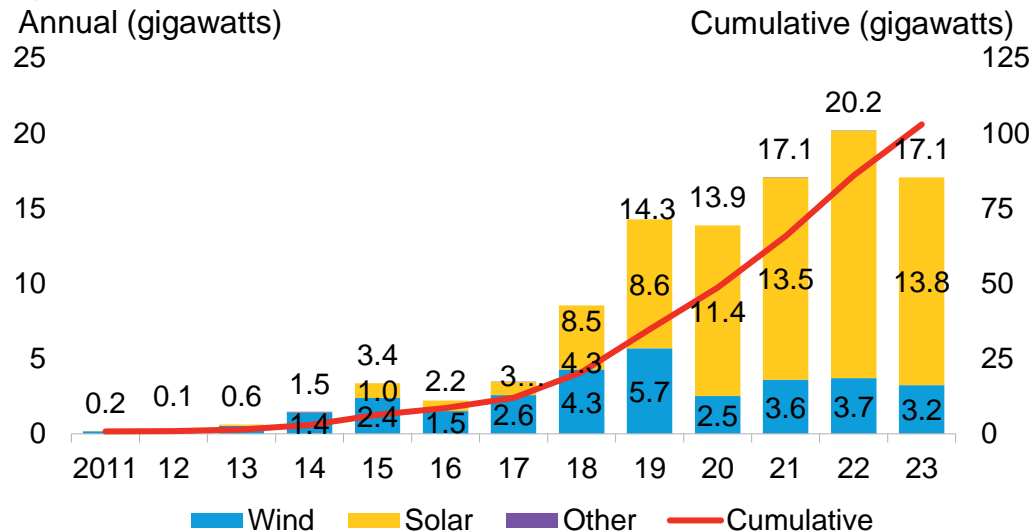


- US sustainable debt issuance fell for the second year in a row in 2023, to reach only \$147 billion. The drop was largely driven by poor macroeconomic conditions and scrutiny over the impact of sustainable debt. The newer, underdeveloped sustainability-linked debt markets are the main cause for concern, with limited impact progress exposing issuers to greenwashing claims. Sustainability-linked loan issuance fell by 77% from 2022, while sustainability-linked bonds dropped by 42%. On the other hand, the green bond market grew by 16%, reflecting its status as the best-established and most robust sustainable debt market.
- Rising anti-ESG (environmental, social and governance) sentiment in the US has led 18 states to enact anti-ESG laws in the past three years. The laws typically remove ESG factors from investment decisions or prohibit states from working with groups that boycott fossil fuels, punishing companies for policies such as divestment goals.
- At the federal level, the Securities Exchange Commissions (SEC) has yet to finalize rules proposed in 2022 that mandate climate-related financial disclosures for listed entities and a classification regime for ESG investment funds. At a state level, California has passed laws requiring large companies operating in the state to disclose greenhouse gas emissions and climate-related risk.

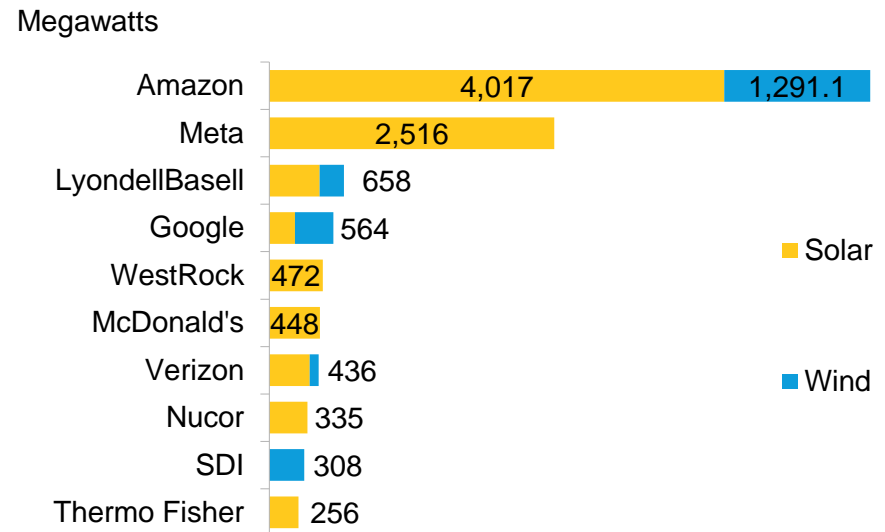
Source: BloombergNEF, US state legislatures, Bloomberg Terminal. Note: Updated as of February 14, 2024. Excludes bills or resolutions. Pro-ESG laws include divestment laws.

Finance: Corporate procurement drops as economics weaken

Renewable capacity contracted by corporations, by sector



Largest corporate offtakers, 2023

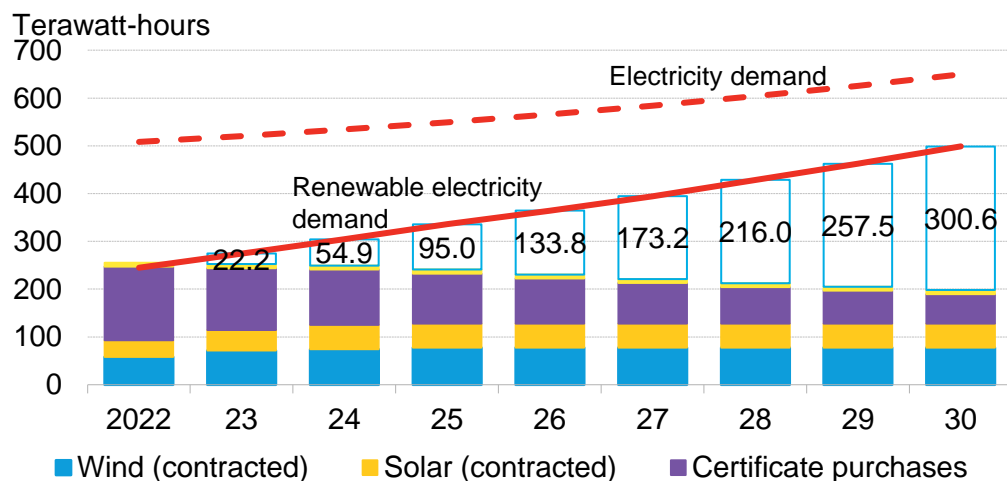


- Corporate power purchase agreement (PPA) volumes announced in the US slumped to 17.1GW in 2023, down 15% from the record 20.1GW in 2022. In addition, it was the first year since 2017 with fewer than 100 deals, with companies announcing only 97 PPAs. Solar dominated, making up 81% of all transactions in 2023, for a total of 13.8GW.
- The drop can largely be attributed to waning economics for clean energy buyers. Corporate PPA prices across the four US power markets with the most activity – Southwest Power Pool (SPP), Electric Reliability Council of Texas (Ercot), PJM and Midcontinent Independent System Operator (MISO) – rose by 4% in the first half of 2023. This was due to high interest rates, interconnection queues and developers saddled with multi-year component contracts that were signed prior to 2023, in the middle of supply-chain constraints. Power prices haven't risen at the same rate, meaning PPAs are not able to compete in the wholesale market.
- While Amazon wasn't able to replicate its 8.3GW of US corporate PPAs announced in 2022, it still led all companies in 2023, with 5.3GW of deals announced. Meta (2.5GW), LyondellBasell (658MW) and Google (564MW) were the next-largest buyers. In total, 38 different corporations announced US PPAs in 2023, with Thermo Fisher Scientific and Fujifilm being notable newcomers.

Source: BloombergNEF. Note: Charts show offsite PPAs only.

Finance: US RE100 membership slows

Clean electricity supply and demand for RE100 members



New RE100 members in 2023

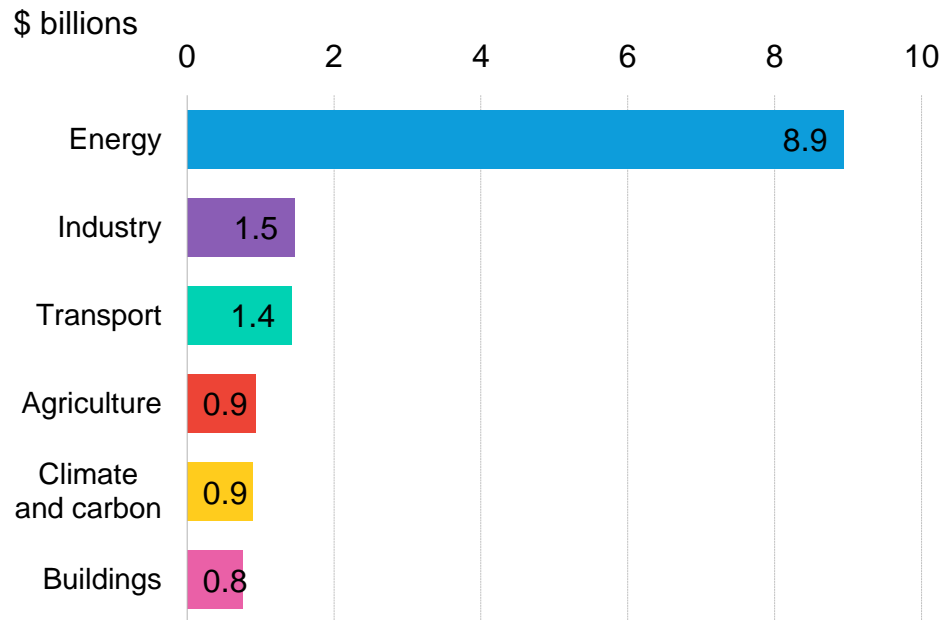


- Just 37 new companies joined the RE100 in 2023, pledging to offset 100% of their electricity consumption with clean energy. That's the lowest number of new members since 2017, when 32 new companies joined. The initiative has lost steam as broader targets like net zero have grown in popularity. Large markets for RE100 goals, such as the US (98 members) and Japan (85) have also seen many of their largest companies already commit, leading to atrophy in new membership. Just one new US company – Cisco Systems – joined the RE100 in 2023, down from six in 2022 and 11 in 2021.
- Some 451 companies have pledged 100% clean electricity as part of the RE100, collectively consuming 508 terawatt-hours (TWh) of electricity each year based on their latest disclosures. BloombergNEF estimates that the electricity demand from the current group of RE100 members will reach 650TWh in 2030 – greater than the annual power consumption of South Korea.
- We estimate that the current 451 RE100 members will need to purchase an additional 301TWh of clean electricity to meet and maintain their goals in 2030. This same group of companies announced 84GW of PPAs between 2017 and 2023.

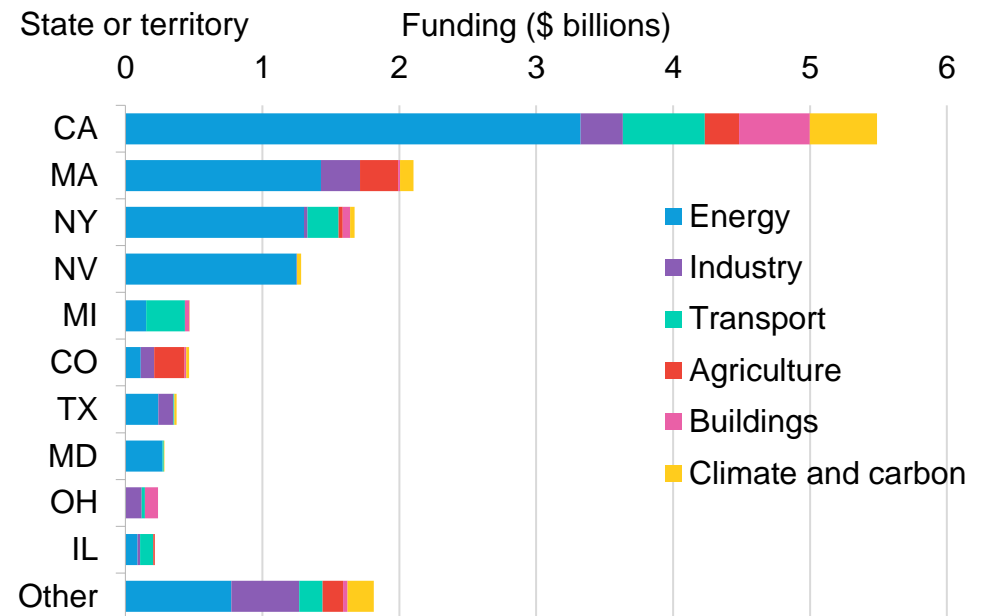
Source: BloombergNEF, Bloomberg Terminal, CDP, company filings. Note: Certificate purchases are assumed to step down 10% each year. Onsite generation and contracted wind and solar purchases remain flat through 2030. Regional breakdown of shortfall is estimated based on each company's share of revenue by region. Electricity demand and renewable electricity demand do not intersect in 2030, as some companies have targets extending out past 2030.

Finance: Venture Capital/Private Equity Investment

US climate-tech VC/PE investment sector



Top 10 states for climate-tech VC/PE investment



- US venture capital and private equity (VC/PE) investment totaled \$14.4 billion across 299 deals in 2023, down significantly from the previous year. The US is not alone in this decline, as the wider VC/PE market for climate-tech fell by 12% from 2022 to 2023.
- California, Massachusetts, New York and Nevada remained the top four markets, with California-based entities receiving 38% of investment.
- Startups working in the energy sector continued their robust fundraising, and startups working on industrial decarbonization raised the same amount of funding in 2023 as in 2022. The remaining sectors saw a decline, with the transport sector experiencing a particularly steep drop. Globally, VC/PE investment in transport companies fell 42% year-on-year.
- Despite the downturn in fundraising for US-based companies, the US continues to be the largest market. Mainland China was second, at \$11.7 billion, followed by the EU at \$10.8 billion.

