2020

Sustainable Energy in America

FACTBOOK

Growth Sectors of the U.S. Energy Economy

The Business Council for Sustainable Energy®

BloombergNEF

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Overview

The 2020 Sustainable Energy in America Factbook is the eighth in a series documenting the revolution in energy production, delivery and consumption in the U.S. This installment documents the events of 2019 and comments on overarching trends seen over the last decade.

U.S. economic growth has outpaced energy consumption growth over the past decade. While GDP expanded 25%, primary demand grew just 6.6%. The economy grew in each of the 10 years of the 2010’s but in only five of those years did energy consumption rise. From 2018 to 2019, it declined 1%. Somewhat milder weather in 2019 compared to 2018 contributed to the fall but building and industrial consumption remained flat compared to the prior year. Mirroring this trend, emissions of harmful greenhouse emissions fell 2.7% 2018-2019 and have dropped 4.1% from a decade ago. Emissions from the power sector fell 7.8% 2018-2019, and are off by more than a quarter in the last 10 years. However, transportation sector emissions rose 5% in the decade to become the largest contributor, accounting for 29% in 2019.

Natural gas-fired power plant and renewables plant completions are continuing. Just over a third of all power-generating capacity added in the 2010’s was represented by natural gas with 2018 the largest single-year for natural gas build in 14 years. Natural gas is the top producer of electricity, accounting for 38% of consumption in 2019, compared to 24% in 2010. Renewable generation also continues to rise and hydro, wind, solar, biomass, and geothermal met 18% of demand in 2019, up from 10% in 2010. Solar capacity grew 80-fold across the decade and wind capacity more than tripled. Coal’s contributions continue to wane and the list of coal-fired plants planning to retire in the next five years continues to grow.

Over the last decade, states took the lead in establishing policies to support sustainable energy growth. California and New York, among others, have established 100% renewable energy goals and targets for 2050. These advancements helped fill gaps left at the federal level. In 2019, federal agencies proposed weakening fuel economy standards for passenger vehicles, rolled back lightbulb regulations, and delayed issuing a permit for the nation’s first major offshore wind farm.

The Sustainable Energy in America Factbook provides a detailed look at the state of U.S. energy and the role that new technologies are playing in reshaping the industry. The Factbook is researched and produced by BloombergNEF and commissioned by the Business Council for Sustainable Energy. As always, the goal is to offer simple, accurate benchmarks on the status and contributions of new sustainable energy technologies.

Table of Contents

BloombergNEF

About the Factbook: What is it, and what's new?

What is it?

- Aims to **augment** existing sources of information on U.S. energy
- Focuses on **renewables, efficiency, natural gas, distributed power and storage** and **sustainable transportation**
- **Fills important data gaps** in certain areas (e.g., clean energy investment flows, contribution of distributed energy)
- Contains data through the end of 2019 wherever possible
- Employs **BloombergNEF data** in most cases, augmented by EIA, FERC, ACEEE, LBNL, and other sources where necessary
- Contains the very **latest information on new energy technology costs**
- Has been graciously underwritten by the **Business Council for Sustainable Energy**
- Is in its **eighth edition** (first published in January 2013)

What's new?

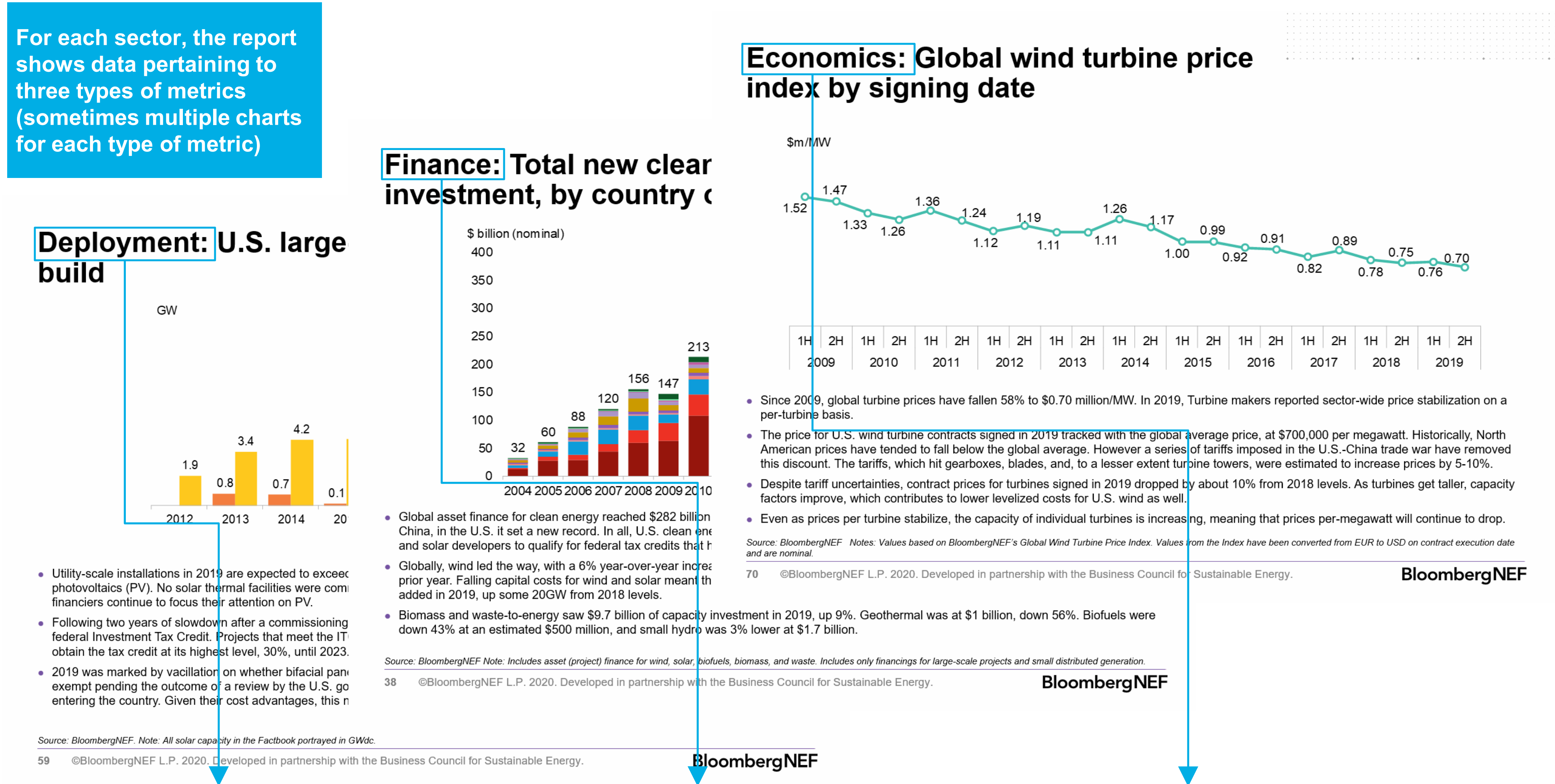
- **New coverage:** This year's report contains both annual and decadal views of and commentary on driving factors in the energy sector. It contains additional content not shown in last year's edition, including data on hydrogen, renewable natural gas, and offshore wind markets, as well as microgrid penetration and energy digitalization. It also contains expanded geographic views on the energy generation mix, clean energy targets and environmental markets.
- **Updated analysis:** Most charts have been extended by one year to capture the latest data.
- **2019 developments:** The text in the slides highlights major changes that occurred over the past year and past decade.
- **Format:** The emphasis of this 2020 edition is to capture new developments that occurred in the past year and overarching trends that occurred in the past 10 years.

About the Factbook: Understanding terminology for this report

	FOSSIL-FIRED / NUCLEAR POWER	RENEWABLE ENERGY	DISTRIBUTED POWER, STORAGE, EFFICIENCY	TRANSPORT
SUSTAINABLE ENERGY (as defined in this report)	• Natural gas • CCS	• Solar • Wind • Geothermal • Hydro • Biomass • Biogas • Waste-to-energy	• Small-scale renewables • CHP and WHP • Fuel cells • Storage • Demand response / digital energy • Building efficiency • Industrial efficiency • Direct use applications for natural gas	• Electric vehicles (including hybrids) • Natural gas vehicles • Biofuels • Fuel cell vehicles
OTHER CLEAN ENERGY (not covered in this report)	• Nuclear	• Wave / tidal		

About the Factbook: The sub-sections within each sector

For each sector, the report shows data pertaining to three types of metrics (sometimes multiple charts for each type of metric)



Deployment: captures how much activity is happening in the sector, typically in terms of new build or supply and demand

Finance: captures the amount of investment entering the sector

Economics: captures the costs of implementing projects or adopting technologies in the sector

About the Factbook: Sponsorship of this report

The Business Council for Sustainable Energy®

The Business Council for Sustainable Energy (BCSE) is a coalition of companies and trade associations from the energy efficiency, natural gas and renewable energy sectors. It includes independent electric power producers, investor-owned utilities, public power, manufacturers, commercial end users and service providers in energy and environmental markets. Founded in 1992, the coalition's diverse business membership is united around the continued revitalization of the economy and the creation of a secure and reliable energy future in America. The Factbook is also supported by the following sponsors: American Gas Association, American Wind Energy Association, Capital Power, Covanta, CRES Forum, Enel North America, First Solar, Ingersoll Rand, ITC Holdings Corp., Johnson Controls, JP Morgan Chase & Co., National Grid, National Hydropower Association, Polyisocyanurate Insulation Manufacturers Association, Sacramento Municipal Utility District, Schneider Electric, Sempra Energy, Solar Energy Industries Association, U.S. Green Building Council and WGL.

Executive summary (1 of 8)

Twenty nineteen marked the close of a decade defined in no small part by the rise of sustainable American energy. Over 10 extraordinary years, the U.S. fundamentally overhauled how it produces, delivers, and consumes hydrocarbons, electrons, and heat. In the process, the economy grew more energy efficient, more energy secure, and less carbon intensive. Thanks to associated lower costs, the American consumer has unquestionably been the primary beneficiary.

This marks the eighth year BloombergNEF and the Business Council for Sustainable Energy have partnered to produce the Sustainable Energy in America Factbook. This year's Factbook takes stock of the remarkable changes last decade while focusing specifically on the events of 2019. It includes many of the same data, charts, and facts as in previous editions while addressing some new emerging topics.

2010-2019: a decade of profound transformation

The sectors defined in this report as sustainable – renewables, energy efficiency, natural gas, and advanced transportation – became dominant in the last decade, transforming the generation, delivery, and consumption of U.S. energy. These changes have reverberated not just through every segment of the American economy, but across the globe as well.

Production

- At the wellhead, U.S. oil and natural gas production boomed thanks to decades of research, technological innovation, readily available capital, and entrepreneurship. Today, the U.S. is the world's number one oil and gas producer. From 2010-2019, domestic natural gas production climbed more than 50%. The U.S went from being a net importer of natural gas in 2010 to being a net exporter as the decade closed.
- The abundance of natural gas resulted in dramatically lower natural gas commodity prices. Those price declines, in turn, made natural gas more competitive for a variety of applications across the economy, particularly power generation, and contributed to significant declines in wholesale electricity prices. Power sector demand for natural gas jumped 60% over the decade and natural gas-fired power generation went from meeting 24% of the nation's needs in 2010 to 38% in 2019. The improving economics of natural gas also hastened the decline of coal-fired power. Coal went from meeting 45% of U.S. demand in 2010 to 23% in 2019.
- Renewables – primarily utility-scale hydro, wind, solar, biomass, geothermal and waste-to-energy – also played a critical role in greening the grid. Generation from these technologies jumped 77% in a decade. Nearly all the new renewable generation came from new utility-scale wind and solar projects, along with rooftop solar systems.
- The results are even more remarkable when considered on a capacity basis. The U.S. has twice the renewable power-generating capacity today compared to a decade ago. Total installed wind has tripled to 108GW. And at 75GW, there is *80 times* more solar capacity online today than at the start of the decade.

Executive summary (2 of 8)

- At first, the build-out of these technologies was spurred by state-level mandates for renewables and federal tax credits. But in the last several years of the decade, projects began winning power-delivery contracts on economic merits alone. In all, almost 150GW of wind and solar was built over 10 years. The U.S. is today second only to China in total installed renewable capacity.
- In the last two years, projects that pair renewables technologies with large-scale batteries have for the first time become economically viable. In particular, "PV+storage" projects have under-bid natural gas-fired plants to win power-delivery contracts in certain states thanks to a 77% drop in the price of typical PV module and an 87% decline in battery pack prices. While the U.S. has made important progress on improving both solar and battery technologies, the drops are largely attributable to sheer economies of scale – specifically, a major manufacturing scale-up in Asia.
- For its part, nuclear generation held largely steady in its overall contribution to the U.S. power grid on a percentage basis, despite a slide in the number of reactors on line. During the second half of the decade, in particular, more nuclear plants became uneconomic and were forced to close or secure state-level subsidies. Still, as of year-end 2019, nuclear accounted for 20% of total U.S. power generation and the majority of zero-emission power produced in the U.S.

Delivery

- The abundance of lower-cost fuels has required larger and smarter delivery networks for hydrocarbons, electrons, heat and other sources of energy. The U.S natural gas distribution pipeline network grew from 2.09 million miles in 2009 to 2.24 million as of year-end 2018 (the last year for which there is complete data), serving more than 75 million homes and businesses. U.S. midstream natural gas expenditures focusing on natural gas delivery totaled an estimated $185 billion through 2018. Still, additional pipelines are sought to move natural gas to New England, or out of production zones, and to new liquefied natural gas export terminals.
- To facilitate the delivery of greater volumes of lower-carbon electricity, U.S. utilities have boosted investment to support transmission grid buildout. From 2010 through 2018 (the last year for which complete data are available), investor-owned utilities invested $170 billion, or $18.9 billion per year (2018 dollars). Even accounting for inflation, utilities have nearly doubled their annual rate of spend on transmission this decade compared to 2010-2018.

Consumption

- Since 2009, the U.S. has posted 10 consecutive years of economic growth. Remarkably, U.S. energy demand expanded only marginally over that time. The nation's gross domestic product grew to approximately $19 trillion in 2019, up about 25% since the start of the decade. Over that same time, total energy use expanded just 6.6%. In five of 10 years of the decade, energy usage actually *shrank* year-on-year.

Executive summary (3 of 8)

- The growth in energy productivity has been supported by a confluence of technology innovation, economies of scale, and policymaking in the energy efficiency sector. The changes are such that the definition of energy efficiency has expanded beyond traditional building and appliance efficiency to include metering and automation. Today, there are over 85 million "smart meters" in U.S. homes and businesses, up from 9.6 million a decade ago. Thirteen states now have smart meter penetration rates exceeding 80% of homes and businesses.
- Costs have dropped sharply for the most modern and efficient household and business equipment. Perhaps the best example is the light-emitting diode (LED) lightbulb. The average price for an "A-type" LED as recently as 2012 was $37 per thousand lumens produced. By 2017 (the last year for which complete data are available), that had fallen to $8, according to the Department of Energy. Meanwhile, usage of these bulbs spiked from virtually zero in 2010 to 1.1 billion units as of 2018. Still, penetration of LEDs remains well below 50% in the U.S., suggesting major opportunities still remain to swap out old bulbs to improve efficiency. There have been similar stories in the roll-out of energy-efficient air conditioners, furnaces, freezers, clothes washers, refrigerators, televisions, cable television boxes, and many other devices.
- These energy efficiency breakthroughs have hardly occurred in a vacuum. The federal government promoted best-in-class standards through its Energy Star recognition program and mandated the phase-out of particularly outmoded and inefficient equipment. States have also lent a hand and today 74% of Americans live in a state with a building energy code that promotes energy efficiency. Finally, cities have taken the lead in establishing benchmarking or disclosure policies, which either require building owners to achieve certain levels of energy efficiency or make public their progress on efficiency. Through 2019, 13% of all U.S. building floor space was required to meet an efficiency or disclosure requirement with cities such as New York, Denver, Atlanta, and Los Angeles leading the way.

The Empowered Consumer

- Technological advances and lower costs have handed American consumers unprecedented control over how they consume energy. The control applies not just to how they use power in their businesses and homes but where they source it from. At least 18 regulated utilities now offer "green tariff" programs to facilitate the delivery of renewable power to corporate customers and nine states have taken actions to offer voluntary tariffs for renewable natural gas to homes and businesses. Other corporate customers – including some of the world's largest tech, manufacturing, and oil companies – have chosen to buy power directly from renewable energy projects. A decade ago "bilateral power-purchase agreements" with renewable project owners were virtually non-existent. As of year-end 2019, U.S. companies had signed contracts with largely wind and solar projects totaling 33.6GW (enough to potentially power nearly 8 million homes).
- Residential customers have broader options to buy clean power as well. Dramatically lower costs have made rooftop solar accessible for the first time to millions of Americans. An average residential PV system cost approximately $34,000 a decade ago. Today, the average system cost is $15,000 or less, depending on system size. Output levels have also risen as PV module efficiency has improved.

Executive summary (4 of 8)

- As the decade came to a close, lower-priced batteries and other energy-storage technologies began empowering a small, but growing number of businesses and homeowners with the option to toggle between consuming locally produced clean electricity or power procured from the grid. “Behind-the-meter” battery systems and thermal energy storage also offer consumers greater resiliency to blackouts and the ability to minimize demand charges during hours of peak consumption.
- American consumers also have a far broader set of choices when it comes to transportation than a decade ago. Ride-hailing services have removed the need to own a car altogether for some. Those looking to buy or lease can choose from a variety of lower fuel usage vehicles and which fuel they would like to consume – gasoline, diesel, biodiesel, ethanol, or even natural gas or hydrogen – or which drivetrain.
- In 2010, U.S. consumers had virtually zero choices when it came to electric vehicles. Today, 44 pure battery electric models are for sale in North America, along with 35 plug-in hybrid electrics. And manufacturers have promised another 40 BEV/PHEV choices by 2022. Americans purchased or leased 1.4 million battery-electric and plug-in hybrid electric vehicles during the decade with 71,000 charging points available by the end of 2019.
- Perhaps unsurprisingly, more choices have also meant lower prices and lower overall energy bills for consumers of all sorts. U.S. businesses have consistently accessed some of the very lowest wholesale power, natural gas, oil, and other fuel prices (though power prices can vary substantially by U.S. region). Meanwhile, U.S. households are putting less than 4% of their average monthly income on a proportional basis toward energy-related expenditures today, down from 5.1% a decade ago. Lower energy costs have helped make inflation a non-factor in the U.S. economy for a decade.

Security, jobs, emissions, and resiliency

- Plentiful resources and stagnant demand have, by reasonable benchmarks, boosted U.S. energy security. High production has led to oil, gasoline, natural gas and wholesale power price drops and dramatically lower reliance on foreign sources. At the start of the decade, the U.S. was a net importer of approximately 10 million barrels of crude oil and petroleum per day. As 2019 came to a close, that had dropped to nearly zero. Oil and natural gas imports have by no means ceased. The build-out of liquefied natural gas (LNG) export hubs is allowing the U.S. to expand trade with allies while countering rivals. Only because the U.S. remains a net importer of electricity (mainly hydro-generated power from Canada) is it not yet a net exporter of energy overall. However, if LNG exports continue to rise, that could change in the next several years.

Executive summary (5 of 8)

- The transformation of U.S. energy – from higher- to lower-carbon generation, from lower- to higher-efficiency delivery and consumption – has had positive impacts on the broader U.S. economy, helping to fuel growth over the decade. The changes have also had more direct economic benefits as well. Since 2010, more than $390 billion has gone into U.S. clean energy assets at a pace of $39 billion per year. By comparison, all pre-2010 clean energy investment totaled approximately $100 billion. In terms of jobs, as of 2018, 3.5 million Americans were working in the energy efficiency, energy storage, renewables, nuclear, and natural gas sectors.
- Finally, the last decade has seen important developments in reducing harmful greenhouse gas emissions. Greenhouse gas emissions from power plants dropped by nearly a quarter and the sector is now the second-biggest emitter, behind transportation. Despite the proliferation of hybrid and electric vehicles, transportation sector emissions rose 5% 2010-2019.
- Overall, U.S. greenhouse gas emissions dipped 4.1% during the decade and as of year-end 2019, U.S. emissions overall were down 12% vs. 2005. While this represents progress, the U.S is not yet half way towards meeting the pledge made during the Obama administration to cut total greenhouse gas emissions 26-28% from 2005 levels by 2025 as part of the Paris Agreement. While the Trump Administration seeks to leave the Paris Agreement, cities and states representing more than half of the U.S. economy and population have pledged to meet the Paris target.
- As the 2010's wore on, the specter of climate change loomed ever larger with weather and catastrophic natural disasters highlighting the critical need for more resilient systems. Hurricanes Harvey in Texas, Irma and Maria in Puerto Rico, Michael in the Carolinas, floods in the Midwest, the wildfires in California, and other tragedies raised vital questions about how to reinforce or rebuild power grids and other energy infrastructure in an era of more frequent and ferocious climate-related events.
- Away from the headlines, but equally important, was climate change's impact on the U.S. energy system. For example, higher high and lower low temperatures boosted air conditioning and heating demand over the decade. If these trends persist, increased energy consumption can make efforts to reduce energy sector emissions more difficult. Further, disaster related power outages, damage to buildings and infrastructure have led to hundreds of billions of dollars in recovery and rebuilding costs at great expense to communities and taxpayers.

2019: a fitting end to the decade

Virtually all the macro trends that have defined the U.S. energy transition over the past decade were also in evidence in 2019. At the highest level, energy productivity – the ratio of GDP growth vs. energy consumption growth – rose 3.3% from 2018. U.S. GDP expanded by 2.3% in 2019 while energy consumption declined 1.0% from the year prior.

Executive summary (6 of 8)

Multiple factors contributed to declining energy use, but less extreme weather conditions compared to the prior year appeared to play an outsized role. The number of "cooling degree days" (CDDs) tracked by the National Weather Service fell substantially from 2018. This lowered demand for air conditioning and reduced stress overall on the U.S. energy delivery system.

Other major 2019 developments were largely consistent with decadal trends, including the following

- **Natural gas production surged; natural gas prices did not.** Total wellhead natural gas production jumped another 8% from 2018, depressing prices to 2016 levels. Henry Hub natural gas traded below $3 per MMBtu every month of the year except January.
- **Natural gas consumption grew across the economy, particularly in the power sector.** Natural gas-fired generation rose to account for 38% of all power produced, up from 36% in 2018.
- **The renewable energy build-out continued.** 2019 marked the second-biggest year ever for new non-hydro renewable energy capacity added with 20GW commissioned. Wind and solar again accounted for the majority of new renewables added on a capacity basis.
- **Renewable power generation rose to 760TWh, or 18% of all electricity consumed in the U.S.** That was up from 17% the year prior. 38% of U.S. power was zero-carbon in 2019.
- **Wind surpassed hydro power on a generation basis.** Total wind generation rose to 302TWh in 2019 from 273TWh the year prior. Hydro generation slipped somewhat from 293TWh to 276TWh.
- **Energy storage deployment expanded and solar+storage projects continued to demonstrate their commercial viability.** At least 2.4GW of solar and 870MW of storage in combined solar+storage projects won contracts under tenders held by U.S. utilities. While the use of lithium-ion batteries is growing, pumped hydropower storage still provides 93 percent of U.S. energy storage capacity.
- **Coal's decline continued.** Power generation from coal slipped to 23% in 2019 from 27% the year prior. 12GW of coal-fired power plants closed in 2019 and the trend is poised to continue as another 14GW have announced they will come off line in the next three years.
- **For the first time, for one month, renewables surpassed coal generation in 2019.** In a potential harbinger, U.S. hydro, wind, solar, biomass, geothermal and waste-to-energy produced more than the country's fleet of coal-fired power facilities in April 2019.
- **Corporations upped their efforts to secure cleaner power.** A record 14GW of bilateral renewable energy power-purchase agreements were signed. New buyers include major oil companies seeking to reduce emissions associated with the extraction of their fuel.

Note: Solar+storage values included Hawaiian contracts announced on the last day of December 2018.

Executive summary (7 of 8)

- **Emissions of harmful greenhouse gasses from the power sector fell rapidly.** Thanks to somewhat less extreme weather, power consumption slipped 2.8%. Lower top-line demand coupled with the general move toward a cleaner power matrix caused power sector-related emissions to crater by a rather incredible 7.8%.
- **Total U.S. emissions fell as well.** Taking into account all segments of the economy, U.S. greenhouse gas emissions slid 2.7% in 2019 from the year prior.
- **Sustainable energy sector employment expanded.** Energy efficiency jobs continue to top the list – with 2.3 million jobs across the nation, according to the U.S. Energy Employment report. While solar jobs dropped 4% in 2018, employment in other segments of the new energy economy rose or held relatively steady.
- **Household spending on energy ticked down.** Consumers did not appear to cut their energy usage dramatically year-to-year but lower natural gas and power prices reduced household energy spend.
- **State policymaking efforts ramped up in 2019 in the wake of the 2018 mid-term elections.** Nine states boosted their renewable portfolio standards (RPS). New York sought to establish a new ISO-wide carbon market, above its RGGI commitment. Other states set zero-carbon, energy efficiency and fuel efficiency targets, including Washington, Nevada, and New Mexico.
- **The Trump administration took steps to stall or weaken policies that would have accelerated clean energy deployment.** The U.S. Environmental Protection Agency proposed weakened fuel economy standards for passenger vehicles. The Department of Energy rolled back lightbulb regulations. The Department of Interior delayed issuing a permit for the nation's first major offshore wind farm.
- **But Congress passed – and Trump signed – extensions of clean energy tax breaks and boosted energy RD&D funding.** In December, the U.S Production Tax Credit benefitting wind, hydropower, biomass, geothermal and waste-to-energy secured extensions while the $1 per gallon biodiesel tax credit was reinstated retroactively. Funding grew for key research, development and deployment programs at the Department of Energy, including the Office of Energy Efficiency and Renewable Energy and the Advanced Research Projects Agency - Energy (ARPA-E).

Looking to 2030

Nearly no one a decade ago predicted the magnitude of change that was to come to how the U.S. produces, delivers, and consumes energy. Washington, DC offered limited guidance as the country lacked a cohesive, legislated national energy strategy. And yet a sector that conventional wisdom held would take decades to change was transformed in the virtual blink of an eye. How?

Executive summary (8 of 8)

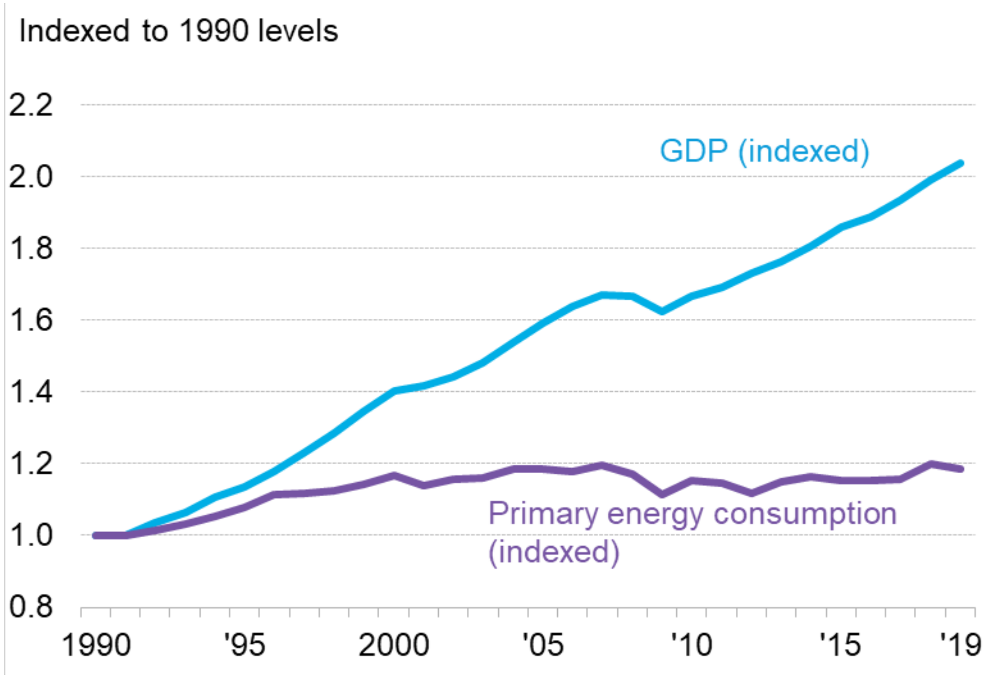
Technological advancements years in the making came to fruition, most notably related to hydraulic fracturing and horizontal drilling for hydrocarbons. A **manufacturing scale-up,** led primarily by Asia-based firms, created economies of scale and drove down prices for PV modules, lithium-ion batteries, LED lightbulbs, and other sustainable energy technologies. **A potent hodgepodge of policies** including the federal economic stimulus law, federal tax credits, the California Solar Initiative, state renewable portfolio standards and state energy efficiency resource standards stimulated market demand. Finally, **an American culture of entrepreneurship supported by billions in investment** created thousands of start-up companies and millions of new jobs.

What will the *Sustainable Energy in America Factbook 2030* have to say about what transpired during the 2020's? Uncertainty abounds, but the lessons of the 2010's are sure to influence the direction of travel. The last decade proved that sustainable energy technologies can as a portfolio deliver safe, reliable, affordable energy services, while meeting evolving consumer needs. The decade also demonstrated that U.S. economic growth and greenhouse gas emissions reduction are not just mutually consistent but mutually *dependent*. These basic principles and others gleaned during these past 10 momentous years will surely dictate what comes next.

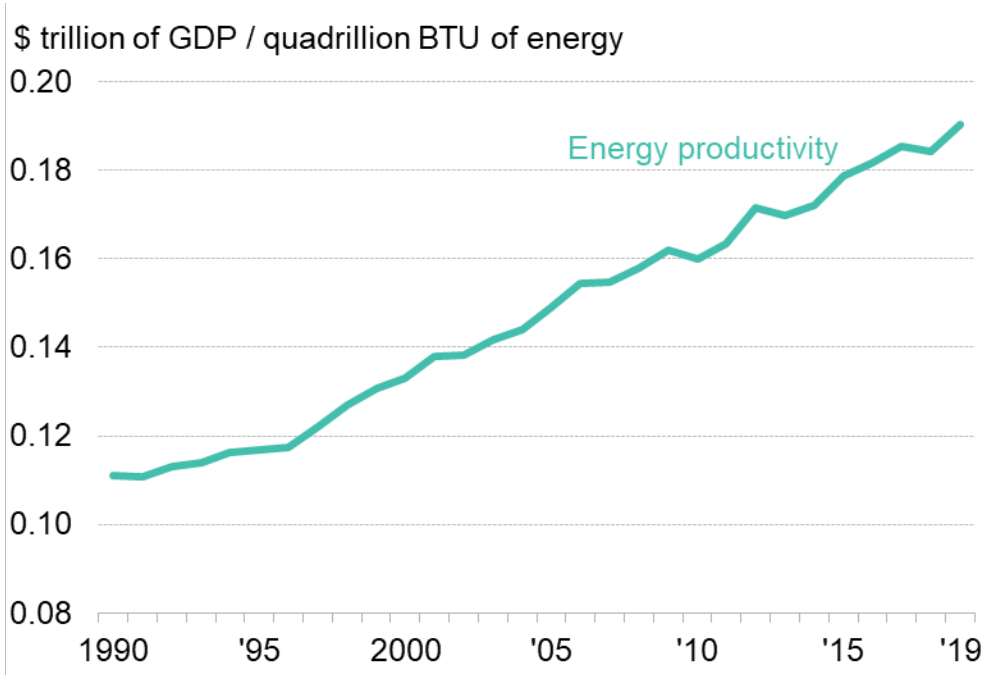
Table of Contents

U.S. energy overview: Productivity

U.S. GDP and primary energy consumption



U.S. energy productivity

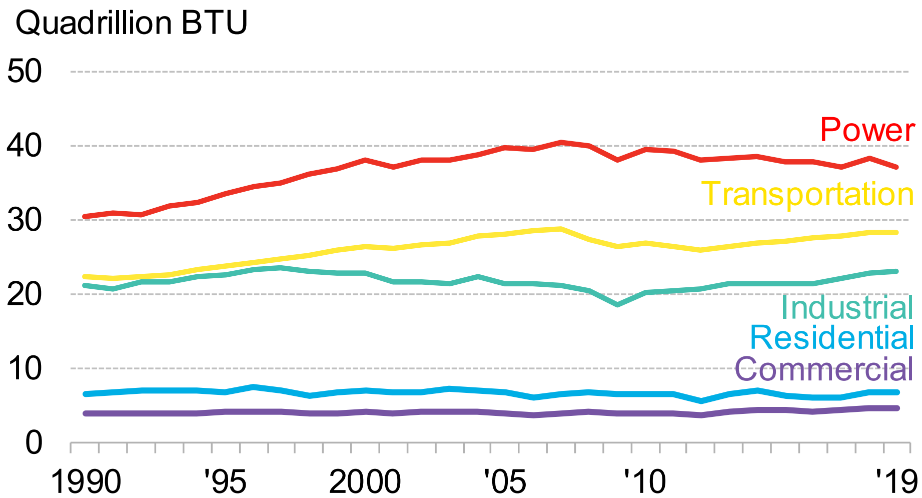


- The U.S. economy expanded by 2.3% in 2019, the slowest pace since 2016. Meanwhile, primary U.S. consumption of energy declined by 1%, marking the first time it's fallen year-on-year since 2015-2016.
- U.S. economic growth continues to be broadly "decoupled" from energy use, as reflected in improvements to energy productivity and efficiency: in the past decade, the overall U.S. economy has grown 25% (in GDP terms) while primary energy consumption has risen just 6.6%, marking an 18% increase in productivity. The 2019 improvement marked a return to form after a 2018 detour when energy productivity actually slipped slightly.
- Since 1990, the U.S. economy has more than doubled in size, while primary energy consumption has grown by just 19%. This suggests a 72% improvement in U.S. energy productivity over three decades.

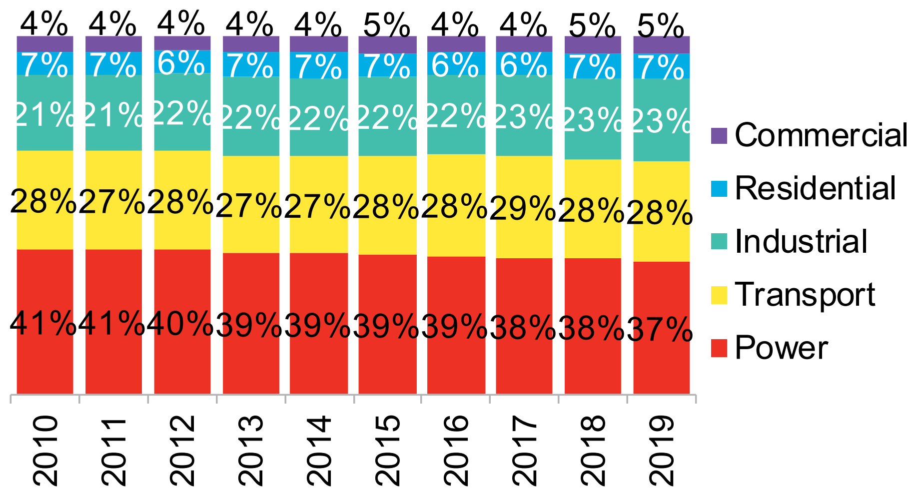
Source: Bureau of Economic Analysis, EIA, BloombergNEF Notes: Values for 2019 are projected, accounting for seasonality, based on latest monthly values from EIA (data available through September 2019). 2019 GDP estimate is a projection from economists compiled at ECFC <GO> on the Bloomberg Terminal.

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

U.S. primary energy consumption, 1990-2019



U.S. primary energy consumption, 2010-2019

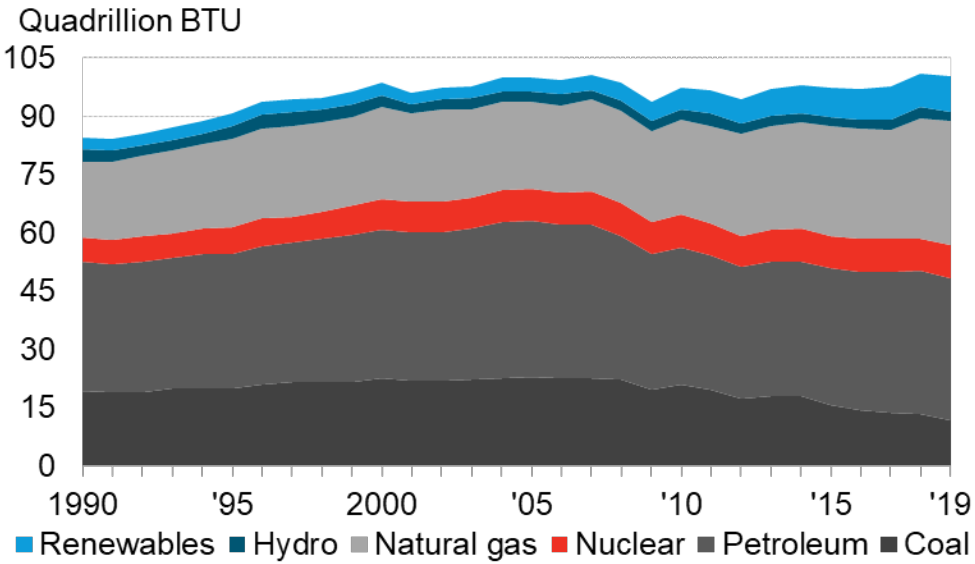


- Total U.S. primary energy consumption ticked down 1% in 2019 from the year prior as declines in the power and transport sectors more than offset slight rises in other areas. Over the last 10 years, overall consumption rose 6.6%, led by 24% and 6.8% increases in the industrial and transportation sectors but countered by a 2% decline in the power sector.
- A somewhat milder 2019 summer cut primary energy usage in the power sector 2.8% year-on-year. "Cooling degree-days", which are indicative of particularly warm weather, dropped 6% year-on-year through September and were just 3% above their 10-year average in 2019. (Figures are annualized to include an assumption for October-December 2019 consumption that mirrors the 10-year average).
- Transportation consumption remained essentially flat, declining 0.15% year-on-year. Vehicle miles traveled per capita rose very slightly.
- The residential and commercial sectors consumed 0.6% and 0.7% more primary energy, respectively. Primary energy is mainly consumed in buildings for heating (electricity consumption is captured by the power sector's primary energy consumption). This suggests that the annual increase in their consumption was due to weather-related factors. Data bear this out: the number of "heating degree-days", a measure of cold weather, rose 2% through September 2019 compared to the same period in 2018.
- Higher industrial activity also contributed to more primary energy demand. Industry consumed 0.8% more energy in 2019 than in 2018.

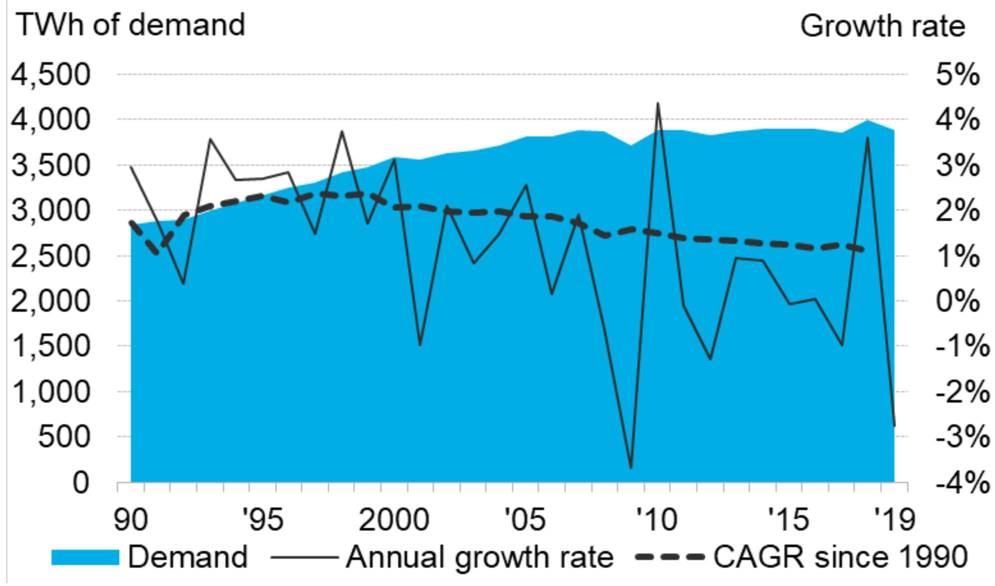
Source: EIA, EPA, BloombergNEF Notes: Values for 2019 are projected, accounting for seasonality, based on latest monthly values from EIA (data available through September 2019)

U.S. energy overview: Energy and electricity consumption

U.S. primary energy consumption, by fuel type



U.S. electricity demand

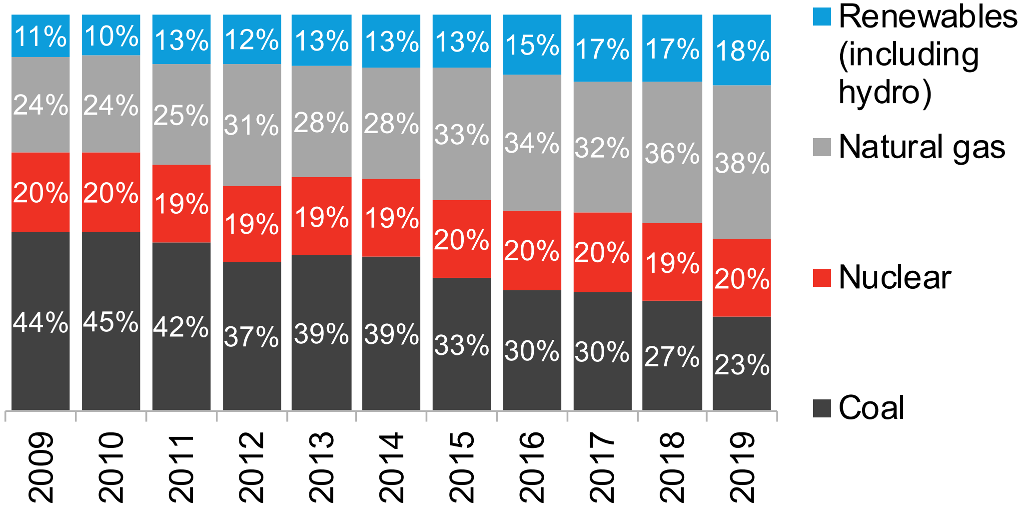


- U.S. total energy consumption slid 1% to 100 quadrillion British Thermal Units (BTU) in 2019 from the year prior. Coal consumption dropped sharply, by 13% in the wake of substantial coal-fired power plant closures in 2018 and 2019. At just 11.6 quadrillion BTU, coal made its smallest contribution to the U.S. economy since the mid-1970s. Usage has dropped by 41% in the last 10 years and is down nearly half since its peak of 22.8 quadrillion BTU in 2005.
- Hydro consumption declined 6.5% in 2019 due to a drier year in the Northwest and Southeast.
- Contributions from non-hydro renewables (wind and solar, primarily but also biomass, waste-to-energy and geothermal) rose 3% in the wake of strong capacity additions in 2018. Natural gas consumption also jumped, by 3.1%, thanks to low prices, the build-out of new gas-fired power plants in the power sector, and growing use of gas in multiple segments of the economy. Nuclear's contribution rose very slightly, by 0.2%.
- Petroleum use slid 0.5% year-over-year. Oil is rarely used in U.S. power generation but accounts for the vast majority of transportation fuel.
- Retail electricity demand dipped, declining 3% year-on-year. Retail demand has risen just 5% since 2009 (excluding contributions from distributed, small-scale facilities).

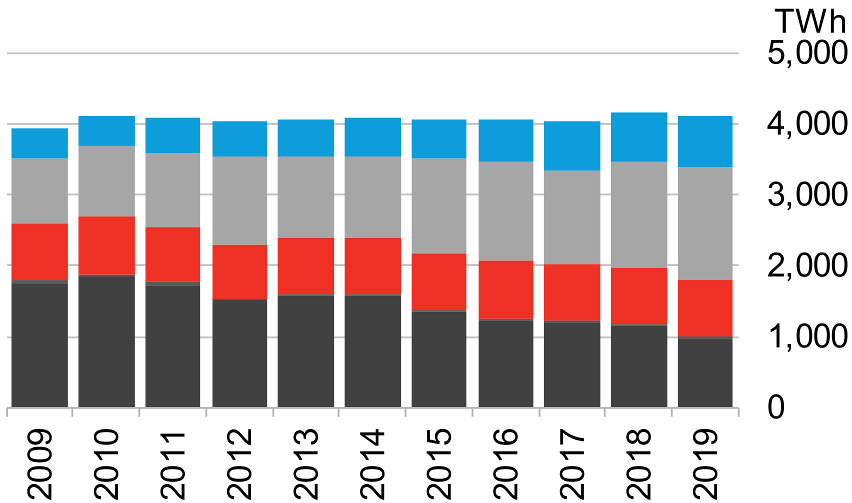
Source: EIA, BloombergNEF Notes: "CAGR" on the right hand side graph is compound annual growth rate. Values for 2019 are projected, accounting for seasonality, based on the latest monthly values from EIA (data available through September 2019). BTU stands for British thermal units.