Source: BloombergNEF, PitchBook. Note: CA is California, MA is Massachusetts, NY is New York, NV is Nevada, MI is Michigan, CO is Colorado, TX is Texas, MD is Maryland, OH is Ohio, IL is Illinois.

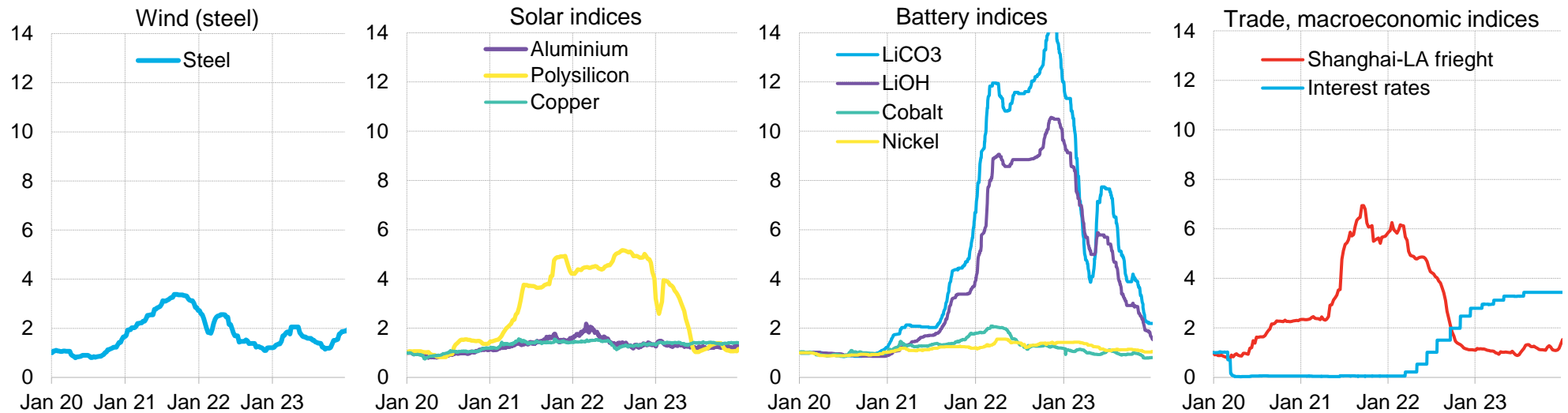
Table of contents



<u>1. Executive summary</u>			
<u>2. A look across the US energy sector</u>			
<u>3. Policy</u>	<u>3.1 Infrastructure and emissions</u>	<u>6. Deployment</u>	
	<u>3.2 Tax credits and stimulus</u>		
	<u>3.3 Vehicle standards</u>		
<u>4. Finance</u>	<u>4.1 Energy transition investment</u>		<u>7. Transportation</u>
	<u>4.2 Utility investment</u>		
	<u>4.3 Corporate sustainability</u>		
<u>5. Economics</u>	<u>5.1 Levelized costs of electricity</u>	<u>6.1 Energy efficiency</u>	
	<u>5.2 Environmental markets</u>	<u>6.2 Natural gas</u>	
		<u>6.3 Solar and wind</u>	
		<u>6.4 Storage</u>	
		<u>6.5 Hydrogen</u>	
		<u>7.1 Gasoline</u>	
		<u>7.2 Fuel prices and EV sales</u>	
		<u>7.3 Renewable natural gas</u>	

Economics: Commodity costs for wind, solar, batteries and other equipment

Price movements since January 2020 (rebased to 1)

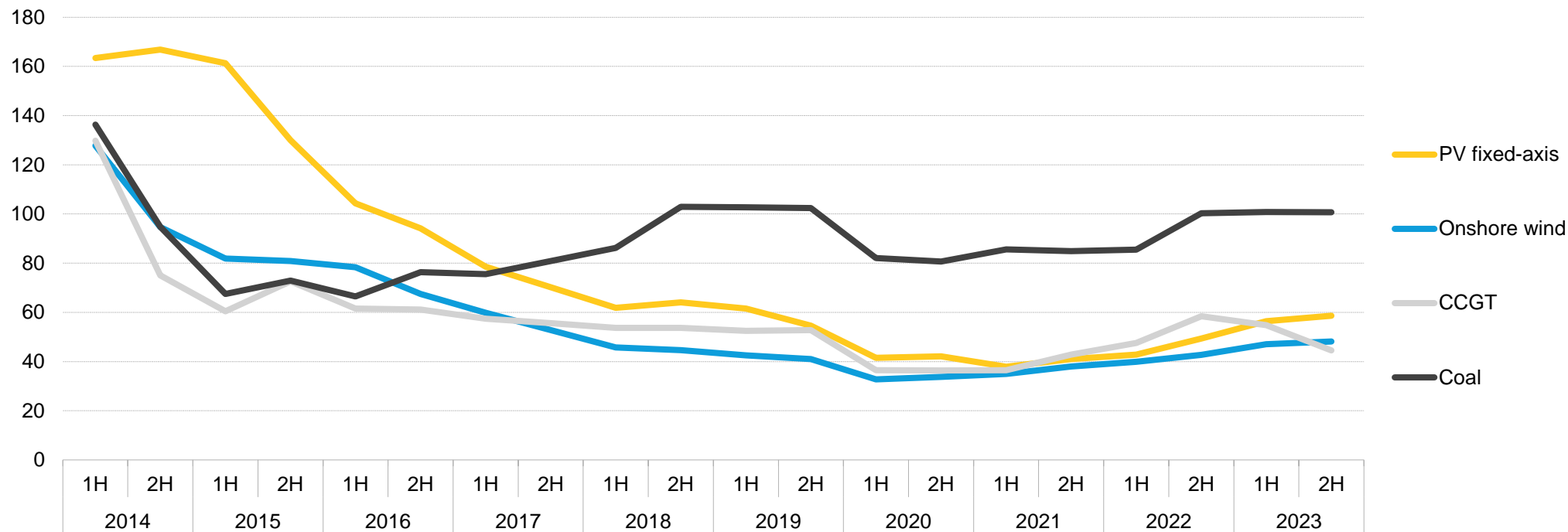


- In a positive development for the energy transition, prices for most key commodities that underpin wind, solar and storage fell in 2023, returning to levels comparable to early 2020, although steel prices remain somewhat volatile. Shipping costs returned to pre-pandemic levels from 2021 highs, completely erasing the nearly three-year surge in costs.
- However, interest rates are higher: the US federal funds target rate sat at 5.33% at the end of 2023, compared to 1.55% in early 2020. This has weighed on project financing costs, offsetting some of the relief from the easing of core commodity prices.
- Polysilicon prices fell steadily over the first half of 2023, as new factories ramped up production and tipped the market back toward oversupply. Prices for other solar plant inputs, such as aluminum for frames and copper for wiring, were largely unchanged in 2023.
- Lithium carbonate and lithium hydroxide prices fell sharply in 2023, reversing the surge seen in 2022, when supply chain disruptions, including Russia's invasion of Ukraine, caused metal prices to skyrocket. By December 2023, prices were trading at twice their pre-pandemic levels – a significant drop relative to 2022, and one attributable to a global increase in mines and processing capacity coinciding with slower than anticipated EV demand growth. Battery pack prices in 2023 ultimately fell year-on-year, reflecting the drop in relevant commodity prices.

Source: BloombergNEF, Bloomberg Terminal. Note: Data rebased to 1 on earliest available date in January 2020. Steel reflects North America costs, aluminum and copper are China prices. LiCO3 is lithium carbonate, LiOH is lithium hydroxide.

Economics: Benchmark US levelized costs of electricity, 2014-23

\$/MWh (2022 real)

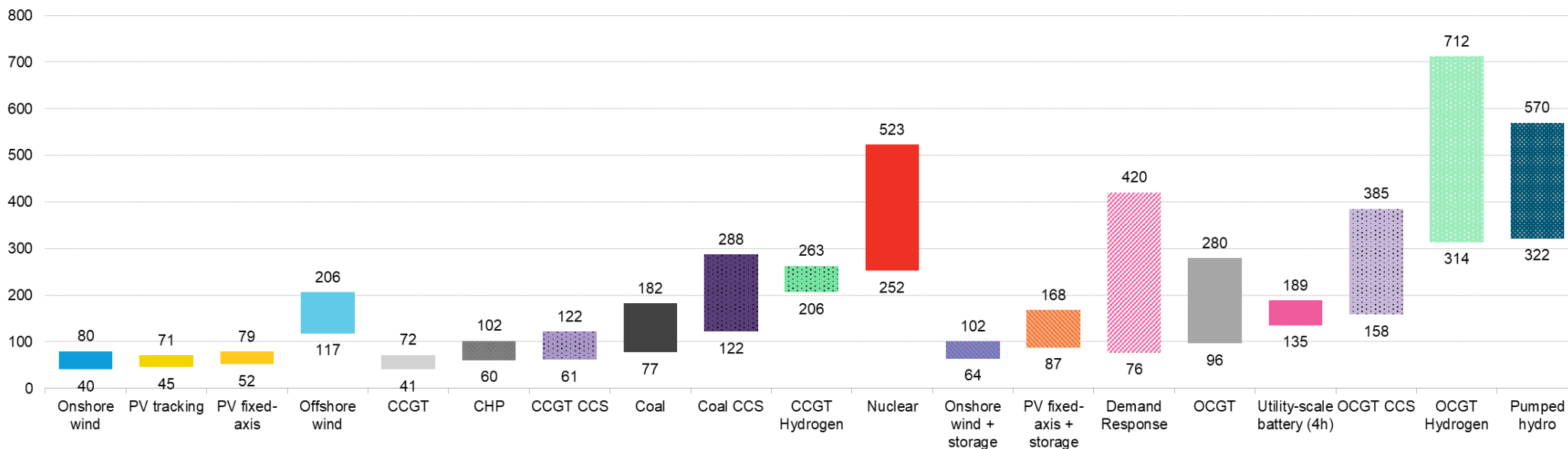


- The levelized cost of electricity (LCOE) for coal remained stable at \$110/MWh over the course of 2023 (reported in nominal terms for 2023 dollars). Yet that plateau follows a 10% rise between 2H 2022 and the beginning of 2023, making the fuel less competitive against others as a source of new power generation.
- The LCOE for combined-cycle gas turbines (CCGT) decreased by a benchmark of 15%, from \$58/MWh in 2H2022 to \$50/MWh in 2H2023, as the price of gas fell from 2022 highs.
- Onshore wind's benchmark LCOE increased 20%, from \$43/MWh in 2H2022 to \$52/MWh in 2H2023, partly due to volatile steel costs. The LCOE for fixed-axis photovoltaic (PV) solar increased by a benchmark of 27%, to \$63/MWh, during the same time due to higher interest rates and hardware costs. Tax credits for renewable generation (not included here) help offset some of this cost increase.

Source: BloombergNEF. Note: BNEF started collecting country-level LCOE inputs in 2014; prior to 2014, only global LCOE are available. LCOE displayed by financing date. Tax credits are not included. Chart is in real terms, but the numbers in the text are in nominal terms (2023 dollars).

Economics: US levelized costs of electricity (unsubsidized for new build, 2H 2023)

\$ per megawatt-hour (nominal)



- US LCOEs for most power-generating technologies rose in 2023, with costs associated with PV tracking projects seeing the largest increase (30%) from 2H 2022.
- Tax credits help new-build renewables remain cheaper than unsubsidized new gas-fired plants for bulk generation in many areas of the US, except for offshore wind. Onshore wind and tracking PV projects have benchmark LCOEs of \$52/MWh and \$79/MWh, respectively, without subsidies, but with tax credits the respective LCOEs drop to \$37/MWh and \$43/MWh. The LCOE for a new-build gas plant is \$50/MWh.
- The benchmark levelized cost of paired onshore wind-plus-battery (four-hour) systems is \$76/MWh, while solar-plus-battery (four-hour) is \$113/MWh. In comparison, gas peaking plants (open cycle gas turbines, or OCGTs) have a higher benchmark LCOE of \$137/MWh.

Source: BloombergNEF. Note: The LCOE range represents a range of costs and capacity factors. Battery storage systems (co-located and standalone) 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 (25-100% of total installed capacity). PV is photovoltaic solar, CCGT is combined-cycle gas turbine, CCS is carbon capture and storage, OCGT is open cycle gas turbine. All LCOE calculations are unsubsidized. Categorization of technologies is based on their primary use case.

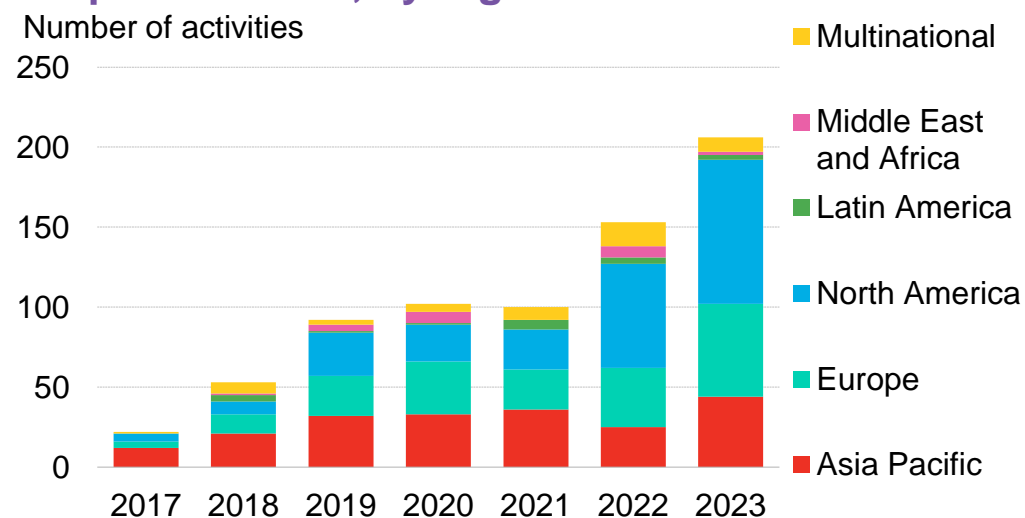
Table of contents



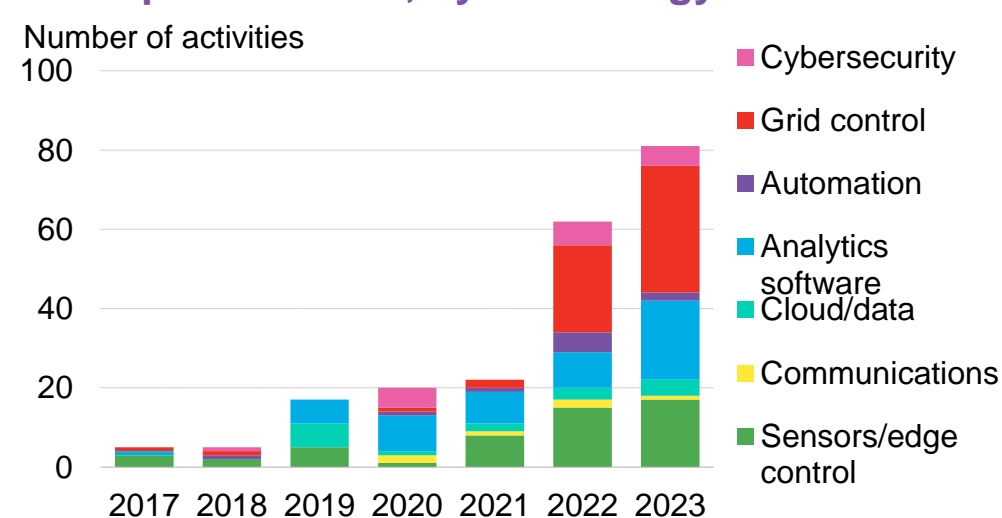
<u>1. Executive summary</u>			
<u>2. A look across the US energy sector</u>			
<u>3. Policy</u>	<u>3.1 Infrastructure and emissions</u>	<u>6. Deployment</u>	
	<u>3.2 Tax credits and stimulus</u>		
	<u>3.3 Vehicle standards</u>		
<u>4. Finance</u>	<u>4.1 Energy transition investment</u>		<u>7. Transportation</u>
	<u>4.2 Utility investment</u>		
	<u>4.3 Corporate sustainability</u>		
<u>5. Economics</u>	<u>5.1 Levelized costs of electricity</u>	<u>6.1 Energy efficiency</u>	
	<u>5.2 Environmental markets</u>	<u>6.2 Natural gas</u>	
		<u>6.3 Solar and wind</u>	
		<u>6.4 Storage</u>	
		<u>6.5 Hydrogen</u>	
		<u>7.1 Gasoline</u>	
		<u>7.2 Fuel prices and EV sales</u>	
		<u>7.3 Renewable natural gas</u>	

Deployment: The US has emerged as a global leader in power digitalization

Number of digital projects and partnerships in the power sector, by region



Number of US digital projects and partnerships in the power sector, by technology area

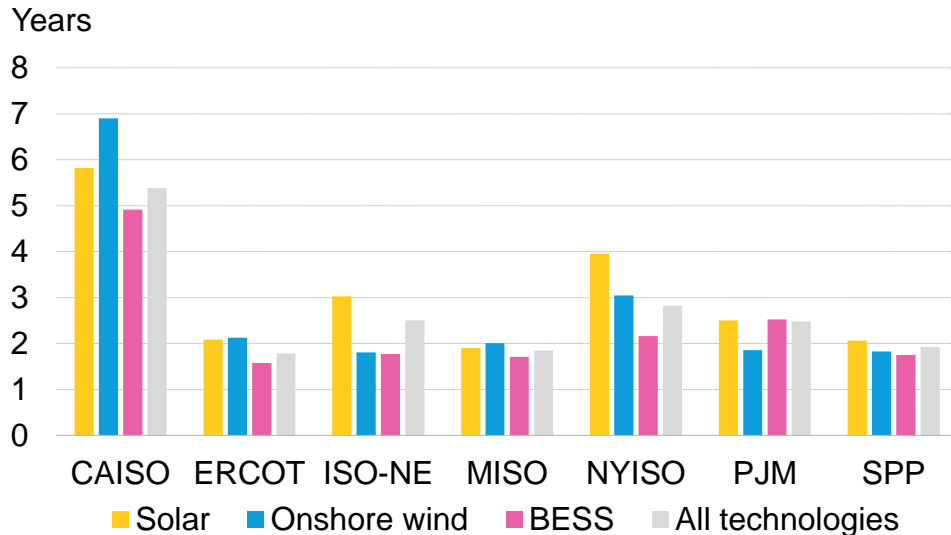


- BNEF tracked 206 digital projects and partnerships in the global power sector in 2023, with the US accounting for the largest share (81, or 40%) of these activities. This is in part due to new US policies like the Bipartisan Infrastructure Bill, and funding opportunities like the [Grid Resilience and Innovation Partnerships \(GRIP\)](#) program, that add momentum to US utility innovation.
- Much of the activity focused on grid control technologies in both 2022 and 2023. This included the use of tech platforms, such as virtual power plants and advanced distribution management systems, that help optimize the distribution grid and integrate distributed energy resources (DERs). Grid control activities accounted for 40% of all digital activities in the US in 2023, and 35% in 2022. This indicates that utilities are looking to gain visibility and coordinate across the power network down to behind-the-meter resources. In addition, analytics software, such as for forecasting generation, and sensors, like advanced metering infrastructure, drove power digitalization in 2023.
- Digital technologies are becoming a pillar in utility strategies worldwide to help improve the efficiency of electricity grids, boost power system resilience, and integrate renewables and DERs. In addition to developing new partnerships, utilities are growing their in-house bases of digital expertise. Avangrid, Iberdrola's US subsidiary, [launched](#) a team of seven people in 2023 to develop artificial intelligence models for the grid.

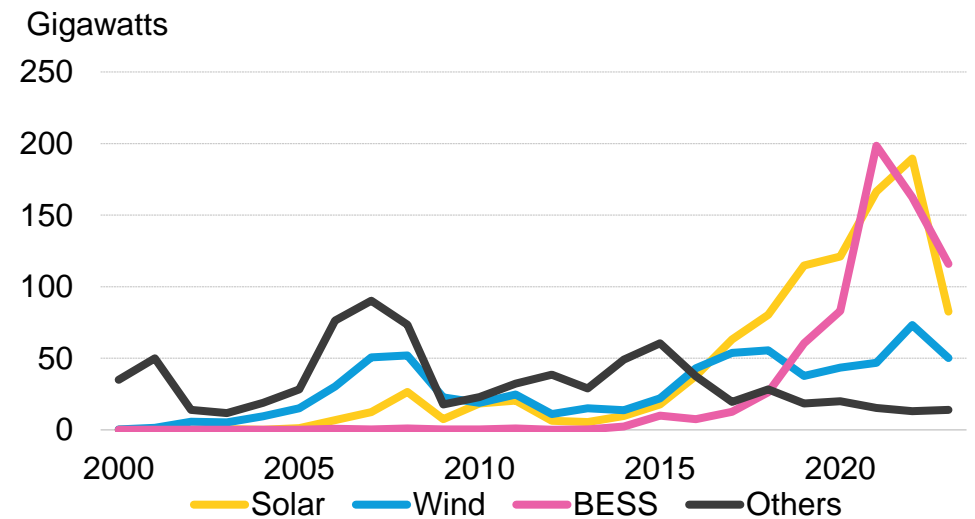
Source: BloombergNEF. Note: For more on this topic, see BNEF's [Digital Trends in Power Series](#).

Deployment: Wait times for power projects seeking grid access

Average age of projects in the queue as of January 2024



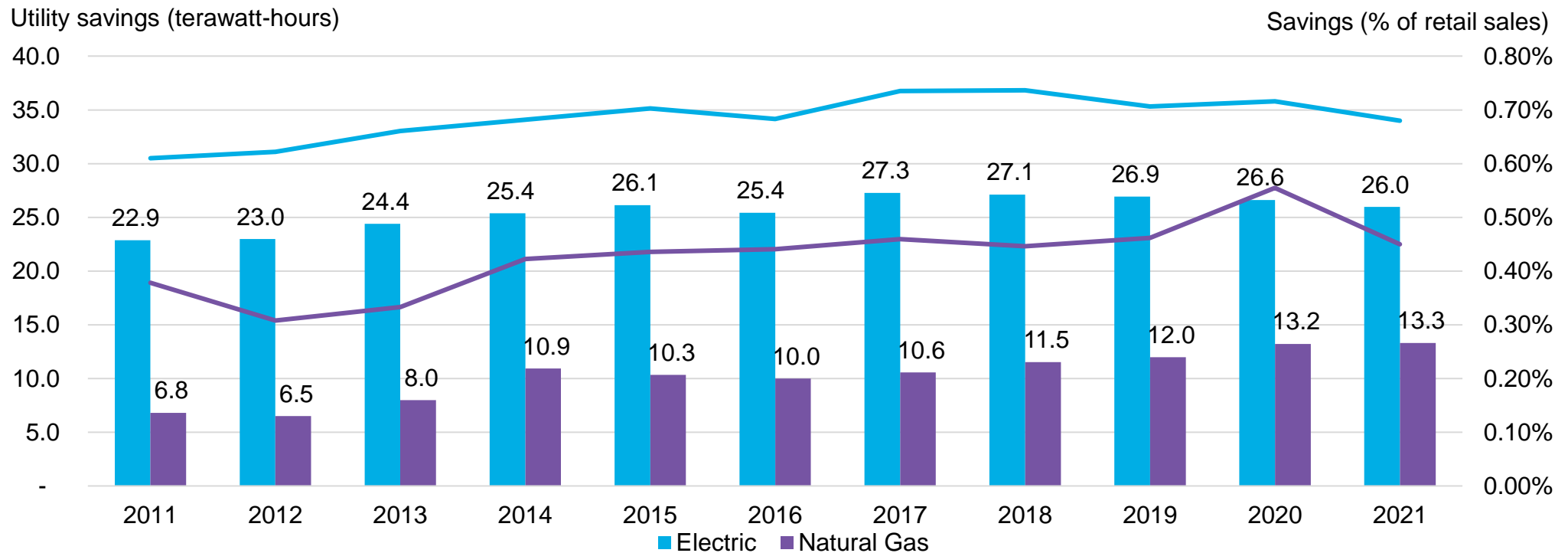
Total yearly generation capacity that applied for interconnection to US ISO power grids



- As of January 2024, over 1,100GW of projects are undergoing interconnection studies in the seven US independent system operators (ISOs). Roughly a quarter of the capacity currently in the queues is paired with other generation sources. Of the total capacity applications, 13% corresponds to co-located solar and battery storage projects. Solar capacity is 41% of active applications, whereas battery storage is 39%.
- Solar, wind and battery storage constitute 90% of the 420GW of projects that started studies since 2019 and have already withdrawn their application from the interconnection process. The surge of new project applications and long delays have resulted in ISOs reexamining their processes; PJM, the largest power market in the world, has moved to cluster processing of applications rather than analyzing projects individually. However, benefits are not expected to materialize for a few years.
- The California Independent System Operator (Caiso) has the highest wait times for active projects in the queue, with onshore wind projects reaching almost seven years. Projects in other regions have been, on average, in the queue for less than three years. This contrasts with the large amount of capacity that has applied for interconnection since 2020, bringing down the current age of projects in the queue.

Source: CAISO, ISO-NE, MISO, NYISO, PJM, SPP, ERCOT, Berkeley Lab, BloombergNEF. Note: BESS is battery energy storage systems. Caiso covers California, ISO-NE covers New England, MISO covers the Midwest region; NYISO covers New York, PJM covers the Mid-Atlantic region; SPP (Southwest Power Pool) covers the central southern US; Ercot covers most of Texas.