U.S. energy overview: Electricity generation mix

U.S. electricity generation, by fuel type



U.S. electricity generation, by fuel type

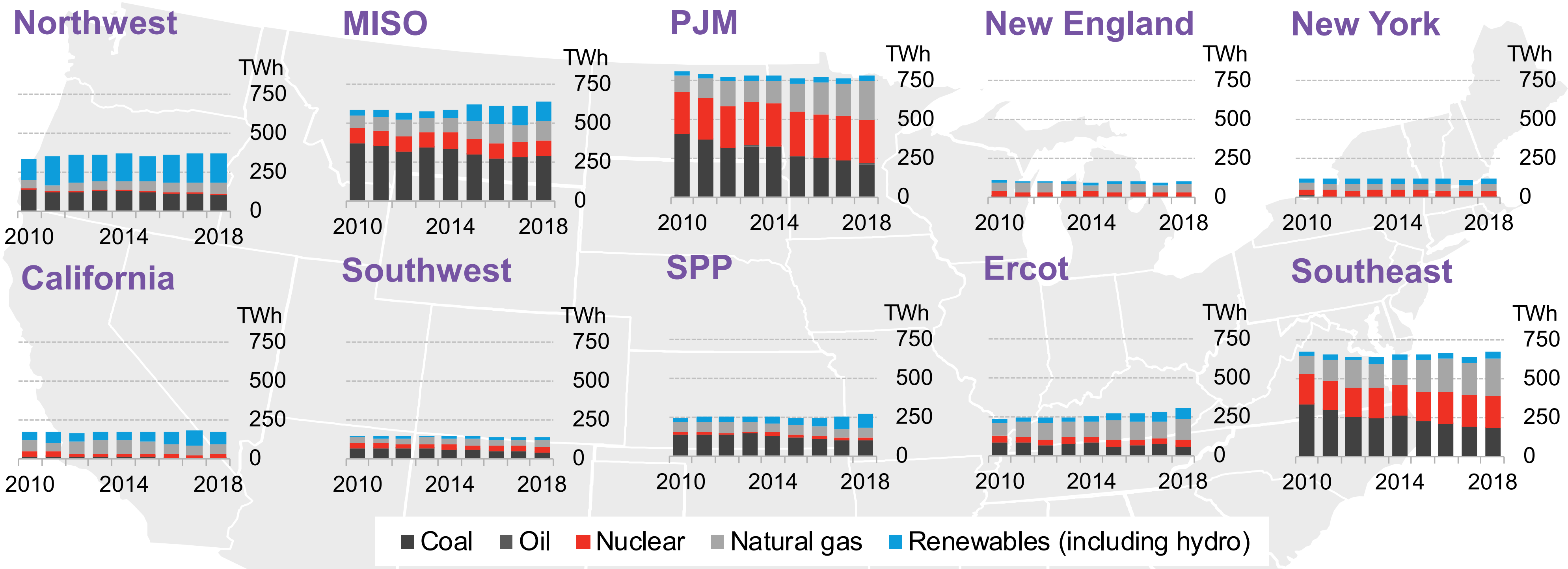


- Natural gas is the largest source of power generation in the U.S. though its year-on-year rate of expansion 2018-2019 was down from 2017-18 growth. Gas accounted for 38% of generation, or 1,588TWh in 2019. That's a 7.1% rise in its contribution from 2018.
- Coal's role waned further in 2019, dropping to only 23% of the mix – the lowest share in the post-war era. In total, coal produced an estimated 969TWh, the least in absolute terms since 1979 and a 15% decline from 2018.
- Renewable power generation's contribution grew 5.1% year-on-year in 2019, as a 13% jump in output from wind and solar was partly offset by a 6% decline in hydropower generation. In absolute terms, renewables generation rose 36TWh to land at 740TWh, or 18% of the total.
- Over the past decade, renewables and natural gas have grown from a combined 35% to 56% of total power generation.
- Despite continuing financial troubles and the closure of the Three Mile Island and Pilgrim plants in September, nuclear's contribution to U.S. power generation rose slightly to 20%.
- Total U.S. power consumption declined 2.8% 2018-2019 due to less extreme weather, which translated into lower usage of air-conditioning and other services, and continued energy-efficiency improvements.

Source: EIA, BloombergNEF Note: Values for 2019 are projected, accounting for seasonality, based on latest monthly values from EIA (data available through October 2019)

  BloombergNEF

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

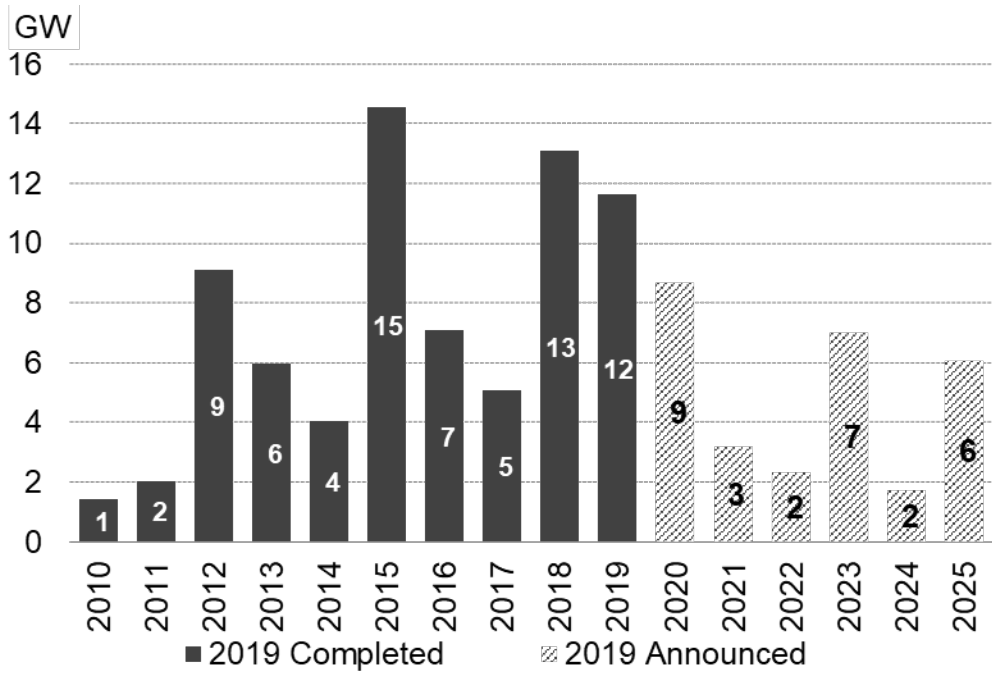


- The energy generation mix varies throughout the U.S. with different power-generating technologies contributing various amounts in different power markets. The top-line volume of generation also varies, with higher demand in some regions. Energy can also be sold between regions, incentivizing areas with lower prices to generate more.
- Major trends over the last 10 years have included the rise of gas-fired generation in the PJM market which encompasses Midwestern and mid-Atlantic states and the growth of renewables, particularly wind and solar, in Ercot (Texas) and California.

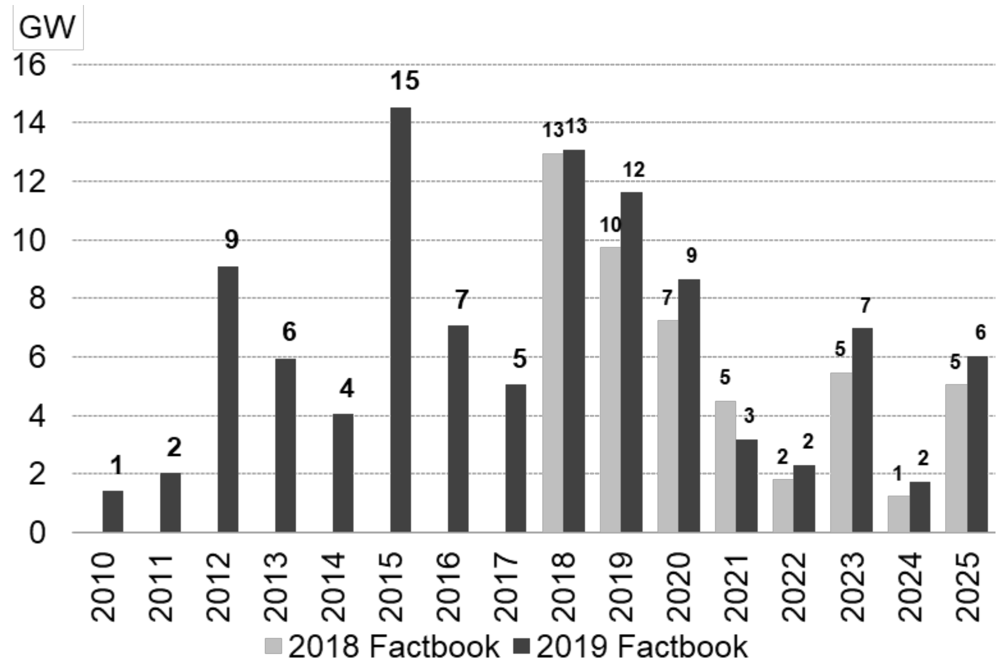
Source: EIA, BloombergNEF Notes: MISO is the Midwest region; PJM is the Mid-Atlantic region; SPP is the Southwest Power Pool which covers the central southern U.S.; Ercot covers most of Texas.

U.S. energy overview: Completed and announced coal-fired plant retirements

U.S. coal retirements, by type



Total U.S. coal retirements, 2018 vs 2019

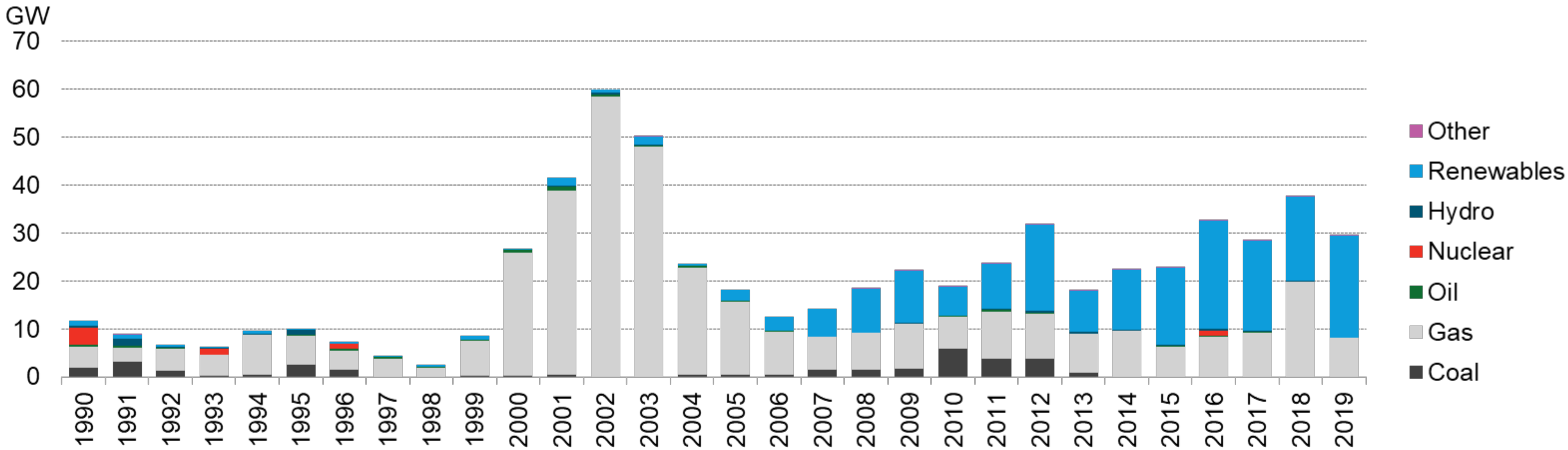


- Coal-fired power plant retirements continued in 2019 at roughly the same pace as the year prior. In all, plants totaling 12GW of capacity came offline, compared to 13GW in 2018. Meanwhile, the pipeline of plants that have announced they will close in the future has also grown. As of year-end 2018, the outlook was for 25GW to retire 2020-2025. In 2019, that rose to 29GW for those same years.
- The U.S. coal fleet is now 20% smaller than a decade ago. Renewable penetration, low gas prices, and a slight dip in load have all compressed coal's margins. State-level support for ailing nuclear plants has also played a role in some regions.
- These trends are poised to continue and put further pressure on coal. However, even in states where these factors are less prevalent, utilities are announcing plans to retire coal in favor of lower-cost gas, renewables, and energy storage.

Source: EIA, company announcements, BloombergNEF Notes: "Retirements" does not include conversions from coal to natural gas or biomass; includes retirements or announced retirements reported to the EIA through October 2019. All capacity figures represent summer generating capacity.

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

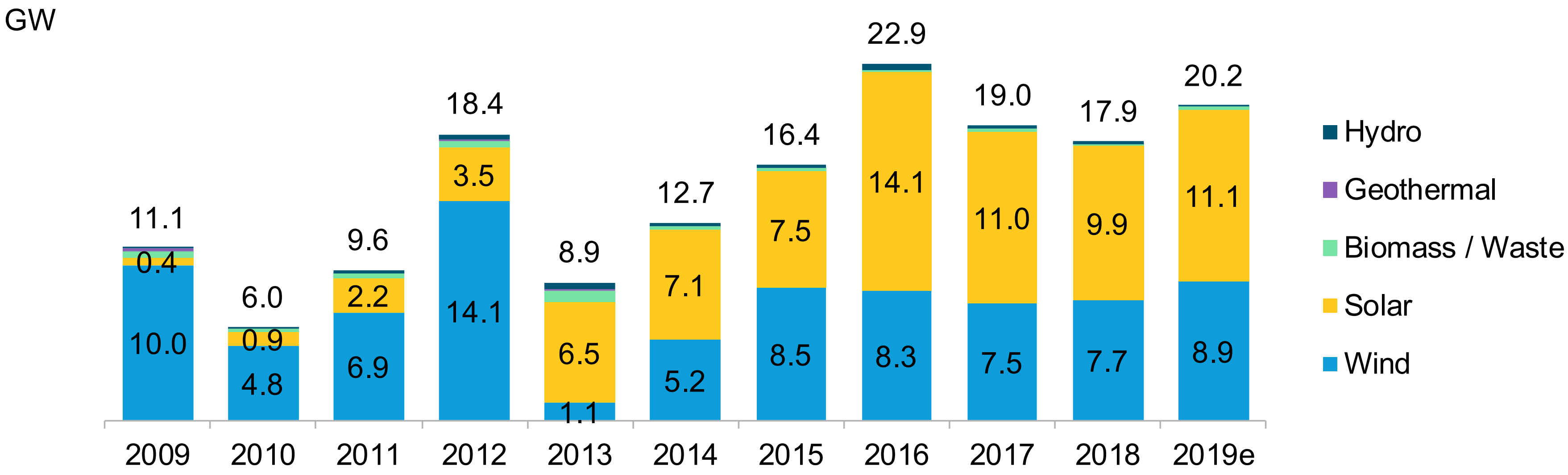
U.S. electric generating capacity build, by fuel type



- 2019 represented another brisk year for total power-generating capacity additions, with just under 30GW commissioned. While this was down from 2018 it was still one of the strongest of the last 15 years.
- Natural gas-fired power plant build continued as developers installed 8.2GW, seeking to take advantage of persistently low gas prices and high profitability in the Northeast and mid-Atlantic regions. However, 2019 build was less than half the capacity added in 2018.
- Non-hydro renewable energy annual build was its second highest of all time. These technologies (wind, solar, biomass, geothermal, others) accounted for the over 71% of total additions in 2019, the highest percentage of all time. In all, they have accounted for 56% of total additions in the last decade.
- Between them, gas and all renewables have accounted for 93% of all build in the last decade and 94% in the last 25 years.

Source: EIA, BloombergNEF Note: All values are shown in AC except solar, which is included as DC capacity. "Renewables" here does not include hydro, which is shown separately. All capacity figures represent summer generating capacity. Includes installations or planned installations reported to the EIA through October 2019, as well as BloombergNEF projections.

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

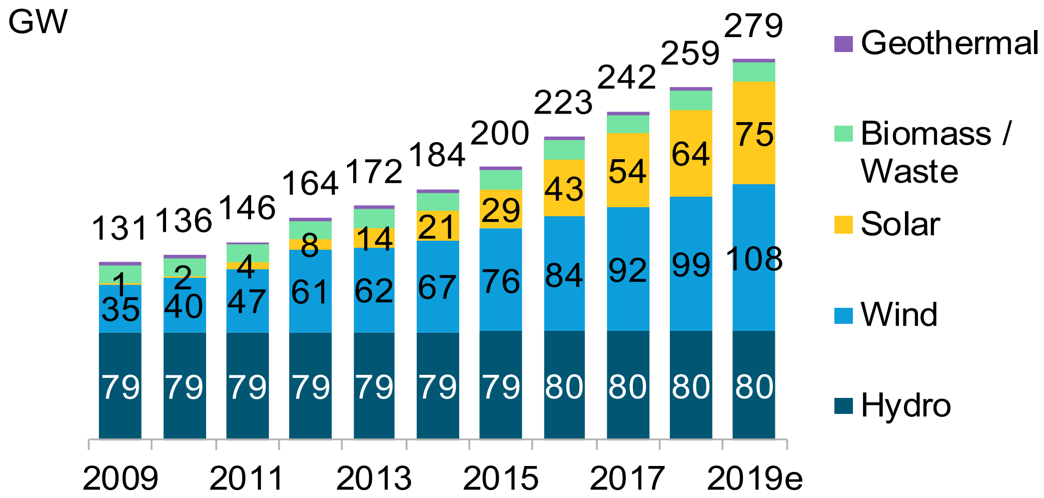


- The U.S. installed an estimated 20.2GW of renewable capacity in 2019, up 2.3GW from 2018 to mark the second-highest year on record. The increase came amid uncertainty surrounding the impact of tax credit roll-offs and trade tariffs.
- Wind build received a boost in 2019 as developers rushed to take advantage of the federal Production Tax Credit (PTC) before expected expiry (Congress ultimately extended the credit by one year in December 2019). Northeastern states also established and raised offshore wind targets, boosting activity around this technology, which is largely new to the U.S.
- Solar additions rose to 11.1GW from 9.9GW in 2019. Build levels recovered from 2018, when challenges securing permits and offtake agreements impacted large-scale project growth in regional markets, particularly Texas. Like their wind counterparts, solar developers strategized around the step-down for their federal Investment Tax Credit (ITC). However, thanks to the long lead times allowed to bring projects online while still qualifying for the ITC, stable/consistent growth continued.
- Build was muted in other clean energy sectors: hydro added 14MW, biomass and waste-to-energy added 165MW and geothermal added no new capacity. Policy support for these sectors has been shorter term and less consistent. However, they received a boost when Congress in December 2019 retroactively extended the tax credits from which they benefit.

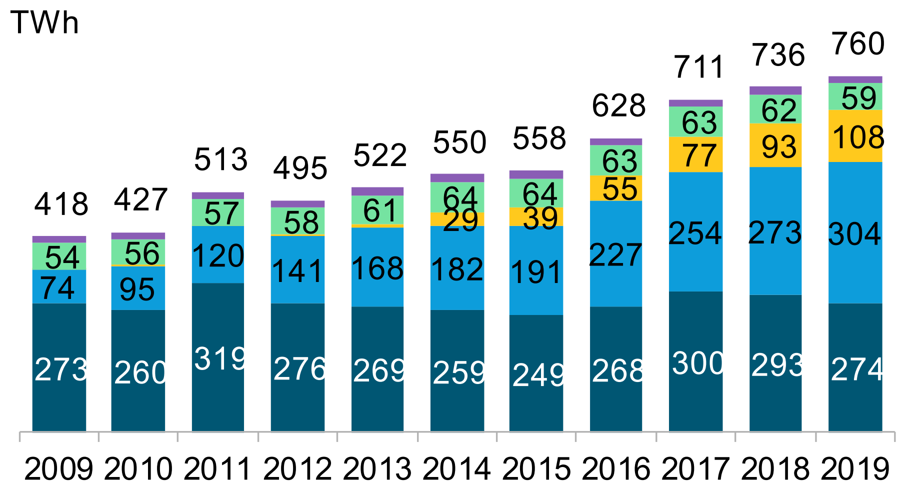
Source: BloombergNEF, EIA Notes: All values are shown in AC except solar, which is included as DC capacity. Numbers include utility-scale (>1MW) projects of all types, rooftop solar, and small- and medium-sized wind. Includes installations or planned installations reported to the EIA through October 2019, as well as BloombergNEF projections.

U.S. energy overview: Cumulative renewable energy

U.S. cumulative renewable capacity



U.S. renewable generation by technology

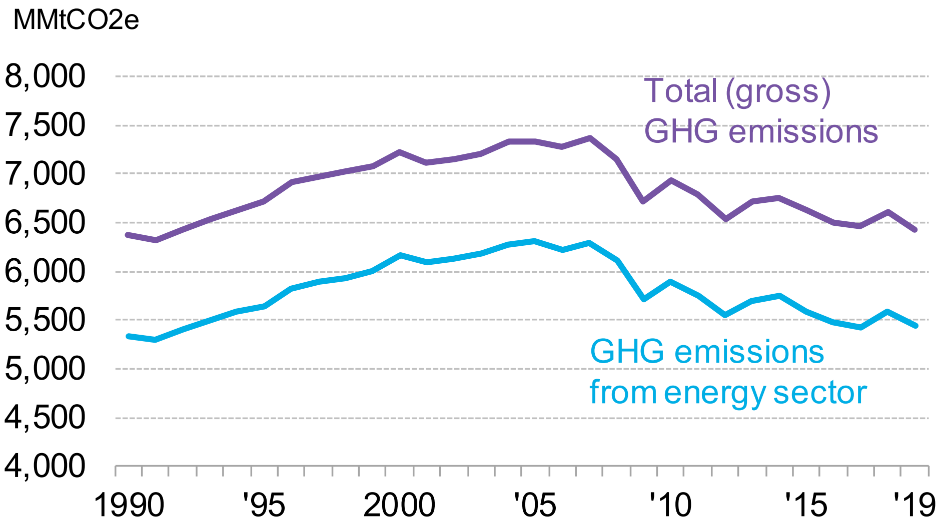


- Total renewable energy capacity has doubled in the past decade to 279GW (excluding hydro pumped storage facilities). Wind and solar have accounted for nearly all new additions, aided by policy support and rapidly falling equipment costs. Wind and solar capacity more than quintupled during the decade, rising from 36GW to 183GW.
- U.S. wind capacity surpassed 100GW in 2019 to reach 108GW and for the first time became the largest source of U.S. zero-carbon power generation at 304TWh. Solar power-generating capacity rose to 75GW from less than 1GW at the start of the decade.
- Thanks in part to strong wind and solar additions, renewables generation in 2019 rose 3% to 760TWh. Solar saw the largest year-on-year growth on a percentage basis, expanding by an estimated 15TWh, or 16%. Wind output jumped 12% year-over-year and now accounts for 40% of all renewable output.
- Hydro generation slipped 19TWh, or 6%, and accounted for 36% of total renewable output.

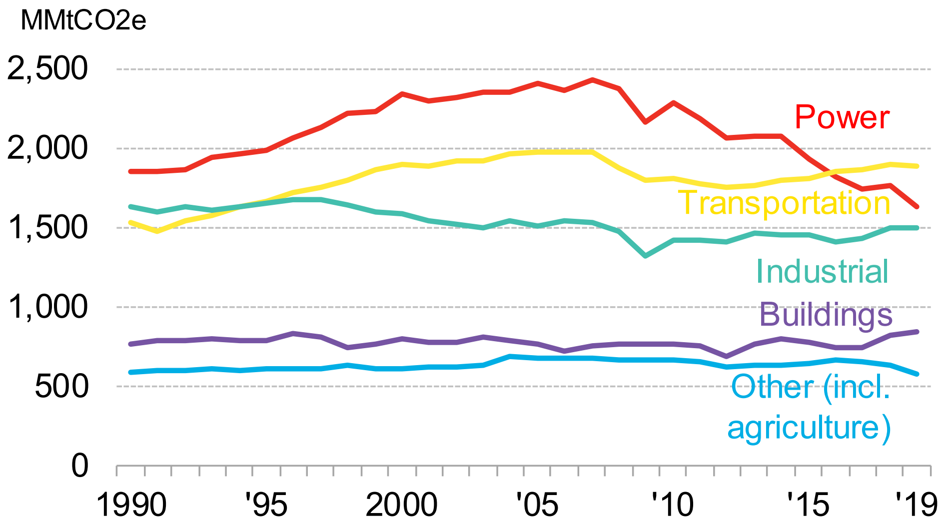
Source: BloombergNEF, EIA Notes: All values are shown in AC except solar, which is included as DC capacity. Hydropower capacity and generation exclude pumped storage facilities (unlike in past Factbooks). Totals may not sum due to rounding. Values for 2019 are projected, accounting for seasonality, based on latest monthly values from EIA (data available through October 2019)

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

Economy-wide and energy sector emissions



Emissions by sector

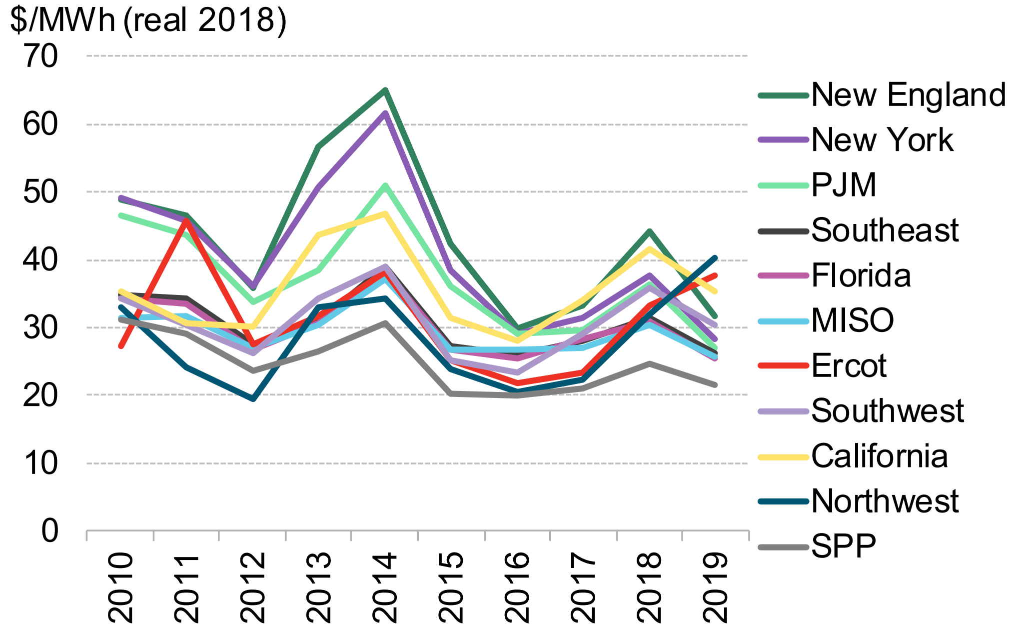


- U.S. GHG emissions returned to long-term trend in 2019, sinking an estimated 2.7% from the year prior. After ticking slightly upward in 2018, they essentially returned to 2017 levels in 2019. A drop in energy-related emissions drove the decline in the headline figure.
- Total gross GHG now sits at roughly 6,437MMt, approximately 12% below 2005 levels. This puts the U.S. slightly under half way toward meeting the minimum goal set by the Obama administration under the Paris Agreement of cutting GHG 26-28% by 2025. (The Trump administration has since notified the UN it would like to remove the U.S. from the pact.)
- The sharpest drop in the last year came from the power sector. A cleaner generating mix and a 2.8% fall in overall consumption led to a 7.8% GHG decrease. Power now accounts for only 2% more emissions than the U.S. industrial sector. The U.S. grew its production from natural gas, wind and solar as higher-emitting coal-fired power plants retired in near-record numbers.
- Transportation-related emissions ticked up 0.4%. The transportation sector remained the largest single source of climate-warming emissions for the fourth consecutive year, hitting 29% of total GHG emissions.

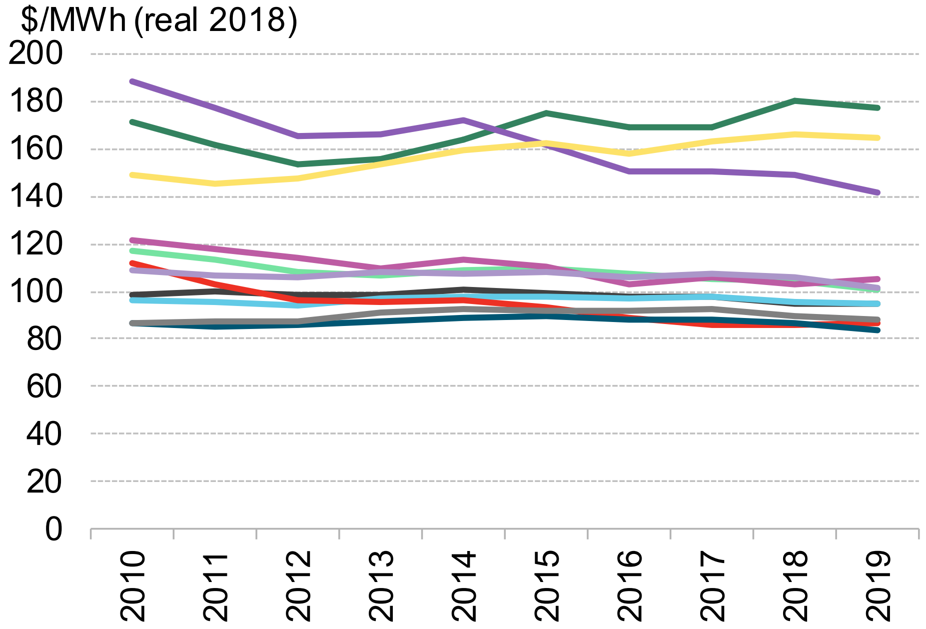
Source: BloombergNEF, EIA, EPA Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2016 Notes: "Sinks" refer to forests and green areas which absorb carbon dioxide. Values for 2019 are projected, accounting for seasonality, based on monthly values from EIA available through September 2019.

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

Wholesale power prices



Retail power prices

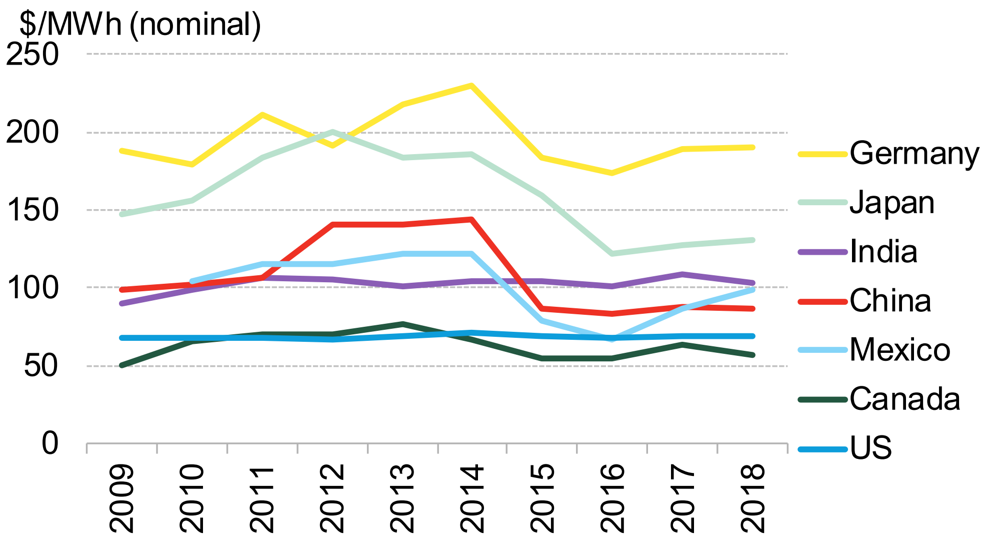


- Wholesale power prices declined in 2019 in most markets, after two years of growth. A fall in average Henry Hub natural gas price and the national shift to renewable generation helped depress wholesale prices across the board relative to 2018 levels.
- Year-on-year, average wholesale prices dropped most steeply in New England, New York and PJM, which fell 18%, 25% and 26%, respectively. Prices only rose in two markets: Ercot and the Northwest, which saw 13% and 26% increases, respectively.
- Despite the downtick, wholesale prices generally remained above their pre-climb 2016 levels in real terms.
- Retail prices rose by close to 1.5% in Ercot (Texas) and Florida. Nationally, retail prices fell by 1.5%, a steeper decline than the 0.8% drop from 2017- 2018.

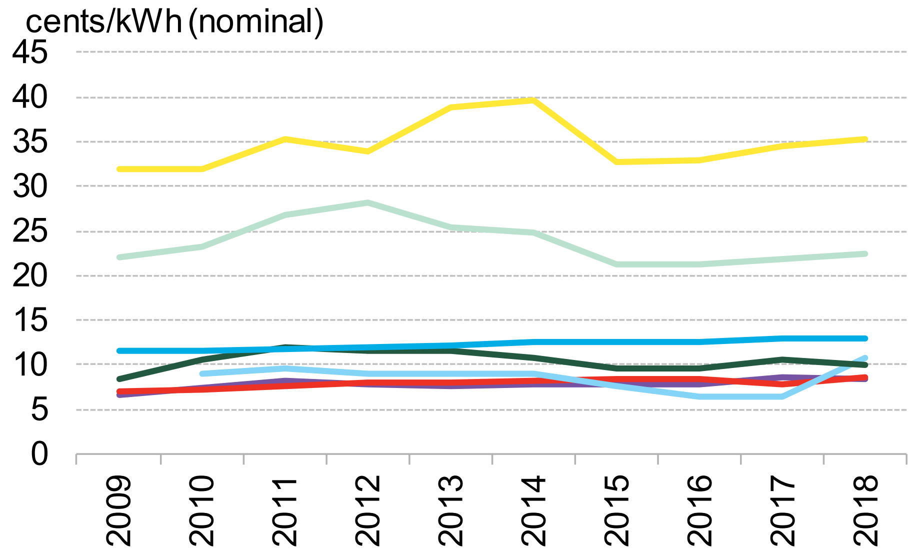
Source: BloombergNEF, EIA, Bloomberg Terminal Notes: Wholesale prices are taken from proxy power hubs in each ISO and are updated through end-2019. All prices are in real 2018 dollars. The retail power prices shown here are not exact retail rates but weighted averages across all rate classes by state, as published by EIA 861. Retail prices are updated through October 2019.

U.S. energy overview: Average electricity rates for industry by country

Industrial power prices



Residential power prices

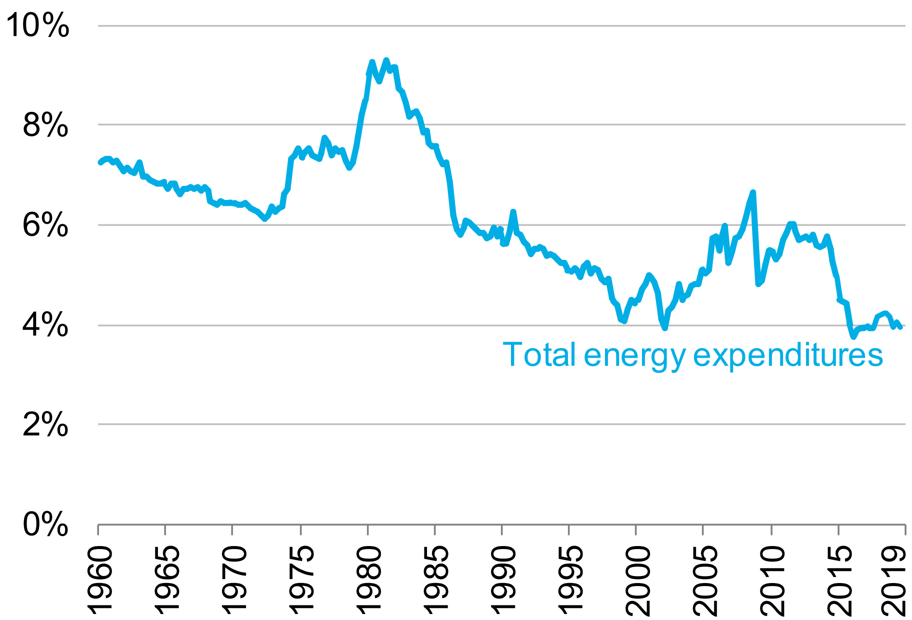


- The U.S. – and North America in general – offers industrial customers some of the least expensive electricity in the world. Among the G-7 nations, the U.S is second only to hydro-rich Canada and offered an average price for industrial customers of 5.6¢/kWh in 2018.
- Prices in Mexico rose sharply from 2017 to 2018. Mexico introduced energy market deregulation and wholesale power pricing in 2016. Since then, the country's oil-fired power plants have played a heavy role in dictating marginal power prices. Specifically, the 2018 power price hike came in the wake of a national oil price spike.
- Canadian power prices declined in 2018, returning to 2016 levels. Canada has a hydropower-heavy energy mix, so prices generally sit relatively low and tend to fluctuate with rainfall levels in a given year.

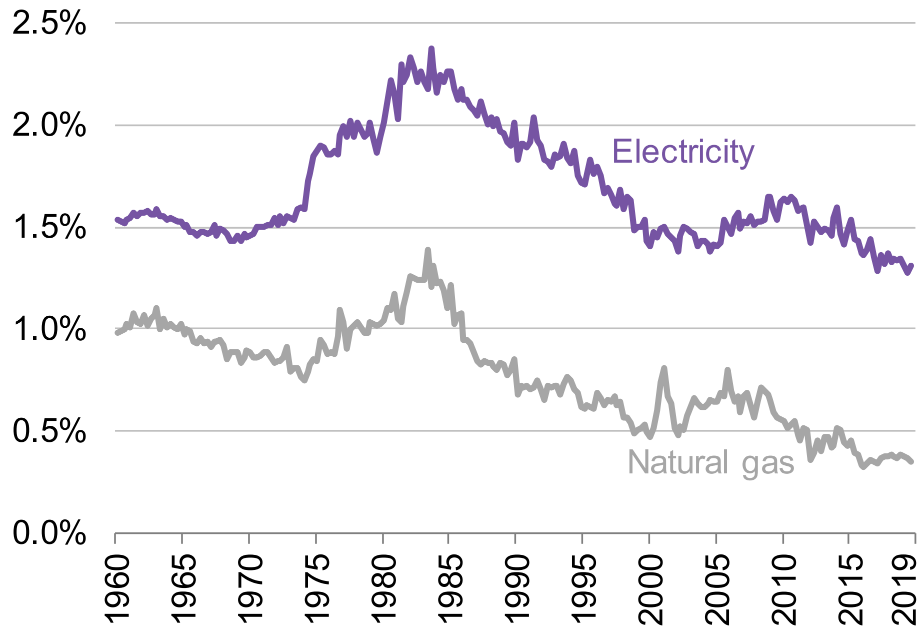
Source: BloombergNEF, government sources (EIA for the U.S.) Notes: Prices are averages (and in most cases, weighted averages) across all regions within the country. Japanese data are for the C&I segment and 2016 figures come from a different source than preceding years.

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

Total energy goods and services as share of total consumption expenditure



Electricity and natural gas as share of total consumption expenditure

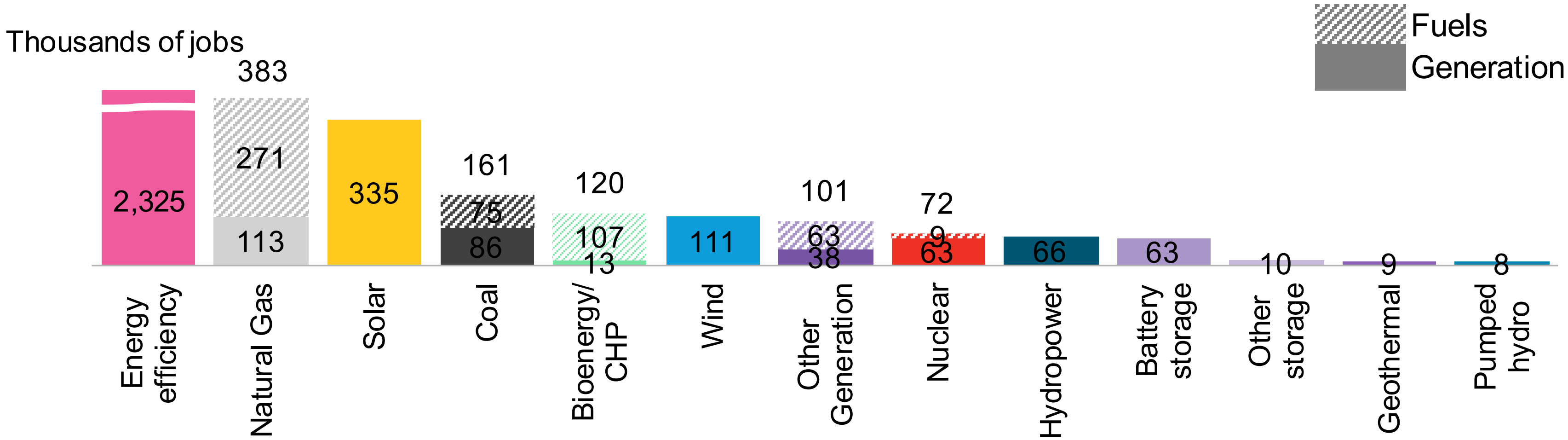


- Energy spending accounted for just under 4% of total U.S. personal consumption expenditures in 2019, down modestly from 2018 levels as overall energy consumption slid. Consumers continue to devote relatively small shares of their total spending to energy compared to historical levels, helped along by the rise of renewables, energy efficiency measures, and technological changes.
- Consumer spending on electricity and natural gas also ticked down, to set a new low. Just 1.66% of household expenditures went to electricity and gas in 2019, slightly below 2018 levels. This breaks out to roughly 1.3% on electricity and 0.36% on natural gas.
- In terms of total energy expenditures, households now spend less than 4% of their budgets on energy-related goods and services. This is down 22% from a 5.1% level of spend in 2009.

Source: Bureau of Economic Analysis, BloombergNEF

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

Jobs in select energy segments, 2018

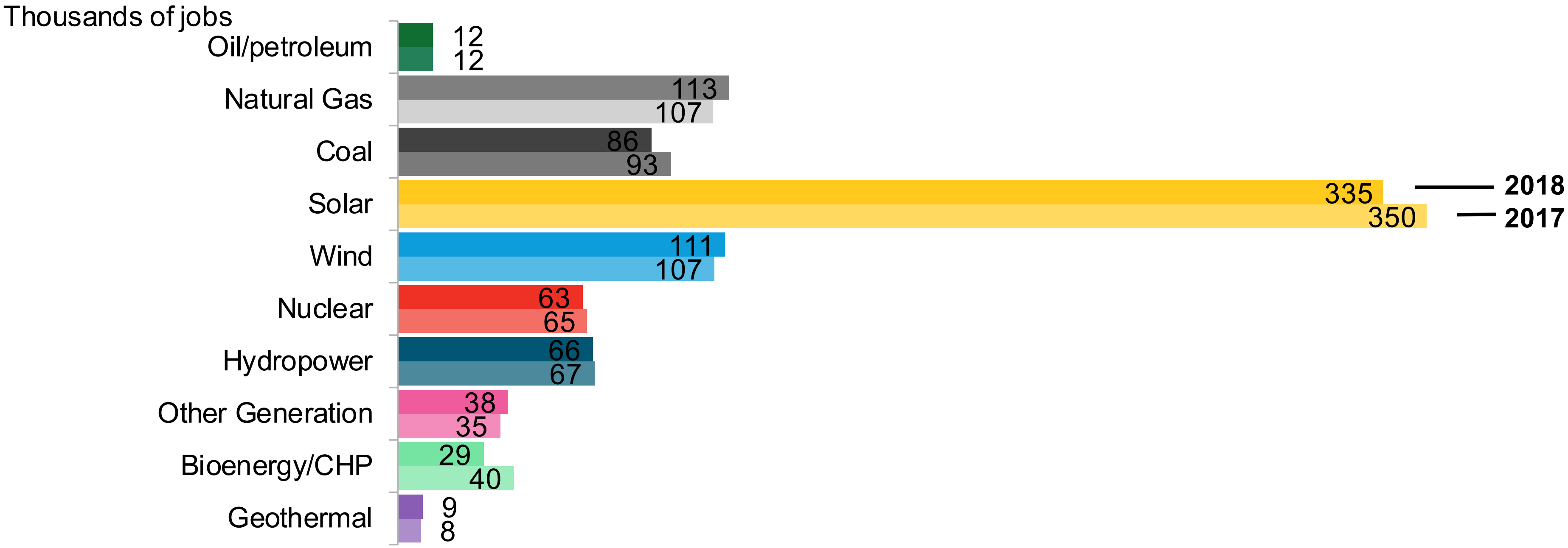


Sustainable, nuclear and storage energy jobs, 2018

- The sustainable, nuclear and storage energy sectors employed an estimated 3.5 million Americans in 2018 (the last year for which complete data are available), according to the U.S. Energy and Employment Report. This number is slightly above 2017 levels. Energy efficiency alone supported 2.3 million jobs, while natural gas supported roughly 383,000 jobs and solar 335,000 jobs.
- Including upstream fuel-related jobs notably boosts total employment for fossil-fired generation and bioenergy. In 2018, 71% of the jobs associated with the natural gas sector came from fuel supply. Coal employed 161,000, with 46% in fuel supply.
- Energy efficiency jobs related to construction often involve individuals who also do other, non-efficiency related tasks. In fact, 79% of the 2.3 million employees involved in energy efficiency spent the majority of their time on energy efficiency tasks.

Source: The U.S. Energy Employment Report, NASEO and EFI. Notes: The data provided rely on thousands of data points provided via survey. Transmission, distribution and storage jobs not included.