Deployment: Incremental annual energy efficiency achievements by utilities

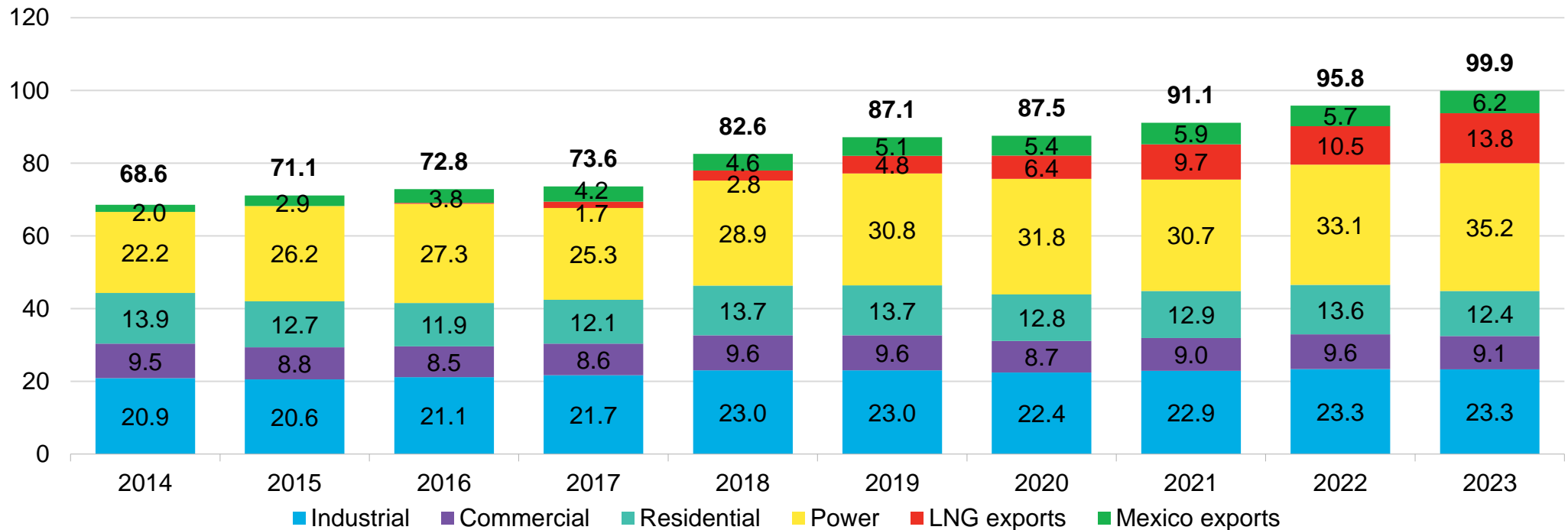


- The years leading up to 2011 saw a growing number of states introducing Energy Efficiency Resource Standards (EERS) mandating that utilities invest in energy savings among their customer base. A corresponding increase in investment in utility energy efficiency programs followed.
- Since then, the number of states and jurisdictions with EERS policies in place has leveled off at 27. In 2021, the last year for which there is complete data, utility electric energy efficiency savings slipped to 26TWh of energy and 0.68% of retail sales. The same year, utility gas energy efficiency savings inched up by 0.1TWh for a total of 13.3TWh, but dropped to 0.45% 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 , AGA. 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 on a fuel-neutral basis, which is appropriate when electrification brings a net positive effect on emissions. ACEEE may adjust their methodology if this practice becomes commonplace.

Deployment: US natural gas demand by end use

Billion cubic feet per day



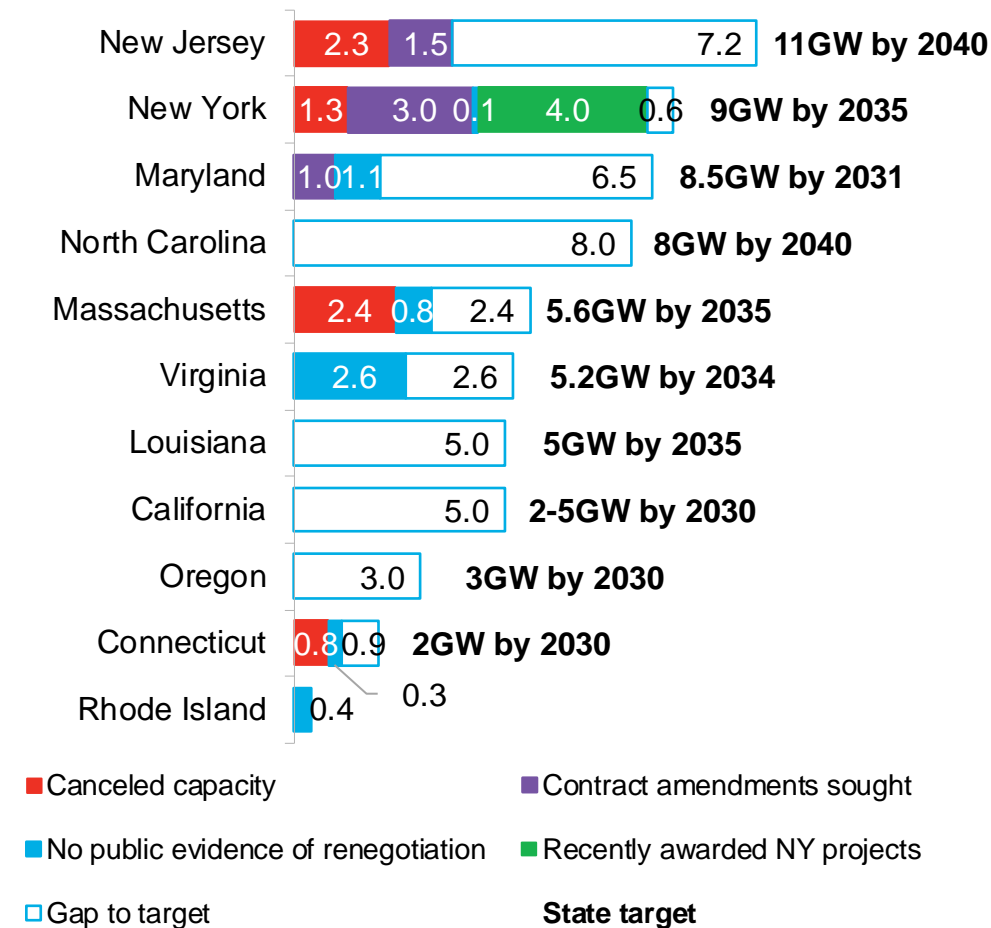
- Demand for US natural gas rose 4.3% in 2023 from the year prior, to reach 99.9 billion cubic feet per day (Bcf/d). The jump was led by stronger power sector consumption, rising liquefied natural gas (LNG) exports, and more exports to Mexico. Residential and commercial end use saw consumption decline.
- Improved gas plant economics, due to relatively low natural gas prices, plus coal plant retirements helped set a new record for power sector gas consumption. The Henry Hub front month contract fell as low as \$2.00/MMBtu. LNG feed gas demand saw an impressive 31% increase driven by the return of Freeport LNG in March 2023 after it had been shut down in June 2022. Exports to Mexico rose by 8.7%, largely driven by hotter-than-average temperatures over the summer.
- On the other hand, commercial and residential demand fell by 5% and 9%, respectively. Abnormally warm weather in January, February and December 2023 caused considerable amounts of heating demand destruction.

Source: BloombergNEF, EIA, US Department of Energy (DOE). Note: November and December 2023 values are forecasts. LNG is liquefied natural gas.

Deployment: Offshore wind struggles amid high costs

Status of contracted offshore wind capacity and targets across US states

Gigawatts

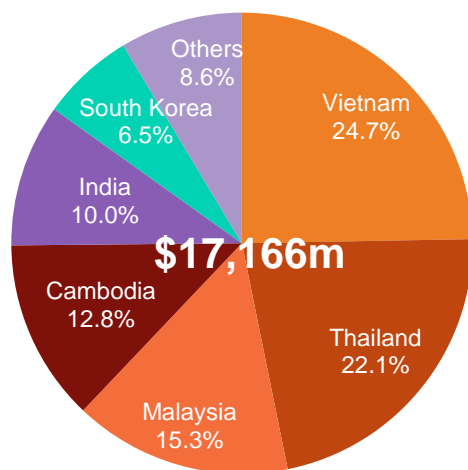


Source: BloombergNEF, news reports, company filings and announcements. GW is gigawatts.

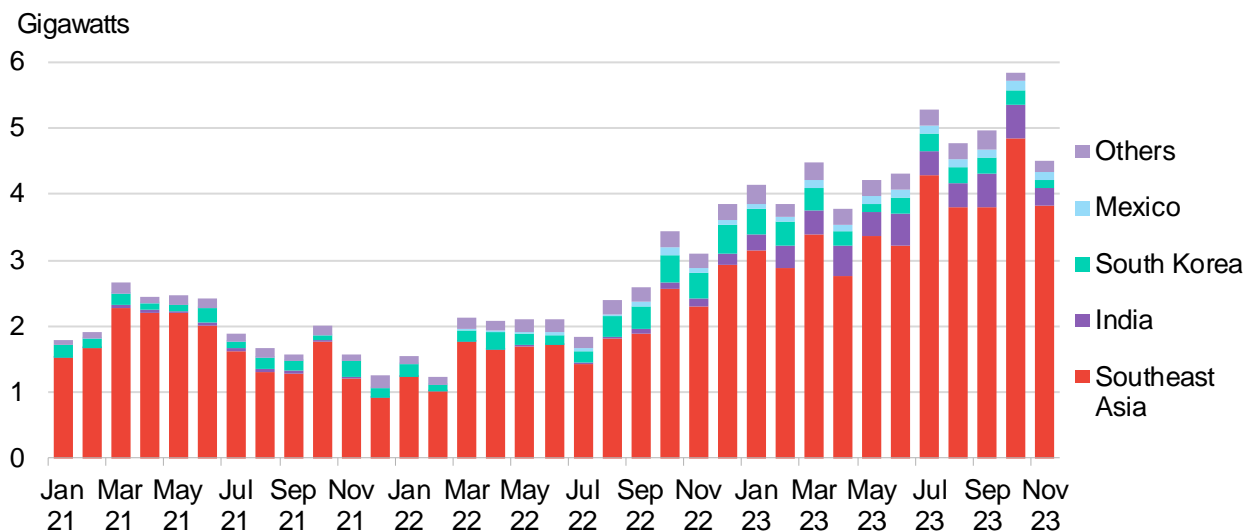
- Developers of over half of all contracted US offshore wind capacity – or some 12.2GW – have sought to either cancel or renegotiate power offtake agreements in the last year, citing high costs of capital, inflation, supply chain constraints and uncertainty over tax credit qualification as key threats to projects’ economic viability.
- Some 6.7GW of projects have canceled contracts across four states so far, including Avangrid’s Commonwealth Wind and Park City Wind projects, Shell and Ocean Winds’ SouthCoast Wind, Orsted’s Ocean Wind 1 and 2, and Equinor and BP’s Empire Wind 2.
- Despite recent challenges, states are still procuring offshore wind. In October 2023, New York provisionally awarded 4GW of contracts to bidders in the US’s largest offshore wind procurement to date. New York, New Jersey, Massachusetts, Rhode Island and Connecticut are planning to award more capacity in 2024.
- The Bureau of Ocean Energy Management (BOEM) hosted a seabed lease auction in the Gulf of Mexico in August 2023, the first in the region. The only site awarded in the auction went for \$55/acre, just 0.6% of the lease prices off New York and New Jersey in 2022.
- BOEM issued four ‘Records of Decision’ – a document approving project construction activities – for 6.5GW of offshore wind capacity in 2023. This is the highest number the US has completed in a single year and includes the 2.6GW Coastal Virginia Offshore Wind project – one of the largest offshore wind projects in development globally.
- Orsted reached a final investment decision on its 704MW Revolution Wind project, the third large-scale US offshore wind farm to reach financial close. Avangrid and Copenhagen Infrastructure Partners also closed the US’s first offshore wind tax equity deal, at \$1.2 billion.

Deployment: US imports of PV modules

US imports of PV modules by origin, January to November 2023



US imports of PV modules, by month and origin

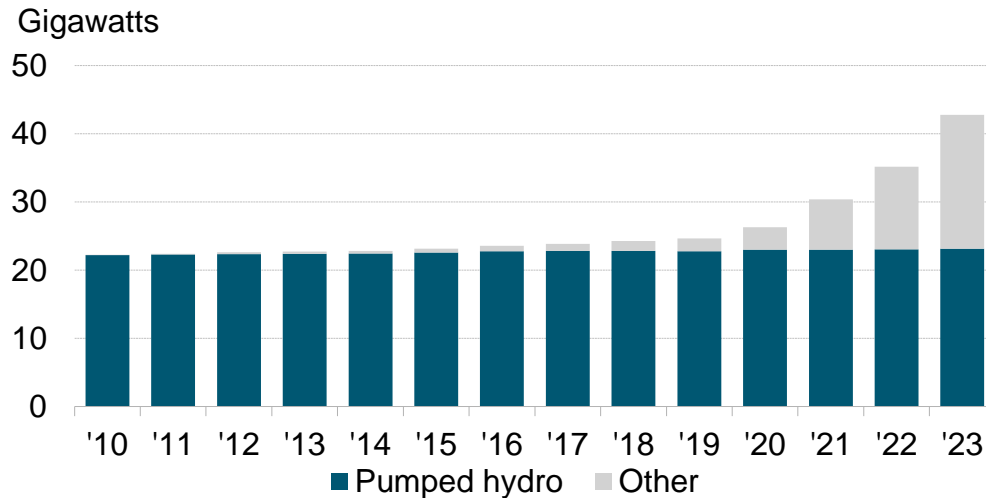


- The US imported over 50GW of PV modules in the first eleven months of 2023, 144% more than during the same period in 2022. Nearly 5.8GW of solar modules landed in the US only in October, breaking another monthly record. Imports from China were less than 0.1% of all imports in the first 11 months of 2023.
- Globally, excess module supply grew in 2023, pushing module prices to as low as \$0.20 per watt. Additionally, manufacturers were keen to sell modules (produced in certain Southeast Asian countries) before a temporary moratorium on tariffs expires in June this year. BNEF estimates module inventory in the US exceeded 30GW at the end of 2023. However, legal challenges to which modules face import tariffs persist; the results are awaited.
- US cell imports also grew to \$666 million last year as of November, 34% more than during the same period in 2022, as new domestic solar silicon module assembly factories ramp up and import cells to assemble into modules. In November, monthly solar cell imports exceeded 500MW for the first time since we began tracking customs data.