U.S. energy overview: Jobs in electricity generation



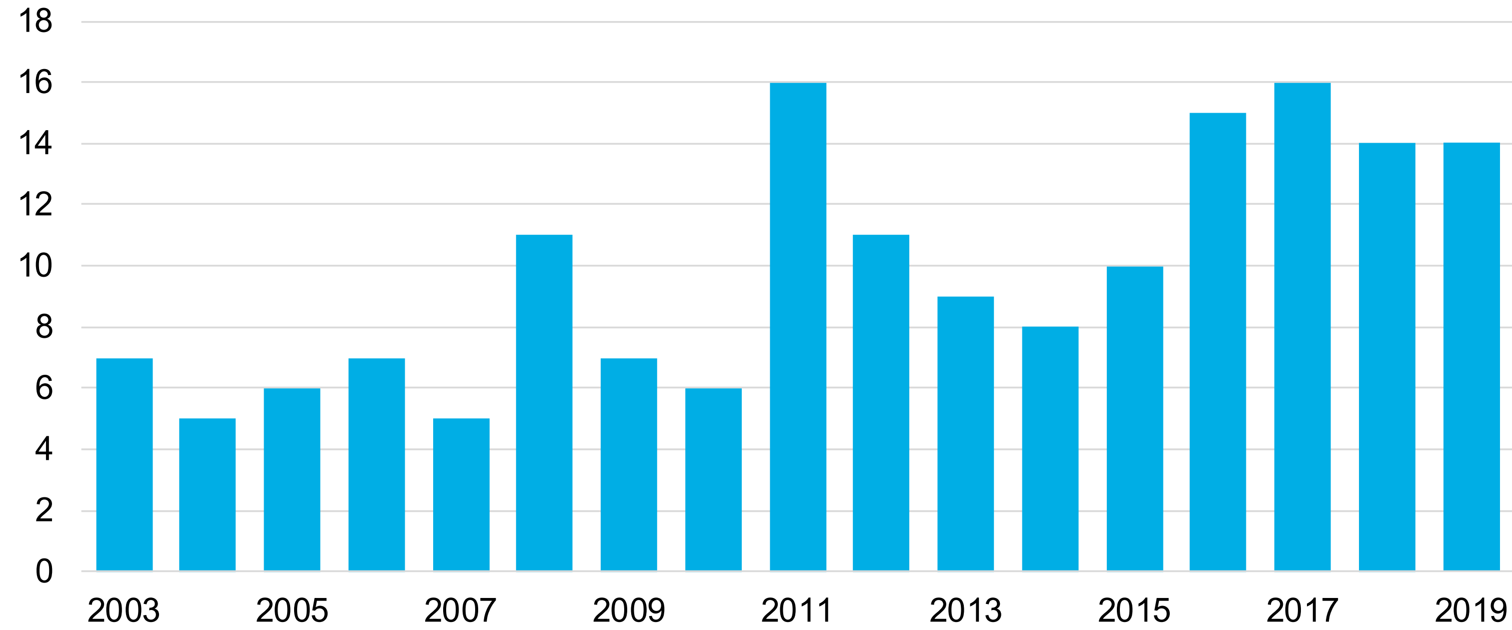
- U.S. power generators employed approximately 875,000 Americans in 2018 (the last year for which complete data are available). This excludes those involved in the upstream processing of fossil fuels. Among the sectors, solar was the single largest employer in generation, supporting 335,000 jobs. Fossil fuels (coal, gas, and oil combined) was the next largest category at 211,000, followed by wind with 111,000.
- Total U.S. generation-related jobs slipped 1% from 2017 to 2018. Gains in natural gas, wind and combined heat and power sectors were slightly more than offset by declines in solar, nuclear and coal. Jobs in the gas sector rose by a net 6,000 year-on-year. This largely reflects the growth in gas-fired generation in the last two years.
- Solar employees often work part-time in other sectors. Of the 335,000 solar industry employees counted by the Department of Energy in 2018, around 72% spent the majority of their time employed in other, non-solar sectors.

Source: The U.S. Energy Employment Report, NASEO and EFI. Notes: 2017 data are from Q2 2017, 2017 data are from 2Q 2018.

Table of Contents

Policy: Infrastructure and resilience

U.S. billion-dollar weather and climate disasters (events)

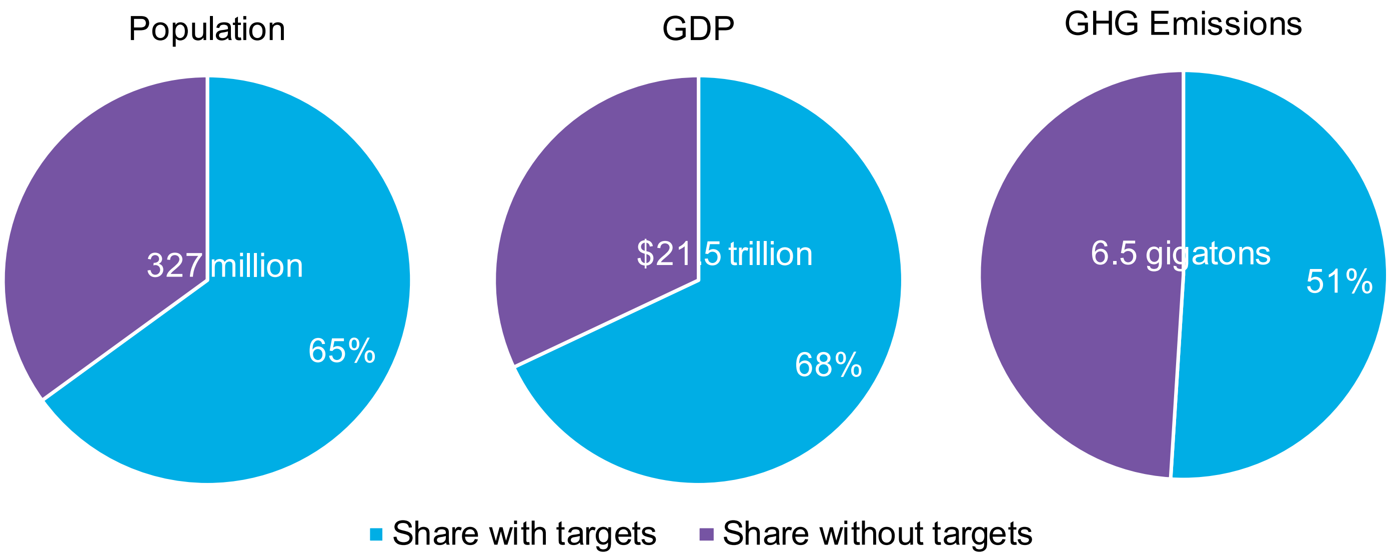


- Congress appropriated more than $20 billion in disaster funding in 2019, of which $3.3 billion was earmarked for the Army Corps of Engineers for flood and storm-damage restoration. The federal Department of Housing and Urban Development also made available about $7.6 billion to states and communities to reduce their vulnerability to future climate events. The 2019 fundings follow passage in October 2018 of the Disaster Recovery Reform Act, which set a new formula for pre-disaster mitigation funding.
- The FY 2020 NDAA enacted in 2019 increased the Energy Resilience and Conservation Investment Program (ERCIP) funding by $40 million for a total of $193 million. ERCIP is a subset of the defense-wide MILCON program that funds projects to increase resilience, save energy or water, produce energy or reduce the cost of energy for the Department of Defense. The NDAA codified the position of Assistant Secretary for Energy, Installations, and Environment for each military department, prioritizing the position and efforts in these areas.
- The McCain National Defense Authorization Act, signed on August 13, 2018, authorizes the Department of Defense to make grants to states and localities to address threats to the resilience of military bases. It defines resilience as the readiness of a military installation to react to extreme weather events.

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

Policy: Sub-national actions to address climate change

Population, GDP and emissions of states and cities with greenhouse gas targets, compared to U.S. totals (2018)

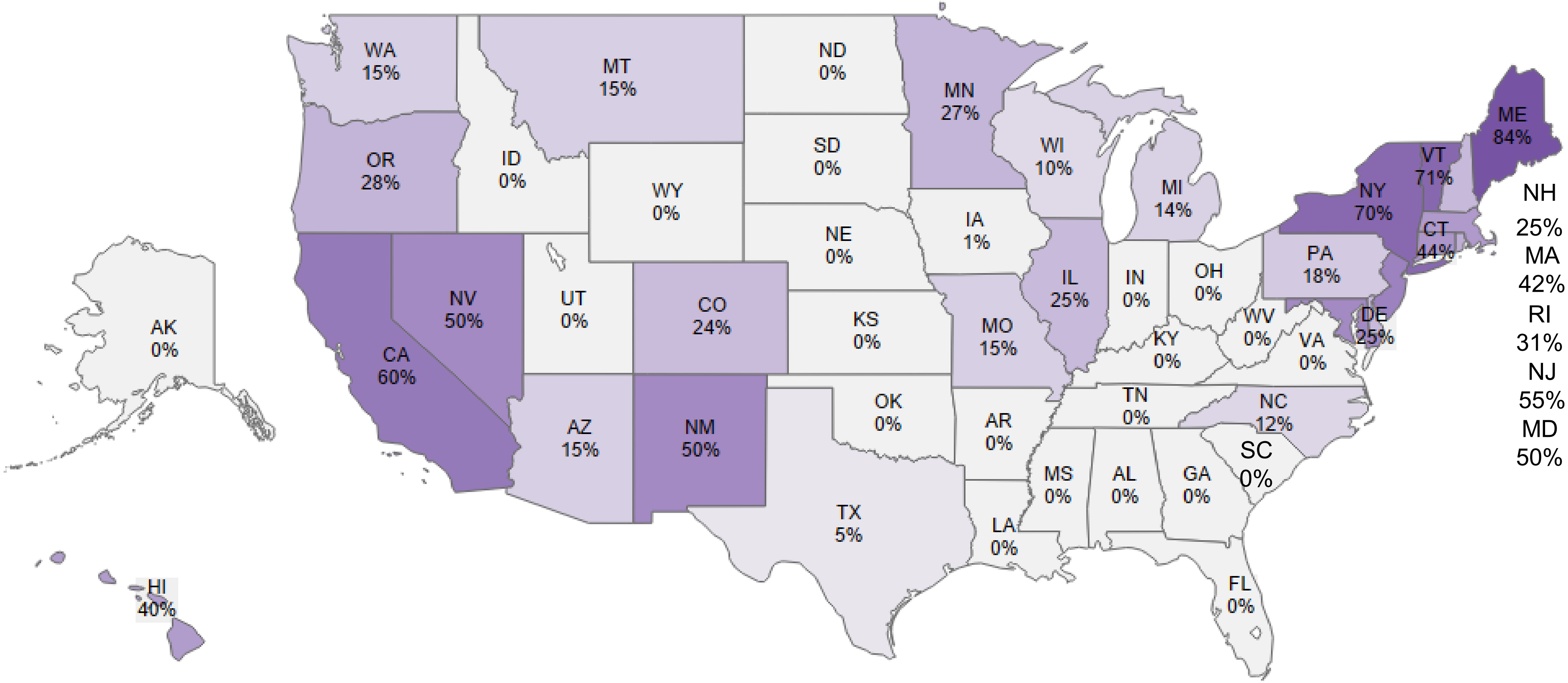


- U.S. jurisdictions encompassing more than 60% of the U.S. population have now committed to CO2 emissions reduction targets, with an eye toward having the U.S. meet the obligations pledged by the Obama administration under the Paris climate accord. Those state, local and municipal governments also account for approximately two-thirds of the national population and GDP and one-half of nationwide GHG emissions, according to Fulfilling America's Pledge, a coalition of governments, businesses and other organizations funded by Bloomberg Philanthropies.
- Since the 2018 elections, eight states have joined the U.S. Climate Alliance: Pennsylvania, Wisconsin, Illinois, Michigan, Montana, New Mexico, Maine, and Nevada. That brings the total to 24 states participating in the group, which aims to cut CO2 emissions in line with Paris.
- Policy changes have come in a number of states where Democrats control both the state legislature and occupy the governor's mansion. One exception came in Maryland where in early 2019, the Democratic-controlled Maryland state legislature raised the state's renewables mandate. Governor Larry Hogan, a Republican, did not sign the bill, but did allow it to become law.

Source: America's Pledge, BloombergNEF

Policy: State clean energy mandates

2030 renewable electricity sales targets

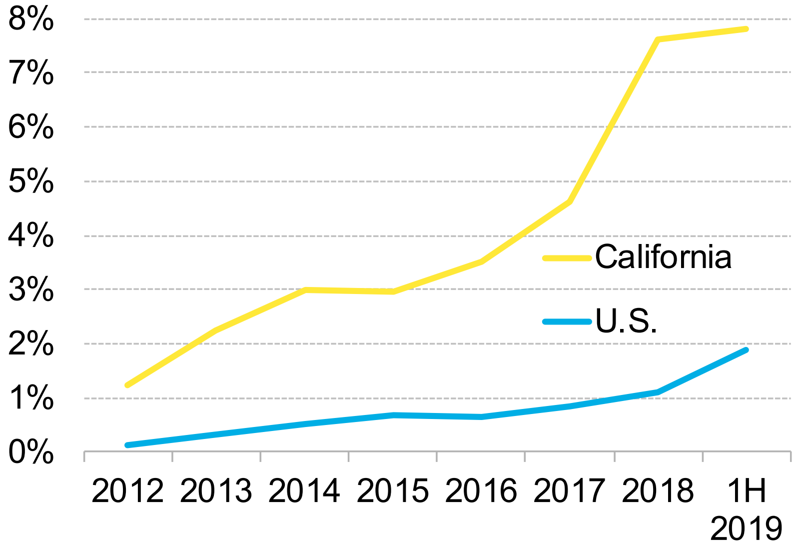


- In 2019, nine states made significant revisions to their legislated clean energy goals. Major updates included New York State increasing its renewable portfolio standard to 70% by 2030 and Nevada boosting its to 50% by 2030. Washington State also set a 100% zero-carbon by 2045 target.
- Away from state policy, there has been a strong uptick in utility commitments over the last two years. In the Midwest, home to strong winds and in some areas conservative politics, major utilities Xcel and Mid American have set some of the most ambitious utility goals.

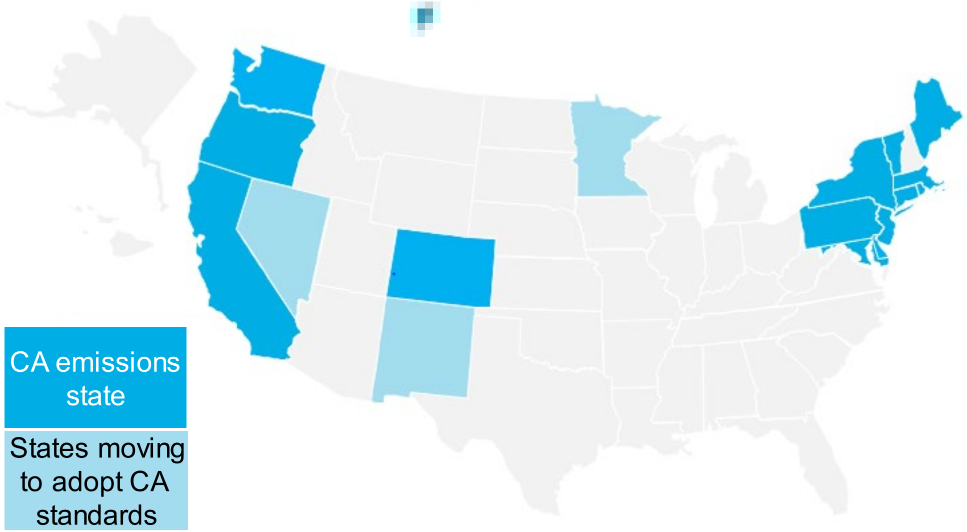
Source: BloombergNEF, Berkeley National Lab. Note: Targets are as of July 2019.

Policy: Vehicle fuel economy standards

EV share of light-duty vehicle sales, in California and nationwide



States that have adopted California's vehicle emissions standards

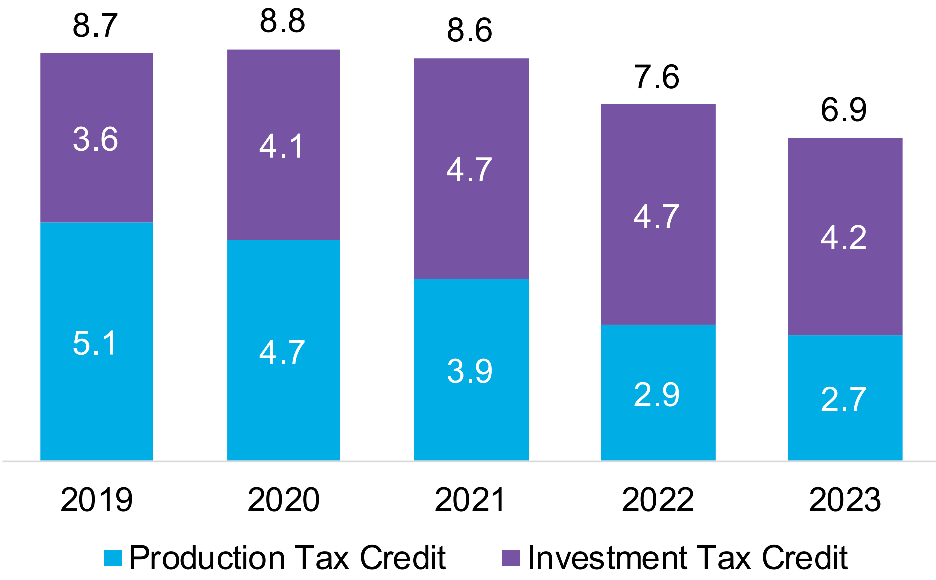


- The transportation sector is the largest source of greenhouse gas emissions in the U.S. Electric vehicle sales are growing but still represent a small share of the on-road fleet.
- The Trump administration proposed to freeze Corporate Average Fuel Economy (CAFE) standards for model years 2021-2025 at 2020 levels, which by its own estimates would increase both motor fuel consumption and greenhouse gas emissions. However, recent news reports suggest the administration's final version of the rule may slow, but not freeze, these standards. California, 14 other states and the District of Columbia adhere to a more aggressive emissions-reduction schedule and have vowed to ignore the federal standards.
- California also has instituted a zero emissions vehicle (ZEV) program, which sets quotas on the sale of non-emitting cars. Most, but not all, of the states embracing California's fuel economy standards have adopted its EV program.

Source: BloombergNEF Note: The 14 jurisdictions that follow the California GHG standard are Colorado, Connecticut, Delaware, District of Columbia, Maine, Maryland, Massachusetts, New Jersey, New York, Oregon, Pennsylvania, Rhode Island, Vermont and Washington.

Policy: Tax credits

Estimated annual cost to federal treasury of renewable energy tax credits ($billions)

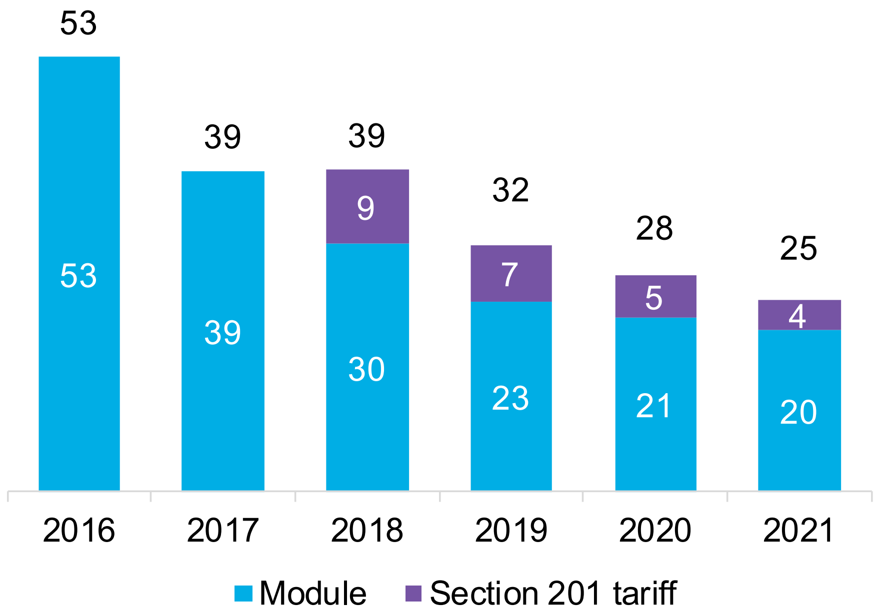


- Federal expenditures on the two main tax credits that support clean energy development – the Production Tax Credit (PTC) and Investment Tax Credit (ITC) – will peak in fiscal year 2020, according to the Joint Committee on Taxation of the U.S. Congress. These credits cover select systems spanning solar, wind, hydro, geothermal, biomass, waste-to-energy and landfill gas technologies.
- Legislation enacted in December 2019 extended PTC eligibility for wind projects from end-2019 to end-2020. It also raised the credit to $15/MWh from the 2019 level of $10/MWh.
- Hydro, geothermal, and biomass saw their ITC eligibility extended, but the legislation contains no extension of the ITC for solar and does not expand the credit to stand-alone energy storage (battery) projects, despite lobbying by those interests.
- The bill extended both retroactively and prospectively the $1/gallon tax credit for biodiesel producers. They now will earn credits for fuel sold in 2018-2022. The alternative fuels tax credit and the alternative fuels refueling infrastructure credit were also both retroactively and prospectively extended for years 2018-2020.

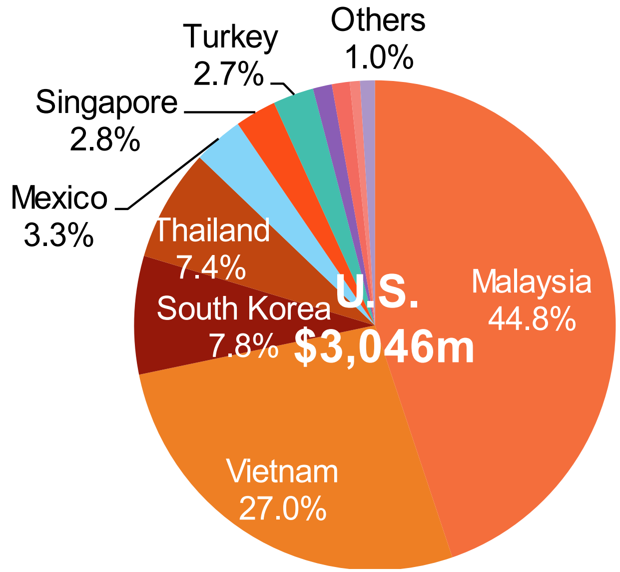
Source: U.S. Congress Joint Committee on Taxation, BloombergNEF

Policy: Trade

Estimated cost of a Chinese-made PV module delivered to the U.S. (cents/Watt)



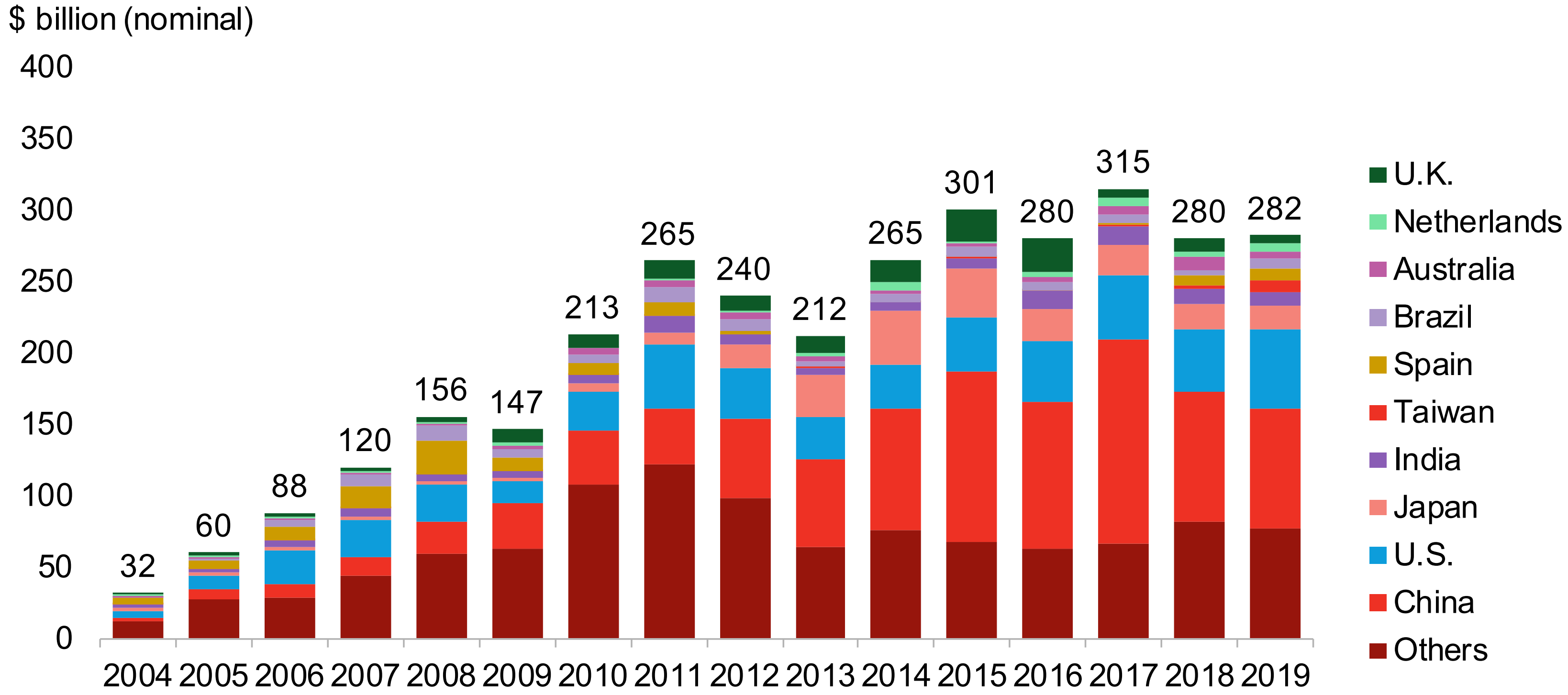
U.S. PV imports by origin, January-August 2019



- President Trump's Section 201 "safeguard" duties on imported solar crystalline-silicon cells and modules were set to shrink from 25% to 20% of value as of February 7, 2020. The tariff reduction, combined with continuing declines in the manufacturing cost of solar technology, will help keep solar cost-competitive in the U.S. The safeguard duties apply to imported mono-facial cells and modules, but thin-film technologies, bifacial modules and a handful of products with smaller markets were exempt. 2.5 GW/year of cell imports are also exempt.
- Trump levied separate tariffs on China in response to a U.S. finding of unfair or discriminatory trade practices. The combined effect of safeguard and unfair-practices duties has effectively pushed Chinese suppliers from the U.S. market. However, many of the substitute Asian sources are controlled by or affiliated with Chinese manufacturers.
- The U.S. House of Representatives and Senate approved Trump's replacement for the North American Free Trade Agreement. The new United States Mexico Canada Agreement (USMCA) sets minimum-content and minimum-wage barriers against Asian suppliers that previously enjoyed significant cost advantages on low-carbon products such as batteries and electric vehicles.
- Meanwhile, both pipeline capacity additions contributed to increasing gas exports in 2019. South Korea is the largest destination of U.S. liquefied natural gas (LNG) exports by value and Asia is by far the largest regional market for U.S. LNG.

Source: BloombergNEF

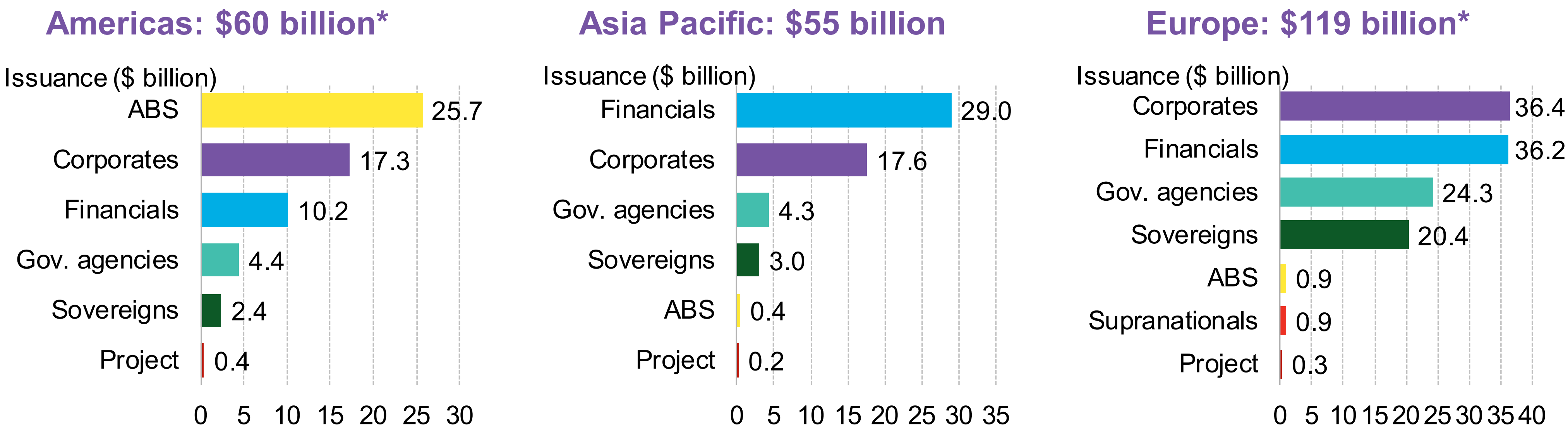
Finance: Total new clean energy asset investment, by country or region



- Global asset finance for clean energy reached $282 billion in 2019, up 1% from 2018. While investment slipped in the world's largest market, China, in the U.S. it set a new record. U.S. clean energy investment surged 28% to $55.5 billion. Instrumental in this was a rush by wind and solar developers to qualify for federal tax credits that had been due for scale-back in 2020. U.S. clean energy asset investment totaled $390 billion 2010-2019, averaging $39 billion per year.
- Globally, wind led the way, with a 6% year-over-year increase to $138 billion. Solar was close behind, at $131.1 billion but down 3% from the prior year. Falling capital costs for wind and solar meant that the two technologies combined are likely to have seen around 180 gigawatts added in 2019, up some 20GW from 2018 levels.
- Biomass and waste-to-energy saw $9.7 billion of capacity investment in 2019, up 9%. Geothermal was at $1 billion, down 56%. Biofuels were down 43% at an estimated $500 million, and small hydro was 3% lower at $1.7 billion.

Source: BloombergNEF Note: Includes asset (project) finance for wind, solar, biofuels, biomass, and waste. Includes only financings for large-scale projects and small distributed generation.

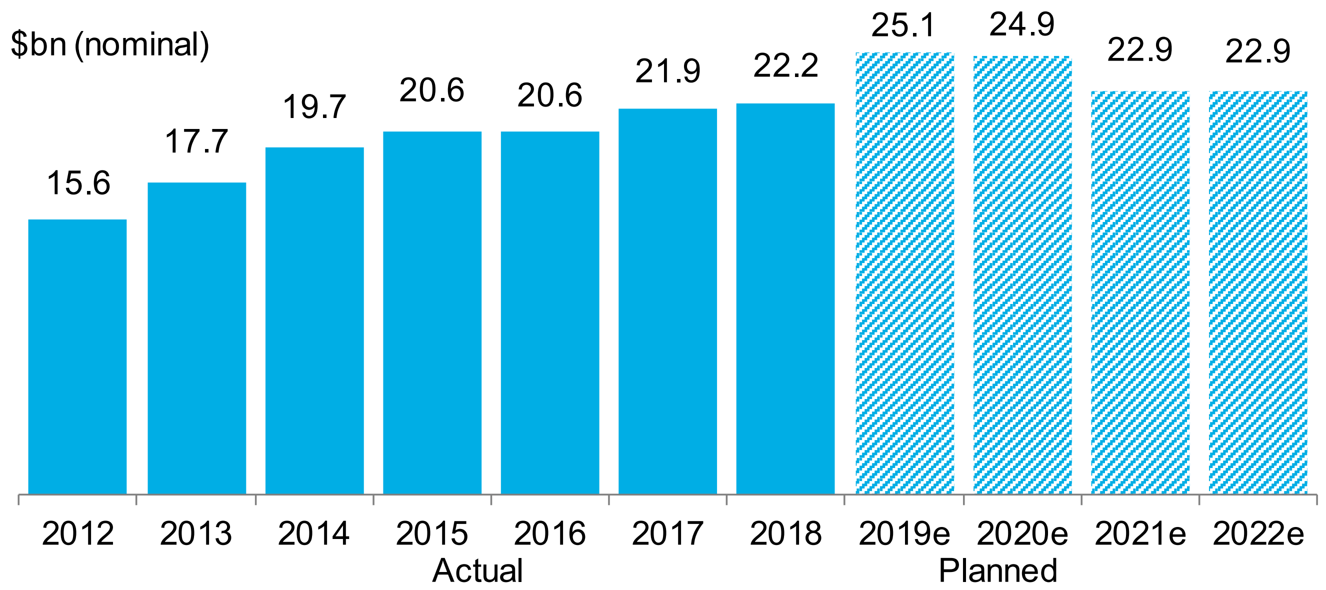
Finance: Global green bond issuance



- Green bond issuances in 2019 grew in all regions compared with 2018 and accounted for 58% of total global sustainability-themed debt (a category which also includes private loans).
- While Europe remains the top-issuing region, the Americas contributed 30% of green bond volumes in 2019. The U.S. alone contributed $70 billion, 87% of the Americas annual amount.
- Nearly $24 billion of the U.S. 2019 total came in the form of corporate and financial bonds. Some $25.7 billion in the U.S. were offered as asset-backed securities (ABS). One such ABS issuer is the Federal National Mortgage Association. Not only did Fannie Mae dominate the U.S. ABS market, but it was the largest 2019 issuer in the U.S. and the world. In 2019 alone, Fannie Mae issued nearly $23 billion in green bonds.
- Despite Europe dominating as the top issuing region of green bonds, the Americas grew more than any other region between 2018 and 2019. Contributing to this were other key U.S. issuers such as MidAmerican Energy, Apple, and Bank of America.
- In 2019, the communications industry offered green bonds for the first time, namely from Vodafone Group, Verizon and Telefonica. Verizon raised $1 billion through a green security early in 2019.

Source: BloombergNEF Note: Graphs are for 2019 issuance only. ABS stands for asset backed securities (green mortgages, solar and EV auto loans). Countries and regions based on area of risk. Note: Americas total value excludes municipal bonds. Europe chart is inclusive of the entire Europe Middle East Africa (EMEA) region though nearly all deals are in Europe. Charts do not include supranational issuances.

Finance: U.S. electric transmission investment by investor-owned utilities and independent developers

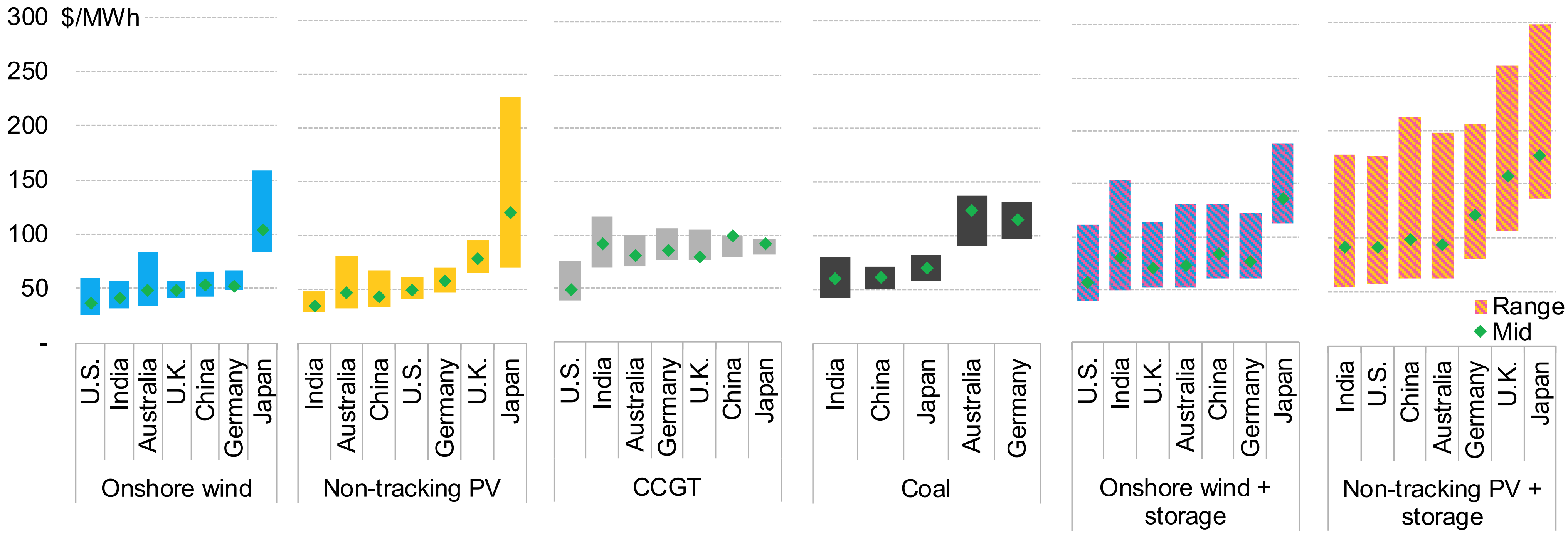


- Investor-owned utilities and independent transmission developers spent a record $22.2 billion on electric transmission in 2018, Edison Electric Institute (EEI) estimates. This is up 1% from 2017 and up 25% from 2013.
- Based on company reports, investor presentations and a survey, transmission investment likely jumped 13% in 2019 to $25.1 billion, EEI estimates. Current capex plans suggest that investment will have peaked in 2019 and investment will slow from 2020 onwards. However, future-year budgets are not yet finalized, and these numbers may be revised upward.
- The transmission investment upswing is driven by a number of factors, all of which concern the utility's fundamental aim of providing reliable, affordable, and safe power. These include a need to replace and upgrade aging power lines, resiliency planning in response to potential threats (both natural and man-made), the integration of renewable resources, and congestion reduction.

Source: Edison Electric Institute, BloombergNEF

BloombergNEF

Economics: Select country levelized costs of electricity (unsubsidized, 2H 2019)

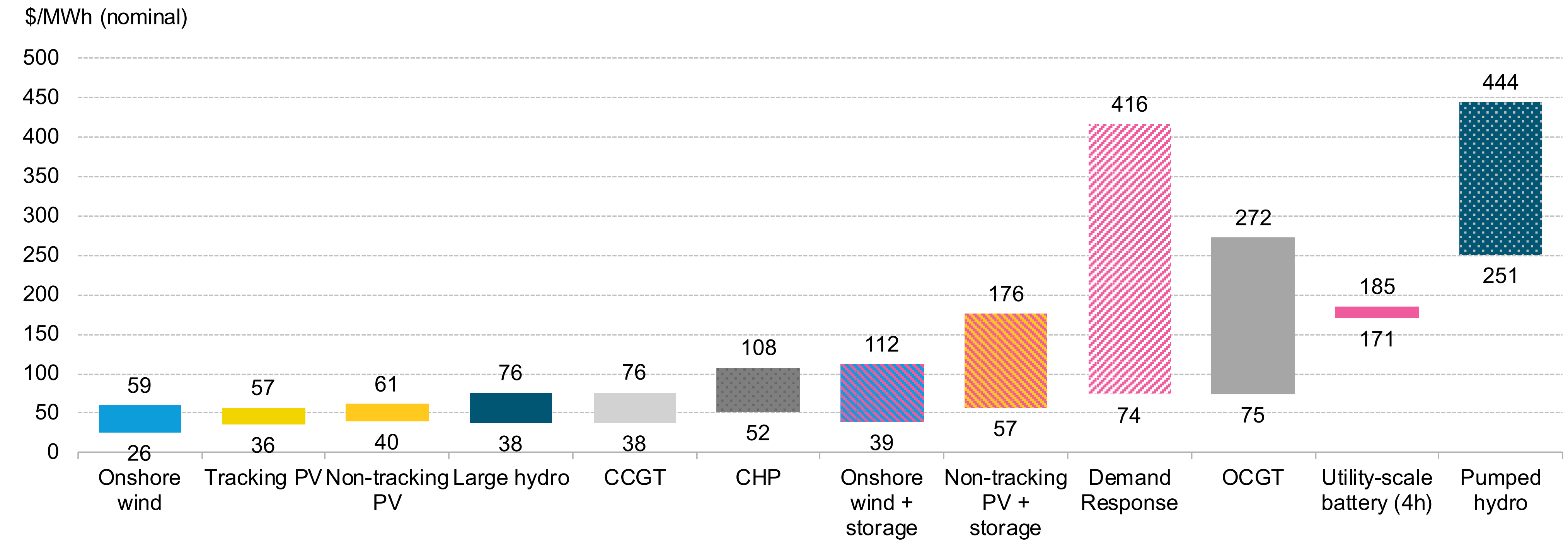


- Levelized cost of electricity (LCOE) is a metric for comparing the relative costs of different generating technologies. It measures the all-in, lifetime costs of operating a plant, accounting for upfront costs as well as anticipated ongoing expenses.
- Under BNEF's 2H 2019 estimates, onshore wind is the cheapest source of new generation across geographies, with the U.S. boasting the lowest all-in costs at $26/MWh. Globally, India features the world's lowest-cost solar, at $28/MWh for non-tracking photovoltaic (PV).
- The U.S. sees the least expensive combined-cycle gas turbines (CCGTs) due to cheap, abundant gas resources and no nationwide price on CO2 emissions. Carbon pricing and relatively poor resources in the U.K. and Germany push up the costs for both gas and coal generation.

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

BloombergNEF

Economics: U.S. levelized costs of electricity (unsubsidized for new build, 2H 2019)

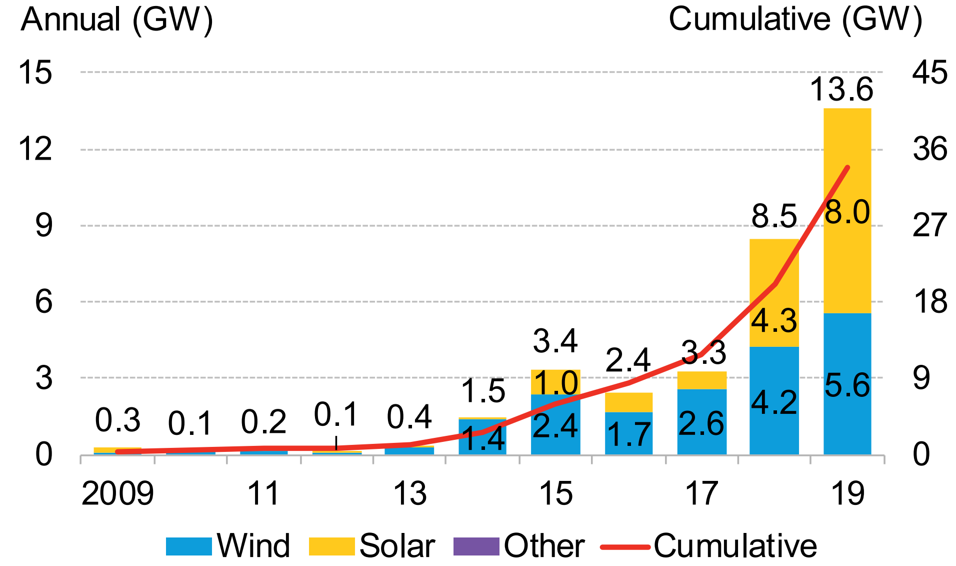


- At $26-59/MWh without accounting for tax credits, onshore wind is cheaper than new gas-fired plants for bulk electricity generation in many areas of the U.S. Combined-cycle gas turbines (CCGTs) represent the cheapest source of dispatchable power, with an LCOE of $38-$76/MWh.
- Projects equipped with photovoltaic (PV) modules that track the sun's progress feature U.S. LCOEs of $36-57/MWh and are almost at parity with new CCGT projects. PV projects without tracking are getting cheaper with LCOEs of $40-61/MWh.
- The levelized cost of paired onshore wind-plus-battery (four-hour) systems ranges $39-112/MWh, while solar-plus-battery (four-hour) is at $57-176/MWh.

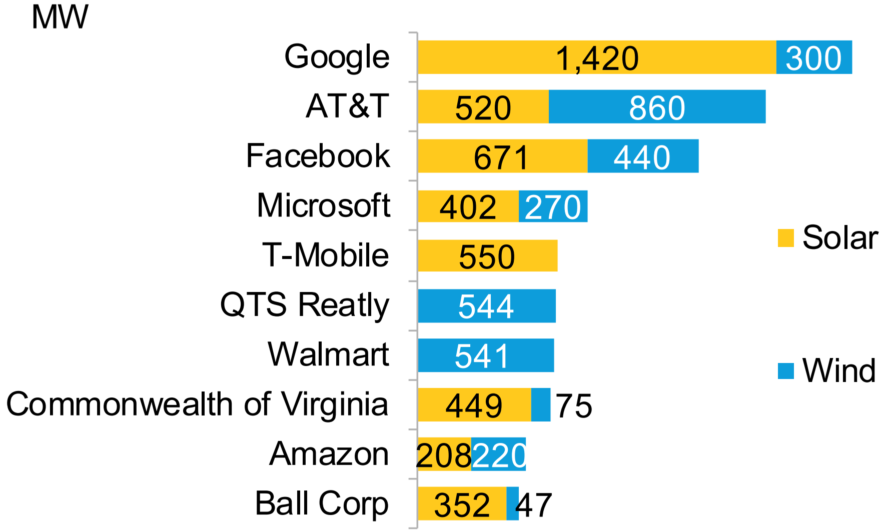
Source: BloombergNEF. Note: The LCOE range represents a range of costs and capacity factors. Battery storage systems (co-located and stand-alone) presented here have four-hour storage. In the case of solar- and wind-plus-battery systems, the range is a combination of capacity factors and size of the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

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

U.S. corporate PPAs, by technology



Largest corporate offtakers, 2019



- Corporations in the U.S. purchased 13.6GW of clean energy through power purchase agreements (PPA), shattering the previous year's record of 8.5GW. Companies are flocking to the Texas power market, where 5.5GW of these contracts have been signed – far more than the second largest market, PJM (2.2GW). Nearly two thirds of PPAs signed in Texas have been for solar power, as companies seek to capture peak pricing in summer months.
- Buyers are turning attention to risk mitigation, seeking opportunities to reallocate term risk, weather risk and credit risk from PPAs. Re-insurance providers like Allianz and Swiss RE have entered the market with products like proxy revenue swaps and volume firming agreements, which allow them to inherit these risks from corporate buyers. Utilities and retailers also offer various "sleeved" programs, which involve them serving as middle-men and the direct offtakers on clean energy contracts, bearing these risks on behalf of corporate buyers.
- Google was the largest U.S. corporate offtaker in 2019, signing contracts for 1,720MW of clean energy. In September 2019, the company announced 936MW of solar PPAs in the U.S., leveraging a unique reverse auctioning program to sign the contracts. The company specified criteria for its clean energy purchases, such as technology, term length and location, and developers participated in a timed, public auction process. The developer that offered the cheapest contract that met all of Google's criteria won the tech giant's business.