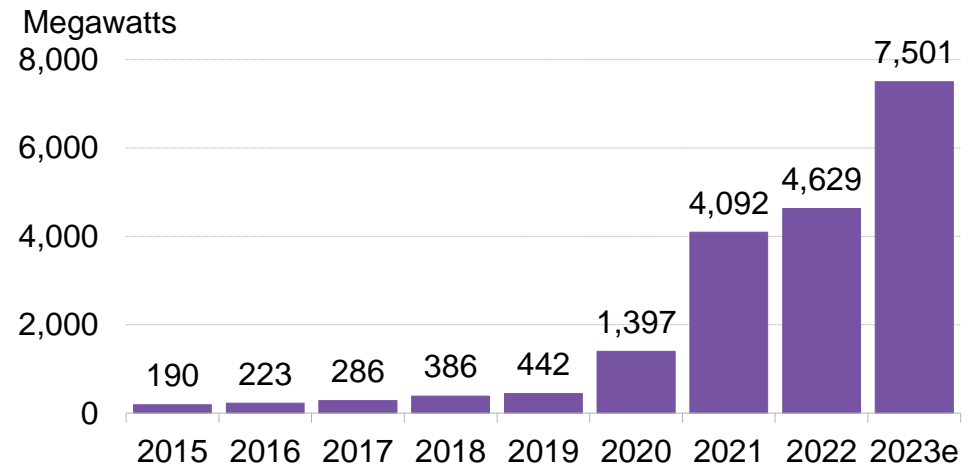
Source: BloombergNEF, [US International Trade Commission Data Web](#). Note: Free-on-board (FOB) value excludes US import duties, freight, insurance and other charges. First Solar's thin-film module is free from Section 201 duty. See monthly average selling price (ASP) derived from US International Trade Commission statistics PV stands for photovoltaic solar.

Deployment: US cumulative energy storage

Commissioned US energy storage capacity



Non-hydro energy storage additions

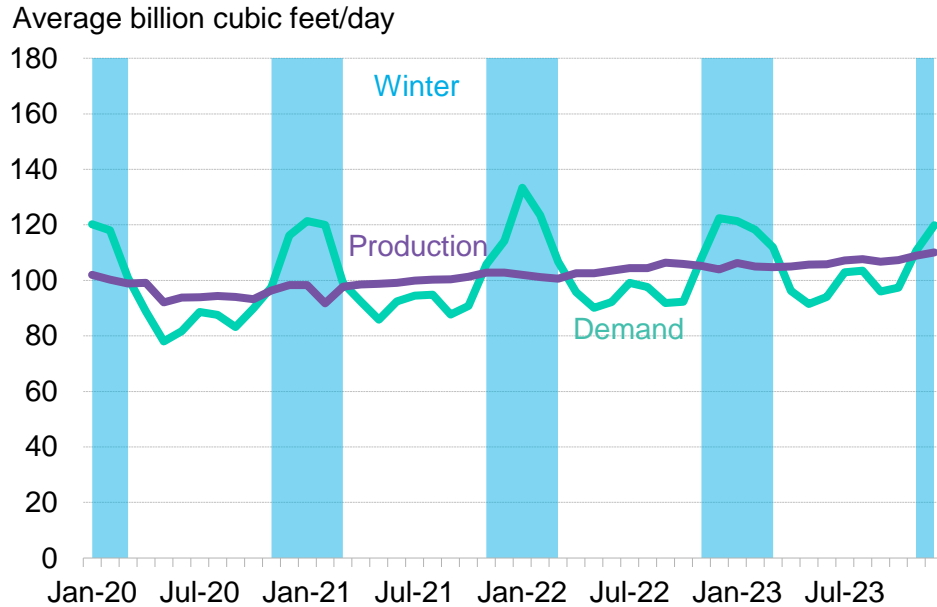


- In 2023, the US commissioned an estimated 7.5GW in non-hydropower storage, making it a record year of installations. This was a 62% increase year-on-year, and brought total non-hydropower storage capacity to 19.6GW. The Inflation Reduction Act has spurred storage deployments and is accelerating investment in the sector. By the end of 2023, there was 19.6GW of battery storage capacity against 23.1GW of pumped hydro storage. Despite this record, the US lost its position as the global leader in energy storage, and now finds itself in second place to China.
- At the same time, pumped hydro represents 96% of the generation from storage (in GWh terms) on the grid. In addition, proposed new pumped storage has the potential to significantly increase the amount of long-duration (eight-hour+) energy storage available on the grid. The US Department of Energy (DOE) announced \$13 million for seven research and development projects to support advanced pumped hydro storage. The DOE is also funding \$505 million towards long duration energy storage (LDES), or projects that can deliver electricity for 10 or more hours.
- Energy shifting is the dominant use case for new batteries, as pairing renewables – particularly solar – with storage is becoming a common, cost-effective option for displacing fossil-fuel projects. Utilities across the US are beginning to cite energy-storage technologies in their long-term resource planning and as solutions to their power system flexibility needs.

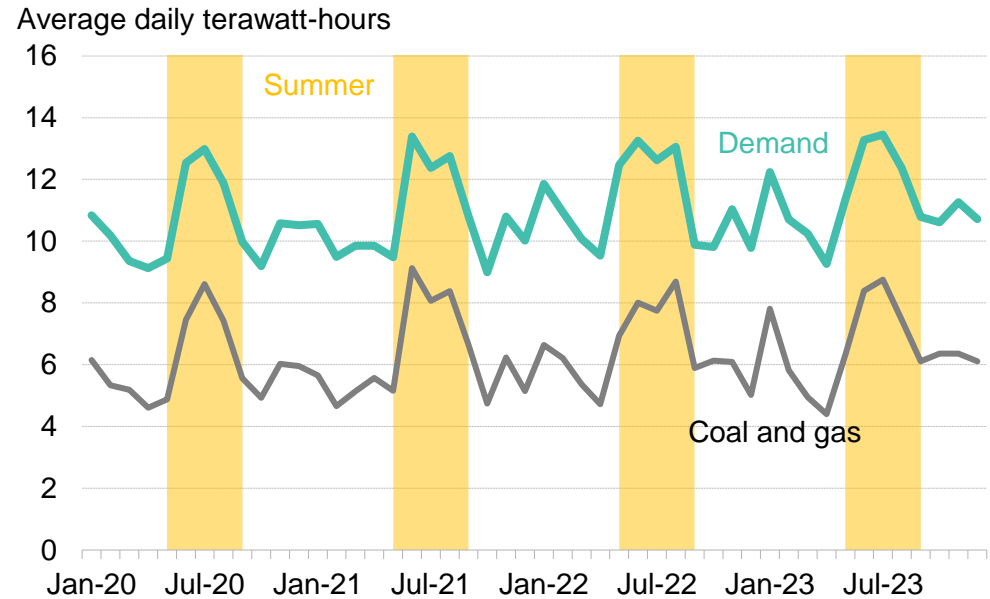
Source: EIA, FERC, BloombergNEF. Note: "Other" includes projects where the technology is unknown, which is frequently lithium-ion batteries.

Energy overview: Seasonal storage needs

Natural gas production and demand



Electricity demand and thermal generation

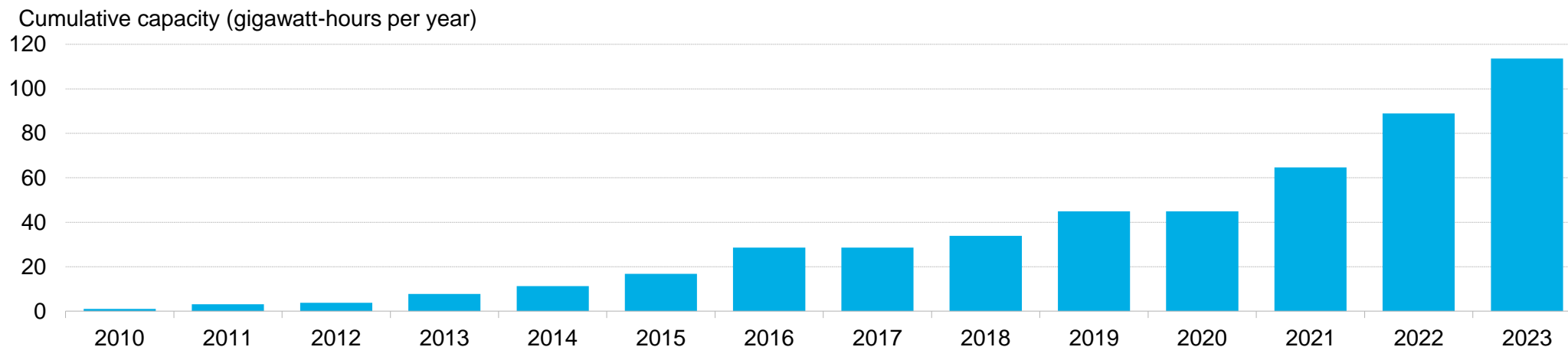


- Seasonality in energy demand has typically been met by some form of storage. Thermal fuels, like coal or gas, can be stored either on-site or in specialized underground reservoirs, and are thus arguably as much a form of energy storage as batteries and pumped hydro.
- The gas market typically sees demand surge in winter, as the fuel is used to heat homes, businesses and industry. Contribution from underground storage helps meet the higher heating needs. During times of high demand, storage can meet up to 50% of daily natural gas demand. An average of 11.3 billion cubic feet per day was consumed from storage over winter 2022/23 (November 2022 through March 2023).
- The power market tends to see demand surge in the summer, and it meets this demand by generating more electricity. The two major sources of electrical energy storage are pumped hydropower reservoirs and lithium-ion batteries. However, both these means of storage are focused on hourly shifting, such as up to 20 hours at a time (hydro), or 4-6 hours (batteries). The power market currently relies on being able to generate more electricity by burning fossil fuels to meet seasonal surges in power demand, rather than seasonal electricity storage.

Source: BloombergNEF. Note: Gas supply includes imports from Canada. Demand includes exports to Mexico and LNG feedgas demand.

Deployment: Current and planned manufacturing capacity

US lithium-ion battery cell manufacturing capacity

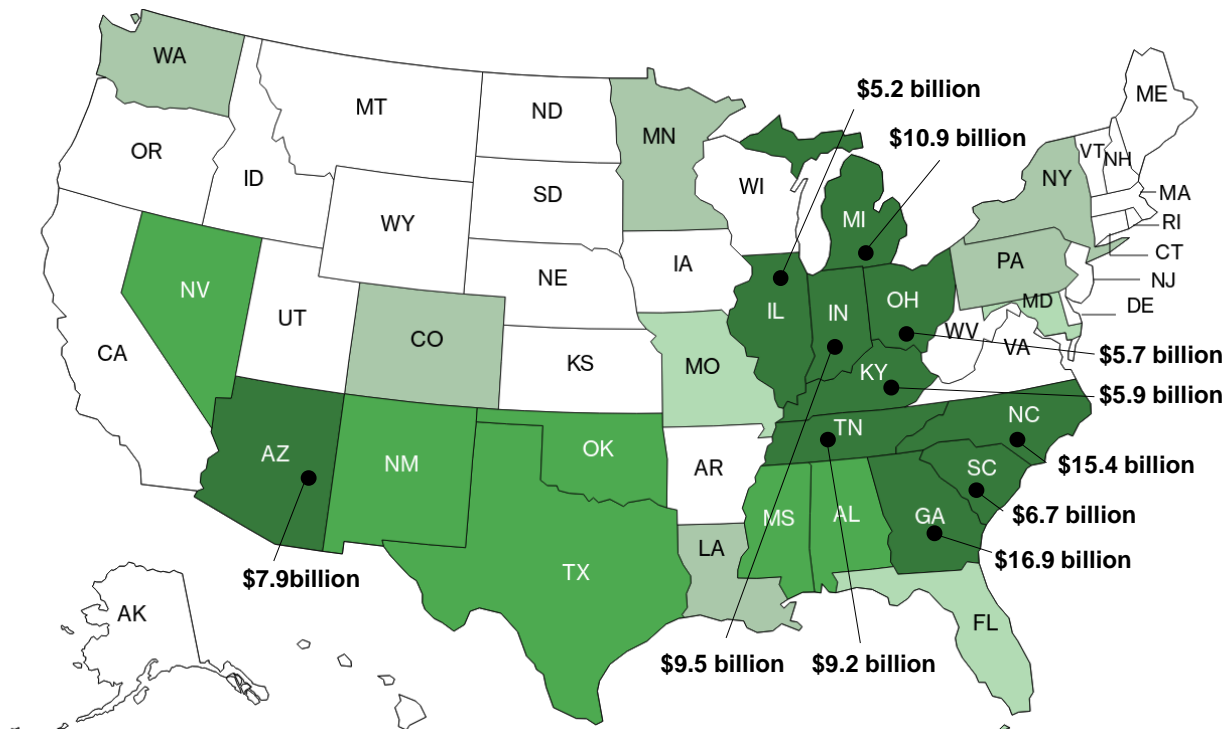


- By the end of 2023, the US had 114GWh of annual lithium-ion battery manufacturing capacity, a growth of 49GWh, or 28%, over the country's capacity at the end of 2022. Notable announcements included Tesla's 100GWh expansion in Reno's Battery Plant and Gotion's 40GWh battery plant in Illinois. However, Ultium Cells, GM's joint venture with LG Energy Solution, delayed commissioning of its facility in Spring Hill, Tennessee, which will start producing batteries in 2024. Another plant in Lansing, Michigan is expected in 2024.
- The IRA introduced a \$35/kWh battery cell and \$10/kWh battery module production tax credit that is already starting to boost battery manufacturing in the US. North American EV and battery supply chain commitments following the IRA's passage have exceeded \$100 billion, the majority of which were for battery cell manufacturing in the US (some investments were announced in Canada). In 2023, 151GWh of new battery cell manufacturing capacity was announced, including investments by LG Energy Solution, Gotion, BlueOval (a Ford and SK On joint venture), and a GM-Samsung SDI joint venture.
- Though capacity grew significantly last year, it remains short of the 178GWh that had been expected to be commissioned by the end of 2023, based on original company announcements. Slower-than-expected EV market demand decelerated expansions throughout the year.

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

Deployment: Manufacturing projects announced since the passage of the IRA

Clean-tech manufacturing investment announcements post-IRA



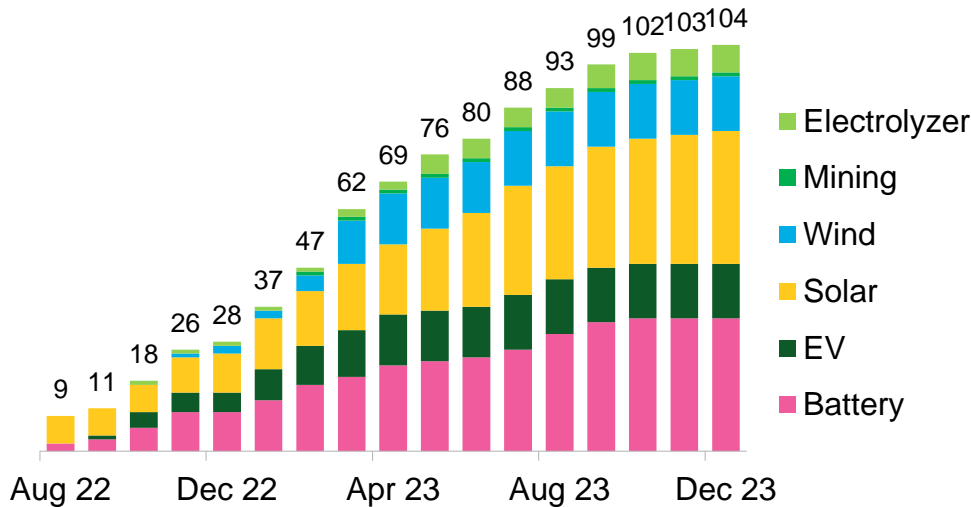
- Over \$131.4 billion in investments have been announced in a total of 28 states.
- Ten of these states accounted for roughly 78% of the total investment, while \$29.3 billion went to the remaining 18.
- Georgia has received the largest amount of any state, with a total of \$16.9 billion in investments announced post-IRA. Of this, \$14.2 billion is from announced battery manufacturing projects, while \$2.6 billion is from solar manufacturing.
- A close second, North Carolina received investment worth \$15.4 billion from a single company – Toyota.

Source: BloombergNEF. Note: Data as of the end of December 2023. Only the top 10 investment figures are labeled.

Deployment: Clean-tech manufacturing investments

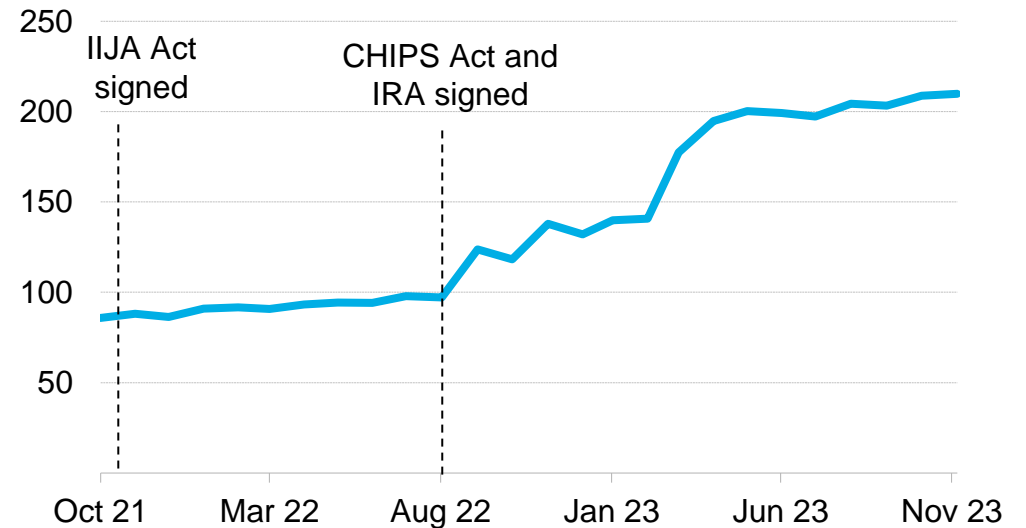
Clean-tech manufacturing investments announcement post-IRA

Number of facilities



Total manufacturing construction spending in the US

\$ billion



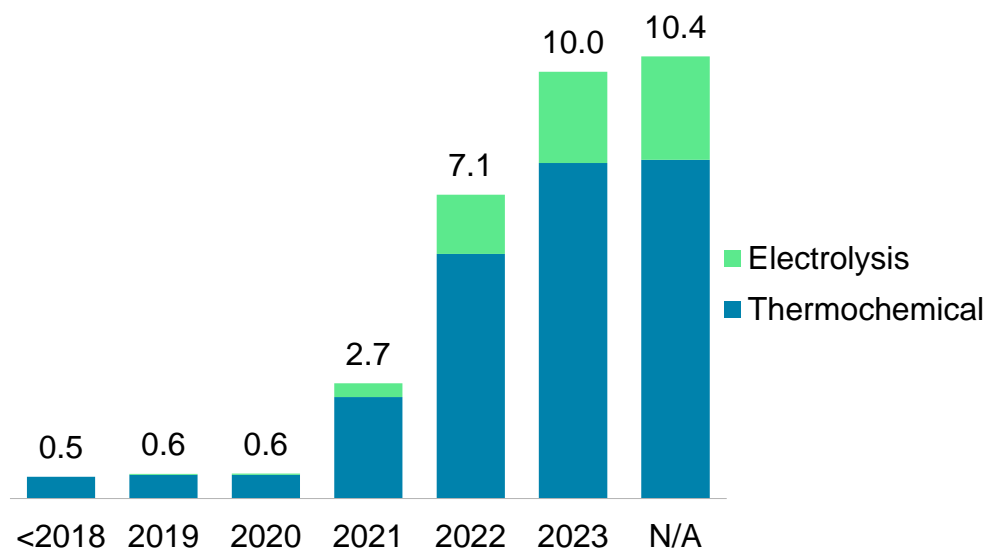
- Since the passage of the IRA, a total of 104 clean-tech manufacturing facilities have been announced, cumulatively representing \$123 billion in announced investments from August 2022 through December 2023. Of these, 34 facilities are across the battery value chain, 34 are in solar, and 14 are in wind and 14 involve EVs. Seven electrolyzer facilities and one mining facility have also been announced.
- Manufacturing construction spending in the US has been on the rise. The uptick in spending started in August 2022, following the passage of the IRA and the CHIPS Act; since then, there has been a 116% cumulative increase in manufacturing construction spending. Data reported includes costs on semiconductor manufacturing facilities, as well as clean power; of these, semiconductor projects are typically more expensive.
- Over two years, manufacturing construction spending increased by 143%, from \$86 billion in October 2021 to \$210 billion in October 2023.

Source: BloombergNEF. US Census Bureau. Note: IIJA is the Infrastructure Investment and Jobs Act; CHIPS stands for Creating Helpful Incentives to Produce Semiconductors; IRA is the Inflation Reduction Act.

Deployment: Regional hydrogen hubs to increase H₂ supply

Cumulative hydrogen project volumes, by year of project announcement

million metric tons of hydrogen per year



Regional hydrogen hubs' planned H₂ production facilities

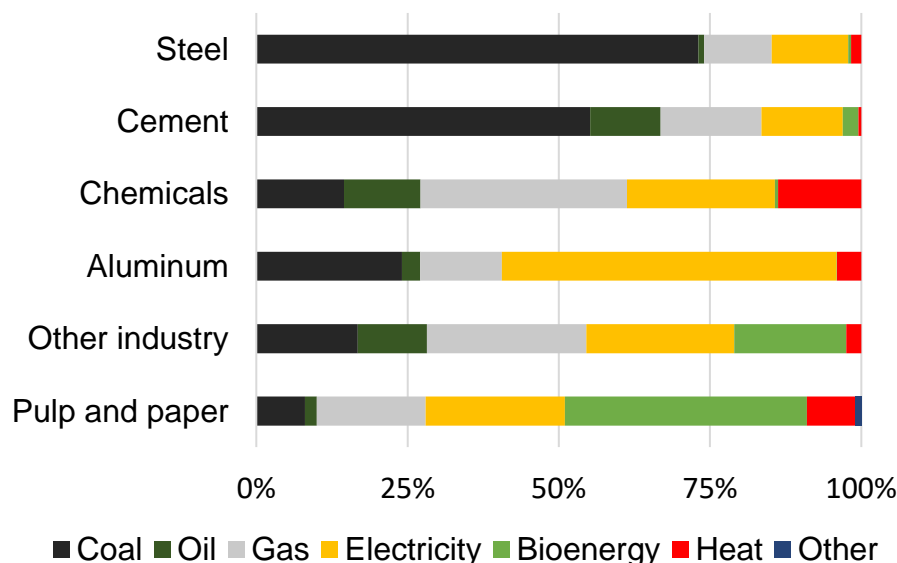


- Approximately 10.4 million metric tons of hydrogen capacity per year have been announced across the US to date. The steep rise in project announcements from 2020 to 2023 is credited to a favorable policy environment for hydrogen producers.
- Over 70% of the US's announced hydrogen volume is composed of blue hydrogen, or hydrogen produced from natural gas with carbon capture, due to the low cost of natural gas. By contrast, the renewables needed to produce green hydrogen via electrolysis are relatively expensive.
- The Biden administration's regional hydrogen hubs plan to contribute an additional three million metric tons of hydrogen per year once all four phases of the program are complete. The hubs are currently in award negotiations with the Department of Energy, which are expected to be completed by mid-2024.

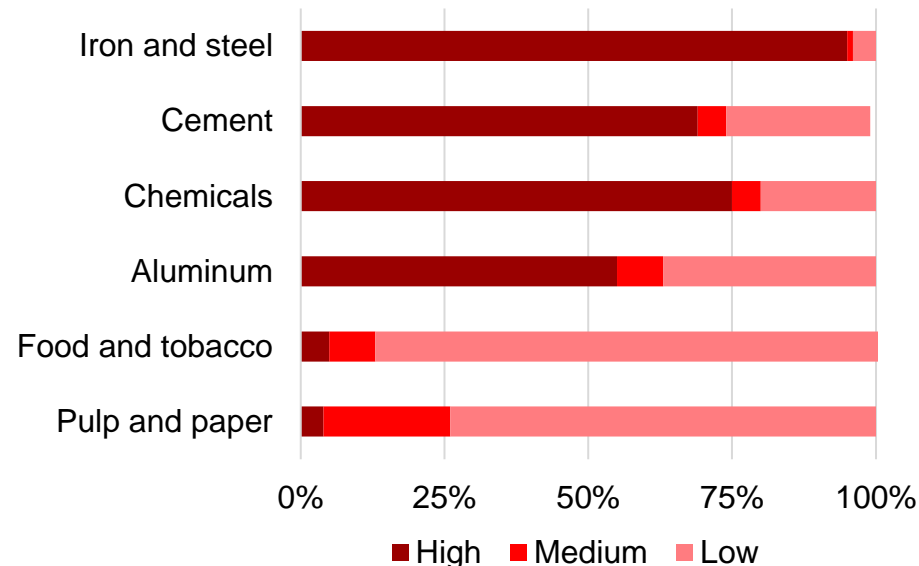
Source: BloombergNEF, Office of Clean Energy Demonstrations (OCED).