Source: BloombergNEF Note: Charts show offsite PPAs only

BloombergNEF

Finance: Corporate procurement of clean energy and energy efficiency

Key players: corporate clean energy procurement

Key players: corporate vehicle electrification

Key players: corporate energy efficiency

Retail

Financial & Insurance

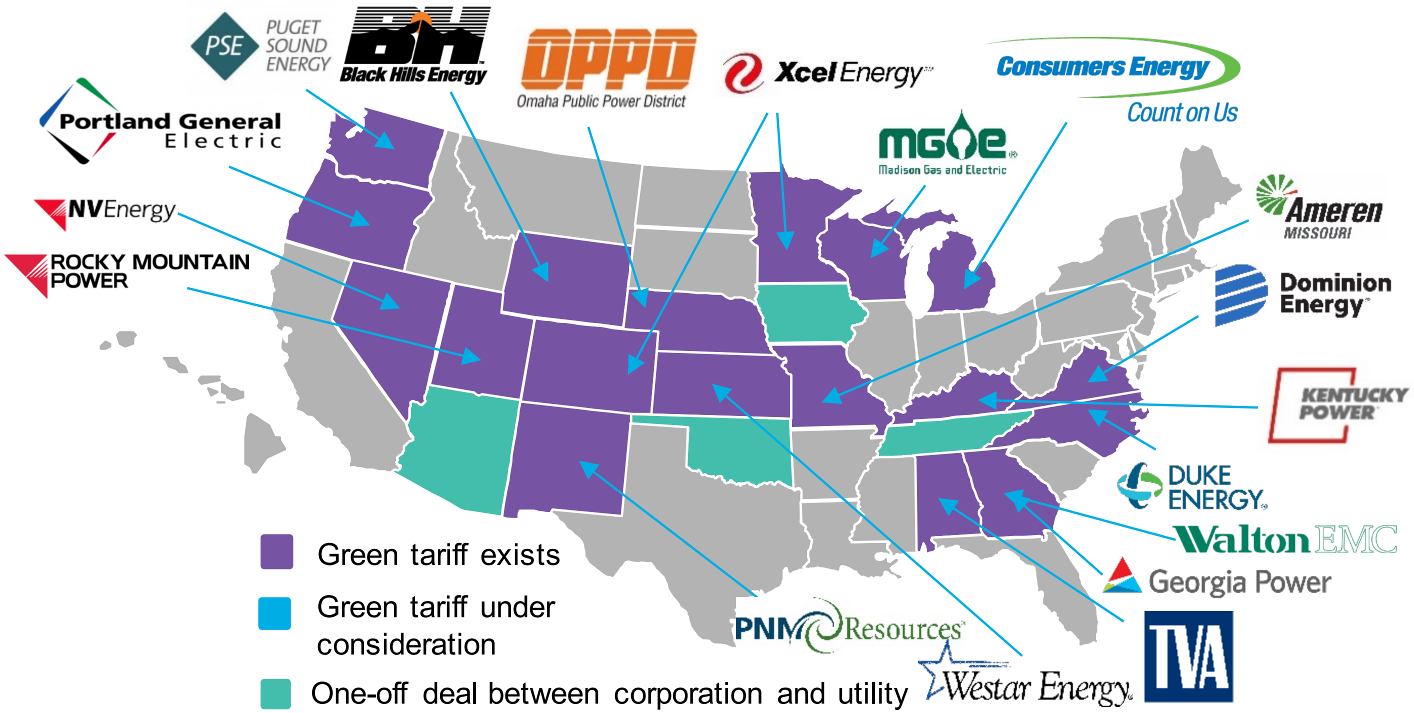
Tech

Manufacturing

- Corporations are setting clean energy targets at record pace. Through 2019, 221 companies have pledged to source 100% of their energy consumption from renewables by signing onto the "RE100" initiative. Nearly 30% of these firms (65) are domiciled in the U.S., trailed by the U.K. (37) and Japan (30). Some 61 companies from 11 countries joined the RE100 in 2019, compared with 41 companies in 2018.
- Through 2019, 64 companies have joined The Climate Group's EP100 campaign, up from 37 companies in 2018. Signatories pledge to double their energy productivity by 2030, while also cutting energy waste and owning and operating energy-smart buildings. Goldman Sachs, Lendlease and Jones Lang LaSalle were notable members to join the initiative in 2019.
- The Climate Group's EV100 campaign also nearly doubled in 2019 to 60 companies. Companies make a public commitment to integrate electric vehicles (EV) into their fleet or support EV charging infrastructure at their operations by 2030. The Port Authority of New York & New Jersey and Tokyo Electric Power headlined new signatories in 2019. In September 2019, Amazon also announced it would purchase 100,000 electric trucks from Rivian, but did not join the EV100.

Source: BloombergNEF, The Climate Group, company announcements, DOE.

Deployment: Corporate procurement of clean energy through green tariffs

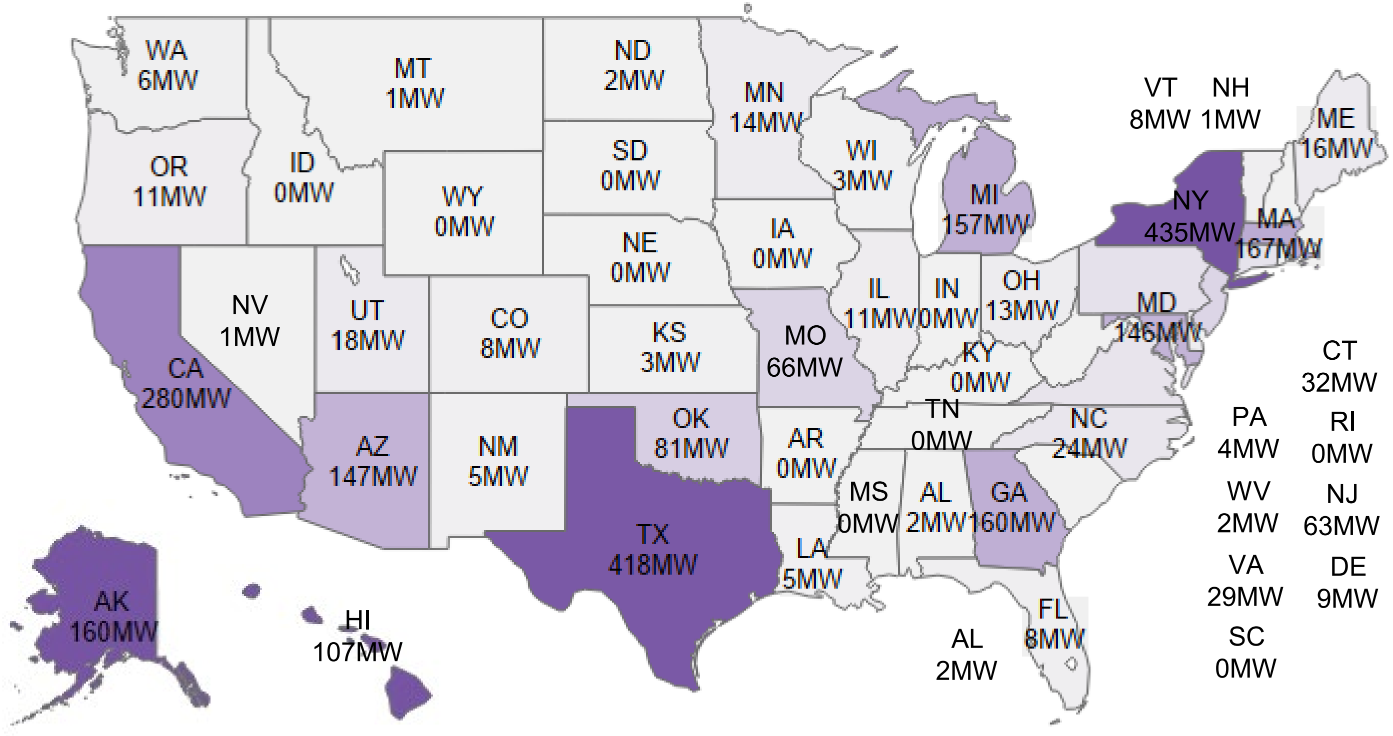


- Through 2019, 18 regulated utilities in 18 U.S. states offer green tariff programs. These utilities will buy clean energy on behalf of a corporate buyer, manage the intermittency with their existing generation portfolios, and deliver it in firmed-up blocks to customers. After a record 2.6GW of clean energy purchased by corporations through green tariff programs in 2018, volume dropped to 2.4GW in 2019.
- Corporate buyers and utilities have been at odds across the U.S. over access to clean energy. Notable examples include the legal battles between Dominion Energy and its customers in Virginia, and Facebook's quarrel with PNM Resources over transmission line payments in New Mexico. These incidents have fueled apprehension among buyers to use green tariffs.
- Google has purchased 783MW of clean energy through green tariff programs in 2019, leading all corporations. Facebook is second with 700MW, leveraging programs in Utah, Georgia and Montana. Companies like Facebook, Google, General Motors and Walmart have leveraged green tariffs to date, but the programs remain a work in progress. While each program is different, many are prohibitive to all but the biggest energy buyers, and some have clauses that don't allow for customers to save on electricity by switching to the programs.

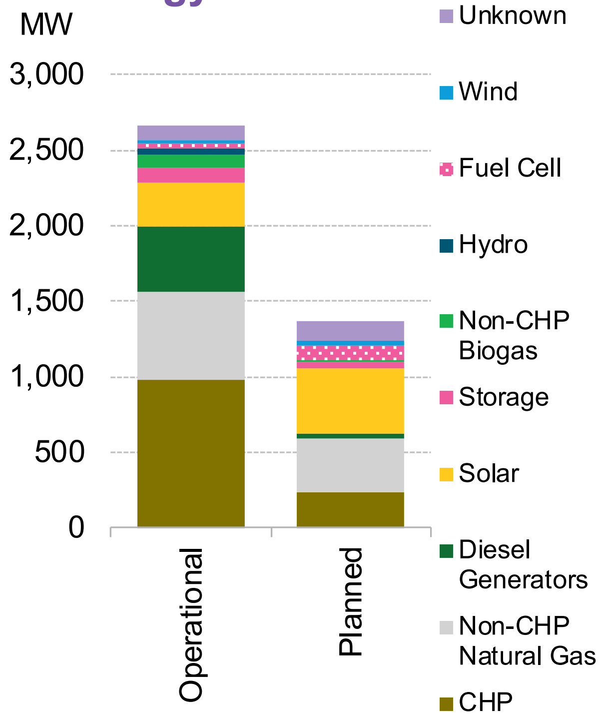
Source: BloombergNEF, World Resources Institute

Deployment: National microgrid penetration

Microgrid penetration by state



Microgrid capacity by technology



- There are currently 2.7GW of operational and 1.4GW of planned microgrids in the U.S. spread across 242 and 138 sites, respectively.
- Of these, 976MW of operational and 230MW of planned microgrid capacity come from combined heat and power (CHP) systems, representing around 30% of all operational and planned capacity. There are currently 25 CHP sites paired with solar generating capacity, 12 with diesel generators and 12 with batteries. Other technologies have six or fewer sites paired with CHP.
- The city/municipal sector has the largest number of CHP systems with a combined 78 operational and planned sites. The military and commercial sectors have the second and third largest with 63 and 61 sites. The military and commercial sectors have 44 and 41 sites currently in operation. With only 29 current sites, the city/municipal sector has the largest “planned” pipeline.

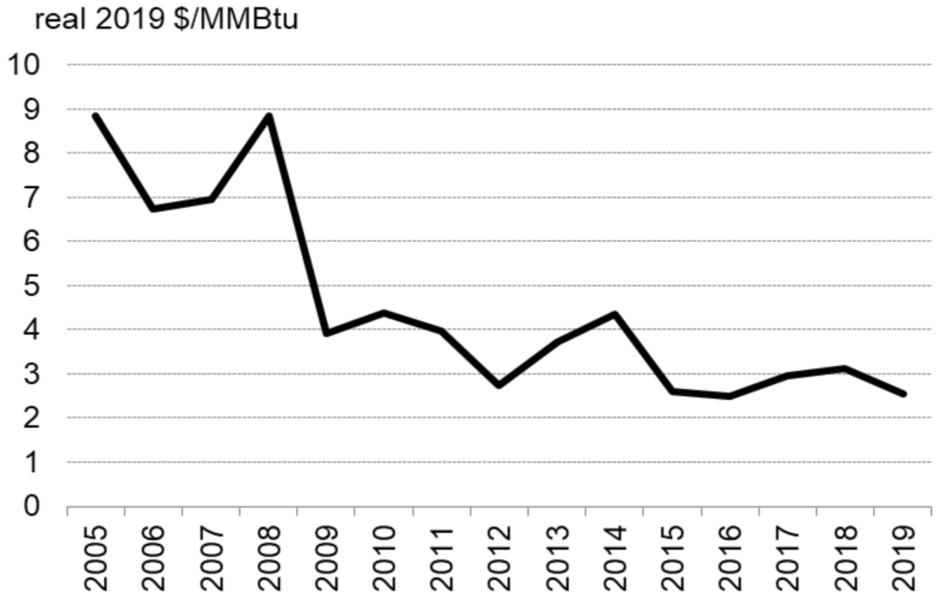
Source: ICF Microgrid Database, BloombergNEF Note: Microgrid is defined as a group of interconnected loads and distributed energy resources (DERs) that can disconnect and re-connect to the utility grid as a single entity, allowing facilities to remain operational during utility outages.

Table of Contents

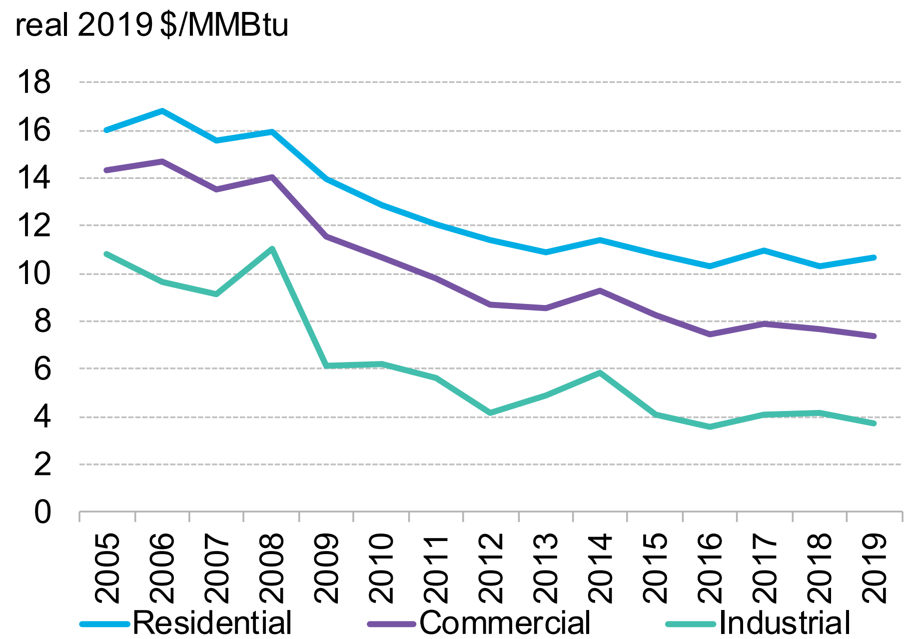
BloombergNEF

Deployment: U.S. natural gas pricing, wholesale and by end use

Natural gas spot prices



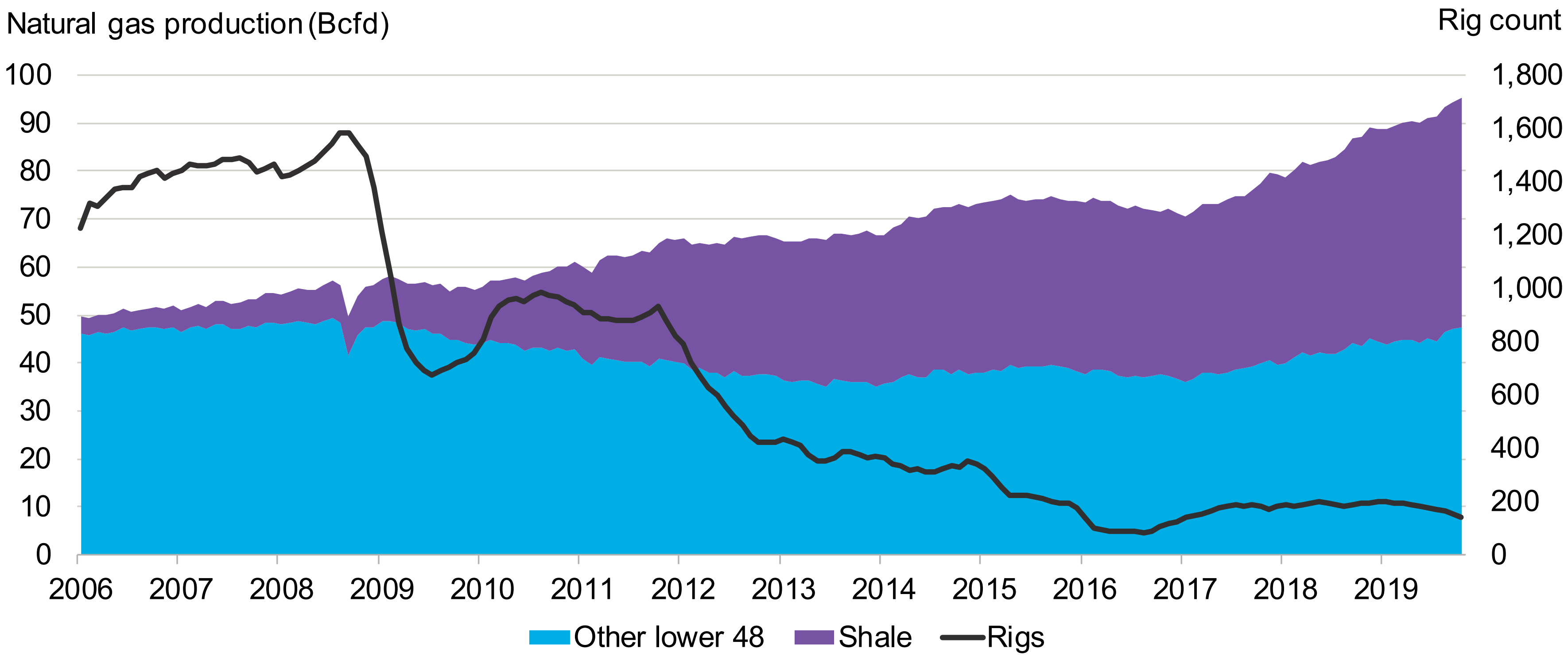
Natural gas prices to end users



- U.S. natural gas production increases overwhelmed the supply-demand balance in 2019. As a result, wholesale prices reverted back to 2016 levels on an annual average basis. Over the last decade, wholesale prices decreased 35%.
- For end users, natural gas prices rose 3% for residential consumers, dropped 3% for commercial consumers, and dropped 9% for industrial customers 2018-2019. Over the last decade, all three segments saw steep declines: residential (-24%), commercial (-36%), and industrial (-39%).
- Residential price adjustments tend to lag and the price in 2019 was still partially impacted by 2018 levels.

Source: BloombergNEF, EIA; Note: Natural gas prices derive from Henry Hub annual spot prices. Values for 2019 are projected, accounting for seasonality, based on latest monthly values from EIA (data available through October 2019).

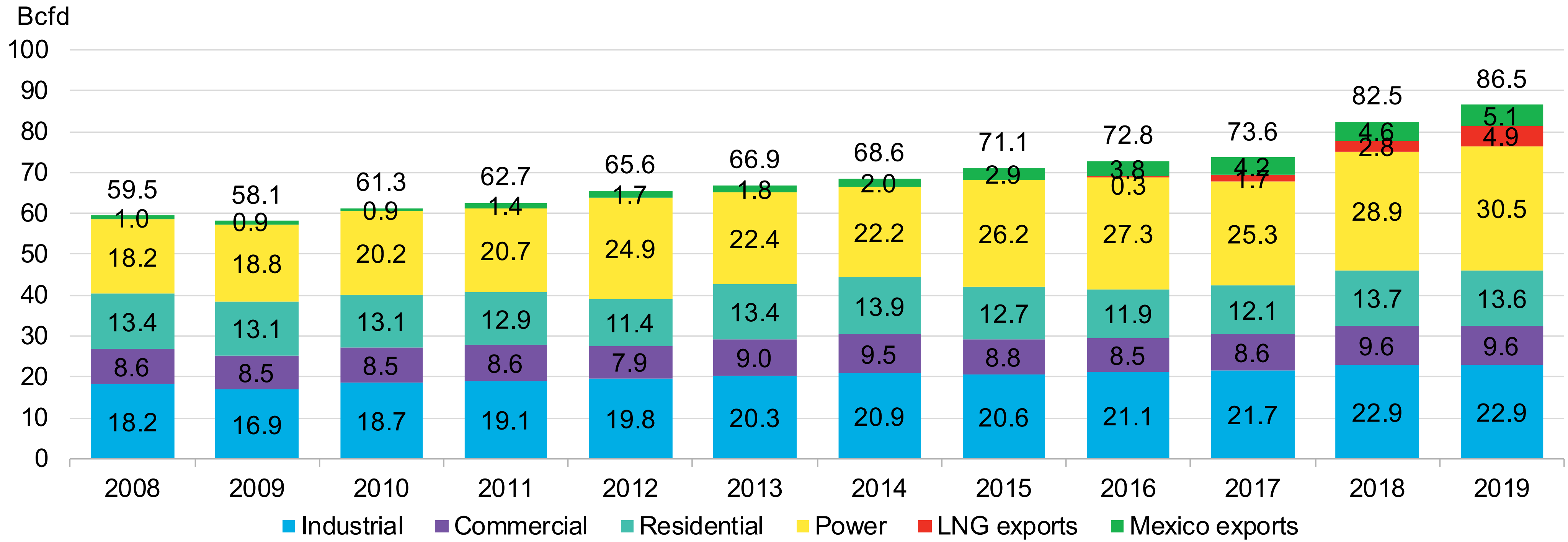
Deployment: U.S. gas-directed rig count and gas production



- Despite flat year-on-year gas-oriented rig count growth in 2019, U.S. natural gas production grew by around 8%. The brunt of the output surge came from oil-oriented drills where gas produced is essentially a byproduct.
- In Appalachia, producers moved larger volumes through higher export capacity to the Midwest and the Mid-Atlantic. In the Haynesville shale, efficiency continued to increase on the fracked wells and in the Permian, a new 2 Bcfd pipeline was quickly filled with associated gas volumes to oil production. Rockies output grew in the first half of the year, but was later curtailed as investors encouraged producer belt-tightening.
- From the end of 2009 through 2019, average monthly production rose from 57Bcfd to 87Bcfd – a 55% jump.

Source: Bloomberg Terminal, EIA, Baker Hughes Note: Data are through October 2019

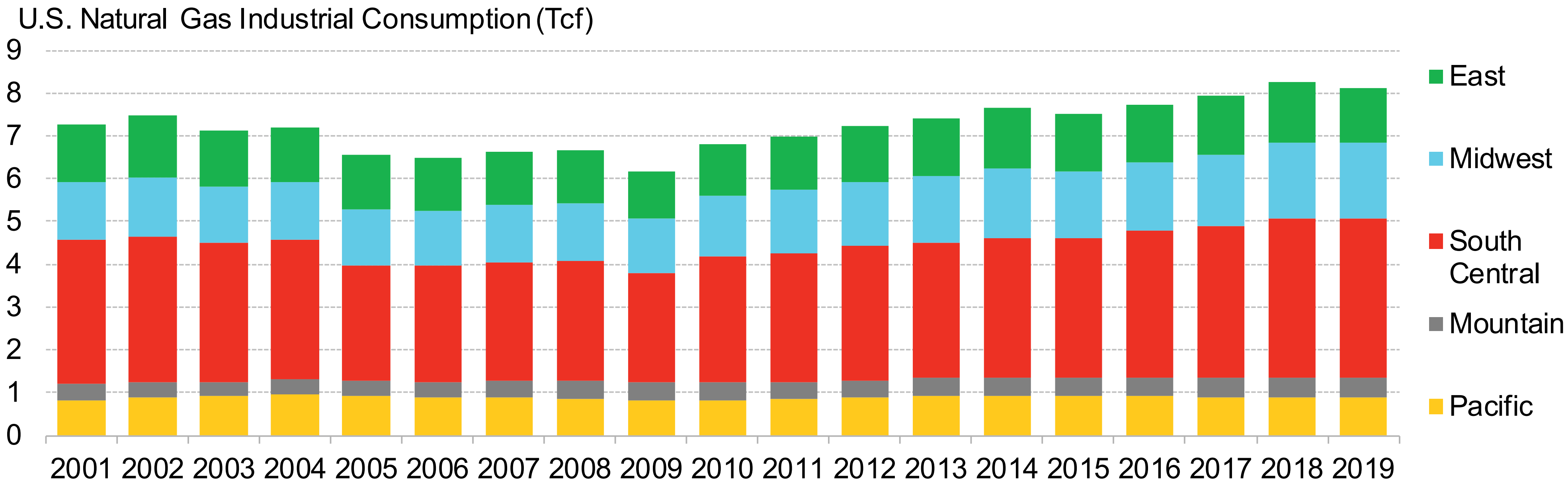
Deployment: U.S. natural gas demand by end use



- Total U.S. annual gas demand has grown 49% in the past decade and 5% in the last year alone to a record-setting 86.5 Bcfd in 2019.
- Power generation gas demand grew by 1.6Bcfd, despite a cooler summer. 12GW of coal-fired power plant retirements and lower year-on-year gas prices boosted demand.
- Industrial, residential and commercial heating demand held flat in 2019, thanks to a repeat relatively cold winter.
- LNG exports also significantly contributed to demand increase; 25MMtpa of new liquefaction capacity came online in 2019. However, this capacity had a utilization factor of less than 90%, due to technical issues at some of the newest plants.

Source: BloombergNEF, EIA. Note: Values for 2019 are projected, accounting for seasonality, based on latest monthly values from EIA (data available through October 2019).

Deployment: Industrial gas demand by region

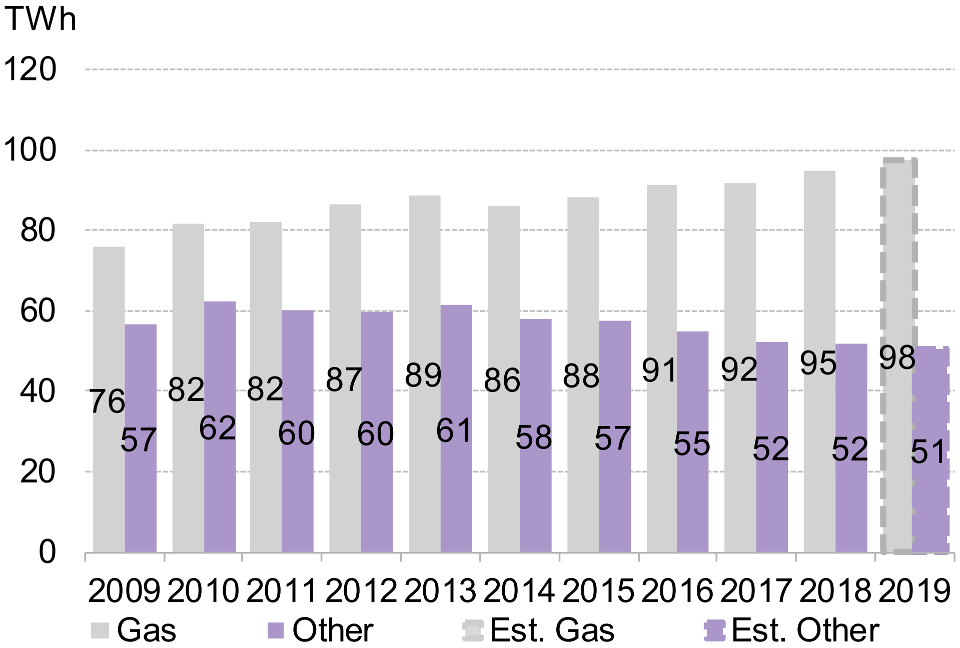


- In the past decade, overall U.S. gas industrial consumption has jumped 32%, spurred by lower prices. The majority of industrial consumption continues to come from facilities in the South Central region, where natural gas is readily available.
- Industrial sector gas consumption totaled 8.1Tcf in 2019, of which 3.7Tcf was consumed in the South Central, 1.8Tcf in the Midwest, 0.5Tcf in the Mountain region, 0.9Tcf in the Pacific and 1.3Tcf in the East.
- Industrial gas consumption actually slipped 1.8% in 2019 from the year prior. Consumption decreased in most regions, but by varying amounts: the East was down 10%; the Mountain region by 3%; the Pacific by 0.9%; and the Midwest by 0.4%. South Central demand actually increased, by 0.7%.
- There has been a long-term gradual slide in gas consumption from the Pacific region. Demand peaked there in 2014 at 0.92Tcf and has declined nearly every year since.

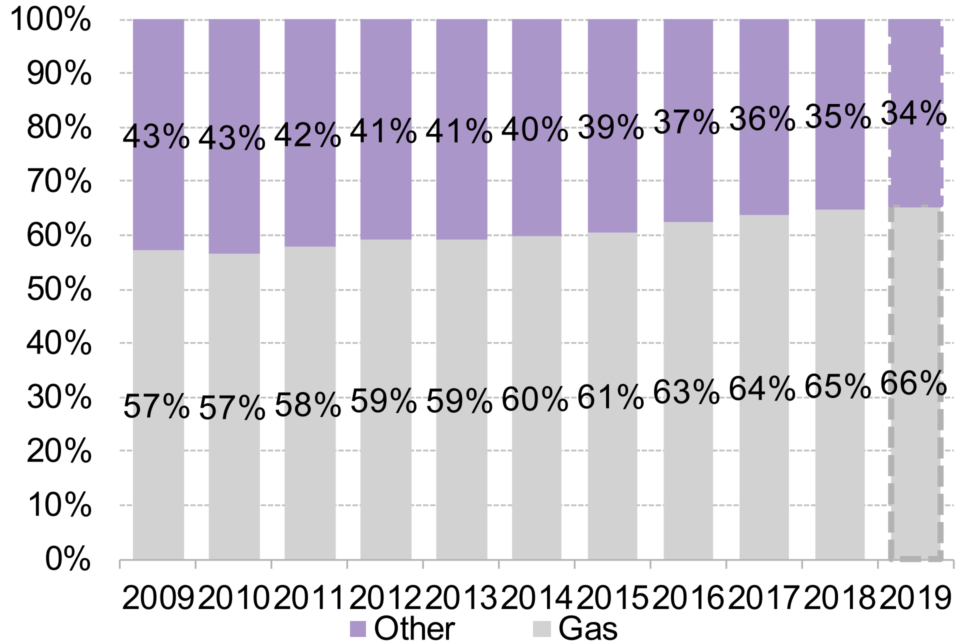
Source: BloombergNEF, EIA; Note: Values for 2019 are projected, accounting for seasonality, based on latest monthly values from EIA (data available through October 2019). 2017 industrial consumption numbers were used as proxies for missing monthly values for a number of states.

Deployment: Industrial on-site power generation, by type of fuel

Industrial, on-site power generation, TWh



Industrial, on-site power generation, % total

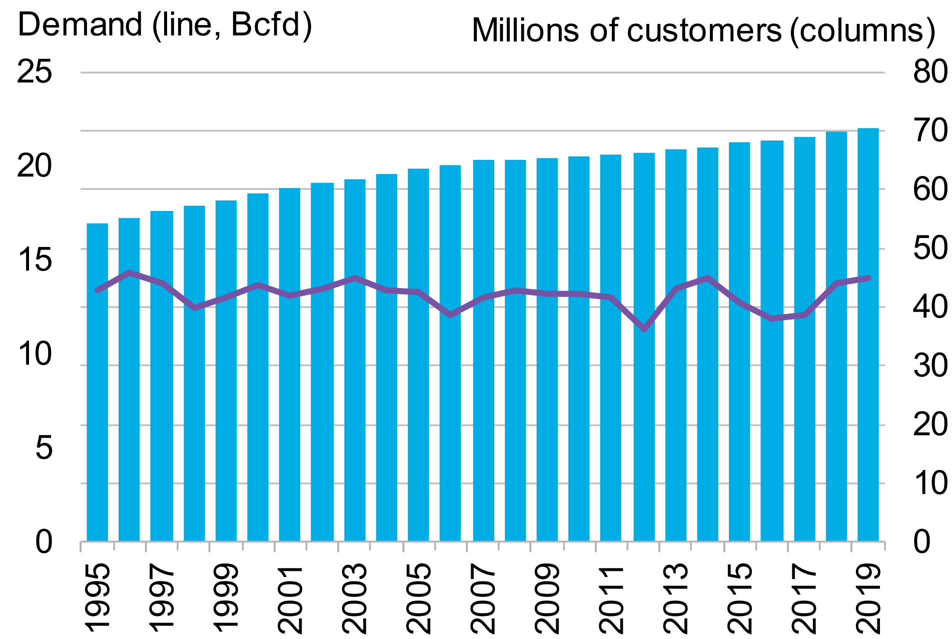


- The industrial sector's energy consumption has risen 24% over the last decade and now accounts for 23% of total U.S. primary energy demand. The sector's total emissions of harmful greenhouse gases rose at a slower, 14% pace over the same period. The industrial sector now accounts for 23% of total U.S. GHG emissions.
- Industrial sector, on-site power generation is when electricity is produced at an industrial plant's premises rather than coming from the grid. From 2018 to 2019, on-site industrial power generation rose 1%. Since the start of the decade it is up 12%.
- In 2019, natural gas was responsible for an estimated 98TWh of on-site generation at industrial facilities. Other sources provided an additional 51TWh. In total, industrial on-site generation increased 1.5TWh over 2018 levels. This uptick is driven by gas-based generation's 2.7TWh increase as gas displaced other, more expensive fuels, namely coal. The percent of on-site generation provided by gas has increased in the last decade, from 57% in 2009 to 66% 2019. This shrunk the size of an otherwise more carbon-intensive, coal-dominated fuel mix.

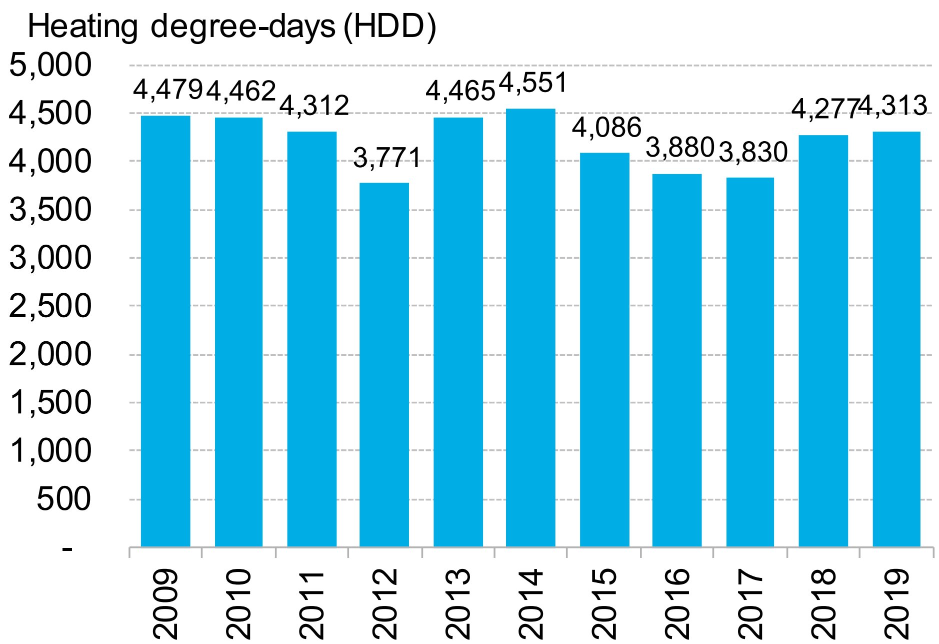
Source: BloombergNEF, EIA; Note: Values for 2019 are projected, accounting for seasonality, based on latest monthly values from EIA (data available through October 2019)

Deployment: U.S. natural gas residential customers vs. consumption

Residential demand vs. consumption



Heating degree-days



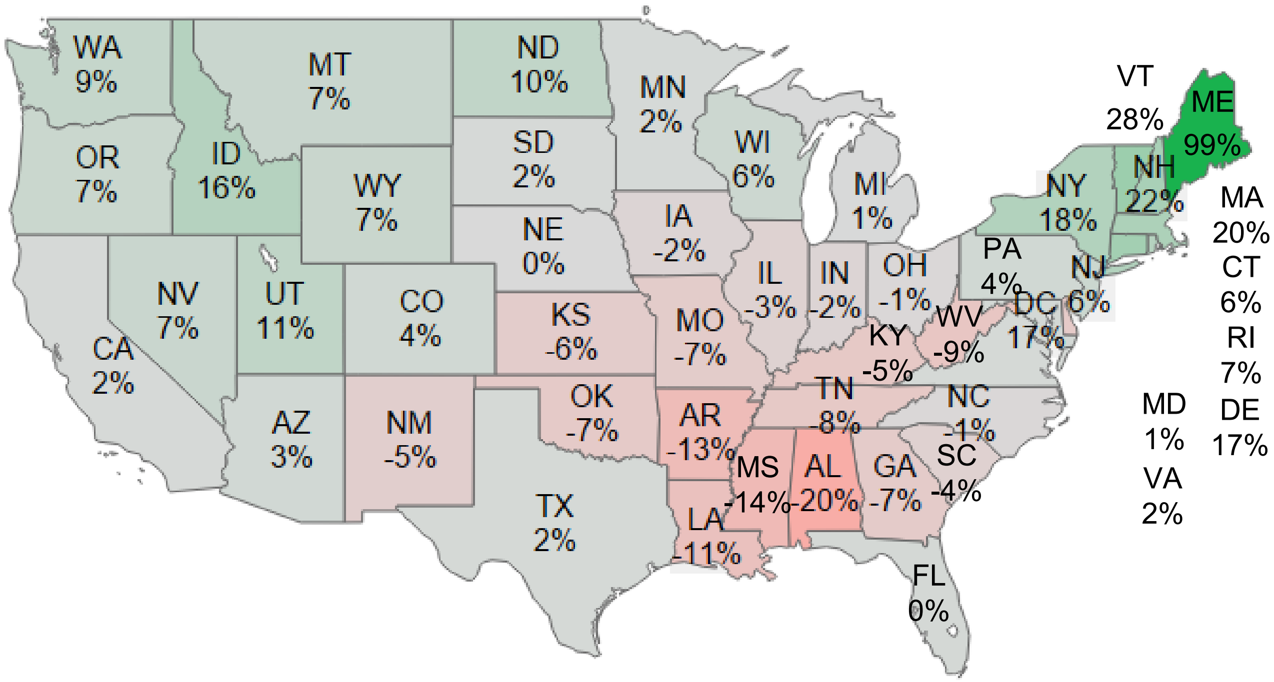
- Residential natural gas consumption decreased by 2% in 2019 even as the number of customers grew by 1%. The customer base for residential gas has expanded by 5 million, or 8%, in the last decade – and by 12.1 million, or 21%, over the past 20 years. Meanwhile, residential consumption remained largely flat over the same time, rising 7% in 10 years, but only 8% in 20 years, due to efficiency gains in the use of gas.
- Residential gas consumption is volatile year-to-year as it's driven by weather patterns. Consumption dropped during the abnormally mild winter of 2012, which saw a 13% fall in the number of heating degree days from the previous winter. It then jumped during the polar vortices of 2013 and 2014. Year-on-year, 2019 will see a 1% rise in demand, partly due to atypically cold weather holding for the second year in a row.

Source: BloombergNEF, EIA Notes: Values for 2019 are projected, accounting for seasonality, based on latest monthly values from EIA (data available through October 2019). Heating degree-day data are available through September 2019.

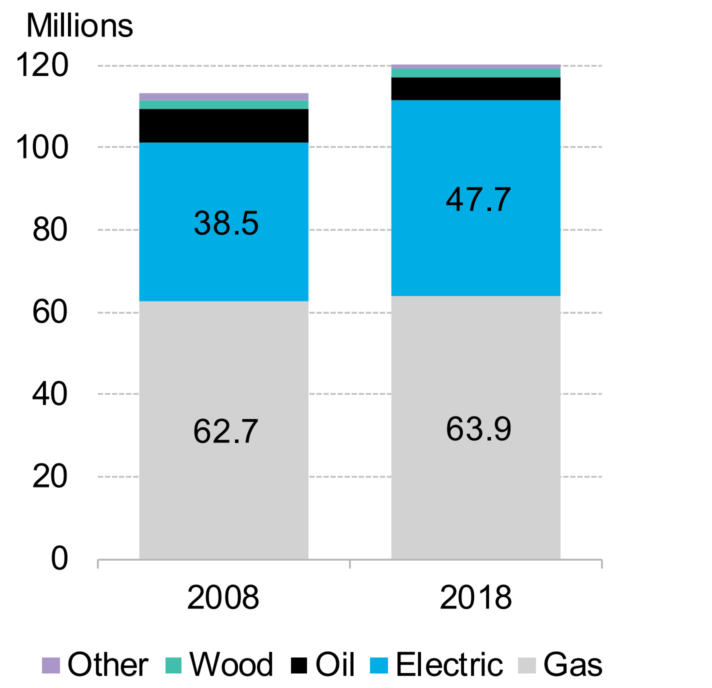
BloombergNEF

Deployment: Heating demand for natural gas

Percent change in households using natural gas for heating, 2008-2018



Primary heating source by household

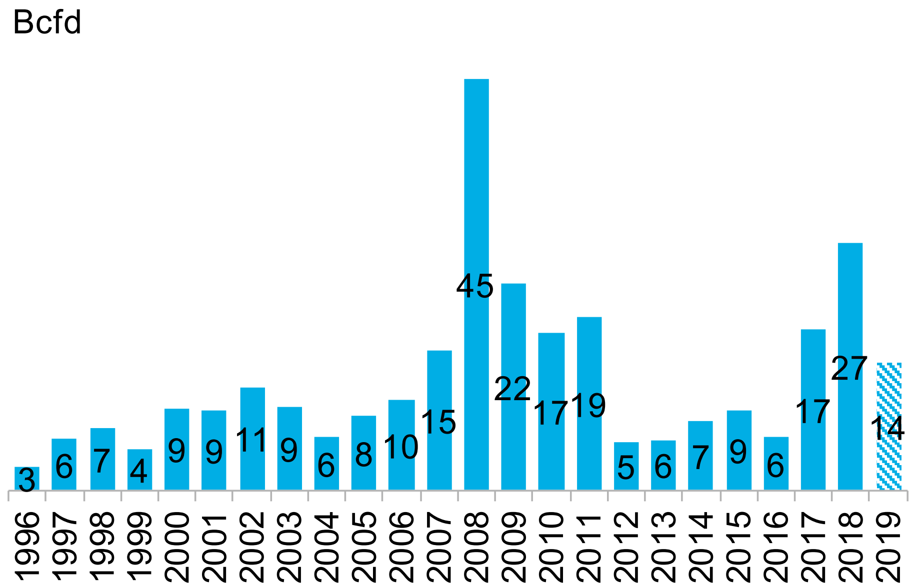


- Natural gas is the largest heating source in the residential sector, with 63.9 million homes heated by utility natural gas or propane. That is equivalent to 52% of U.S. households. The second largest heating source, electricity, accounts for 39% of households.
- In absolute terms nationwide, the total number of households using natural gas for heating has risen by 2% since 2008.
- However, changes have varied substantially by region. On a percentage basis, usage grew swiftly in the New England states as the share of consumers burning more costly home heating oil dropped by double digits in many states. However, gas usage declined in other regions of the country, where electric heating gained popularity.

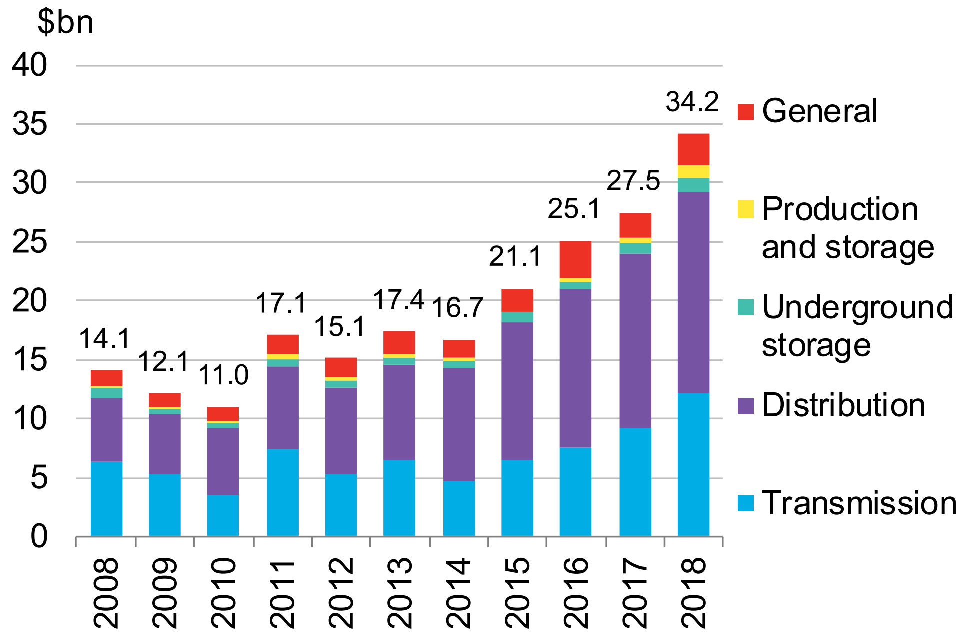
Source: BloombergNEF, US Census Bureau

Deployment: U.S. midstream infrastructure capacity and investment

U.S. transmission pipeline capacity additions



U.S. gas utility construction expenditures

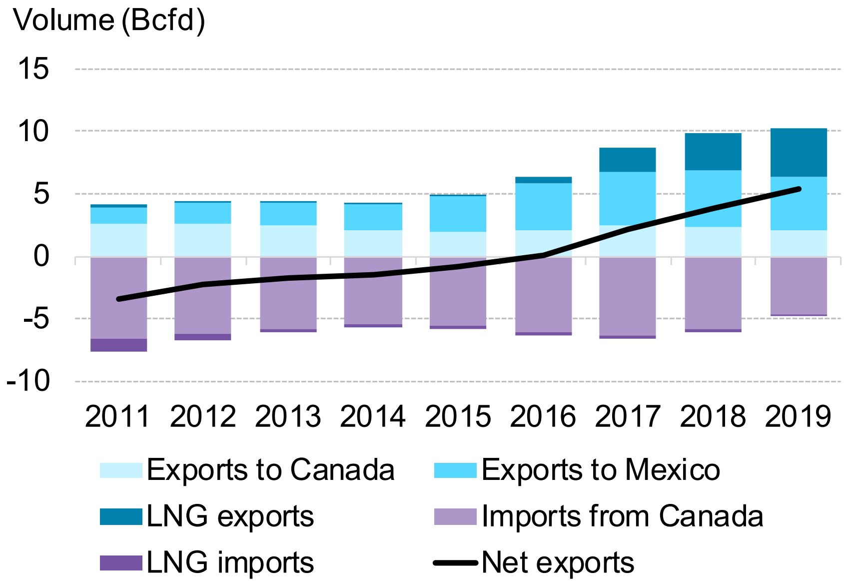


- Completion delays at the end of 2018 resulted in a lower-than-expected total capacity additions in 2019. Growth in the lower 48 states pipeline network slowed in 2019. Only two new pipelines came online: Kinder Morgan's 2Bcfd Gulf Coast Express, which carries gas from the Permian to south Texas, and Enbridge's 2.6Bcfd Valley Crossing, which feeds into an export route to Mexico.
- Midstream expenditures kept rising in 2018, reflecting the strongest level of capacity additions since 2008. Total expenditure grew by 24% in 2018, after 25% growth in 2017. However, midstream investment appetite has begun to dry up with the 2018 MLP tax reforms and unfavorable market conditions for producers.