Deployment: The role of heat in industrial processes

Share of energy supply for industrial processes globally, 2022



Temperature profile for industrial process heat globally, 2022



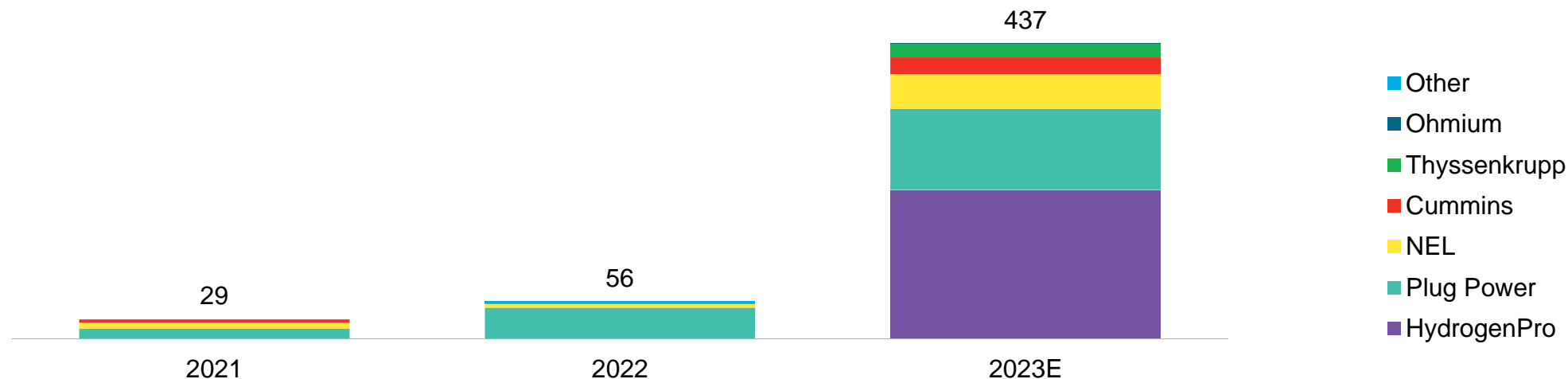
- Industrial processes accounted for 32% of global energy use in 2022 and around one-fifth of all greenhouse gas emissions. Most industrial energy consumption is used to produce process heat.
- Some industries use significant amounts of renewable energy for heat. Some sectors, such as food and tobacco or pulp and paper, use a relatively high proportion of renewable heat sources like biomass and biogas, thanks to the ready availability of organic waste at their sites. These two sectors have the lowest temperature profile of any of the sectors in the right-hand chart.
- Other industries, such as chemicals, cement and iron and steel, use a higher proportion of fossil fuels. These industries have the highest temperature profiles.

Source: BloombergNEF, New Energy Outlook, IEA, Energy Balances, European Commission. Other industry includes food processing, manufacturing and construction

Deployment: Electrolyzer shipments on the rise

Completed electrolyzer shipments to the US, by year and company

Megawatts

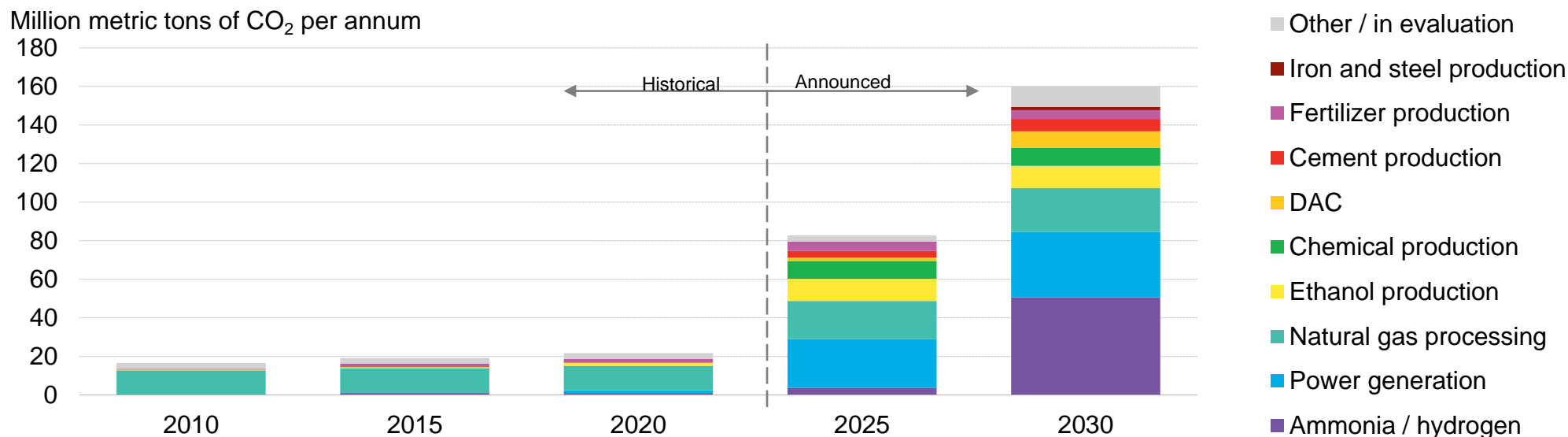


- In the US, electrolyzer shipments increased dramatically from 2022 to 2023, growing 680% year-on-year to reach a record 437MW. Favorable policy, such as the Inflation Reduction Act, is leading developers to source electrolyzers to create green hydrogen. This marks a departure from the predominant method of producing hydrogen to date, through the oxidation of natural gas.
- The increase was largely driven by shipments from HydrogenPro and Plug Power. HydrogenPro delivered a total of 220MW to the ACES Delta project in Utah, accounting for about 50% of the shipments made in 2023. Plug Power delivered 120MW in shipments, accounting for roughly 27% of the total.
- Under recently updated draft guidance, the IRA's 45V hydrogen production tax credits would provide up to \$3 per kilogram of hydrogen produced, for projects that meet incrementality, time matching, deliverability and lifecycle carbon emissions rules. Based on these criteria, electrolyzer projects stand to benefit the most.

Source: BloombergNEF. Note: Data is estimated based on publicly available information as of August 28, 2023.

Deployment: US deployment pipeline for carbon capture projects

Historical and proposed carbon capture capacity in the US, by source



- At the end of 2023, the US had nearly 23 million metric tons of CO₂ per annum (Mtpa) of installed carbon capture, utilization and storage (CCUS) capacity. Most of this capacity is used in the natural gas processing sector, but the CCUS landscape is diversifying rapidly.
- Currently, the US has 137Mtpa of announced capacity. Sectors like ethanol, power generation, ammonia and hydrogen, and chemicals make up most of the demand from these plans.
- A revised 45Q tax credit drove project announcements last year, with developers racing to start construction before 2033, when the scheme expires. Announcements have now tapered off as developers wait for the IRS to release guidance providing clarity on project eligibility.
- However, planned projects must contend with permitting and regulatory headwinds. In 2023, the Navigator pipeline was canceled, a 5Mtpa blow to the ethanol market, with developers citing unpredictable regulatory processes. To mitigate associated transport and storage bottlenecks, the government has both granted primacy to Louisiana, and allocated funding from the Bipartisan Infrastructure Law towards midstream CCUS projects. These initiatives are bolstered by 45Q credits which, despite the aforementioned roadblocks, cement the US as the global market leader through 2030.

Source: BloombergNEF. Note: DAC is direct air capture.

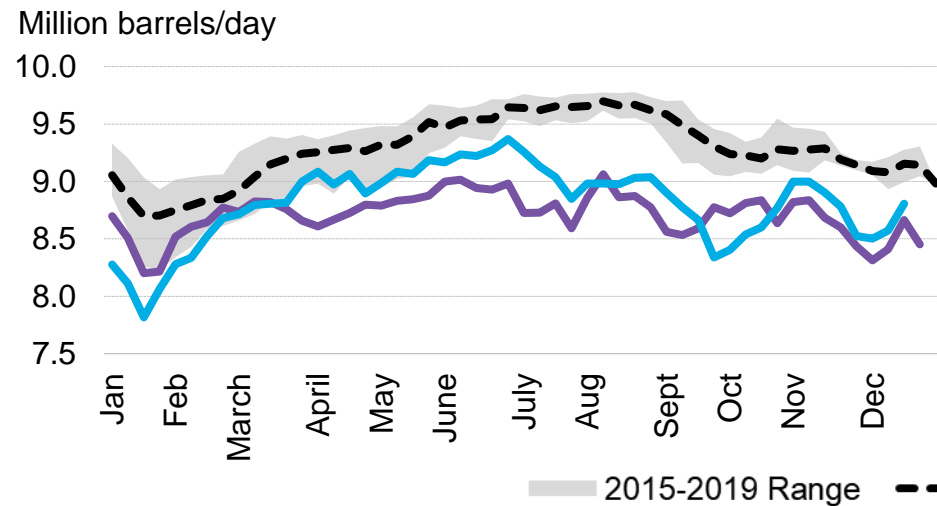
Table of contents



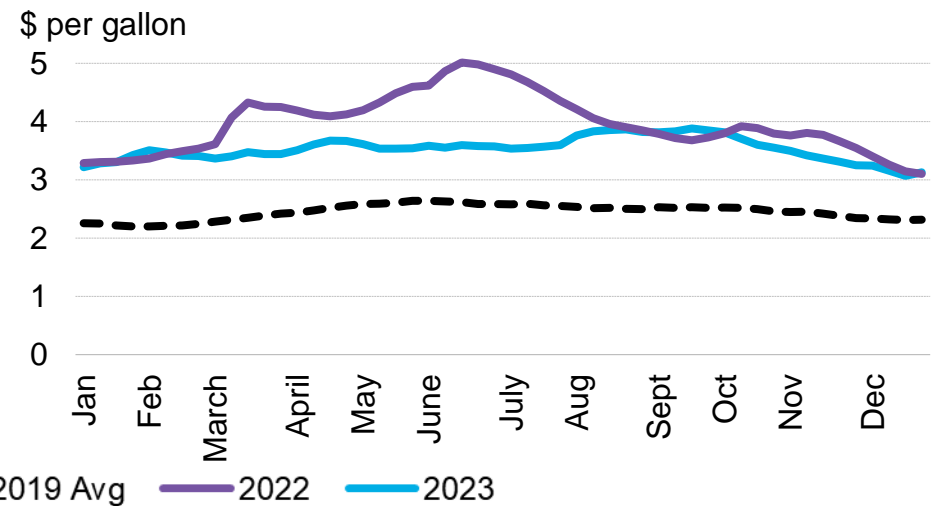
<u>1. Executive summary</u>			
<u>2. A look across the US energy sector</u>			
<u>3. Policy</u>	<u>3.1 Infrastructure and emissions</u>	<u>6. Deployment</u>	
	<u>3.2 Tax credits and stimulus</u>		
	<u>3.3 Vehicle standards</u>		
<u>4. Finance</u>	<u>4.1 Energy transition investment</u>		<u>7. Transportation</u>
	<u>4.2 Utility investment</u>		
	<u>4.3 Corporate sustainability</u>		
<u>5. Economics</u>	<u>5.1 Levelized costs of electricity</u>	<u>6.1 Energy efficiency</u>	
	<u>5.2 Environmental markets</u>		
			<u>6.3 Solar and wind</u>
		<u>6.4 Storage</u>	
		<u>6.5 Hydrogen</u>	
		<u>7.1 Gasoline</u>	
		<u>7.2 Fuel prices and EV sales</u>	
		<u>7.3 Renewable natural gas</u>	

Transportation: Gasoline demand and prices

US gasoline demand



US wholesale gasoline prices

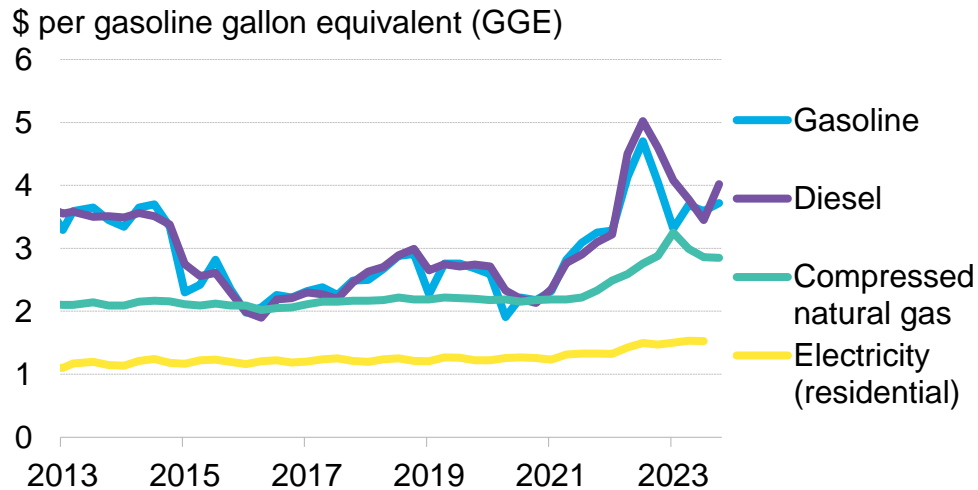


- US gasoline demand increased year-on-year in 2023 but remained well below pre-pandemic (2015-2019) averages. The US consumed an average of 8.8 million barrels a day (b/d) of gasoline in 2023, some 97,000 b/d more than in 2022. Nonetheless, 2023 US gasoline demand was 480,000 b/d lower than the 2015-19 average.
- Higher gasoline prices are a large part of the reason US gasoline demand has been below pre-pandemic levels. Wholesale US gasoline prices averaged \$3.52 per gallon in 2023, \$1.07 per gallon higher than the 2015-19 average. US drivers are price sensitive, and higher gasoline prices have led to demand destruction. Elevated gasoline prices were partially a result of lower global refining capacities, as a number of refineries were shuttered in the previous years owing to weak refining margins. This limited refined product supplies as economies around the world reopened after the pandemic and consumption of refined products recovered, leading to higher gasoline prices.
- There are also structural factors at work that have led to lower US gasoline demand. Work-from-home remains a popular option for many workers across the US, reducing the need to commute to work and denting gasoline consumption.