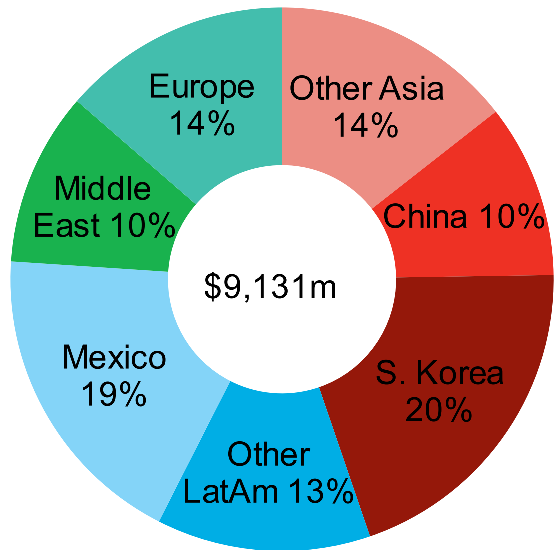
Source: BloombergNEF, American Gas Association, EIA Notes: EIA data include both first-mile takeaway capacity and pipeline additions that do not impact takeaway capacity. 2019 transmission capacity is a BloombergNEF estimate. Expenditure values reflect figures reported to the AGA by companies across the supply chain, including transmission companies, investor-owned local distribution companies, and municipal gas utilities. "General'" includes miscellaneous expenditures such as construction of administrative buildings. Totals may not sum due to rounding.

Deployment: U.S. natural gas exports and imports

Volume of LNG exports, 2016 – Oct 2019



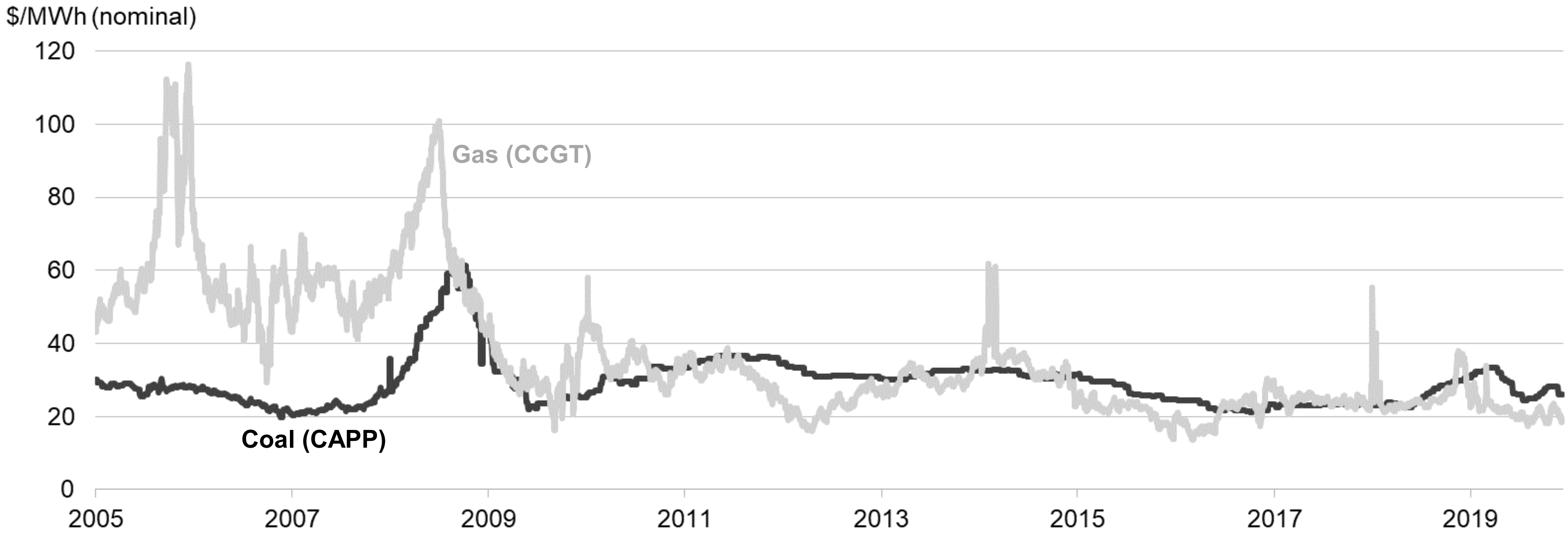
Value of LNG exports, 2016 – Oct 2019



- Both pipeline and liquefied natural gas capacity additions contributed to increase gas exports in 2019.
- LNG exports grew by an annual average 1.6Bcfd thanks to the commissioning of the Cameron and Freeport LNG terminals (train 1 and 2 for each), as well as the completion of train 2 at the Corpus Christi terminal in South Texas.
- South Texas is also the exit point for the newest Mexico-bound export pipeline that came online in 2019. The 2.6Bcfd Sur-de-Texas pipeline can currently only flow 800MMcfd because of the lack of interconnecting capacity in the Southeast Mexican market. As intra-Mexico pipeline and power plant projects get completed in 2020, exports should increase out of Sur-de-Texas and other recent capacity originating in West Texas.
- South Korea is the single largest destination of U.S. LNG exports by value, representing 20% or $1.83bn of revenues. This contributes to Asia remaining by far the largest regional market for U.S. LNG, making up 44% of total export value from the start of 2016 through October 2019.

Source: Bloomberg Terminal, EIA, Department of Energy. Notes: Data through October 2019; dollar values represent the price at export point, times the value exported.

Economics: Generating electricity from natural gas vs. coal in the U.S.

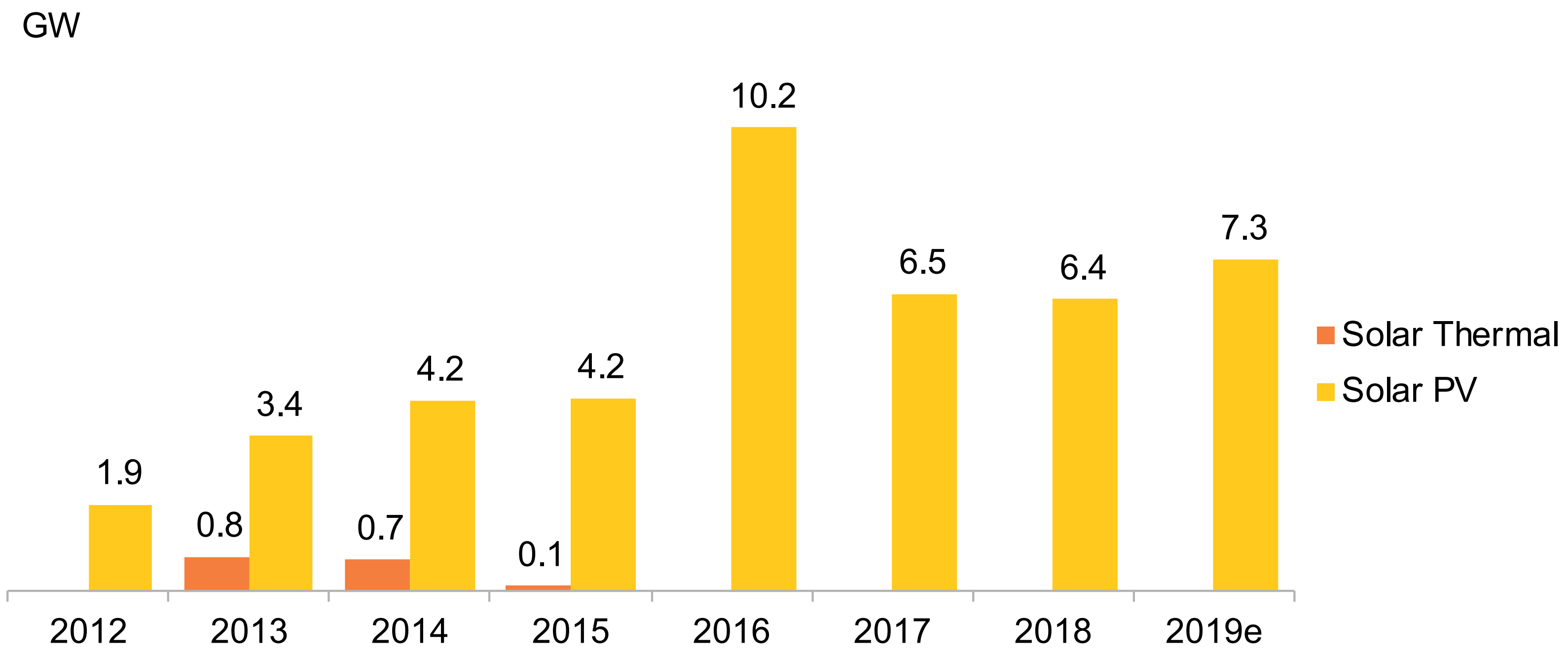


- In the U.S., power is the primary source of gas demand price elasticity. When the price of gas falls below that of coal, gas burn rises until the price differential (in $/MWh) between the two fuels closes.
- The 2019 increase in natural gas demand was due to both structural and market changes. Coal-burning capacity was reduced by 12GW in 2019, while 8.2GW of new natural gas-fired capacity was added. About 3.8GW of un-economic gas-fired generation was retired, but the impact on gas demand was minimal due to low capacity factors.
- Gas prices had to realize cheaper than equivalent coal prices during most of 2019 in to order increase demand and slow the pace of injection refills.

Source: BloombergNEF Notes: Assumes heat rates of 7,410Btu/kWh for CCGT and 10,360Btu/kWh for coal (both are fleet-wide generation-weighted medians); variable O&M of $3.15/MWh for CCGT and $4.25/MWh for coal. Gas price used is Henry Hub. CCGT stands for a combined-cycle gas turbine. CAPP represents Appalachian coal prices.

Table of Contents

Deployment: U.S. large-scale solar build

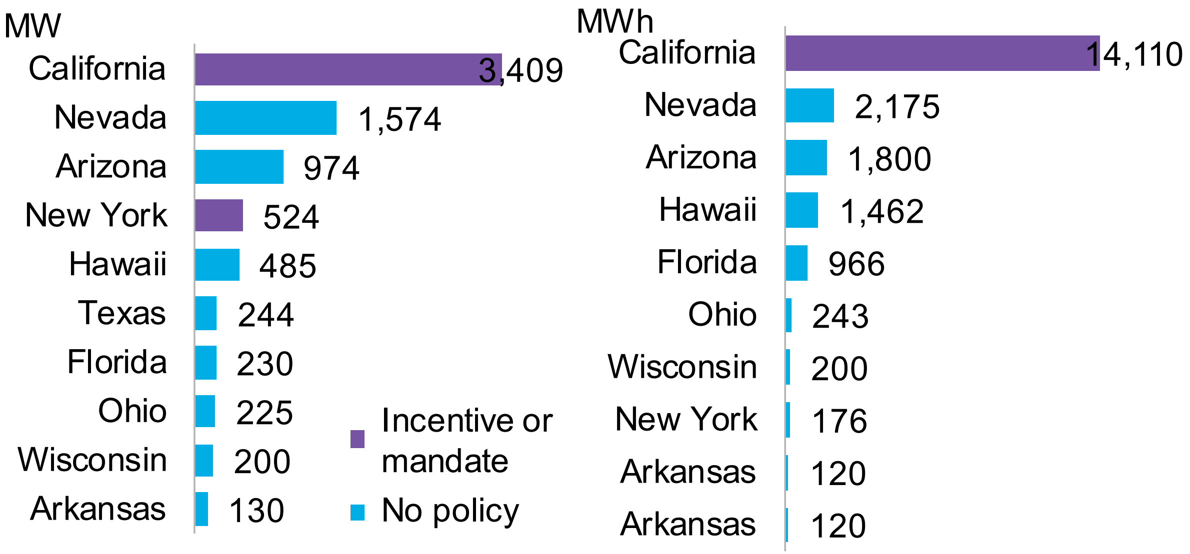


- Utility-scale installations in 2019 are expected to exceed 2018 by 14%, at an estimated 7.3GWdc. The new build was entirely represented by photovoltaics (PV). No solar thermal facilities were commissioned in the U.S. in 2019, and none has been announced. Developers and financiers continue to focus their attention on PV.
- Following two years of slowdown after a commissioning rush in 2016, commissioning activity has started to pick up again, incentivized by the federal Investment Tax Credit. Projects that meet the ITC's safe-harbor criteria in 2019 through one of two *commence-construction* clauses can obtain the tax credit at its highest level, 30%, until 2023.
- 2019 was marked by vacillation on whether bifacial panels are exempt from Section 201 import tariffs. At the time of writing, bifacial panels are exempt pending the outcome of a review by the U.S. government. They thus undercut conventional monofacial panels that are tariffed upon entering the country. Given their cost advantages, this new module technology is getting increased interest from developers.

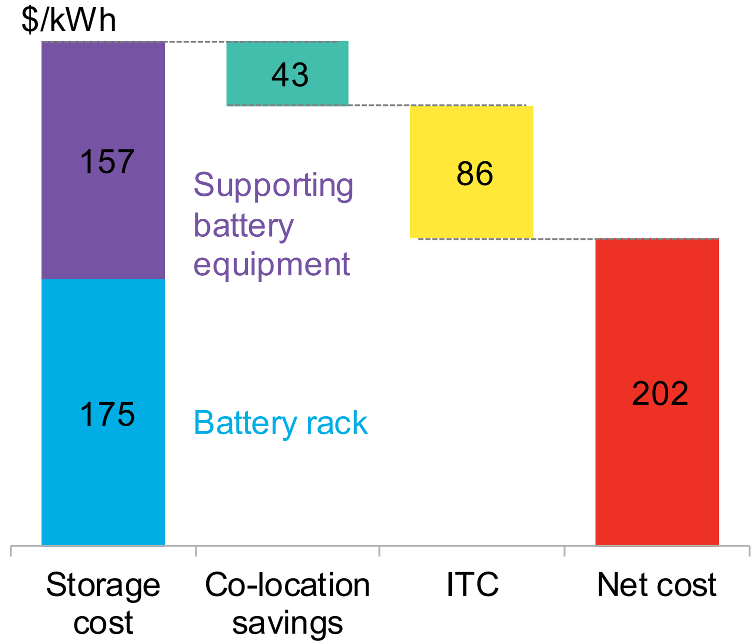
Source: BloombergNEF. Note: All solar capacity in the Factbook portrayed in GWdc.

Deployment: Solar + storage

Co-located solar and storage projects commissioned, by state



Cost advantage to co-locating storage with solar

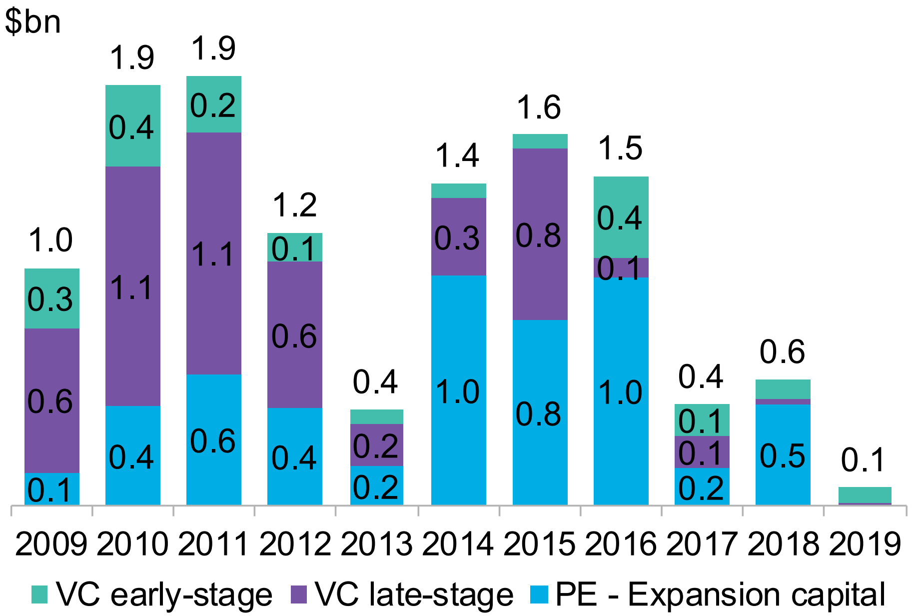


- With 8.3GW solar and 6GW/21.6Wh of paired storage announced through the end of 2019, co-located photovoltaics and storage (PVS) is steadily becoming a part of mainstream U.S. solar. It is common practice for solar developers to offer both PVS as well as PV projects in competitive solicitations. Contract structures vary widely, with little standardization among them.
- Hawaii, California, and states in the Southwest lead the nation in planned projects. These states host nearly 75% of the country's disclosed PV+S. These regions share a rich solar resource that makes PVS economics favorable. Procurement activity favors PVS projects; for example, NV Energy's most recent request for proposals prioritizes dispatchability.
- While the cost of battery storage systems has fallen, tax credits continue to play a major role in lowering the cost to build these assets. In the absence of a stand-alone tax credit for storage, batteries attached to solar are able to claim credits worth 30% of the capital expenditure provided they charge primarily with solar.

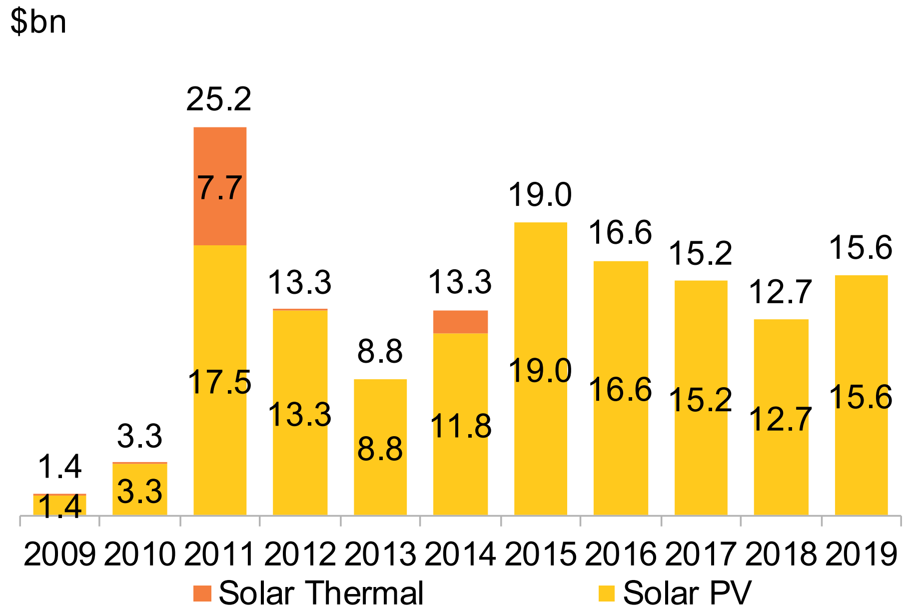
Source: BloombergNEF. Note: Storage capacity uses two metrics: MW which signifies power output (based on the inverter capacity) and the MWh which specifies the energy storage capacity and relates to the duration the input/output can be sustained for (ie, a 10MW/40MWh system can sustain 10MW for 4 hours).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

Financing: U.S. solar investment

Venture capital / private equity investment in U.S. solar by type of investment



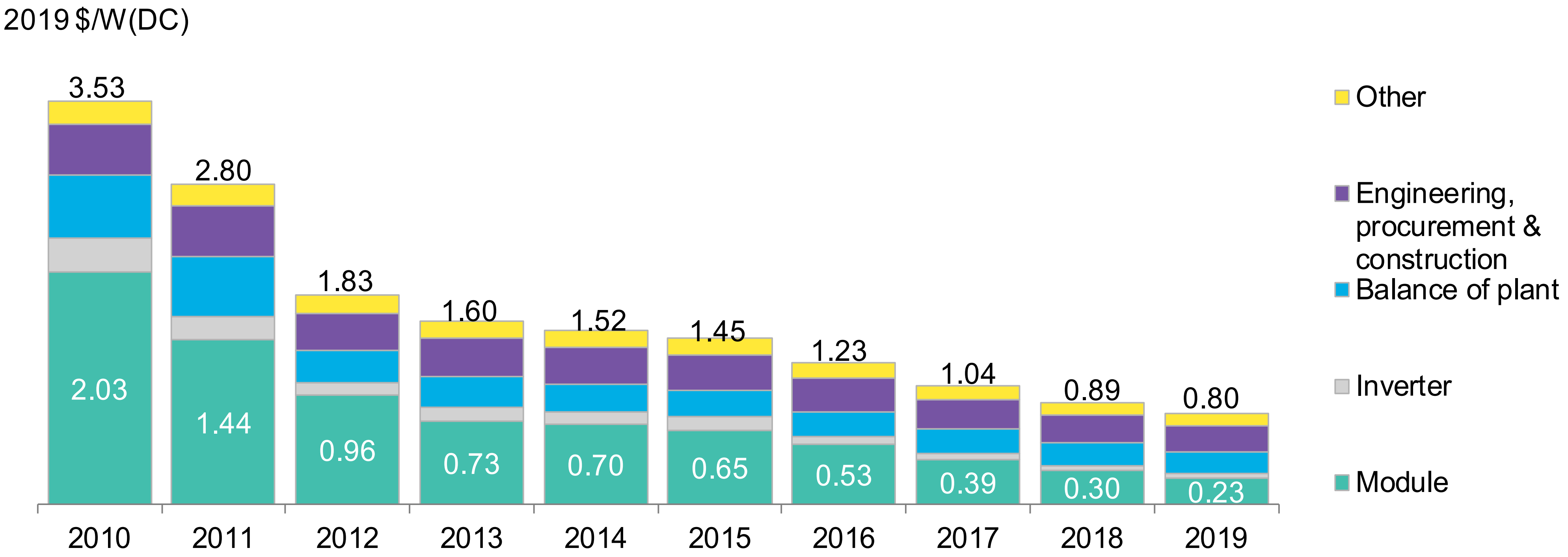
Asset finance for U.S. large-scale solar projects by technology



- Asset finance activity for U.S. solar increased to $15.6 billion in 2019. The rise supports expectations of a recovery in capacity additions in 2020, as assets are typically financed a year before commissioning. Given falling technology costs, the year's investment estimates will be able to support a larger GW figure for capacity brought online.
- Private equity and venture capital investment estimates were low in 2019 and the lowest of the last 10 years. Early stage venture capital activity remained nearly the same year on year, but few company expansions took place through late stage VC and private equity funding. Established solar developers took on more passive investors and institutional capital, anticipating a return to market growth.

Source: BloombergNEF

Economics: Global benchmark capex for utility-scale solar PV



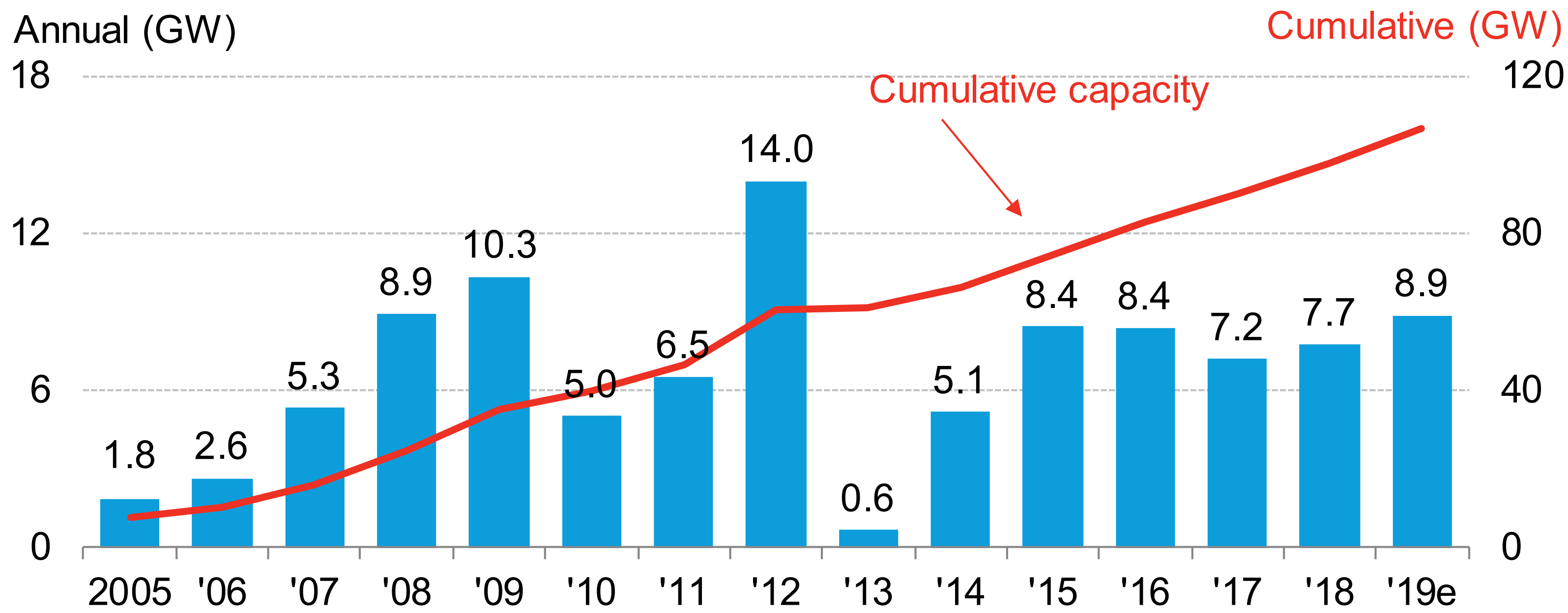
- Utility-scale solar costs continue to fall. With some regional variations, the average fixed-tilt solar project can be built for less than $1/W. Modules, typically the most expensive part of the solar project, are 11% of the cost they were in 2010.
- Efficiency gains in manufacturing and product innovations are expected to drive costs lower still. The newest manufacturing trend, bifacial solar panels, promises additional gains in output ranging from 4-9%, depending on the reflectivity of the underlying surface. Changes to module design allows them to last longer, with manufacturers offering an additional 5 years of warranty as compared to monofacial panels.

Source: BloombergNEF   Note: 'Other' refers to developer fees, land acquisition fees, finance arrangement, contingency and other miscellaneous costs. Does not include tariff costs.

Table of Contents

  BloombergNEF

Deployment: U.S. large-scale wind build

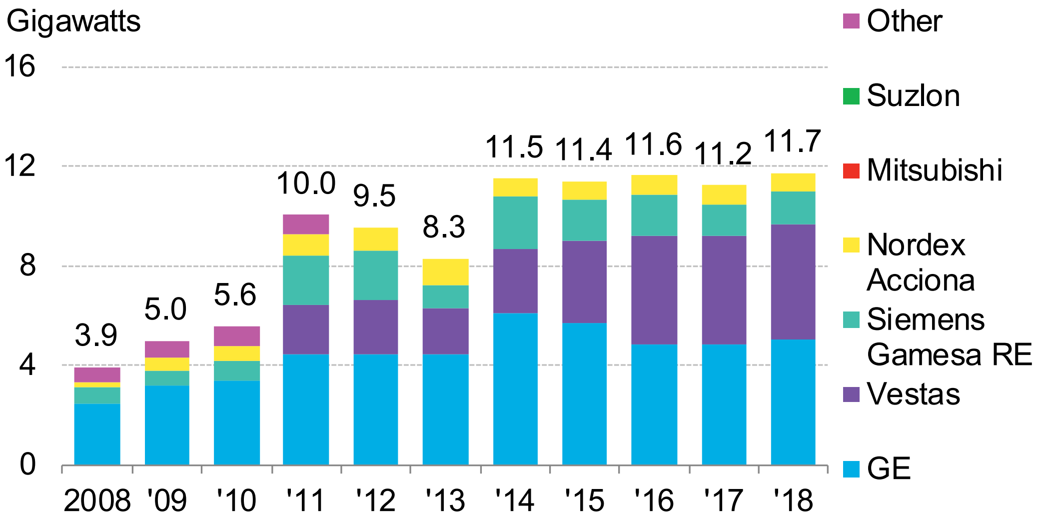


- The U.S. built nearly 9GW of new wind power-generating capacity in 2019 as cumulative installed wind topped 100GW for the first time. New build in 2019 was 16% higher than in 2018 making 2019 the biggest year for installs since 2012. In advance of the expected phase-out of the Production Tax Credit (PTC), developers rushed to build and secure "safe-harbored" equipment, which could benefit from the value of the PTC.
- On December 20, 2019, Congress extended the PTC one additional year. Previously, the PTC was on a step-down schedule whereby projects online by 2020 could receive 100% of the credit, projects online in 2021 80% of the original credit, 2022 projects 60% and 2023 projects 40%. In the wake of action by Congress, projects online in 2024 are eligible for the credit at 60% of original value of $25/MWh, or $15/MWh.
- A majority of the 2019 new wind capacity was added in Texas, Iowa, Illinois, and Kansas, thanks to high capacity factors in those states and relatively low build costs. Despite the economic viability in these states, transmission congestion remains pervasive across much of the interior U.S. In response, developers are diversifying, particularly into new states with renewables targets in the Northwest and Southwest.
- Small- and medium-scale wind turbines continue to account for less than 1% of overall wind capacity. The U.S. added 3.1MW of small and medium wind in 2018, the last year for which complete data are available.

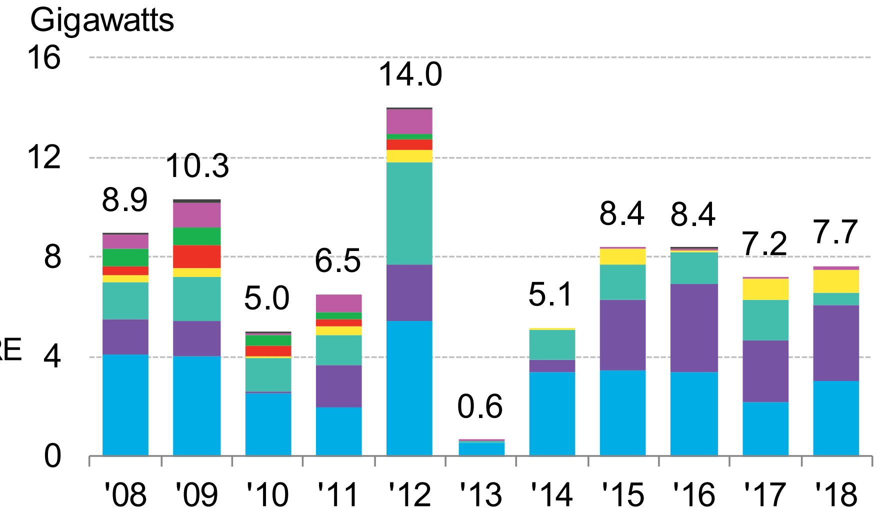
Source: BloombergNEF. Notes: Includes all utility-scale wind development, excluding partially commissioned projects and including distributed turbines that are above 1MW (BloombergNEF threshold for utility-scale).

Deployment: U.S. wind turbine production and contracting

U.S. wind turbine production capacity by manufacturer



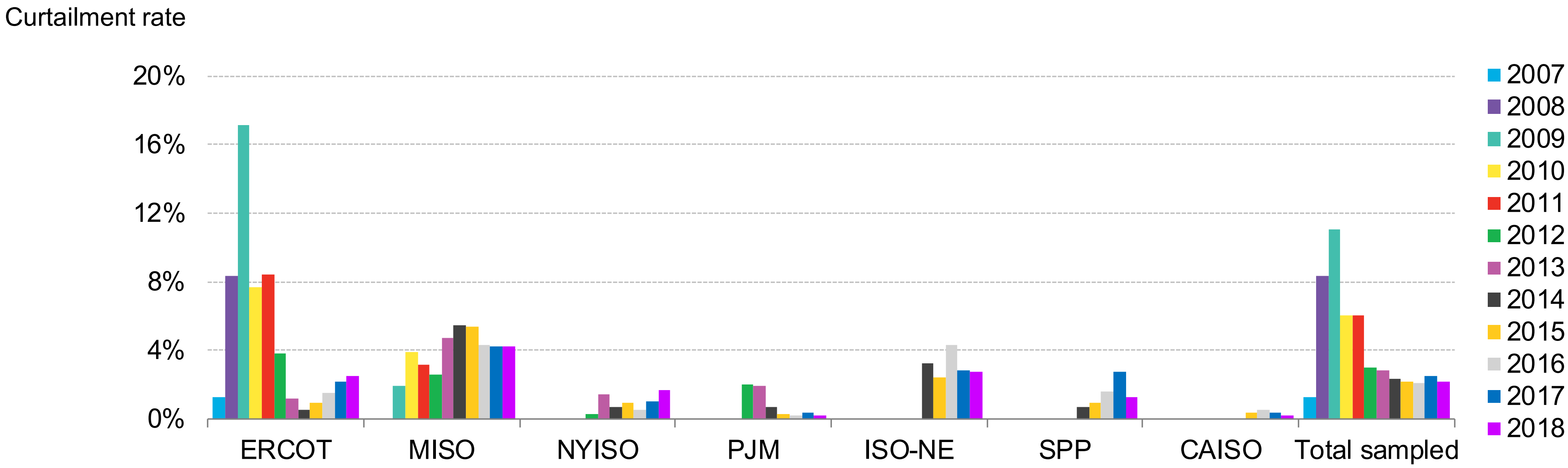
U.S. wind turbine supply contracts for projects by commissioning year, by manufacturer



- Consolidation in the U.S. wind turbine market has continued in recent years following global trends. The U.S. is now home to four major turbine manufacturers: Vestas, General Electric (GE), Siemens Gamesa Renewable Energy (SGRE), and Nordex Acciona. In the U.S., GE and Vestas accounted for 82% of local manufacturing capacity in 2018, the last year for which BNEF has complete data.
- Market share of installed turbines follows a similar trend to manufacturing. In 2018, Vestas supplied turbines for 3.05GW of the total 7.7GW commissioned, effectively tying with GE who supplied 3GW of the market. Collectively, the two companies accounted for 79% of the market. Nordex Acciona maintained its 2017 levels, installing 866MW, while SGRE installed 535MW, and boosted its market share from 2017 levels. Goldwind, a Chinese supplier, broke back into the U.S. market after a two year hiatus, installing 200MW.
- GE was the top wind turbine maker for U.S. project installations from 2003-2015, but was displaced by Vestas in 2016 and again in 2017. The U.S. has been an important market for GE historically: almost two-thirds of GE's all-time installations by capacity have been in the U.S., compared to a quarter for Vestas. Over the past four years, the two companies have supplied nearly identical volumes.

Source: BloombergNEF. Notes: Production capacity measured by nacelle assembly on U.S. soil.

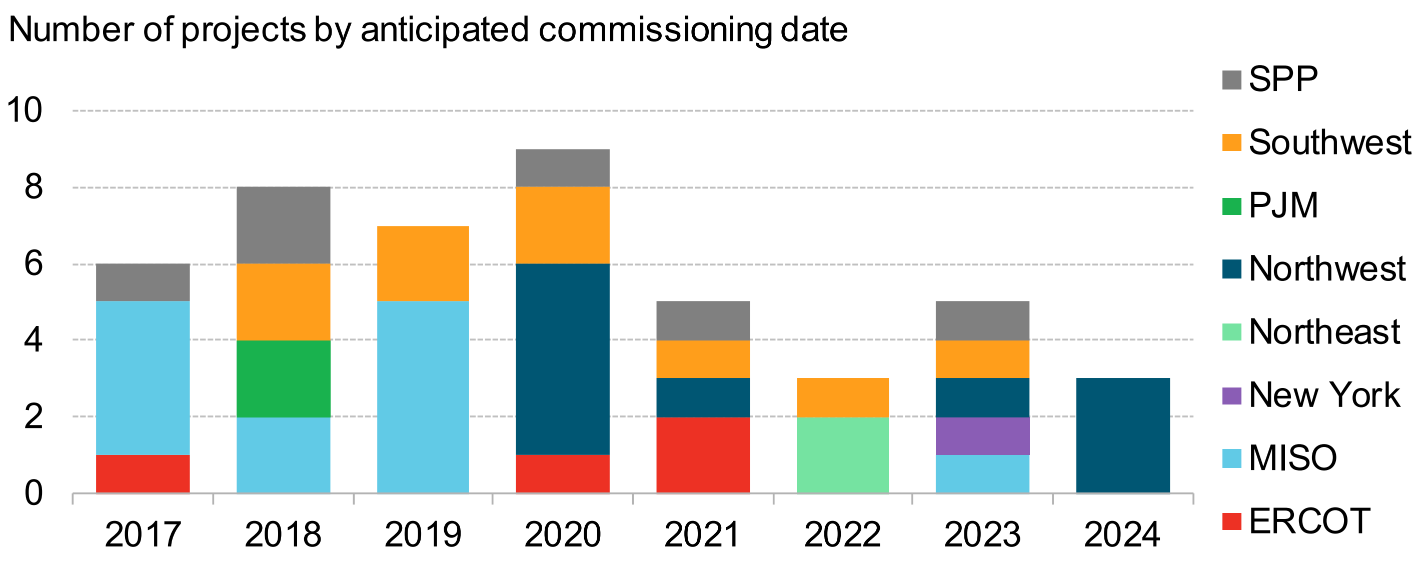
Deployment: U.S. wind curtailment



- Curtailment can occur due to transmission constraints, inflexibilities in the grid and environmental or generation restrictions. Overall, U.S. curtailment rates have declined by about 80% since 2009 thanks to transmission build outs. Time-varying influences have also played a role: in 2015, for example, the western and interior U.S. experienced below-normal wind speeds, reducing generation – and curtailment.
- Curtailment was a significant problem in ERCOT (Texas) from 2008-2013, but the build-out and upgrade of the Competitive Renewable Energy Zone (CREZ) transmission lines and the efficiency of the wholesale electricity market have reduced concerns more recently. ERCOT curtailment fell to only 0.5% in 2014, down from a peak of 17% in 2009. However, it has slowly been rising since 2015 as build continues, with about 2.5% curtailment observed in 2018.
- Over the past five years, PJM experienced the lowest curtailment of any independent system operator, at 0.2%, while MISO curtailment has topped 4%, the highest of all regions examined. Still, MISO wind curtailment dropped 27% from 2015 to 2017, as transmission build began to alleviate congestion. Most of MISO's Multi-Value transmission Projects (MVP) should be online by 2019, which should rein in grid congestion.
- SPP's curtailment more than halved between 2017 and 2018, to just 1.3%. This is likely the result of three 345kV AC lines installed in 2017-18.

Source: BloombergNEF, Department of Energy. Note: All curtailment percentages shown in the figure represent both forced and economic curtailment. PJM's 2012 curtailment estimate is for June through December only. Department of Energy sourced data from ERCOT, MISO, CAISO, NYISO, PJM, ISO-NE, SPP.

Deployment: Commissioned and planned transmission lines serving wind

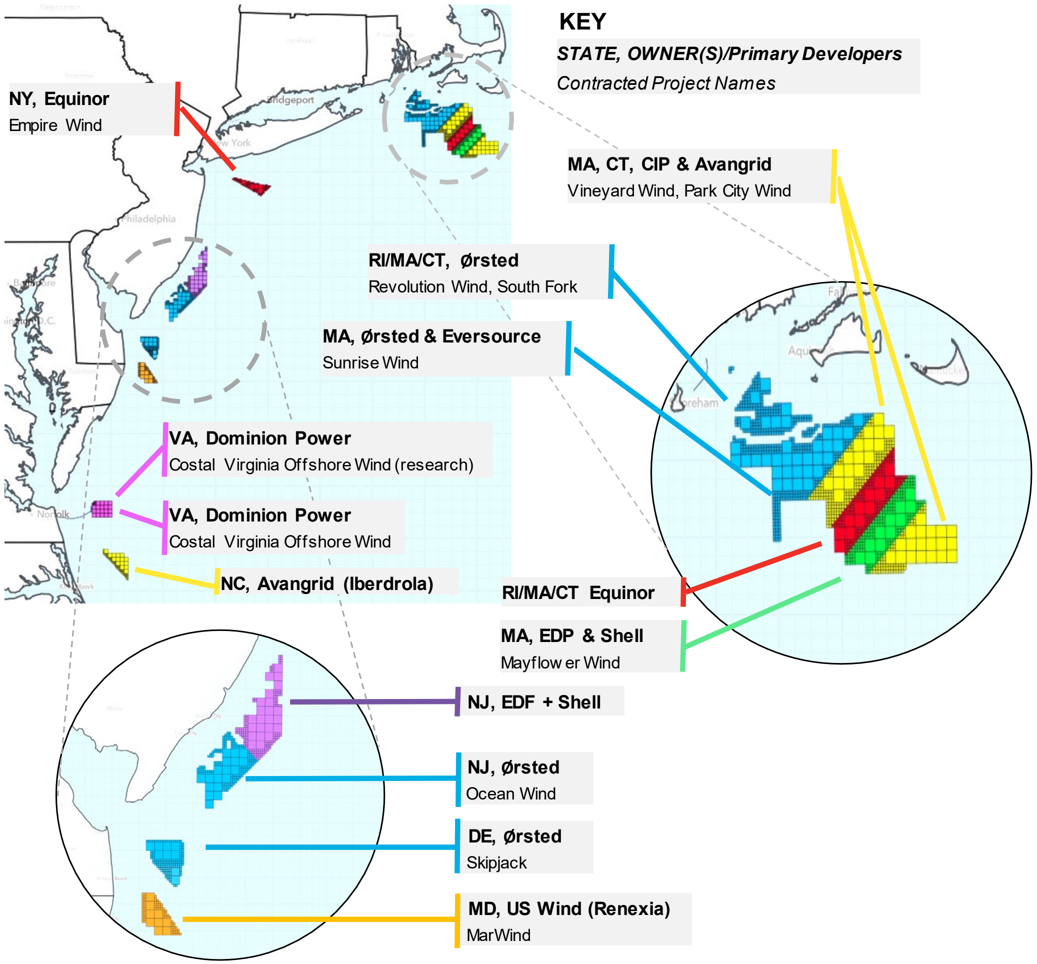


- Wind tends to be one of the first sources to be curtailed when transmission congestion occurs, and congestion tends to rise as more generation assets are added to the grid without accompanying transmission upgrades.
- New transmission can maximize the value of low-cost, emissions-free wind energy. The American Wind Energy Association (AWEA) estimates that transmission proposals across the U.S. could enable tens of thousands of megawatts of new wind capacity between 2017 and 2024.
- From 2017-2019, MISO led the way for most new projects installed, bringing online transmission projects across Iowa, Minnesota, Illinois, and North and South Dakota. There are several projects in development in the Northwest and Southwest. Many of these aim to bring more wind energy to California to help the state meet its renewable energy targets.
- There are plans for lines in several other regions in coming years, including for three in Texas (ERCOT) and one in New York. Many of the proposed transmission projects have yet to begin construction, and projects may be delayed or canceled. Generally, transmission built within a specific state or region receives full approval faster than those lines that cross multiple jurisdictions. The TransWest Express, which is scheduled to come online in 2022 in the Northwest to connect Wyoming wind to customers in California, Arizona and Nevada, was first proposed in 2005. If successful, however, this project will enable more than 2GW of new wind projects to come online in Wyoming.

Source: BloombergNEF, AWEA Note: two projects, Ledyard-Colby line in Iowa, and MVP 7 line through IA and MO don't yet have in service dates set and are not included. Graph includes lines with voltages 320kV-765kV, and includes both AC and HVDC.

Offshore wind: Delayed but with high potential

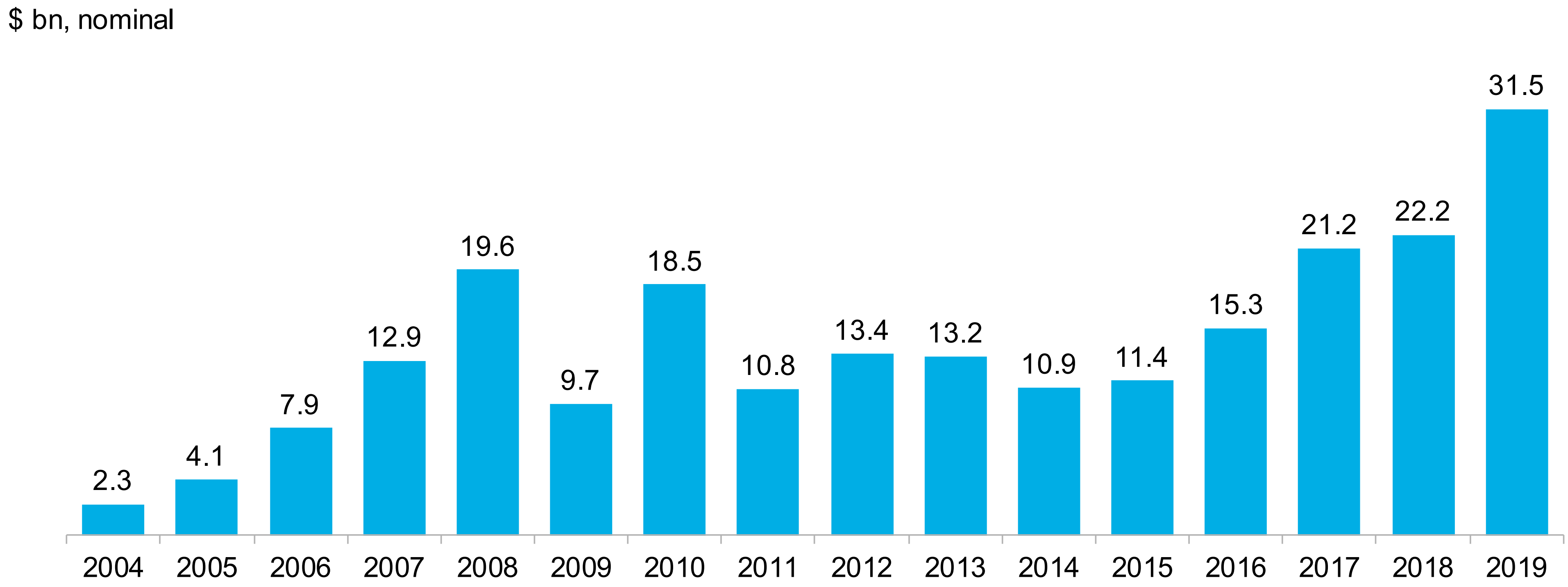
Location and owners of U.S. offshore wind leases issued by BOEM



- The U.S. offshore wind sector spent 2019 poised for rapid growth but ended the year somewhat in limbo as the country's first potential large-scale project awaited a federal permit.
- The Bureau of Ocean Energy Management (BOEM) is charged with issuing leases for commercial-scale projects three or more miles from shore. To date, BOEM has issued 14 leases for sites off Massachusetts, Delaware, Maryland, New Jersey, New York, North Carolina and Virginia. The agency is expected to identify more lease areas off the coast of New York state in 2020.
- Northeastern states have between them approved measures targeting 25.4GW offshore by 2035.
- Vineyard Wind, which stands to become the first large-scale project in U.S. waters experienced permitting delays in late 2019. The 804MW project, a joint venture between Avangrid and Copenhagen Infrastructure Partners, was originally scheduled for commissioning in 2021. Now, BOEM plans to make a decision on its final construction permits in early Spring 2020. If delayed much further, the project could lose qualification for the federal Investment Tax Credit (ITC), which allowed it to submit a winning bid in Massachusetts' first offshore auction.
- In December 2019, Congress extended the ITC for wind by one year at 60% of the credit's original value. This could provide some relief for Vineyard Wind and allow an extra cushion for other developers targeting commissioning before 2025.

Source: BloombergNEF, Bloomberg, CARTO, Mapbox, OpenStreetMap, BOEM. Notes: This map was created using MAPS <GO> on the Bloomberg Terminal. The shape file of U.S. offshore wind zones can be found on BOEMs website (link).

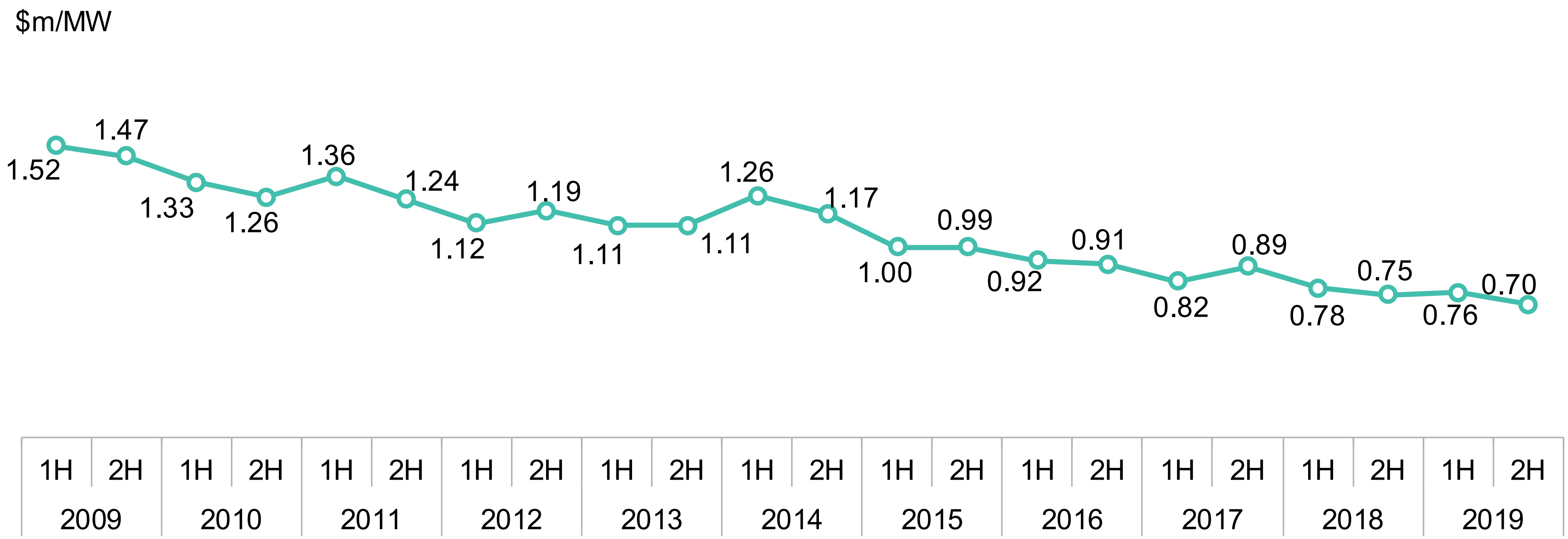
Financing: Asset finance for U.S. large-scale wind projects



- The $22.2 billion worth of wind projects financed in 2018 and the $31.5 billion financed in 2019 indicate that the U.S. has a very strong 2020 and 2021 new-build pipeline. Both are anticipated to be record-breaking years.
- Asset financing has tracked closely with the status of the Production Tax Credit (PTC), which has expired and been retroactively extended multiple times since 2012. The final chance to receive the full value of the PTC was for projects financed and under construction in 2016. Such projects now need to be online by year-end 2020, hence the large financing figure in 2019. Projects that started construction later will receive a phased-down credit, and projects that start after 2020 (online after 2024) will receive no federal support.

Source: BloombergNEF   Notes: Values include estimates for undisclosed deals. 2015 figure includes $323m directed towards an offshore wind project, the Deepwater Block Island Offshore Wind Farm.

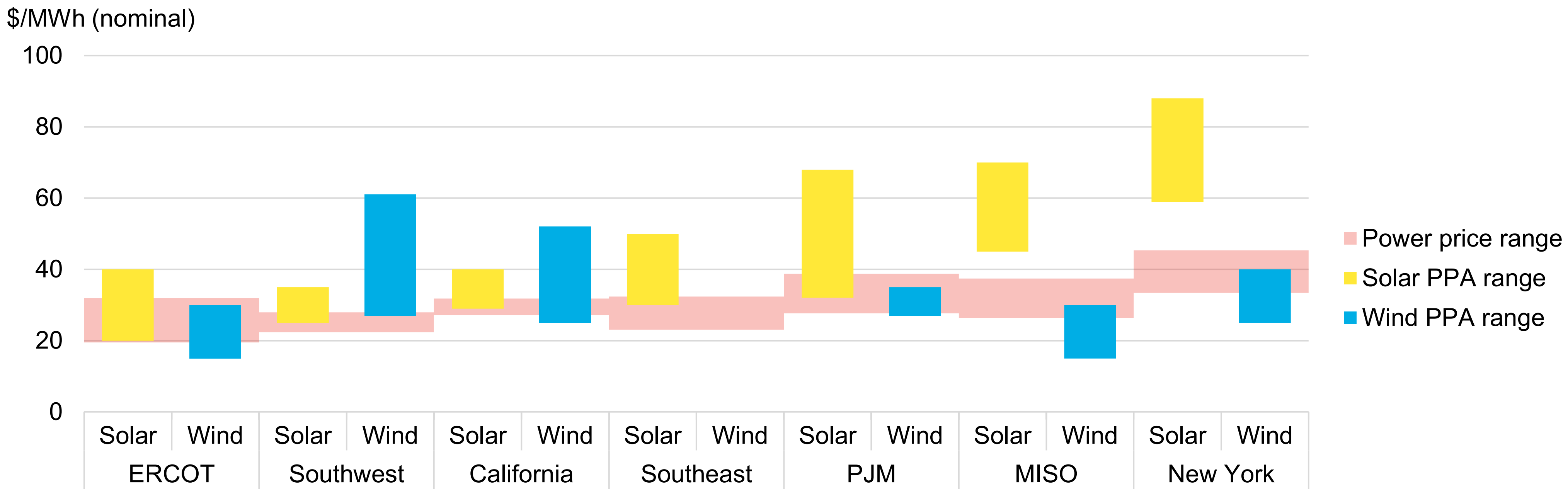
Economics: Global wind turbine price index by signing date



- Since 2009, global turbine prices have fallen 58% to $0.70 million/MW. In 2019, Turbine makers reported sector-wide price stabilization on a per-turbine basis.
- The price for U.S. wind turbine contracts signed in 2019 tracked with the global average price, at $700,000 per megawatt. Historically, North American prices have tended to fall below the global average. However a series of tariffs imposed in the U.S.-China trade war have removed this discount. The tariffs, which hit gearboxes, blades, and, to a lesser extent turbine towers, were estimated to increase prices by 5-10%.
- Despite tariff uncertainties, contract prices for turbines signed in 2019 dropped by about 10% from 2018 levels. As turbines get taller, capacity factors improve, which contributes to lower levelized costs for U.S. wind as well.
- Even as prices per turbine stabilize, the capacity of individual turbines is increasing, meaning that prices per-megawatt will continue to drop.

Source: BloombergNEF   Notes: Values based on BloombergNEF's Global Wind Turbine Price Index. Values from the Index have been converted from EUR to USD on contract execution date and are nominal.

Economics: U.S. wind PPA prices compared to wholesale power prices

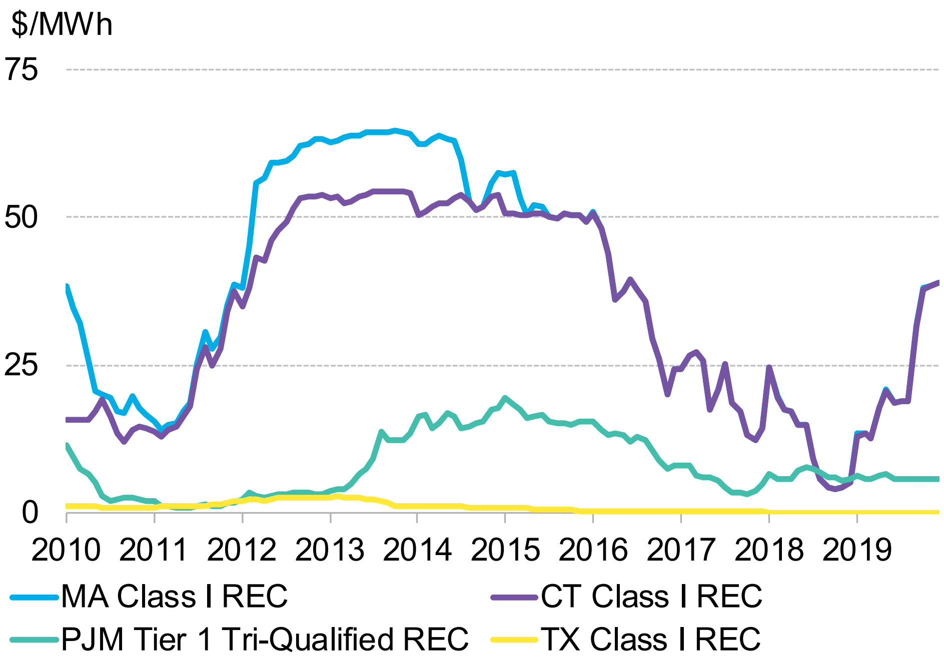


- Prices for wind power purchase agreements (PPAs) have fallen dramatically as levelized costs declined. According to interviews with project developers, projects secured offtake agreements in the mid-teens in the middle U.S. in 2018 (the last year for which complete data are available). For comparison, data reported to the Federal Energy Regulatory Commission indicate that offtake prices for contracts signed in 2011 averaged $47/MWh.
- The top regions for utility PPAs are high wind-speed regions with low development costs like SPP, MISO and ERCOT. Conversely, developing projects in New England can be costly and time consuming, and average project capacity factors are typically among the lowest in the country.
- A significant number of wind projects commissioned in 2016 – representing 1.6GW of capacity – secured corporate PPAs. The popularity of corporate PPAs has only grown in recent years and a record volume of such contracts was once again signed in 2019.

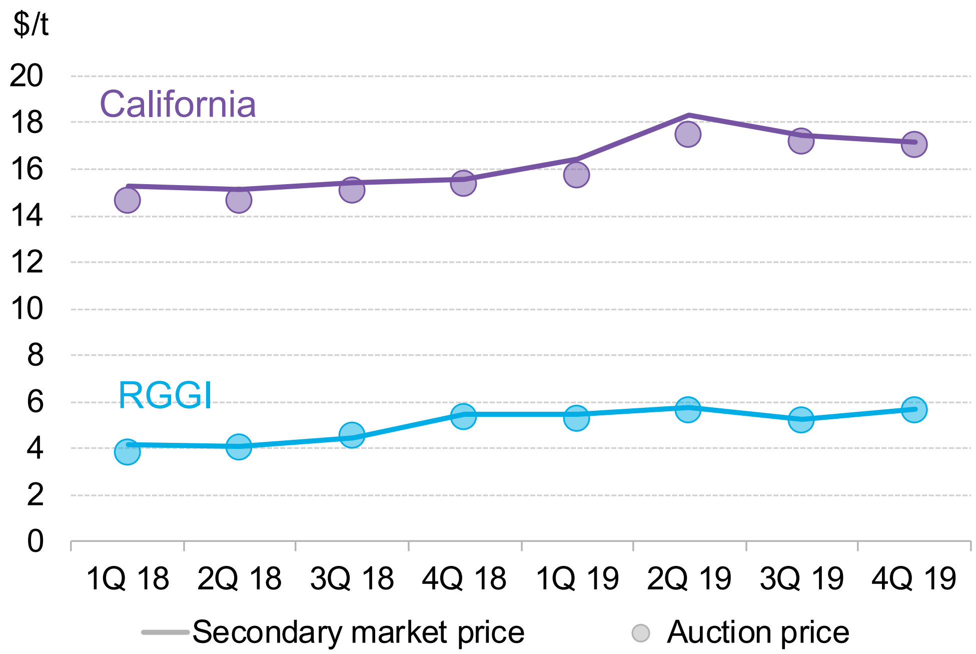
Source: BloombergNEF, SEC filings, interviews, analyst estimates Notes: MISO is the Midwest region; PJM is the Mid-Atlantic region; SPP is the Southwest Power Pool which covers the central southern U.S.; NEPOOL is the New England region; ERCOT covers most of Texas. Wholesale power prices are based on market-traded futures for calendar year 2018 for select nodes within the region.

Economics: U.S. environmental markets

Class I REC prices in select U.S. markets



U.S. carbon allowance auction prices



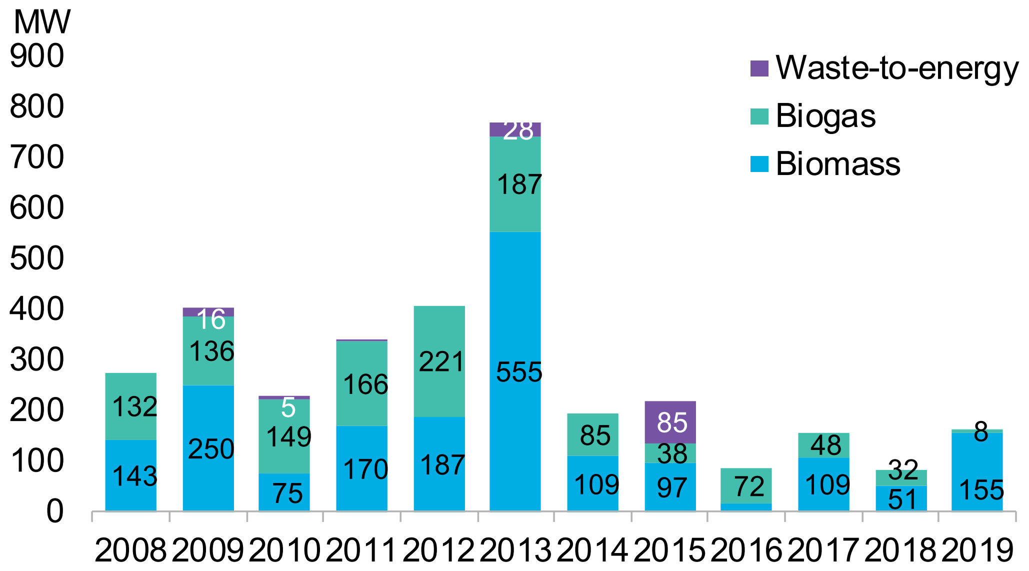
- In states with Renewable Portfolio Standards (RPS), eligible renewable generators receive Renewable Energy Credits (RECs) for each megawatt-hour of electricity they supply to the grid. REC prices typically rise when policy-makers raise overall goals for clean energy generation, increasing demand for credits. The U.S. also has two carbon cap-and-trade markets. In participating states, emission allowances are won by bidding entities in auctions held each quarter. Those allowances can then be traded in the secondary markets between auctions.
- From 2018 into 2019, major RPS markets have been bolstered as clean energy targets have risen. At the end of 2019, Connecticut Governor Ned Lamont mandated a 100% carbon-free grid by 2040 for his state. This raised demand for CT and MA Class I RECs and their prices rose.
- Carbon markets have seen little movement as they remain oversupplied. The auction and trade prices tend to follow the floor prices determined by auction organizers. In California, the carbon price is making the economics of the state's coal-fired power plants less tenable.

Source: BloombergNEF, Bloomberg Terminal, CARB, RGGI NOTE: RGGI is the Regional Greenhouse Gas Initiative. RGGI auction is in short tons and CCA auction is in metric tons

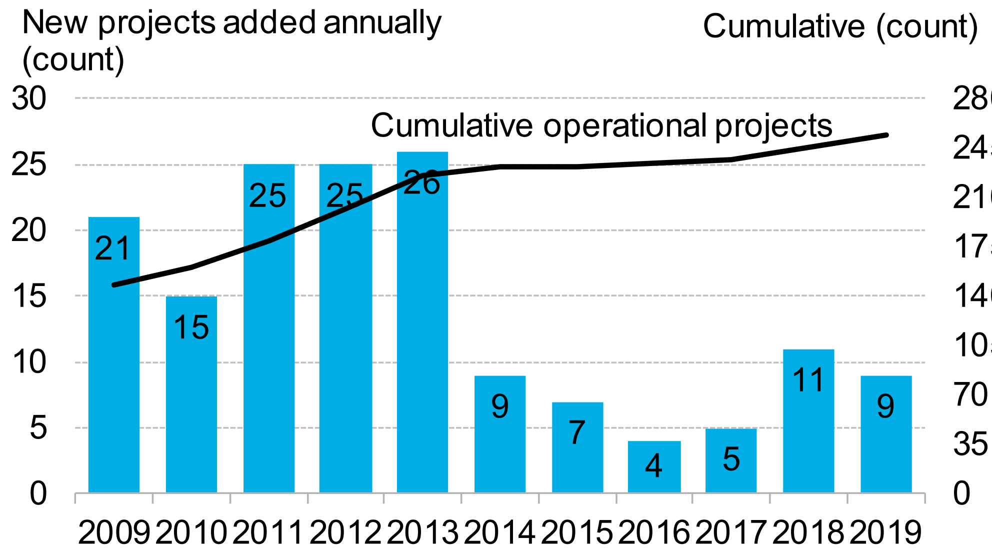
Table of Contents

Deployment: U.S. bioenergy and anaerobic digester build

Annual build: large-scale bioenergy



Annual build: farm-based anaerobic digesters

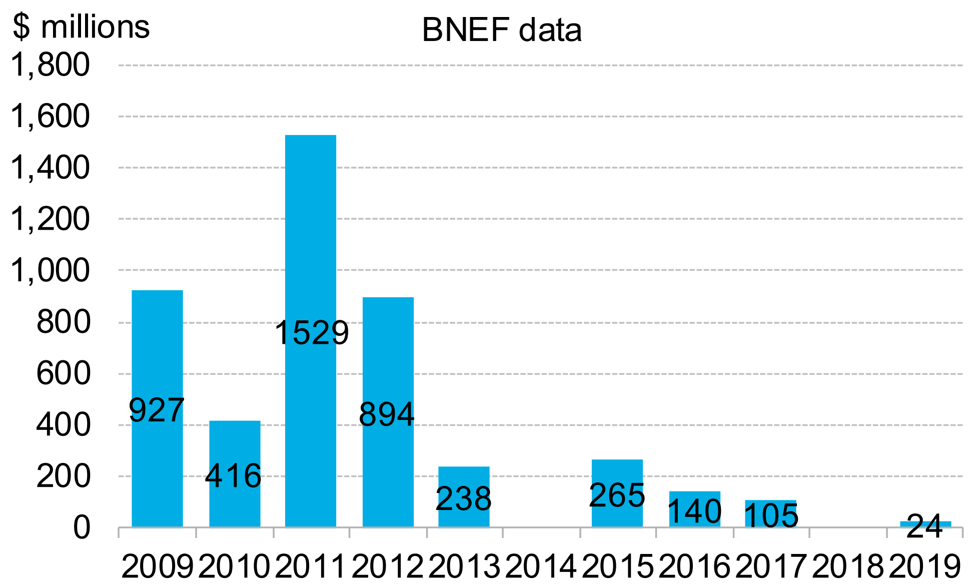


- In 2019, the U.S. installed 155MW of biomass and 8MW of biogas projects. Bioenergy build has tapered since 2013, when the Production and Investment Tax Credits, as well as the 1603 Treasury grant program, encouraged nearly 800MW of new installations. However, these technologies will benefit from the PTC extension that Congress approved at the end of 2019.
- Waste-to-energy technology has seen more growth in countries such as China, where 111 projects representing 1,800MW were awarded in 2019, up from 86 and 64 projects in 2017 and 2018, respectively. In all, 3,700MW of waste-to-energy projects is expected online in China 2018-2020. The U.K. also has provided important policy support to waste-to-energy. There are now 49 operational plants in the U.K., 12 under construction, 11 in advanced development and another 17 possibly on the way.
- Nine new anaerobic digesters were added in 2019 in the U.S. On average, since 2014, seven new systems have been built annually. The total count of operational projects (accounting for retirements) has increased 9% since 2014. In addition, there were nearly 775 operational landfill gas plants, 66 food scrap digester systems and 1,269 wastewater digester systems in 2019, not shown in the graphs above.

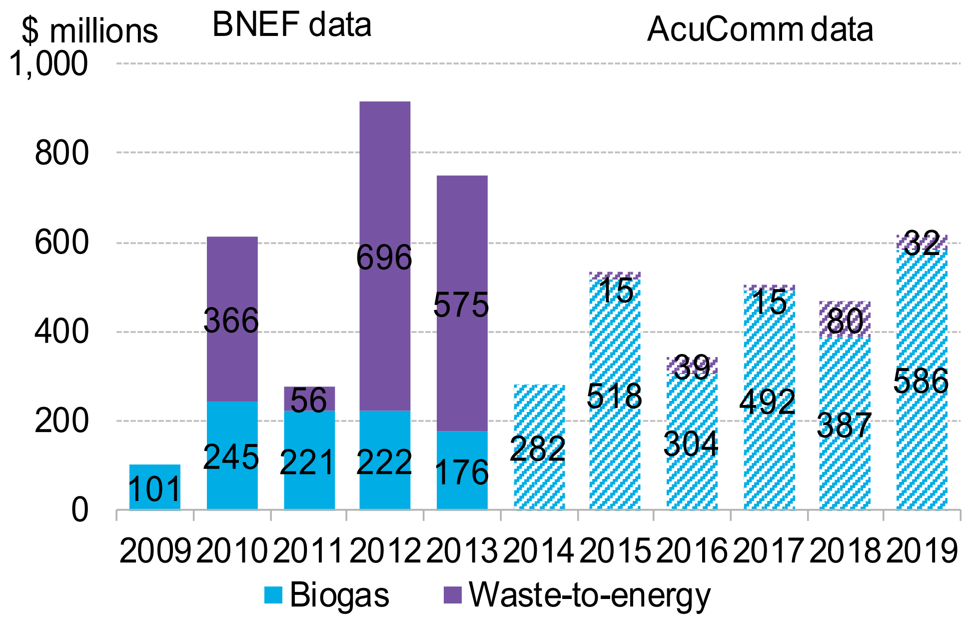
Source: BloombergNEF, EIA, company announcements, EPA, WEF Notes: Biomass includes black liquor. Biogas includes anaerobic digestion (projects 1MW and above except wastewater treatment facilities). The graph on the right reflects anaerobic digesters on livestock farms in the U.S. and is sourced entirely from the EPA AgSTAR database.

Financing: U.S. bioenergy asset finance

Asset finance for U.S. biomass



Asset finance for U.S. biogas, waste-to-energy

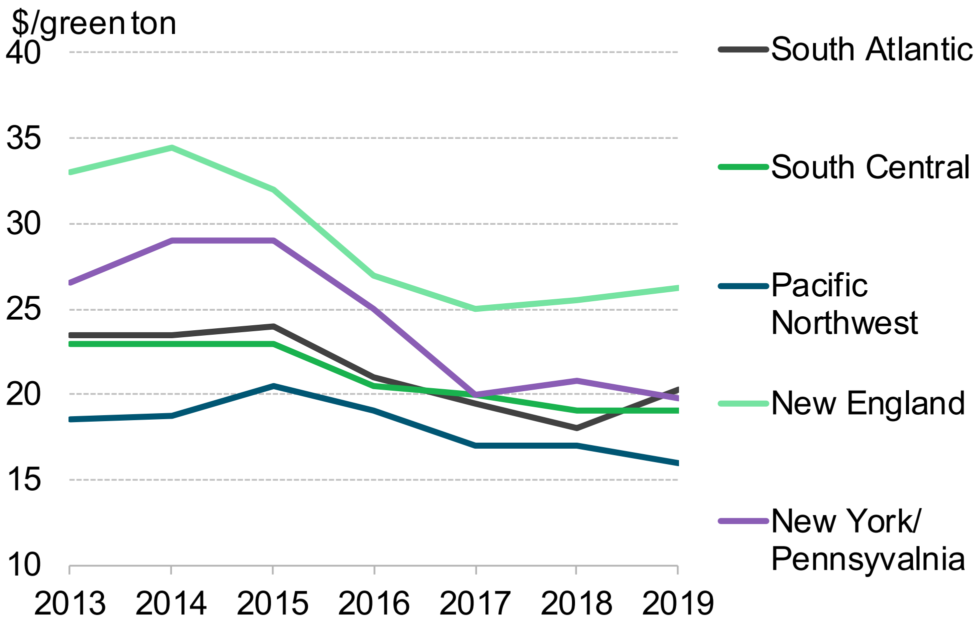


- Asset (project) finance for new biomass and biogas build continues to fluctuate, with an resurgence of biogas investment in 2017-2019. In 2019, AcuComm and BNEF tracked 15 investments into large biomass, biogas and waste-to-energy projects with a combined capacity of over 70MW and total investment value of $643 million, around double the capacity of – and 32% the investment value of – bioenergy plants financed in 2018.
- Lower investment for biomass in the past five years suggests that new build will continue to be subdued. Plants take two to four years to build and commission, so investment functions as a leading indicator for build.
- AcuComm is an alternate data provider providing coverage of select bioenergy plants throughout the U.S.

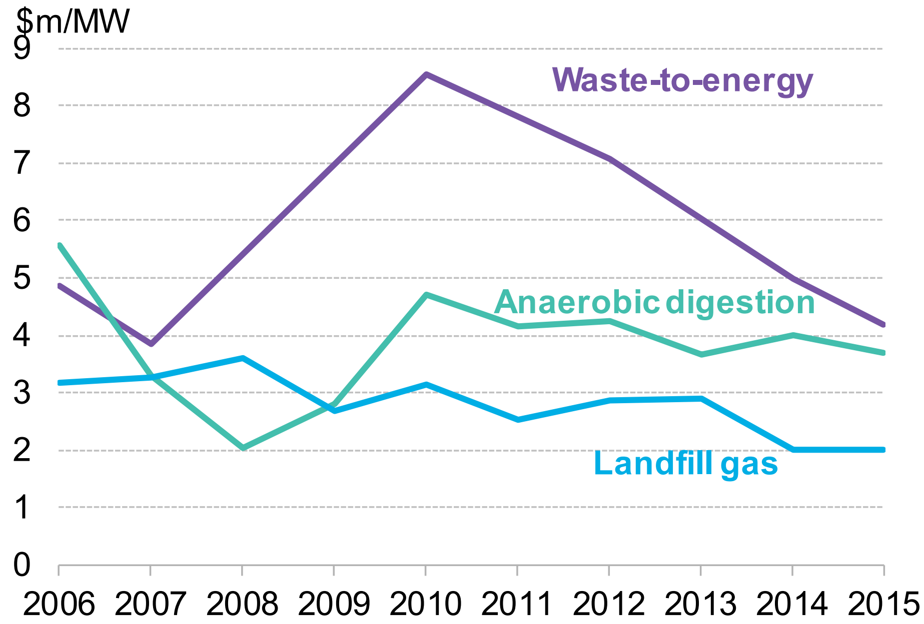
Source: BloombergNEF, EIA, company announcements, AcuComm Notes: Values are nominal and include estimates for deals with undisclosed values. Biogas includes anaerobic digestion (1MW and above, except for wastewater treatment facilities) and landfill gas.

Economics: Bioenergy feedstock prices and capex

Biomass feedstock prices in select U.S. markets, 2013-2018



Capex for biogas and waste-to-energy projects by type



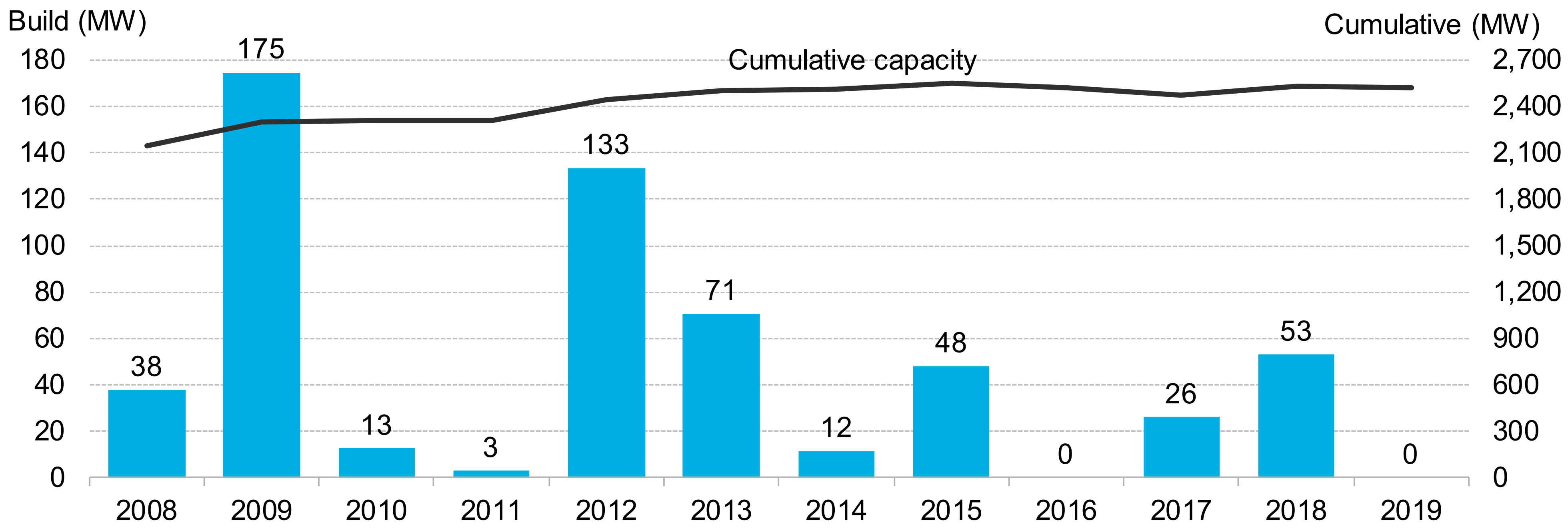
- Biomass feedstock prices rose somewhat in the South Atlantic and New England regions of the U.S. in 2019. South Central plateaued at $19/green ton. Pacific Northwest and New York prices each slipped by about 5% to $16/green ton and $20/green ton, respectively.
- The Capex associated with waste-to-energy projects fell sharply from 2010 through 2015 (the last year for which complete data are available). Anaerobic digester costs have also declined over that time but not as dramatically.
- There are very projects under development domestically using these technologies, so the annual changes in capex figures can be strongly influenced by the costs and circumstances of individual projects.

Source: BloombergNEF, FastMarkets RISI, U.S. Department of Agriculture, EIA Notes: Capex values are for projects 1MW and above. A 'green ton' is 2,000lbs of fresh cut woody material.

BloombergNEF

Table of Contents

Deployment: U.S. geothermal build



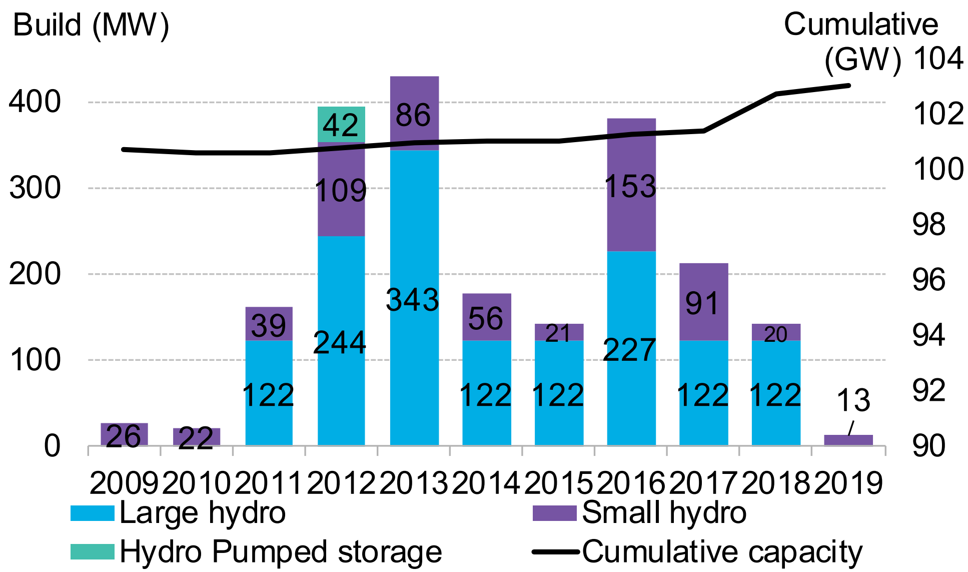
- No major U.S. geothermal plant was commissioned in 2019. Unlike other renewable resources, geothermal projects have long project completion periods of 4-7 years. In addition, the technology lacks strong policy support and faces high development costs. These factors contributed to the low build volumes.
- One geothermal plant currently sits in the EIA build queue. The 25MW summer capacity Dixie Valley Power Partnership is currently slated to come online in Nevada in 2020. The plant is owned by AES and the company intends to sell power from the project into the California market.
- The 2.9MW of the Soda Lake Geothermal project in Churchill, Nevada was retired in 2019.

Source: BloombergNEF, EIA. Note: Cumulative figure refers to summer project capacity, not nameplate.

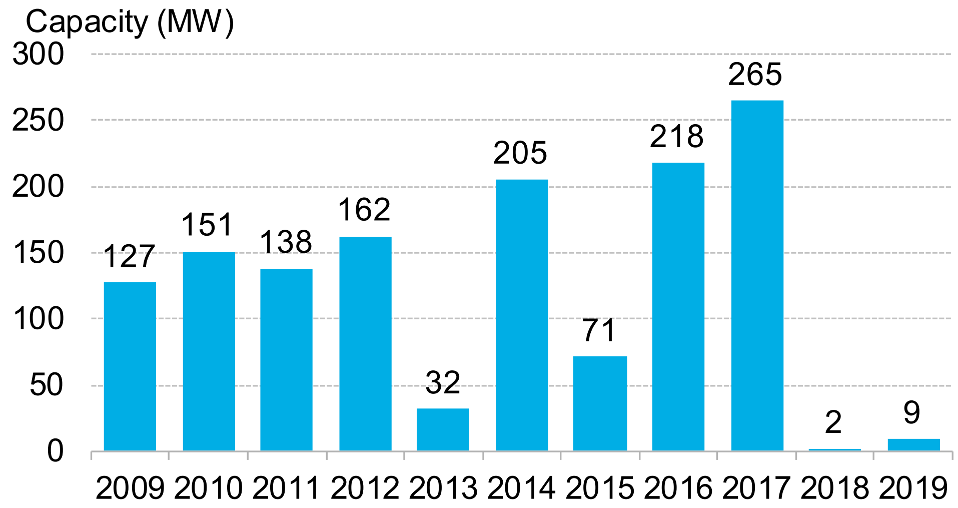
Table of Contents

Deployment: U.S. hydropower build and licensed capacity

U.S. hydropower build and cumulative capacity



U.S. new hydropower capacity licensed or exempted by FERC

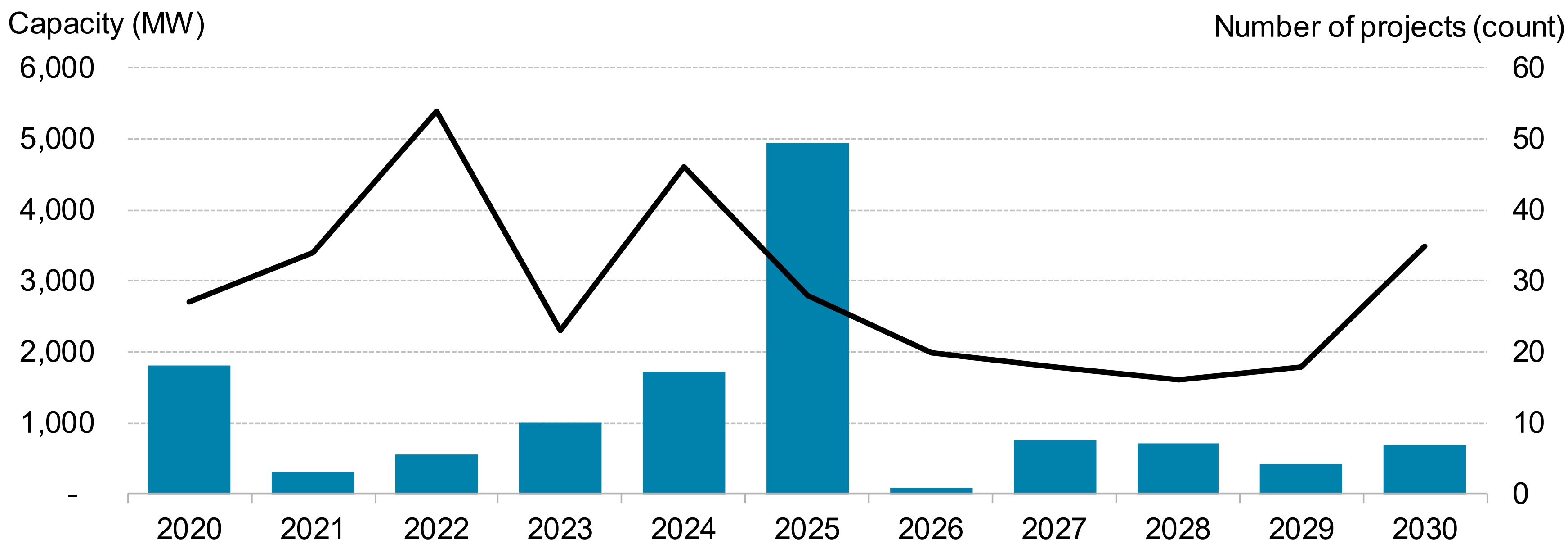


- While fewer megawatts of hydropower capacity were commissioned in 2019 than the previous year, the industry continues to see some growth through small hydro projects. These represented all 13MW of 2019 build, the most sizable being the 6.5MW Gay Robinson project in Kauai, Hawaii. Following the completion of construction in fall 2019, the Red Rock Hydroelectric Project in Pella, Iowa is scheduled to come online. Built on an existing dam, the project is 36.4MW.
- Only 9MW of new hydropower capacity was licensed by the Federal Energy Regulatory Commission (FERC) January-November 2019. Hydro projects that began construction pre-2018 were retroactively eligible for the PTC and ITC thanks to the 2018 Bipartisan Budget Act. While 2018/2019 hydro build was ineligible for the PTC at the time of build, it received retroactive qualification at the end of 2019, including 2020 build eligibility.
- With the simpler qualifying pathway for small, non-federal conduit projects, which first became available in 2013, 117 conduit projects totaling 38MW have been deemed eligible for construction by FERC. (None is included in these charts.) With the passage of the 2018 AWIA legislation, this process was amended to increase eligibility to projects up to 40MW.

Source: BloombergNEF, EIA, FERC Notes: Hydropower build and cumulative 2019 values are projected, accounting for seasonality, based on latest values from EIA . Licenses data are from the Office of Energy Projects' (OEP) Energy Infrastructure Update in November 2019. Licensing figures exclude pumped storage and qualifying conduit hydro facility information which has a separate FERC filing process. Conduit hydro facility information can be found at https://www.ferc.gov/industries/hydropower.asp.

Pipeline for licensing and re-licensing hydro plants

U.S. hydropower plants seeking to be re-licensed by FERC

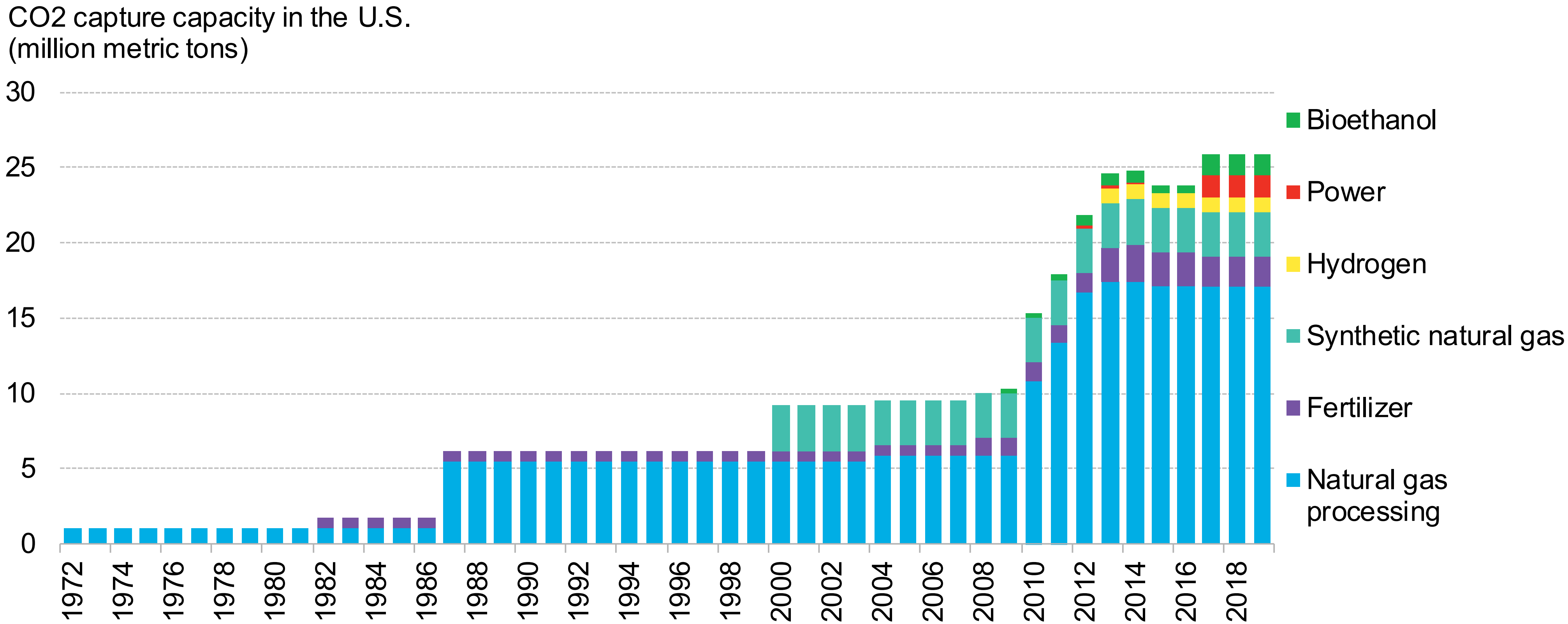


- High cost and delays associated with re-licensing remain primary threats to existing and new U.S. hydropower and pumped storage projects. Licensing typically takes 5-10 years but can last even longer in certain cases.
- As of year-end 2019, 319 hydropower projects totaling 13GW were up for relicensing between 2020-2030, according to the Federal Energy Regulatory Commission (FERC). Hydropower and pumped storage projects go through re-licensing every 30-50 years. During the process, the licensee works with stakeholders to balance power and non-power benefits of the project, including recreation, irrigation, environmental restoration, and energy generation.
- 19.3GW of pumped storage projects have received preliminary permits from FERC, with over 2GW in both Arizona and Oklahoma. 24.7GW have preliminary permits pending. Preliminary permits, which are issued for up to four years, do not authorize construction, but maintain priority of application for license while the permittee studies the site and prepares to apply for a license. Three new pumped storage projects with a combined capacity of 2.1GW have received licenses in the last few years – Eagle Mountain in California, Swan Lake in Oregon, and Gordon Butte in Montana. Construction on all could potentially start by 2021. The last large pumped storage facility was built in 1995.