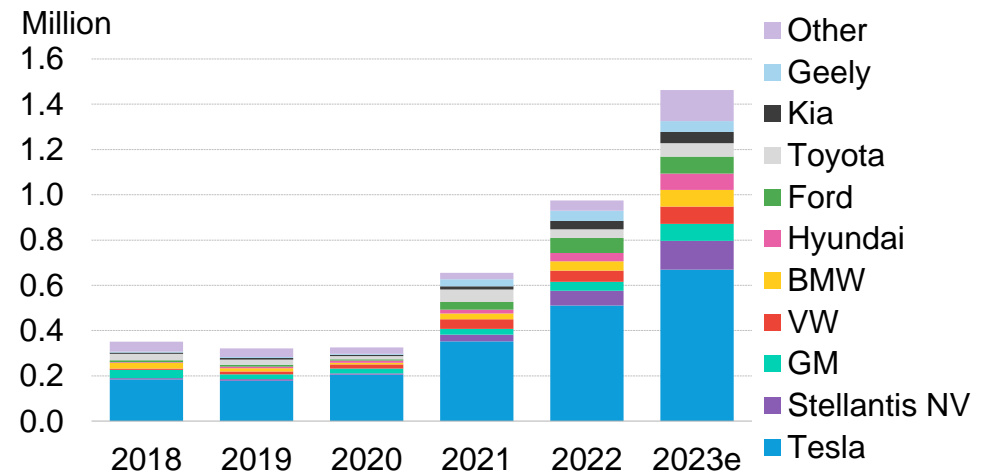
Source: BloombergNEF, EIA, American Automobile Association; Note: Gasoline demand data is the four-week rolling average for gasoline supplied data from the Energy Information Administration (EIA). Wholesale gasoline prices are the daily national average gasoline price.

Transportation: Vehicle fuel prices and EV sales

Average vehicle fuel prices



US electric vehicle sales

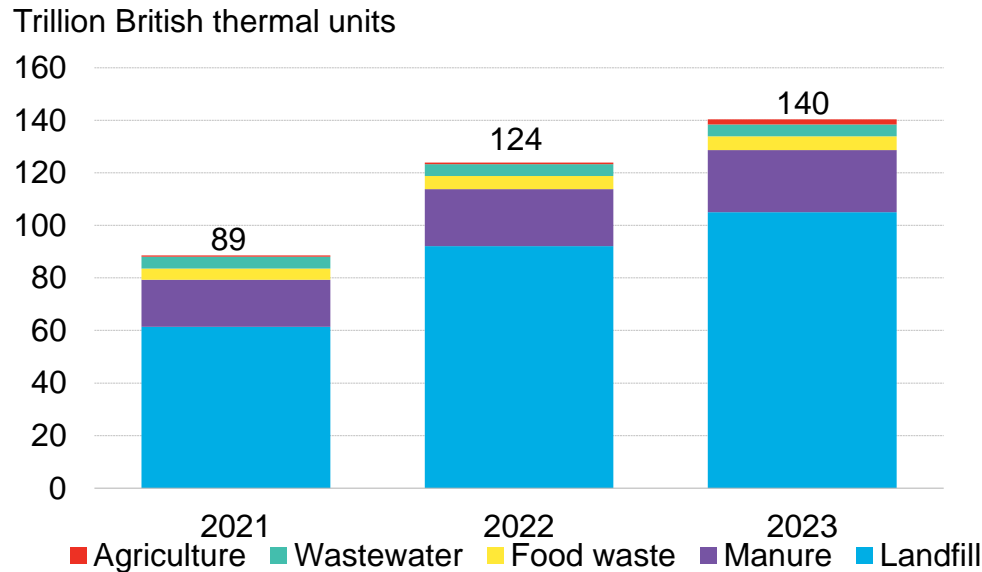


- After skyrocketing in 2022 – due in part to Russia’s invasion of Ukraine – US gasoline prices fell nationwide in 2023. Yet compared to fueling an electric vehicle, filling up a gas car remain expensive. Through the first three quarters of 2023, gas prices averaged \$3.53 per gallon. When comparing electricity costs on an equivalent per-gasoline-gallon equivalent basis (\$/GGE), consumers paid about \$1.52. Thus, gas prices were about 2.25 times higher than electricity as a vehicle fuel.
- A widening gap between gasoline and electricity prices makes EVs more appealing. In 2023, the global volume-weighted average price of battery packs declined. In addition, subsidies like the clean car tax credit can help lower upfront EV costs for consumers.
- The US electric vehicle market reached a number of milestones in 2023. In total, an estimated 1.46 million Evs were sold, up from 971,000 in 2022. This 50% year-on-year growth was driven by new EV incentives, Tesla’s price cuts and more EV models released.
- Tesla was once again the dominant automaker in the US, but saw its share of nationwide EV sales decline from 52% in 2022 to 46% in 2023. Stellantis, Hyundai-Kia, GM, BMW and VW were the other top-selling EV automakers in the US for the year.
- Battery-electric vehicles made up an estimated 80% of 2023 electric vehicle sales, with plug-in hybrid electric vehicles making up the remaining 20%. Fuel-cell vehicles accounted for less than 1% of sales.

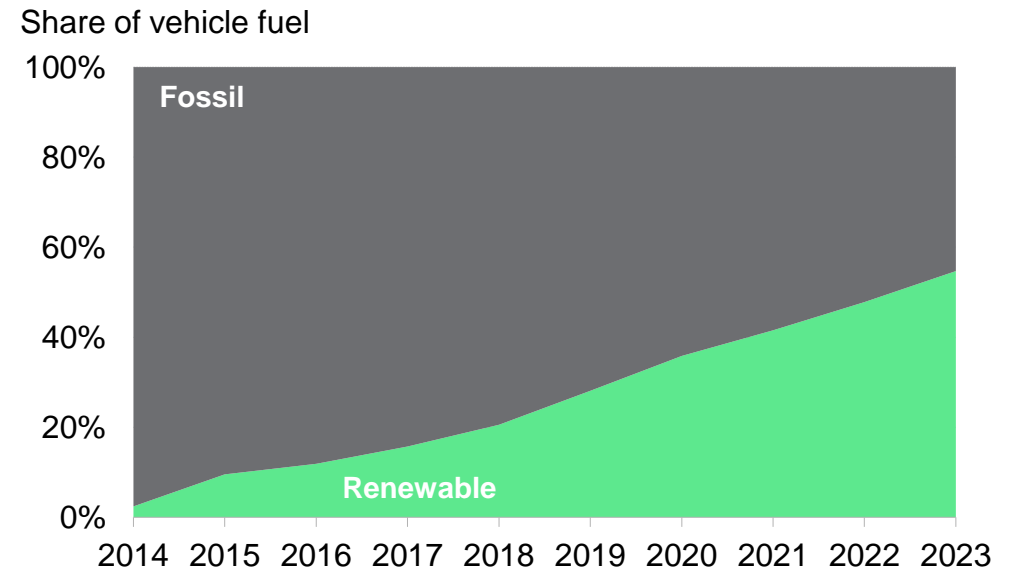
Source: BloombergNEF, Marklines, US Department of Energy, EIA. Note: Electricity was converted from residential prices to \$/gasoline gallon equivalent (GGE). Efficiency metrics used included 1 kilowatt-hour = 3.54 miles driven and 1 kilowatt-hour = 33.7 GGE.

Transportation: Renewable natural gas production and vehicle demand

RNG production capacity, by source



US natural gas vehicle demand, by source

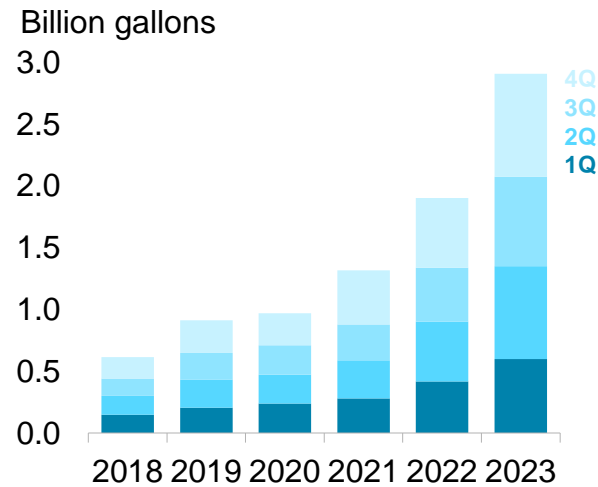


- Renewable natural gas (RNG) production capacity and consumption have both grown swiftly off a low base over the past decade, thanks in part to the requirements of the federal Renewable Fuel Standard (RFS) and California’s Low Carbon Fuel Standard (LCFS). RNG expanded its share of total natural gas vehicle consumption, reaching 55% in 2023, the first time ever it has surpassed conventional natural gas, according to BloombergNEF estimates.
- The US continues to build out more RNG production capacity, which grew 13% year-on-year in 2023. Investment tax credits included in the IRA can offset the cost of new-build RNG facilities by 6-30% of eligible costs. The credits started in 2023 and run through 2028.
- The total number of compressed natural gas and liquified natural gas fueling stations fell 12% from 2019 to 2022, according to the US Department of Energy. There are approximately 175,000 natural gas-powered vehicles on US roads today, out of approximately 290 million cars and trucks.

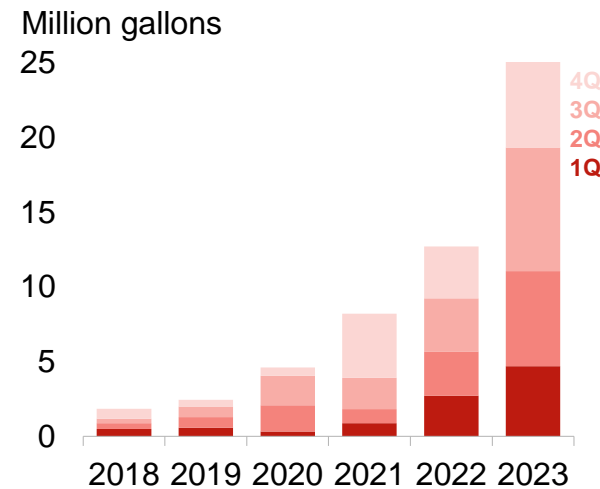
Source: BloombergNEF, Argonne National Labs, RNG Coalition, company announcements, California Air Resources Board, EPA. RNG is renewable natural gas.

Transportation: Renewable fuel supply continues to climb to new highs

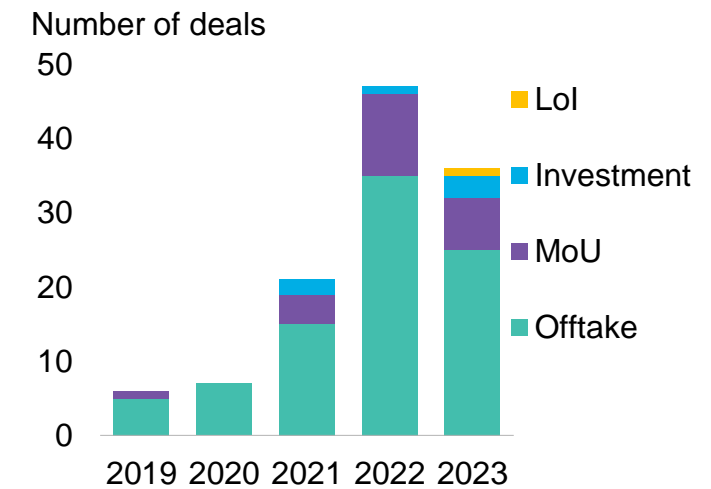
US renewable diesel supply



US SAF supply



Airlines' SAF procurement agreements



- Renewable diesel supply continues to post strong year-on-year growth rates, with 2023 volumes up a whopping 52.8% compared to 2022. Domestic production, which now accounts for 83% of US supply, rose to 693 million gallons, a fresh record, as new facilities continue to ramp up production.
- Renewable jet fuel supply decreased 24.2% in 4Q 2023 compared to the previous quarter, but was up 81.2% year-on-year. Government incentives such as investment tax credits under IRA are driving renewable jet fuel production. Demand for such fuel is increasing among some airlines' corporate customers, especially those looking reduce their Scope 3 carbon emissions.
- Globally, airlines signed a total of 36 agreements to procure sustainable aviation fuel (SAF) from January to early December 2023, the second-highest annual figure (after 2022). To date, the US-based airlines lead SAF procurement, likely reflecting government incentives such as the IRA's investment tax credits for SAF producers.

Source: BloombergNEF, EPA, company press releases, ICAO, US Securities and Exchange Commission. Note: SAF stands for sustainable aviation fuel, Lol stands for letter of intent, MoU stands memorandum of understanding.

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