Source: BloombergNEF, FERC

Table of Contents

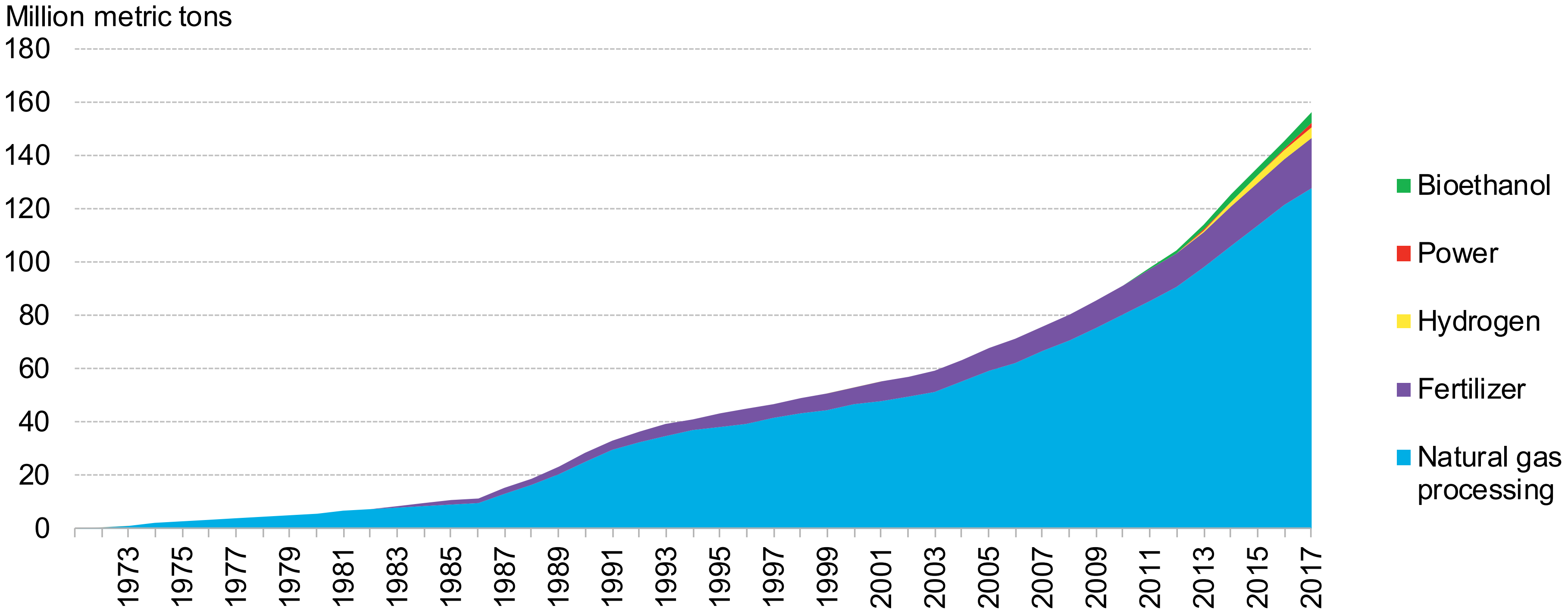
Deployment: Cumulative installed CCS capture rate in the U.S.



- Industrial processes that cannot easily substitute renewable energy sources for fossil-fuel power generation are drawing more attention from government funding programs and technology developers. The U.S. Department of Energy has said it expects hubs of CCS infrastructure to develop in certain industrial areas, suggesting some momentum behind U.S. CCS projects linked to chemicals production and other industries.
- In April 2017, the Illinois Industrial Carbon Capture and Storage project, capturing 1 million metric tons of CO2 a year for geological storage, began operating. The project was funded with $141 million from the DOE and about $66 million from private sources. The Petra Nova Carbon Capture plant in Texas, capturing 1.4 million metric tons of CO2 a year from a 240MW slipstream of flue gas, is the world’s largest CCS system retrofitted to a coal-fired power plant.

Source: BloombergNEF, Global CCS Institute

Deployment: Cumulative CO2 injection in the U.S., by technology



- As of 2017, cumulative CO2 injected in the U.S. since the early 1970's was just under 160MMt. This cumulative volume total equals approximately 2% of *annual* U.S. greenhouse gas emissions.
- The U.S. remains the global leader in carbon capture and storage (CCS). Eleven out of a total 19 large-scale CCS facilities operating globally are in the U.S. The majority of these, along with small-scale operating CCS plants, are in the Midwest and Texas, and the majority of completed, but not yet operating, small-scale plants are further east and in New England. The total capacity of large-scale projects either operating or in development is around 45 million tons. Of this capacity, around 65% is used, or slated for use, in enhanced oil recovery (EOR).
- CCS gained momentum in the U.S. with the 2018 passage of the FUTURE Act, which expanded the tax credit for CCS projects that commence construction before 2024. The act also eliminated a cap on eligible volumes, providing certainty for projects that take years to develop, and lowered the eligibility threshold from 500,000 to 100,000 tons of carbon stored on an annual basis.

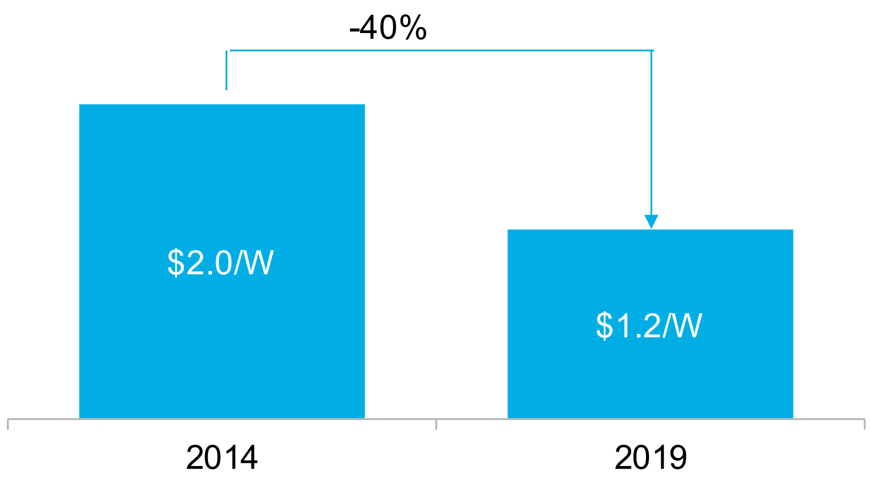
Source: BloombergNEF, Global CCS Institute

BloombergNEF

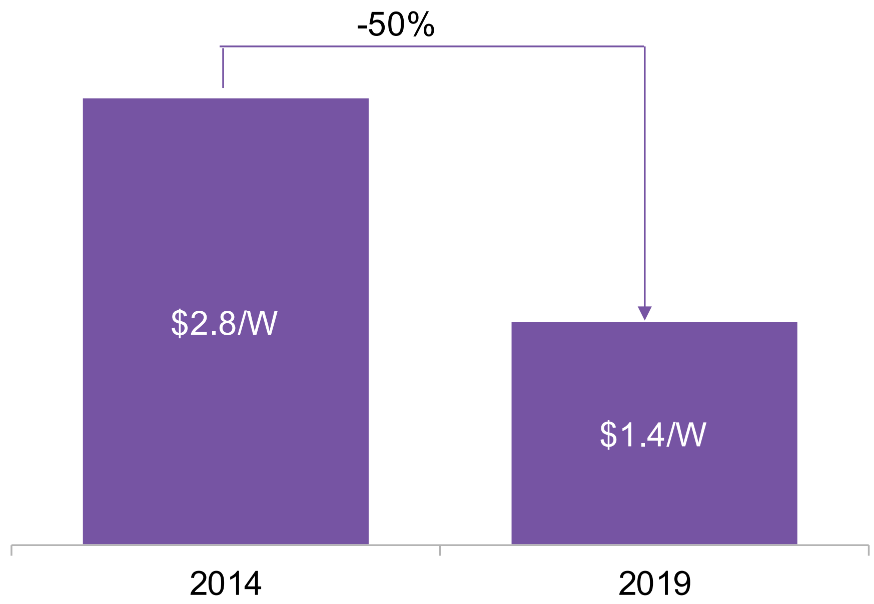
Table of Contents

Economics: U.S. hydrogen plant capex

Western-made Akaline electrolyzer system costs



Western-made PEM electrolyzer system costs



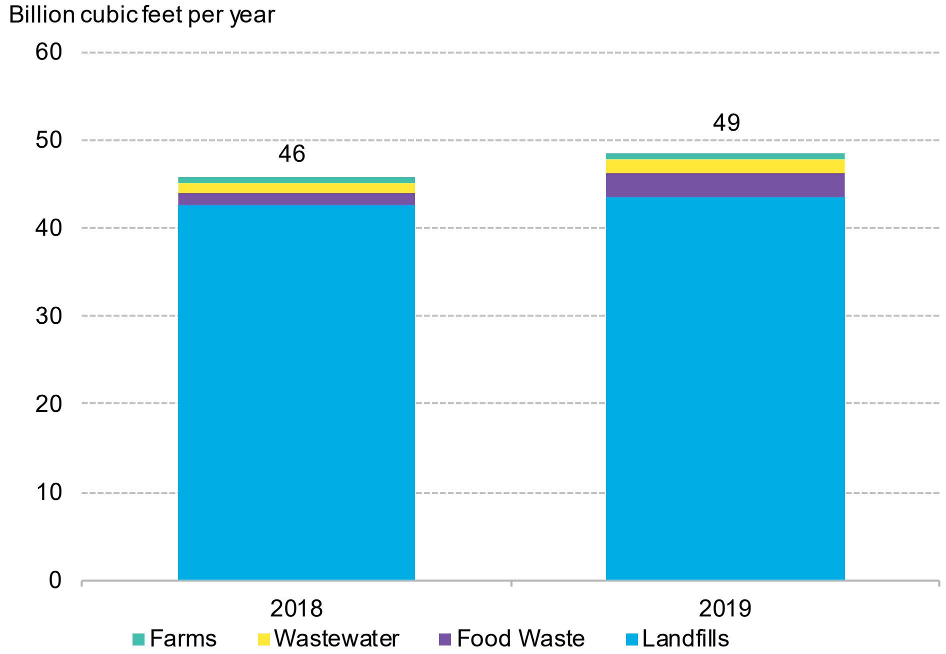
- Hydrogen has the potential for much wider use in the U.S. energy system, including as a means for storing what would essentially be dispatchable, zero-carbon energy. Producing hydrogen through electrolysis remains costly, however. To make the fuel viable on a zero-carbon basis will require both lower clean power-generation costs and lower electrolyzer system costs. Fortunately, levelized wind and solar costs have trended sharply down in recent years.
- BNEF has also tracked a sharp decline in the dollar-per-Watt cost of U.S. and European-made electrolyzer systems. The price of an alkaline electrolyzer system has dropped 40%, from $2/W in 2014 to $1.2/W in 2019. Polymer electrolyte membrane electrolysis (PEM) electrolyzer systems have fallen by an even sharper 50% over that same period. BNEF has also found that Chinese firms will sell electrolyzer systems for as low as $0.2/W.
- To date, most demonstration-scale low-carbon hydrogen projects have been in built in Europe though several are under development in California. With hydrogen production costs declining, the fuel has the potential for wider use toward the end of this decade or into the 2030s.

Source: BloombergNEF Note: The values are for MW-scale systems. PEM is short for proton exchange membrane.

Table of Contents

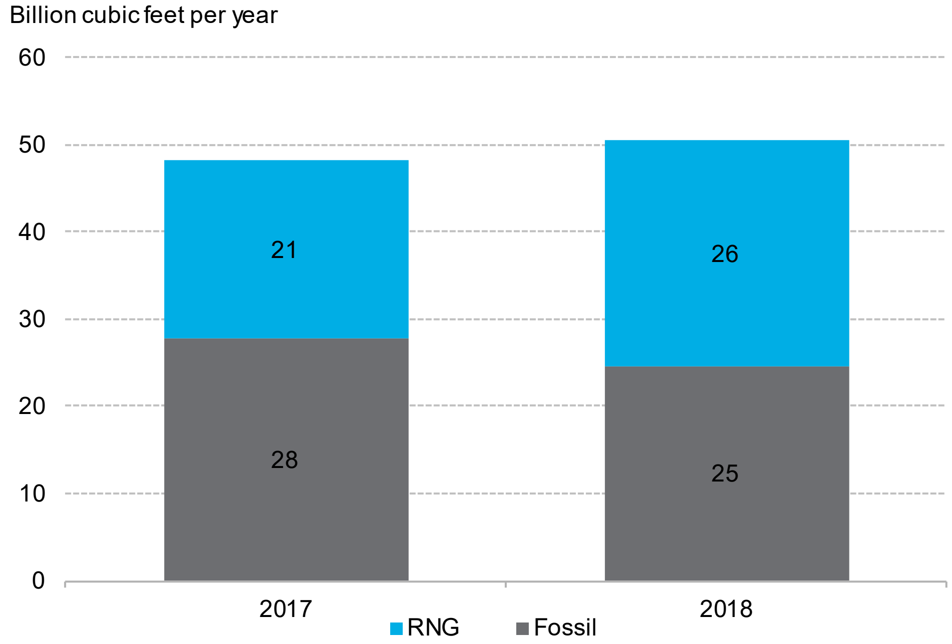
Renewable natural gas (RNG) deployment: Production and use in transportation

RNG production capacity, by source



Source: The Coalition For Renewable Natural Gas, Argonne National Laboratory (As of June 2019)

U.S. natural gas vehicle fuel consumption



Source: RNG: EPA – Moderated Transaction System, Fossil – EIA Natural Gas Consumption

- The vast majority of U.S. RNG is produced through biological decomposition of waste in landfills. In 2017, RNG met 43% of natural gas demand from the transportation sector, according to the EPA and EIA. In 2018 (the last year for which complete data exist), that rose to 51%.
- Key drivers of consumption have been the California Low Carbon Fuel Standard and the national Renewable Fuels Standard. Under the latter, credits known as renewable identification numbers (RINs) are critical to making RNG competitive, specifically “D3” RINs. In 2019, prices for RINS collapsed 57% from approximately $2.04/RIN in January, to $0.87 in October, according to the EPA. This drastic drop in price was triggered by small refinery exemptions granted by the EPA that diminished demand for D3 RINs.
- There were also and estimated 5.24 million gallons, 5.9 million gallons and 5-6.5 million gallons of U.S. renewable propane production in 2017, 2018 and 2019, respectively.

Source: BloombergNEF, FERC

The RNG value chain

Process	Waste Collection	RNG Production	On-Road Transport	Heat
Companies Involved	WM Waste Management; Republic Services; Renewable Dairy Fuels (an ampAmericas company); CR&R Incorporated environmental services	California Bioenergy; Chevron; Clean Energy; bp; Morrow Renewables; aria energy	Trillium; TruStar Energy; Clean Energy; ampRENEW (an ampAmericas company); UPS	SoCalGas (A Sempra Energy utility); nationalgrid; CenterPoint Energy; DTE Energy Foundation; Vermont Gas; FortisBC Energy at work; Dominion Energy

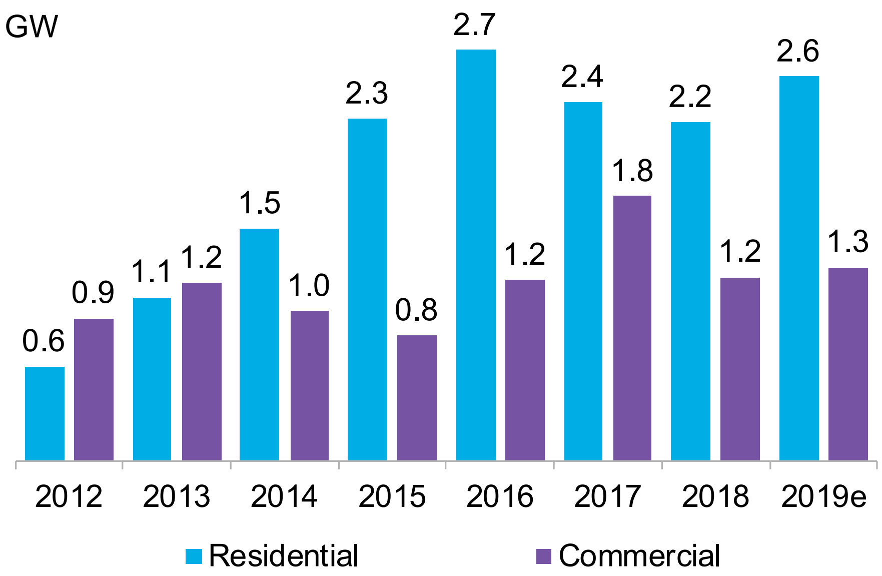
- Traditionally, biogas (the feedstock for RNG) has been converted to electricity for use onsite or sold into the power market. However, thanks to supportive policies and industry growth, an increasing number of biogas systems are converting their biogas to RNG for sale to larger corporations, including oil and gas majors, who want to shrink their corporate carbon footprints.
- Over the last several years, large oil companies have taken a greater interest in this space. In 2017, BP purchased Clean Energy Fuels Corp's upstream RNG business for $155 million. In 2019, Chevron announced a jointed venture to develop RNG from 18 dairy digesters in California.
- Meanwhile, large investor-owned natural gas utilities either facing or concerned about potential regulations on CO2 emissions plan to green their gas systems by replacing geologic natural gas with RNG. In 2019, for instance, SoCal Gas and VGS (formerly Vermont Gas Systems) committed to displacing 20% of their gas supply with RNG by 2030, Summit Utilities committed to 5% by 2020 and Dominion Energy committed to 4% by 2040. FortisBC committed to 15% of its supply by 2030.
- VGS offers its customers the option to buy RNG instead of geologic natural gas. Other gas utilities, National Grid, Summit Utilities, SoCalGas and CenterPoint Energy are currently working with public utility regulators to establish similar voluntary RNG procurement programs.

Source: BloombergNEF Note: Waste Collection is defined as the processes of landfilling, waste water treatment, animal manure management and food waste gathered from residential or commercial facilities

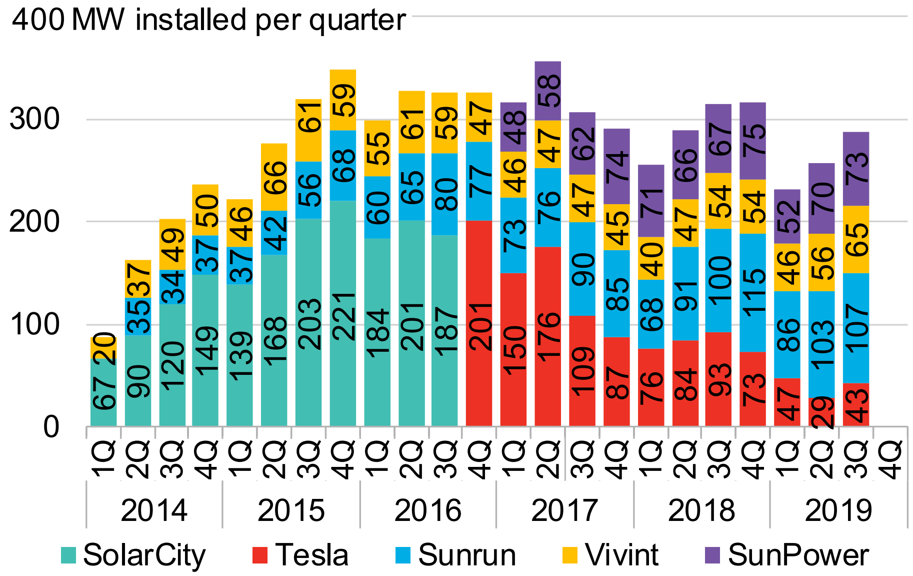
Table of Contents

Deployment: U.S. small-scale solar build by type

Annual U.S. small-scale PV build



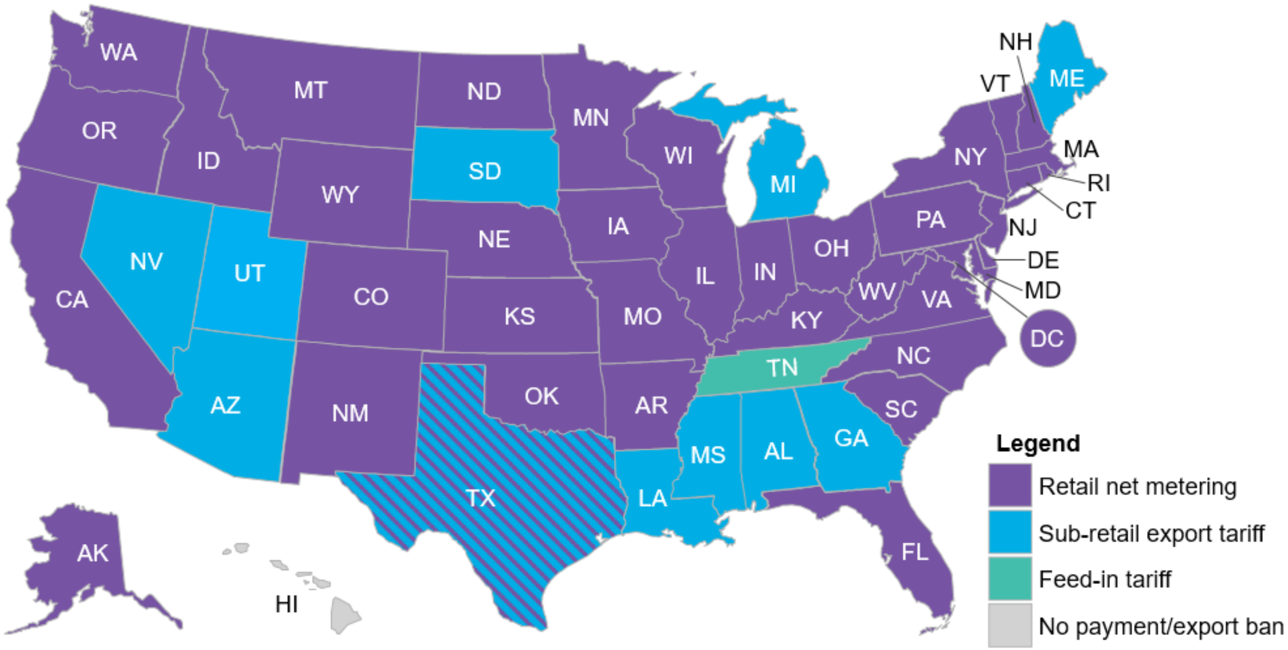
Installations of top residential PV vendors



- Growth returned to residential solar markets in 2019. Fewer vertically integrated installers remain to take advantage of the growing market, with 11 notable market exits or bankruptcies since 2016. The industry's shift to a more sustainable business model is underway, with more customers choosing to buy their systems outright from local installers.
- California remains the largest state market. Interest in rooftop solar is growing, following widespread blackouts in fire-risk regions. Vivint and Sunrun now market their residential solar-and-storage products as a resilience investment.
- Onsite commercial and institutional (C&I) solar build is showing a revival. Interest in serving this segment has picked up, with a restructured SunPower committing to more C&I build, and large utility-scale developers like Invenergy dedicating teams to serve C&I customers.

Source: BloombergNEF, company filings Note: All solar capacity in the Factbook portrayed in MWdc. Q4 2019 data for individual vendors was not available at time of production. SunPower changed its reporting format for segment-wise installations in 2018, and historical data in the new format is only available as far back as 2017. Community solar located behind the meter is included in the commercial figures above, but community solar in front of the meter is not.

Policy: Net metering state policies as of December 2019



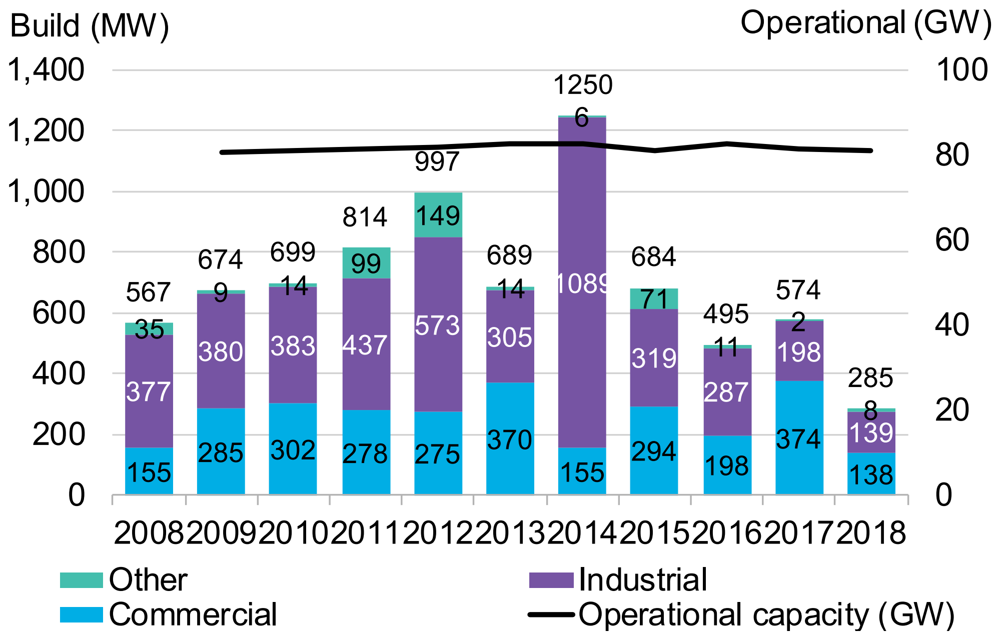
- As of December 2019, net metering at the full retail rate was available to most customers within 38 states and Washington, D.C.
- Compensation for generation fed back into the grid remained under discussion in 2019. Utilities proposed increases to the fixed charges in some states, and community solar saw increased interest.
- Louisiana adopted a successor to net metering at an avoided-cost rate for all projects coming online from 2020 onward. The avoided cost is applicable to virtual net metered projects that sign up for community solar as well.
- South Carolina's reform process eliminated the cap on the number of net metered customers the state's utilities could allow. In Minnesota, Xcel's requested changes to the Value of Solar methodology will compensate community solar at a higher value in 2020.

Source: BloombergNEF, DSIRE. Note: the map displays the mechanism offered to the majority of residential customers where the incentives vary within a state.

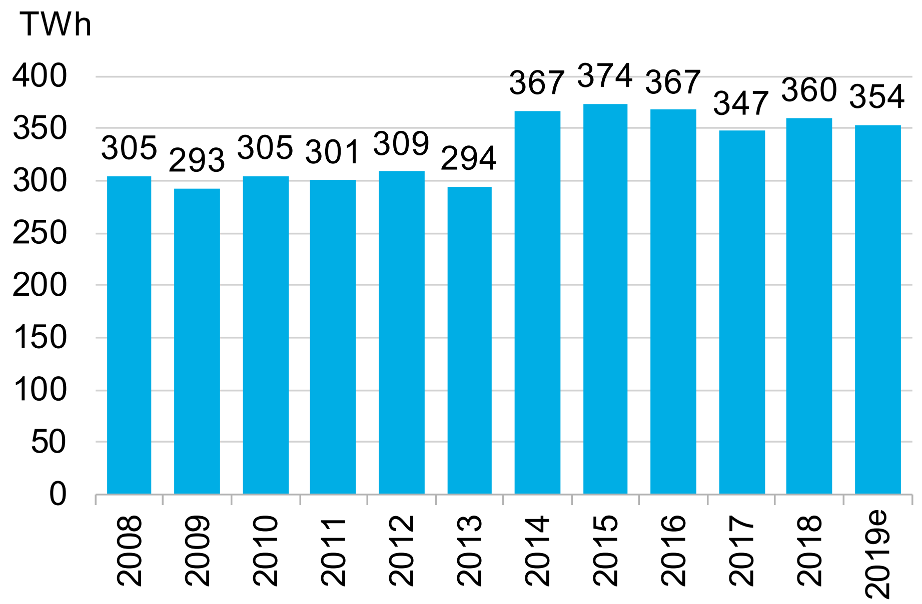
Table of Contents

Deployment: U.S. CHP build and generation

U.S. CHP build and cumulative capacity



U.S. CHP generation (EIA-tracked plants)

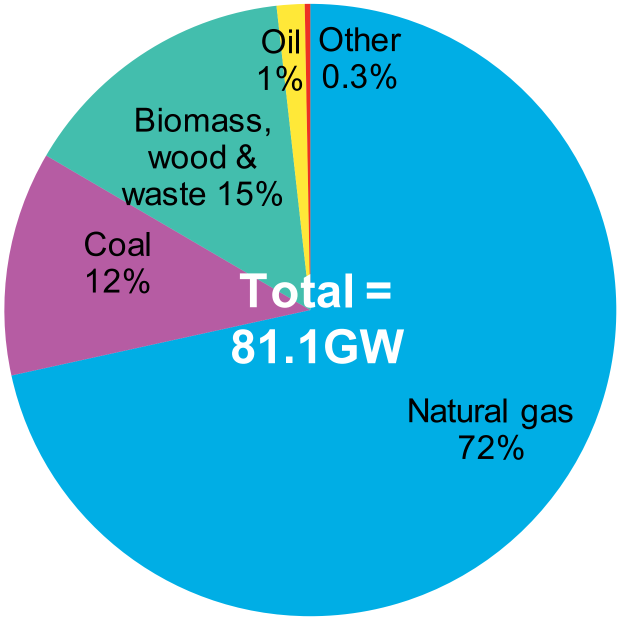


- CHP new capacity additions slid in 2018 (the last year for which complete data are available) to 285MW from 574MW the year prior.
- Operational CHP capacity has declined from a peak in 2014 of 82.7GW 81.1GW, its lowest level since 2010. This is mostly due to industrial plant site retirements of approximately 1GW outpacing new build.
- We expect generation from CHP plants remained consistent 2018-2019, accounting for around 7-8% pf total U.S. generation.

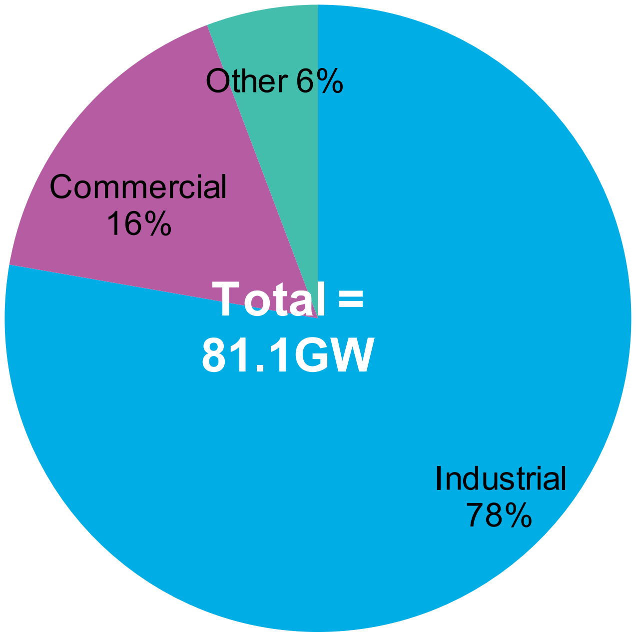
*Source: BloombergNEF, DOE CHP Installation Database (maintained by ICF) Notes: EIA is the best available source for generation data, but is not comprehensive for CHP. The generation figures here are thus underestimated. Specifically, EIA does not collect data for sites <1MW, and EIA categorizes some CHP systems as "electric power" rather than "industrial CHP," among other reasons. *Values for 2019 are projected, accounting for seasonality, based on latest monthly values from EIA (data available through September 2019).*

Deployment: U.S. CHP deployment by fuel and sector, 2018

U.S. CHP deployment by fuel source



U.S. CHP deployment by sector

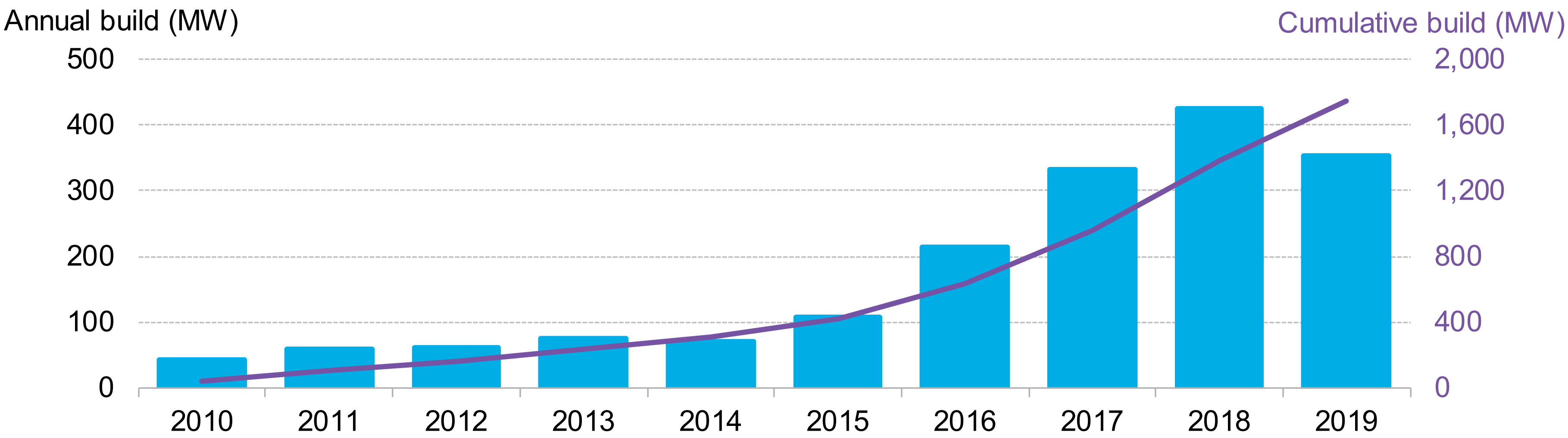


- Fuel source distribution of CHP essentially remained the same from 2017 to 2018, the last year for which complete data exist. Natural gas continues to supply the majority of CHP at 72% (58MW). 15% of total operational capacity relies on units using biomass, wood, or waste. Coal's contribution ticked up 1%, from 11% to 12%. This is due to a new coal CHP plant at the University of Alaska-Fairbanks and waste and wood fuel industrial plant closures at refineries and mills. Additionally, there are 13 propane systems operating in the U.S. and its territories. Two of these systems help provide energy to critical infrastructure.
- Retirements of industrial CHP facilities in 2018 led to a slight drop in its share of the market to 78%. Meanwhile, overall commercial build and usage has outpaced retirements to boost commercial's share to 16%.

Source: BloombergNEF, DOE CHP Installation Database (maintained by ICF) *Note: totals may not add to 100% due to rounding.*

Table of Contents

Deployment: U.S. fuel cells in stationary, material handling and transportation



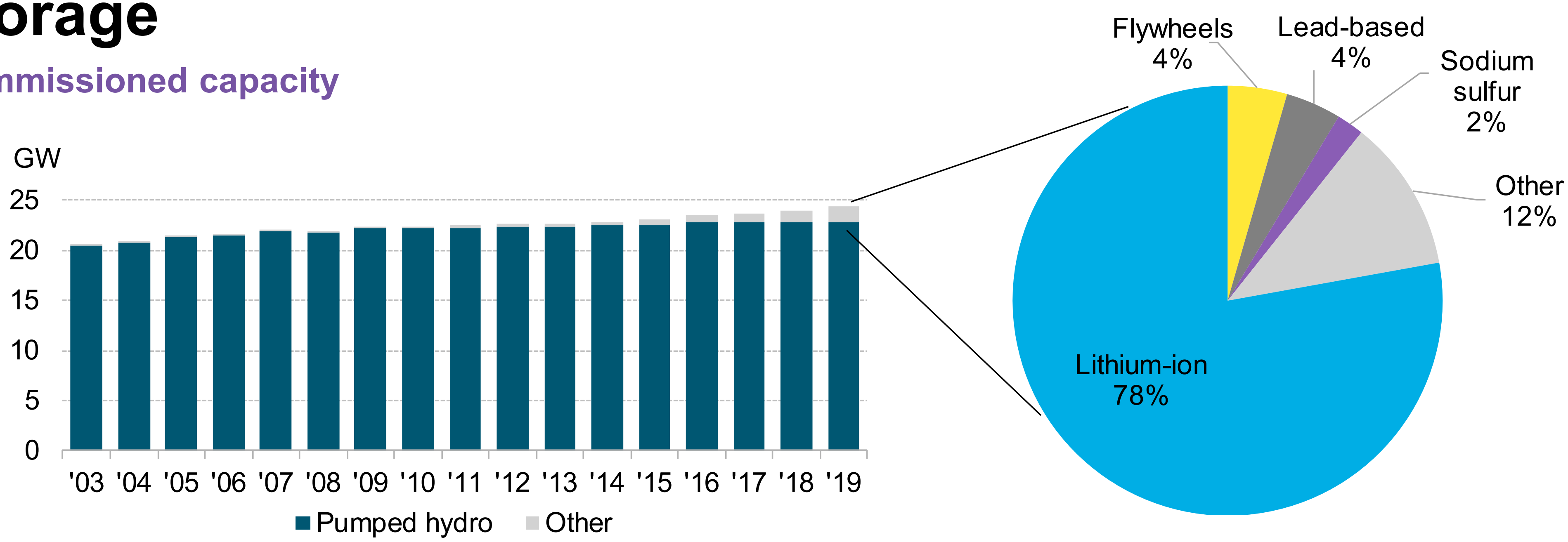
- The U.S. is home to major large-scale fuel cell manufacturers: Bloom Energy, FuelCell Energy and Doosan Fuel Cell America. In 2019, Congress reinstated the federal Investment Tax Credit applicable for fuel cells, but it was still a mixed year for these firms.
  - Bloom Energy signed an agreement with Duke Energy to distribute 37MW of fuel cells to Duke's customers. Abroad, it had 7MW in sales to South Korea and its first 8.5MW in sales to India.
  - FuelCellEnergy (FCE) embarked on a business restructuring in 2019. In November, it agreed a $200 million loan facility with Orion Energy Partners.
  - Doosan Fuel Cell America is a spin-out business from Doosan, the Korean industrial. It reports a 45MW installed base and a 30MW pipeline.
- Material handling and forklifts are a fuel cells success story, with over 30,000 in operation in the U.S. Fuel cell forklifts are more suitable indoors than emissions-producing natural gas-powered forklifts or battery-powered forklifts, which require substantial charging infrastructure. New York-based Plug Power in 2019 received orders from customers including Walmart, Amazon, BMW and Fiat Chrysler.
- In transport, California is the global leader for fuel cell passenger vehicles with nearly 8,000 on its roads. There were 35 fuel cell buses in operation nationally at the end of 2018, with another 39 planned. The majority of those planned for deployment are in California where a policy requires 25% of buses procured starting in 2023 to be zero emission. This target rises to 40% by 2040.

Source: E4tech Fuel Cell Industry Review 2019, BloombergNEF.

Table of Contents

Deployment: U.S. cumulative energy storage

Commissioned capacity



- Pumped hydropower storage projects account for around 93% of installed energy storage capacity in the U.S. While pumped hydro will remain the bulk of energy storage capacity in the U.S., other technologies, mainly lithium-ion batteries, have dominated new build since 2011. State-level energy storage mandates or solicitations generally exclude pumped storage.
- As of December 2019, there were at least four existing pumped storage hydro projects that were issued a new license (relicense) - 1,785MW Ludington in Michigan; 1,160MW Blenheim-Gilboain New York; 452MW Seneca in Pennsylvania; and 262MW Salina in Oklahoma. Additionally, there were pending licenses for projects totaling 1,145MW in new capacity. FERC also issued a new license for the 393MW Swan Lake North Pumped Storage Project in April 2019 – combined with other new projects, new hydro pumped storage will offer approximately 2,100MW in additional capacity.
- As of the end of 2019, FERC had approved most of the U.S. market operators' Order 841 compliance plans, with comments. The Order, issued in February 2018, is a landmark rule. It aims to remove barriers and bring consistency to how storage assets participate across organized power markets. The rule should ensure energy storage can compete fairly against other generators. This should encourage additional storage deployments and create new opportunities for energy storage to participate across multiple services.
- While Lithium-ion holds the majority of the remaining market share, thermal energy storage in the form of ice-based systems are emerging. In North America, 6.6 MW of these systems were installed in 2018 with projections showing a potential 68.8 MW by 2027.

Source: EIA, FERC, BloombergNEF, Navigant

Deployment: U.S. announced and commissioned energy storage projects

OR: energy storage target equivalent to 1% peak load

CO: Xcel approved for 275MW/ 1,100MWh storage paired to solar

MN: passed law which requires utilities to consider storage in long-term planning

PJM: 280MW+ operational for frequency regulation

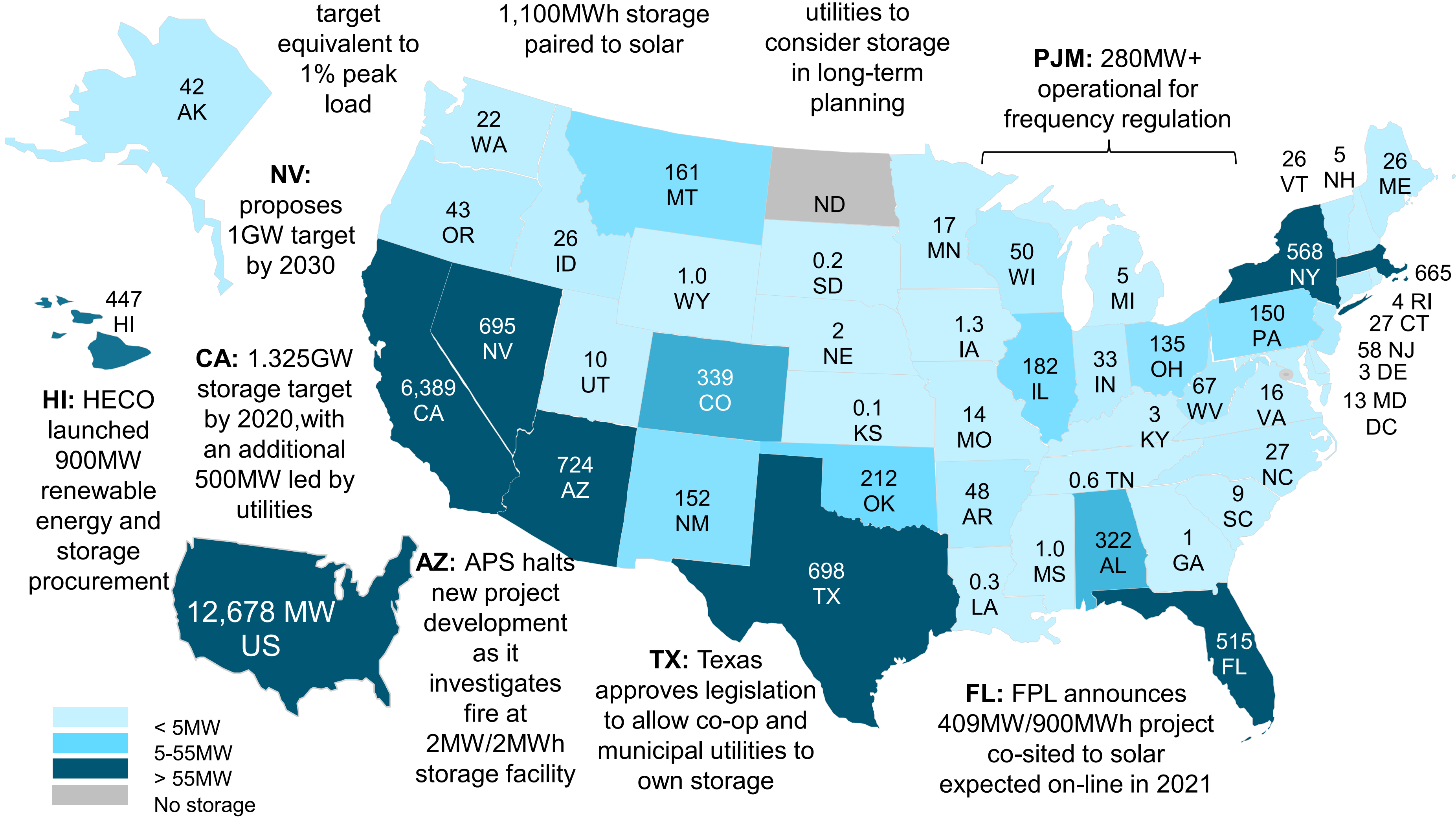
MA: 1,000MWh aspirational energy storage target + clean peak standard approved

NV: proposes 1GW target by 2030

CA: 1.325GW storage target by 2020,with an additional 500MW led by utilities

HI: HECO launched 900MW renewable energy and storage procurement

NY: utilities issued 350MW storage RFP. NY PSC toughens regulation for old peaker plants



AZ: APS halts new project development as it investigates fire at 2MW/2MWh storage facility

TX: Texas approves legislation to allow co-op and municipal utilities to own storage

FL: FPL announces 409MW/900MWh project co-sited to solar expected on-line in 2021

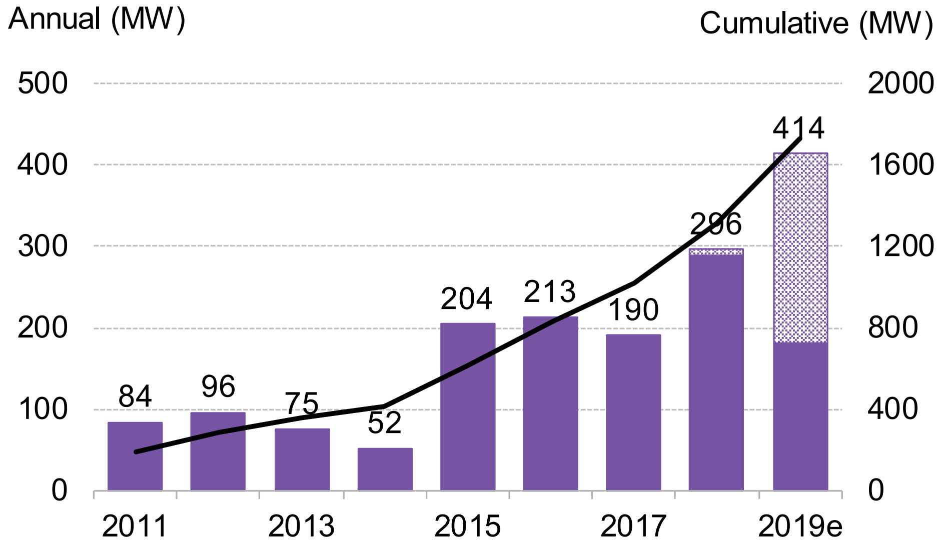
MD: established energy storage pilot program, utilities to solicit projects, totaling up to 10MW/15MWh

Source: BloombergNEF Note: Includes projects larger than 500kW/500kWh that have announced specific locations and been confirmed by relevant companies through public data. Indiana NIPSCO capacity not included in state capacity because individual project capacity is not yet disclosed. Capacity excludes thermal storage.

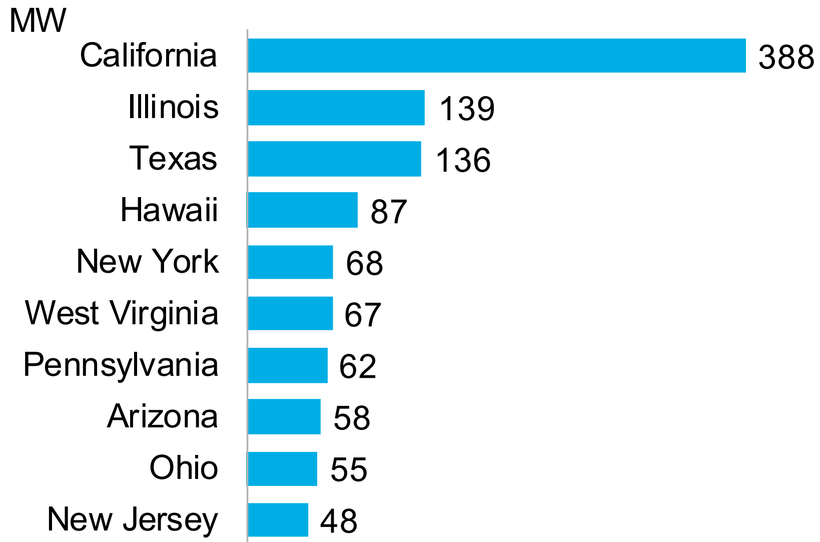
BloombergNEF

Deployment: U.S. non-hydropower commissioned energy storage capacity

Commissioned capacity



Installations by state (top 10 states in 2019)

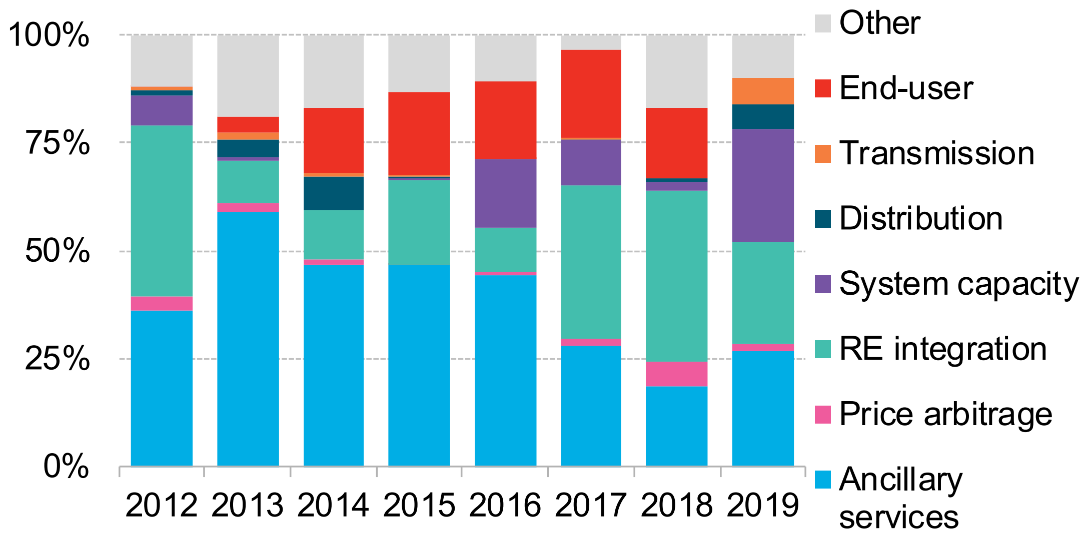


- Annual energy storage installations have increased significantly since 2014. Build ramped in 2015 from projects seeking to participate in the PJM frequency regulation market and these assets represent most of the capacity in Illinois, West Virginia, Ohio and Pennsylvania. Between 2018-2019, the amount of commissioned capacity grew by 20%.
- California became the largest market in the U.S., surpassing PJM in 2019. Build surged in the state starting in 2016 and early 2017 in response to emergency gas supply shortages expected from the Aliso Canyon gas storage facility leak-mitigation efforts. The state continues to lead installations as projects come on line to meet the state's 1.8GW target by 2024.
- In 2019, markets continued to expand beyond PJM and California. New York, New Jersey and Texas each added more than 20MW of capacity from larger-scale (10MW+) projects, while Massachusetts added a variety of 3-5MW projects primarily reducing transmission charges from peak demand shaving.
- Falling lithium-ion battery pack prices have helped to lower costs for new stationary storage applications. Between 2018-2019, pack prices dropped by 13% and over the last decade, by 87%.
- Ice storage systems have also proven to be cost-effective for commercial and industrial applications under certain rates in some markets. Over 80 ice storage projects, totaling 99MWh, have been implemented in North Carolina.

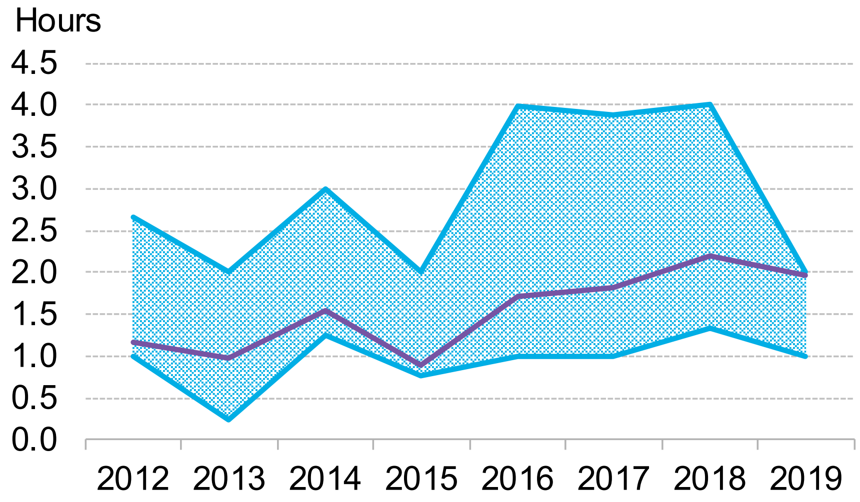
*Source: BloombergNEF, NC State University Notes: *2019 includes expected but unconfirmed capacity as of January 15, 2020. Unconfirmed capacity is marked in white. Does not include underground compressed air energy storage or flooded lead-acid batteries. Minimum project size included is 500kW or 500kWh. Cumulative capacity subtracts decommissioned capacity.*

Deployment: U.S. non-hydropower energy storage by application

Applications (% by MW)



Project duration volume weighted average (line) and top and bottom quartiles (shaded area)

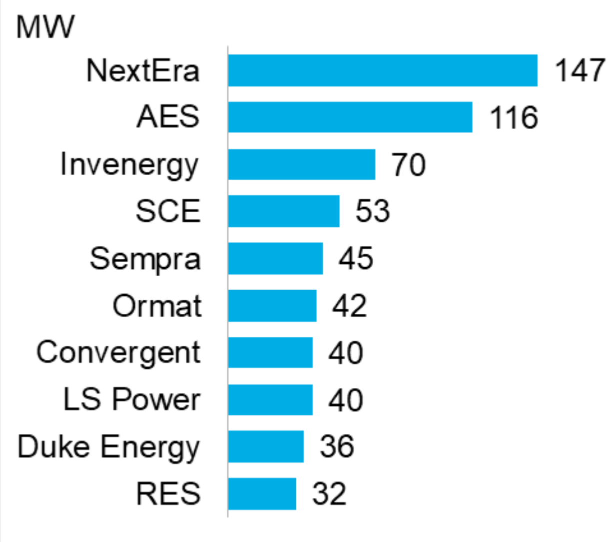


- Since 2017, the major application for energy storage projects has been renewable energy (RE) integration. Such projects support wind and solar additions to the grid. In 2019, system capacity and RE integration together accounted for half of total deployments on a megawatt basis.
- System capacity rose in relevance in 2016 and 2017, driven by a wave of projects commissioned in California tied to Resource Adequacy contracts. These installations are required to be available for four hours whenever called upon. The shift from PJM frequency regulation projects to California Resource Adequacy projects and the growth of RE integration projects explain the trend up in average project duration, which increased from 0.9 hours in 2013 to 2.0 hours in 2019.
- Between 2011 and 2016, ancillary services (mainly frequency regulation) was the most common application for new storage systems. Much of this was driven by deployments in PJM. However, the market for frequency regulation in PJM is now essentially saturated, and opportunities for this service in other territories are less attractive.
- In 2019, larger longer-duration projects were announced, including 300MW four-hour storage facility co-located to 400MW solar, developed for Los Angeles Department of Water and Power and a potential 315MW Ravenswood project of up to eight hours of storage in New York City.

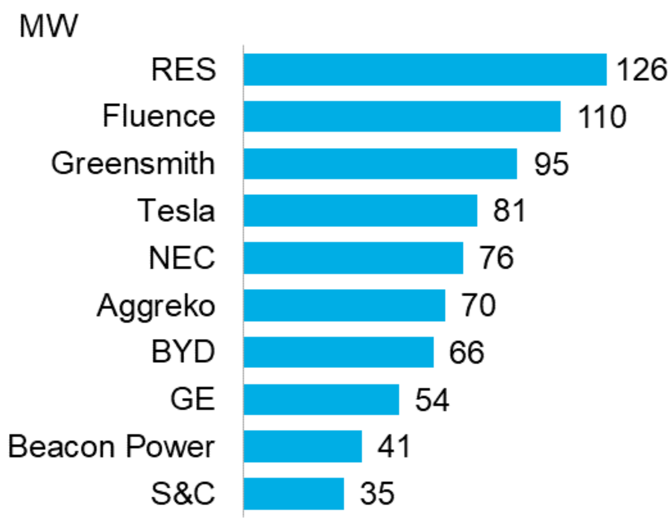
Source: BloombergNEF Notes: Pumped hydropower storage is not included as it would dwarf all other technologies. "Other" refers to applications not represented in the legend; many of these are government-funded technology testing or proof-of-concept pilot projects. Purple duration line represents volume weighted duration, range represents interquartile ranges.

Deployment: U.S. non-hydropower energy storage, top 10 companies

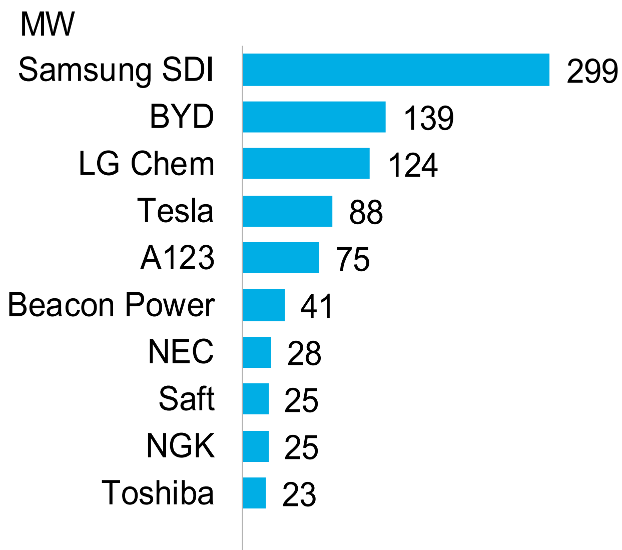
Storage owners



Storage integrators



Technology providers

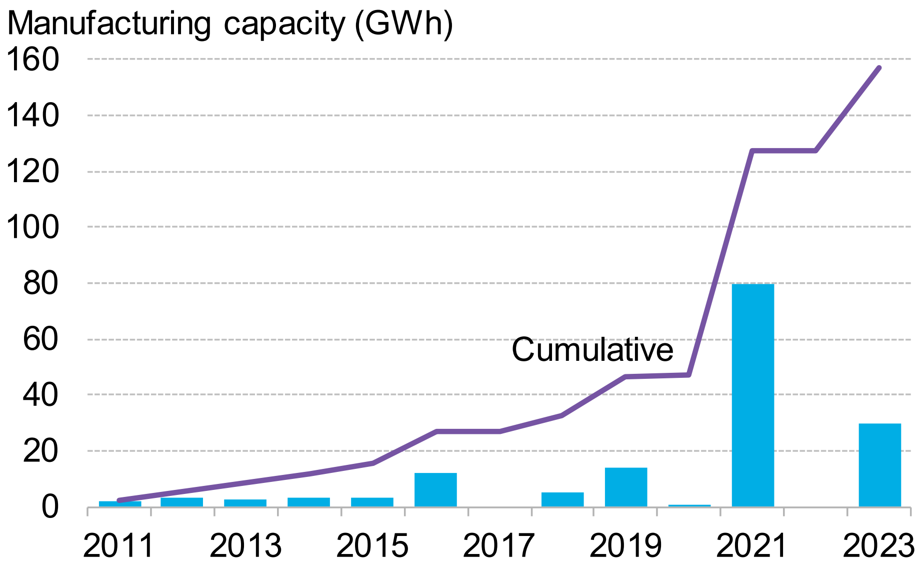


- Storage project ownership is dominated by large utilities and independent power producers such as NextEra, AES and Invenergy. These owners have operational portfolios of at least 330MW of capacity, which is generally a small but rapidly growing portion of their total generation fleet. More recently, ‘pure-play’ storage developers and owners such as Convergent have started to emerge.
- Most major storage integrators – suppliers of turnkey systems to customers – such as Fluence, Greensmith and NEC, are part of large power equipment providers.
- Projects using batteries produced by larger lithium-ion manufacturers such as Samsung SDI and LG Chem are more generally regarded as lower risk and more financeable compared to projects using technology from smaller, emerging companies. Lithium-ion is also cheaper than other technologies on a turnkey basis, and its price is falling faster rate than other technologies.
- Lithium-ion batteries are widely available and mass produced globally. They are also modular and can be installed in multiple scales (from a few kW in homes to hundreds of megawatts for bulk systems), can provide high power for short-duration applications (e.g. frequency regulation) and four hours or even more of energy capacity for longer-duration applications (e.g. investment deferral).

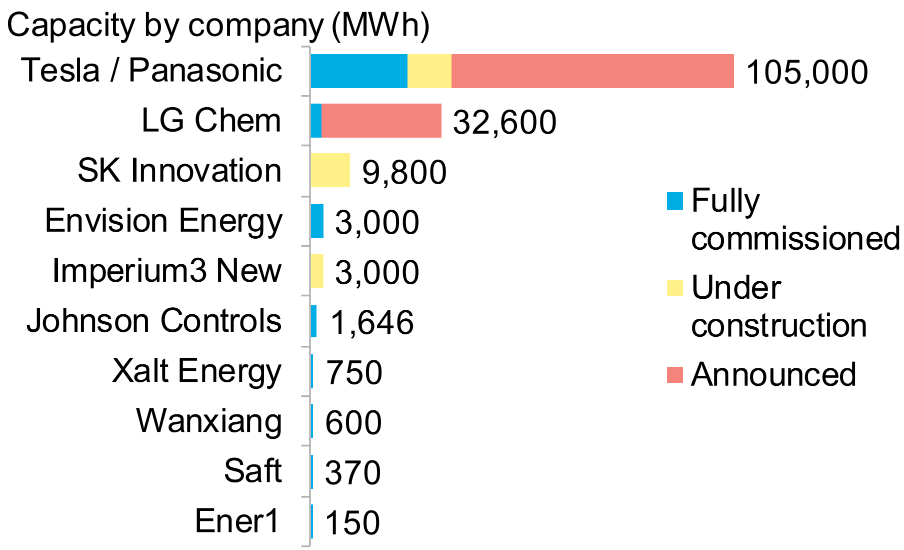
Source: BloombergNEF Notes: “Other” refers to applications not represented in the legend; many of these are government-funded technology testing or pilot projects to prove concepts. Top 10 based on commissioned capacity. Top 10 storage providers based on disclosed capacity at a project level, may exclude capacity not disclosed at a project level.

Deployment: Current and planned manufacturing capacity

U.S. lithium-ion battery manufacturing capacity



U.S. lithium-ion battery manufacturing capacity by company

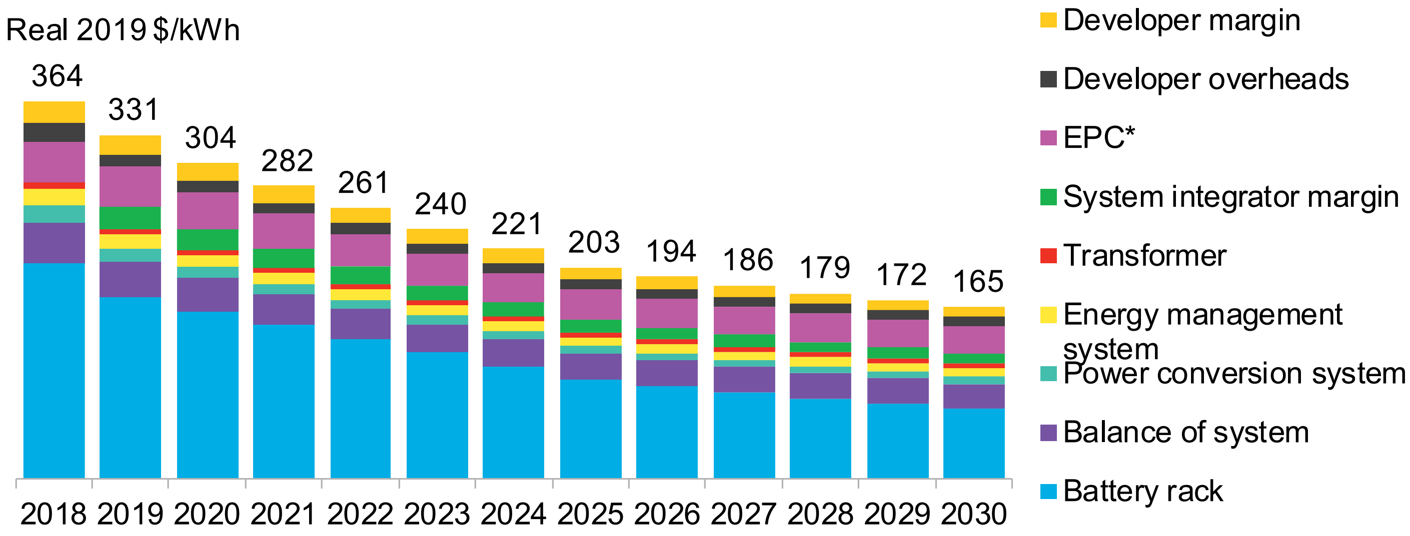


- As of the end of 2019, the U.S. had 47GWh total lithium-ion battery manufacturing capacity. Capacity grew 43% in cumulative terms from 2018 to 2019, mainly due to Tesla's expansion of its Gigafactory in Nevada to meet demand for its Model 3.
- In 2019, there were two major battery manufacturing plant announcements:
  - South Korean SK Innovation pledged to invest $1.7 billion in a factory in Commerce, Georgia, which would reach 9.8GWh production by 2022. The plant is expected to supply batteries for multiple vehicle manufacturers, including Volkswagen in Chattanooga.
  - General Motors and South Korea's LG Chem said they would jointly invest $2.4 billion in a new electric-vehicle battery plant in Lordstown, Ohio. That would make LG Chem the second largest lithium-ion battery manufacturer in the U.S. after Tesla / Panasonic.
- The U.S. is expected to reach almost 160GWh of battery manufacturing by the end of 2023. Growth is expected mainly from the Tesla Nevada Gigafactory, LG Chem's joint investment with General Motors in Ohio, as well as SK Innovation's investment in the Georgia facility.

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

Economics: Capex - energy storage system costs

Capital costs for a fully-installed usable 20MW/80MWh AC energy storage at beginning of life



- The fully-installed cost for a four-hour utility-scale system in 2019 was $331/kWh, down 9% on that benchmark cost from 2018. Lithium-ion battery price declines are the biggest reason why storage systems overall have dropped. The trend is poised to continue through to 2030.
- Energy storage systems costs include: battery racks (battery modules installed onto racks), balance of system equipment (electrical infrastructure, containers, HVAC, fire suppression systems), power conversion systems, energy management systems (software), and transformers. They also include margins for systems integrators and developers, plus engineering, procurement and construction (EPC) costs.
- The continued decline in full system prices is due technology improvements, manufacturing scale, competition between manufacturers, greater product integration ahead of installation and rising overall industry expertise.
- On September 1, 2019, the U.S. imposed 15% tariffs on lithium-ion batteries imported from China. If the impact is limited purely to battery racks, the overall system cost increase would be 7%. Potential additional knock-on effects could incur a price hike of 8-18%.

*Source: BloombergNEF Note: Excludes warranty costs, which are often paid annually rather than as part of the initial capital expenditure. These costs do not explicitly include any taxes, although due to a lack of transparency in the market, some may be unknowingly included. This is for a brownfield development so excludes grid connection costs. *Includes a 5% engineering, procurement and construction (EPC) margin for 2019 and a 10% EPC margin for 2018. Does not include salvage costs or project augmentation.*

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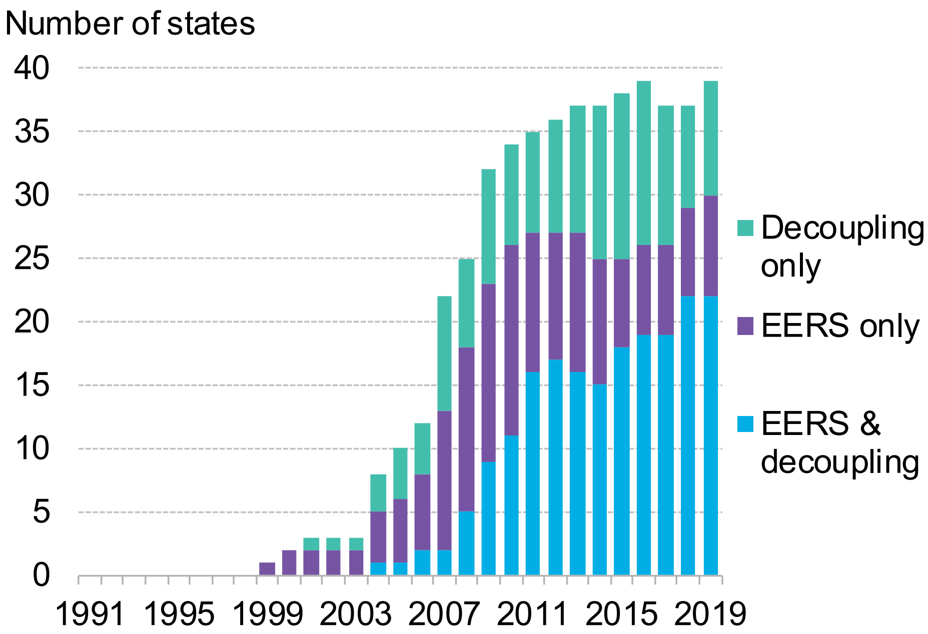
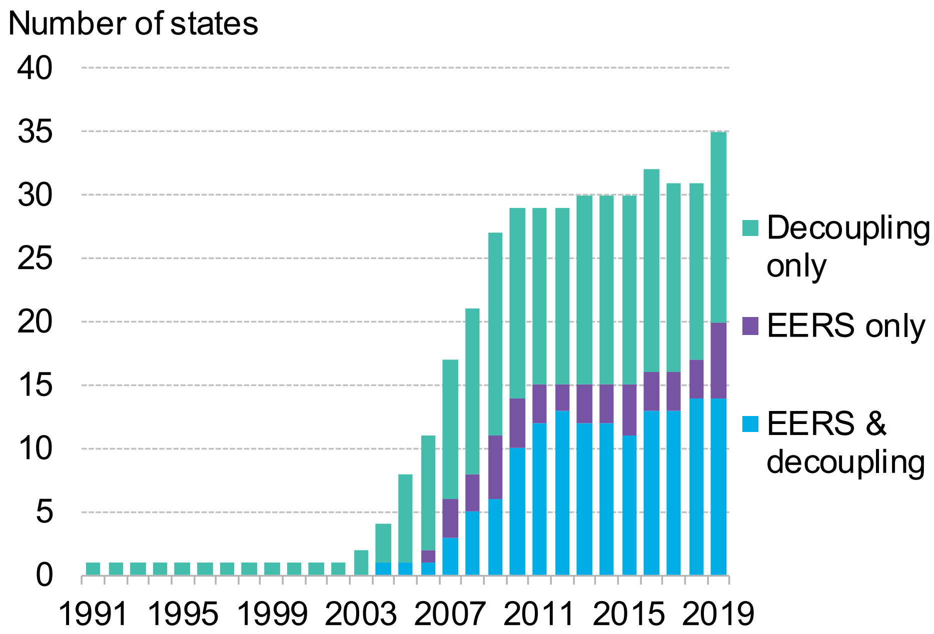
Table of Contents

Policy: U.S. states with EERS and decoupling for electricity and natural gas

Electricity



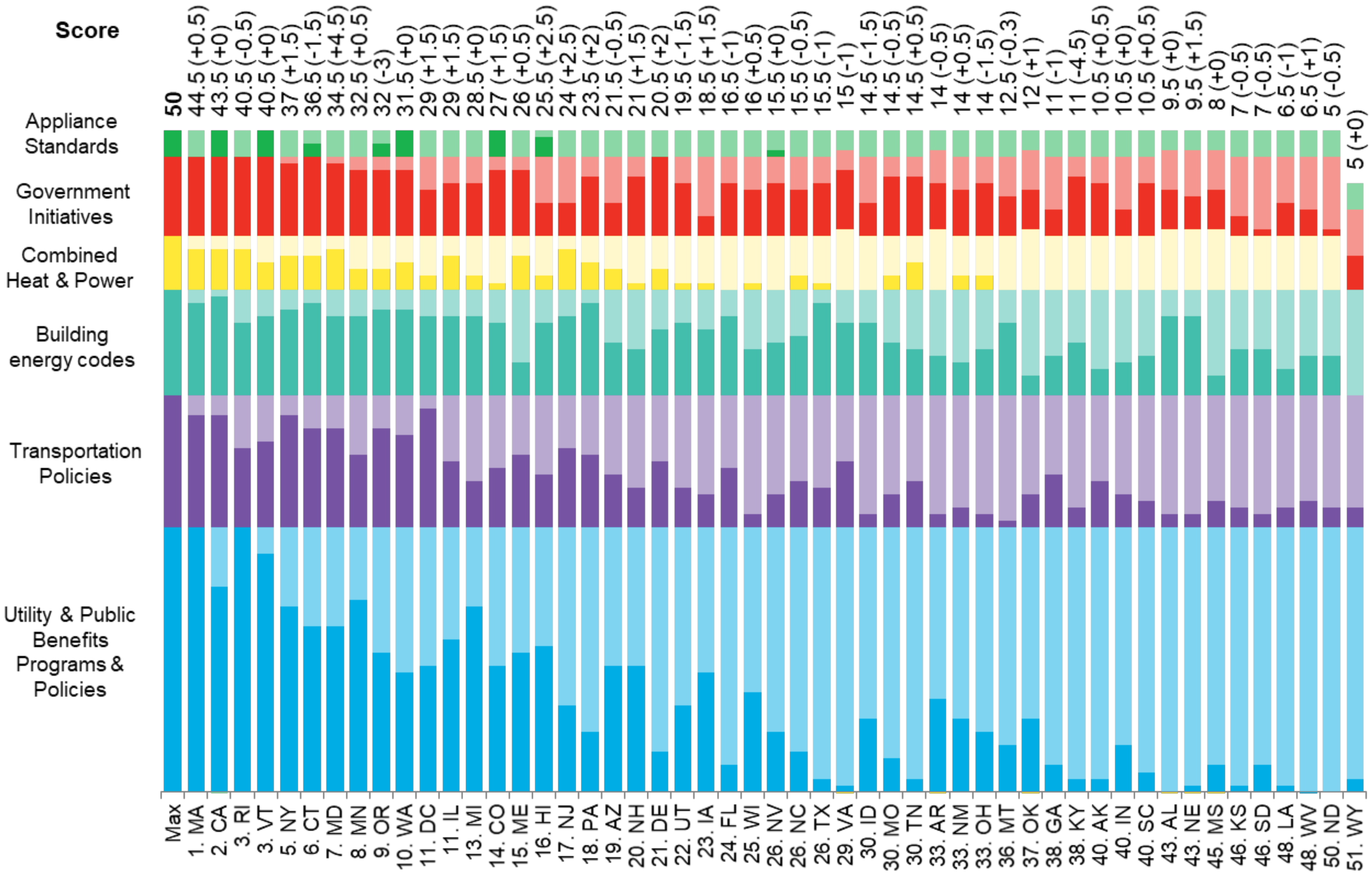
Natural gas



- 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. Decoupling is a regulatory framework in which utilities' revenues are based on the reliable provision of energy, not volume sold. Decoupling addresses the disincentive for utilities to invest in efficiency. Utilities are most likely to invest in energy efficiency in states with both EERS and decoupling. Currently, 39 states have electricity policies and 35 have natural gas policies.
- More states than ever participate in EERS or decoupling incentives. Three new states have adopted EERS: Washington, Arizona and Wisconsin. New Mexico added electric decoupling incentives in 2019, and New Jersey added a gas decoupling incentive.

Source: ACEEE, BloombergNEF Notes: Decoupling includes all lost revenue adjustment mechanisms, but no longer includes pending policies per a methodology change in ACEEE reporting.

Policy: ACEEE state-by-state scorecard for energy efficiency policies, 2018



- Massachusetts maintained first place for the ninth year in a row. According to the state's 10-year progress report, state energy efficiency policies have contributed to a 3.4% reduction in GHGs from 1990 levels.
- Maryland added 4.5 points to its score, leaping from 10th to 7th place. Utilities in the state ramped up efficiency programs, spurred by strong energy reduction goals established by its energy commission to reach 2% annual savings. Efforts have saved more than 8 million MWh, with expected savings of approximately $9 billion over the life of installed measures.
- Kentucky lost 4.5 points, dropping nine positions to 38th place, the largest rankings fall in 2019. Kentucky's point loss is due to the state public service commission's decision last year to discontinue almost all of Kentucky Power's demand-side management programs.

Source: ACEEE, EIA, BloombergNEF Note: Numbers in parentheses at the top denote the change in score from 2016 levels.

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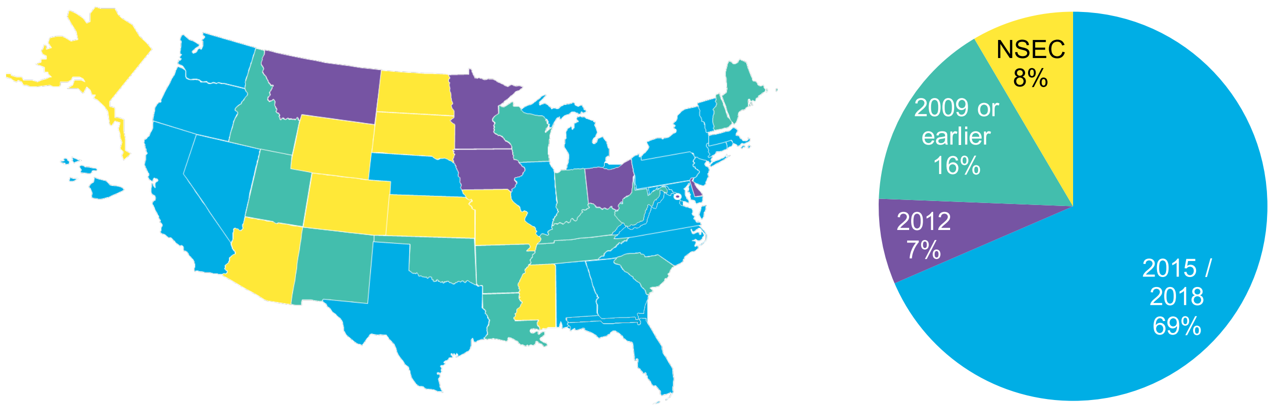
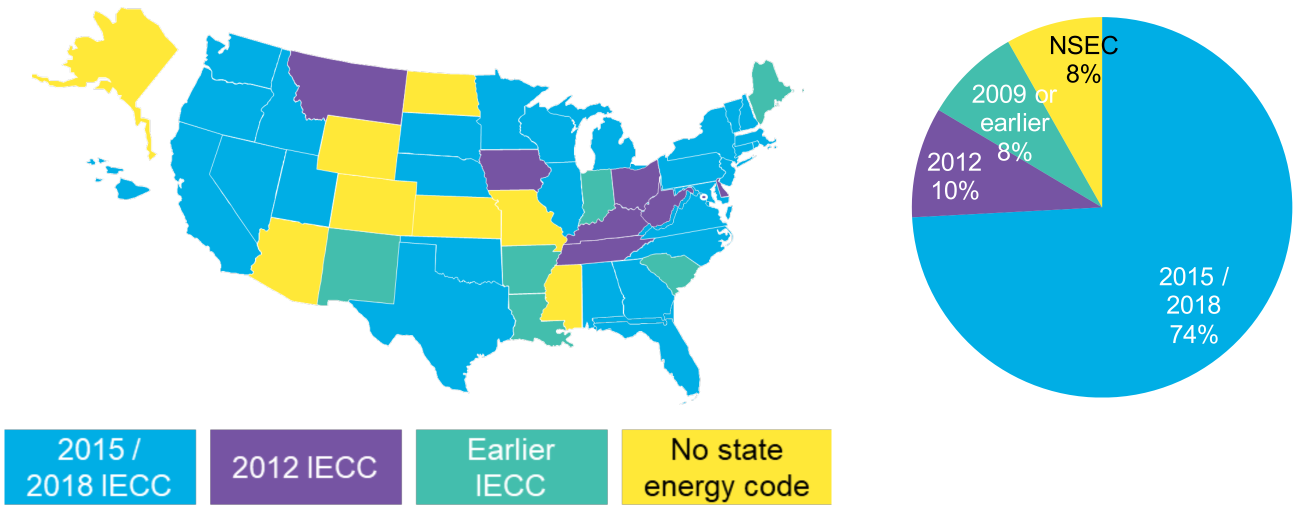
Policy: State adoption of building energy codes

Residential buildings, as a percentage of U.S. population



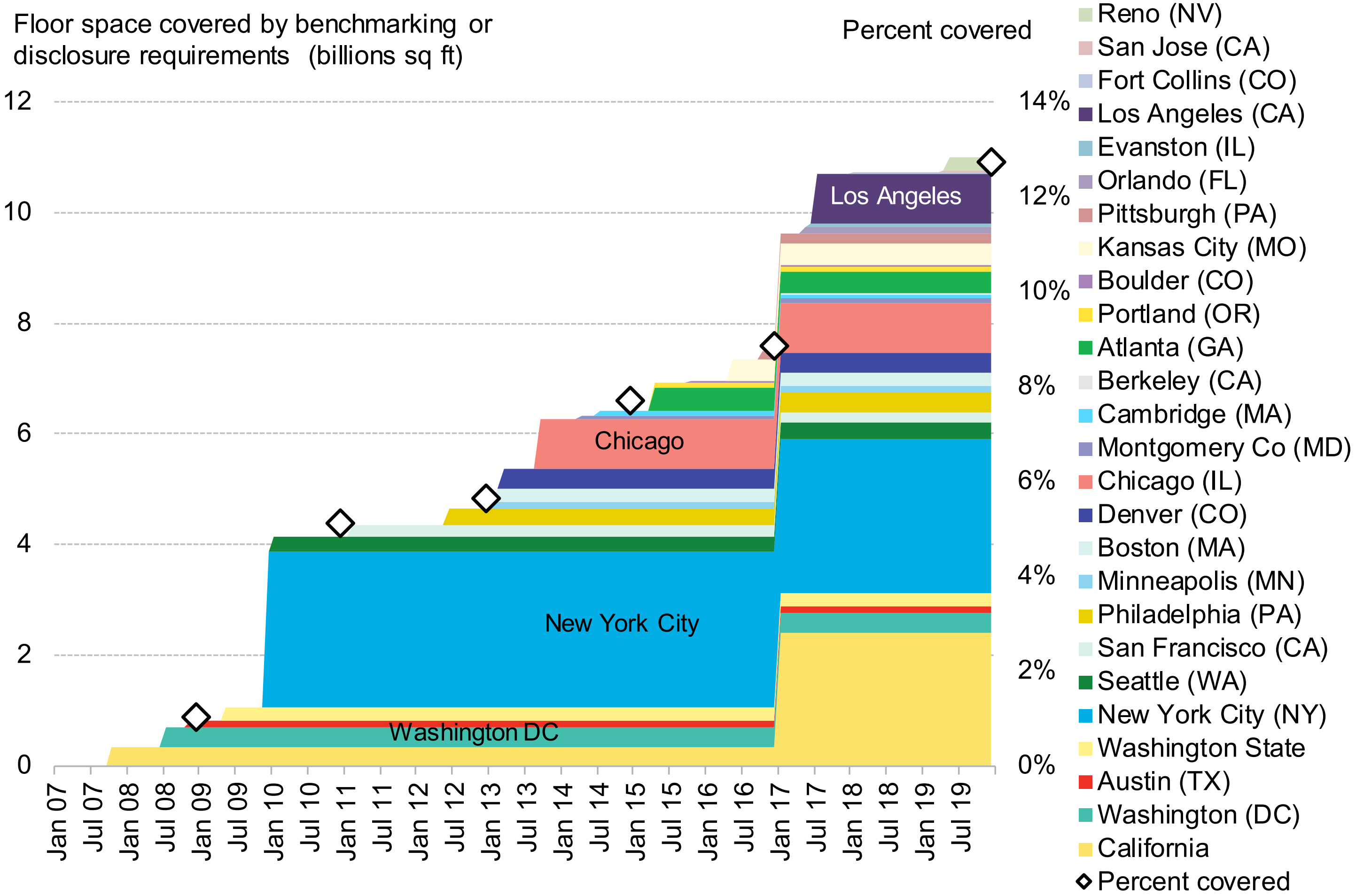
Commercial buildings, as a percentage of U.S. population



- The majority of states have adopted some version of the International Energy Conservation Code (IECC) for both residential and commercial buildings.
- The more populous states have adopted the 2015 and 2018 IECC. Even for states that are labeled as having "no state energy code," many jurisdictions within these states have adopted a recent version of the IECC.
- Over time, codes are updated and become more stringent. States that have adopted the most recent (2018) standard have stronger minimum requirements in place.
- Adoption of the two most recent versions of the IECC (i.e., 2015 and 2018) has increased from 46% of the U.S. population in January 2018 to 69% and 74% in January 2020 for commercial and residential buildings, respectively.
- 16% of the U.S. population still lives in an area where the residential energy code would be considered outdated (i.e., 2009 or earlier).

Source: U.S. Department of Energy, U.S. Census Bureau, BloombergNEF. Note: Current building energy codes use 30% less energy compared to typical codes that were in place less than 10 years ago.

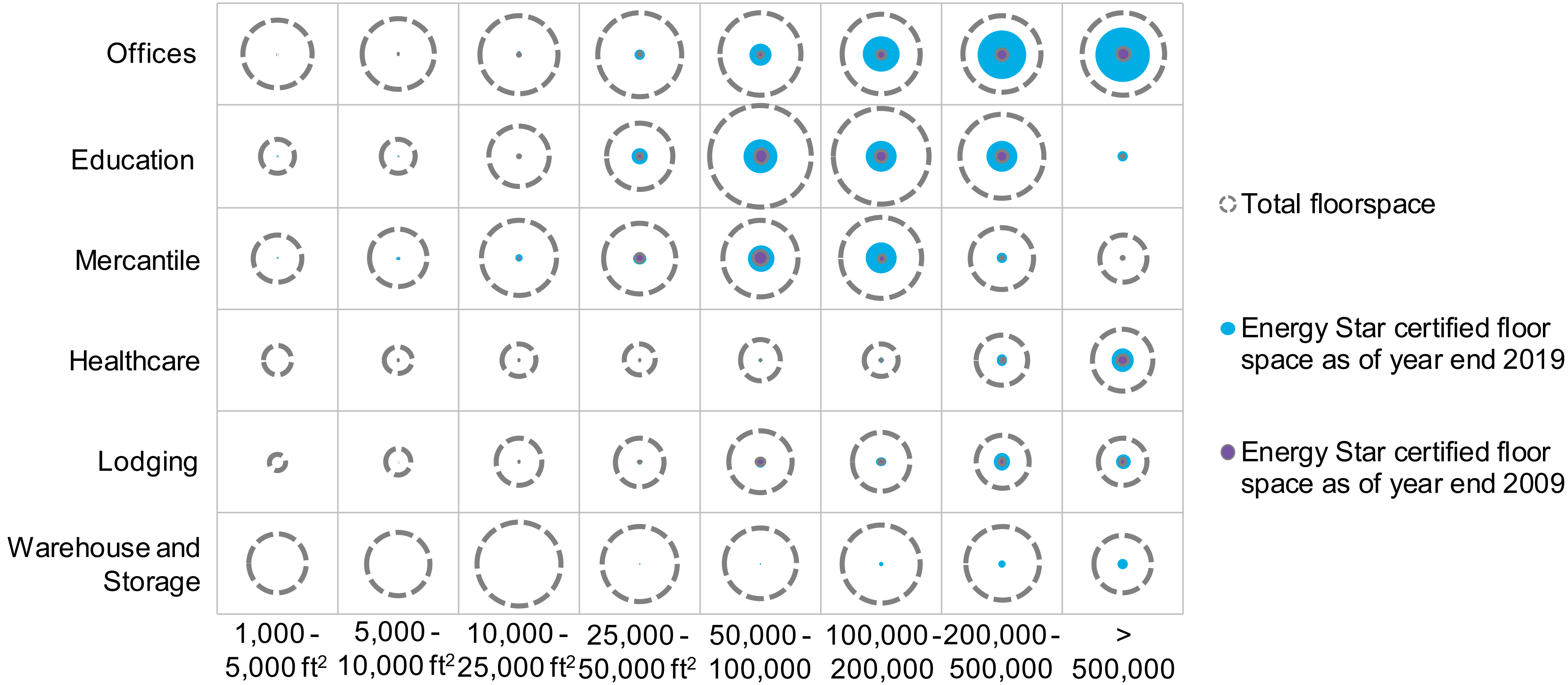
Policy: U.S. building floor space covered under state or local energy use benchmarking/disclosure policies



- To boost transparency of building energy usage, states and cities have created building energy use policies such as energy efficiency benchmarks and mandates. The square footage of commercial building space covered by such policies jumped from 9% in 2017 to 13% in 2019, covering around 11 billion square feet.
- California's existing law required utilities to begin disclosing whole-building aggregated energy use data to owners of commercial buildings and multifamily homes at the start of 2017. On the county level, San Jose passed new benchmarking laws that came into effect for multifamily, non-residential and public/government buildings in May 2019.
- Similar laws for Reno, Nevada also came into effect mid-2019.

Source: Institute for Market Transformation (IMT), U.S. DOE's Buildings Energy Data Book, BloombergNEF Notes: Accounts for overlap between cities and states (e.g., no double-counting between Seattle and Washington state). Assumes that the Buildings Energy Data Book's definition of floor space covered at least roughly corresponds to IMT's definition. Shaded areas show amount of floor space covered, diamonds represent percentage of U.S. commercial sector floor space covered.

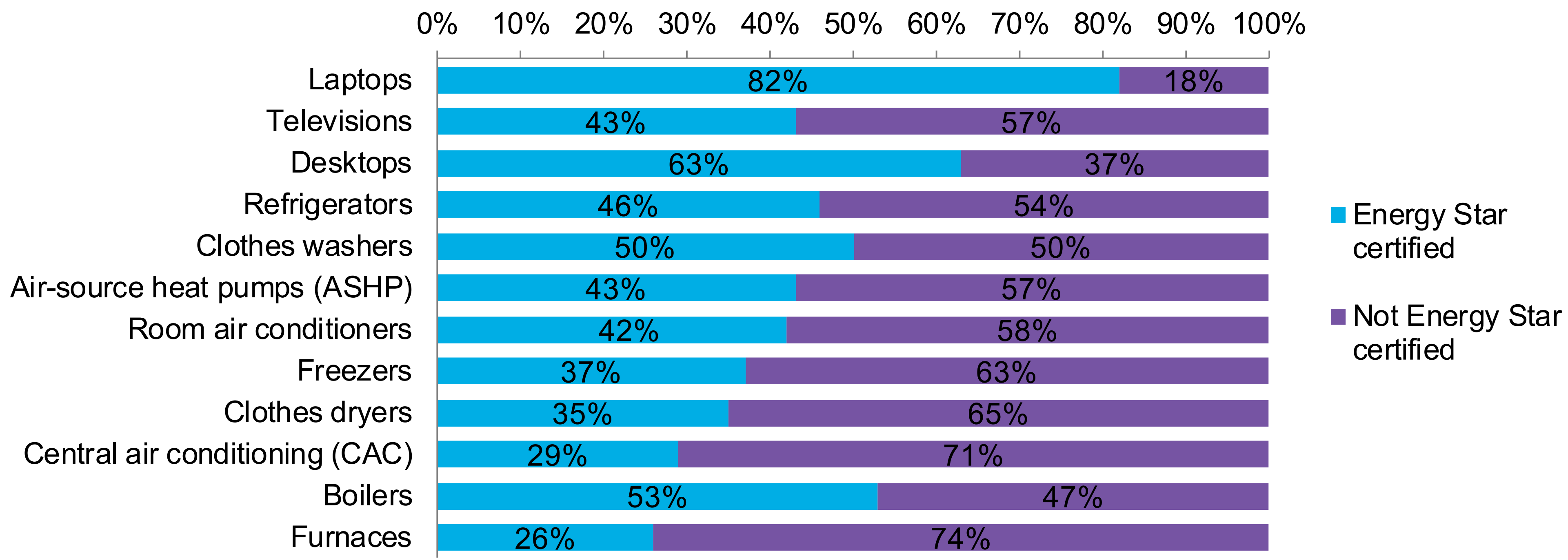
Deployment: Energy Star-certified floor space for U.S. commercial buildings



- Energy Star certification is highest in large buildings, particularly offices. This is unsurprising given that the scale of large buildings mean that certification can have a greater impact for the investment as would be the case for smaller buildings.
- Although the majority of early certification was in offices, the past decade has seen buildings used for education and retail emerge as important segments for certification. Large mixed-use buildings have the largest improvements from 2009, and saw a 37% jump in energy star-certified floor space since 2018.
- The challenge remains finding an effective strategy for increasing uptake in buildings below 50,000 ft^2, where uptake remains low.

Source: EPA, EIA, BloombergNEF Notes: There are insufficient data for total U.S. floor space of educational buildings in excess of 500,000ft^2.

Deployment: Energy Star-certified products sold by product type, 2018

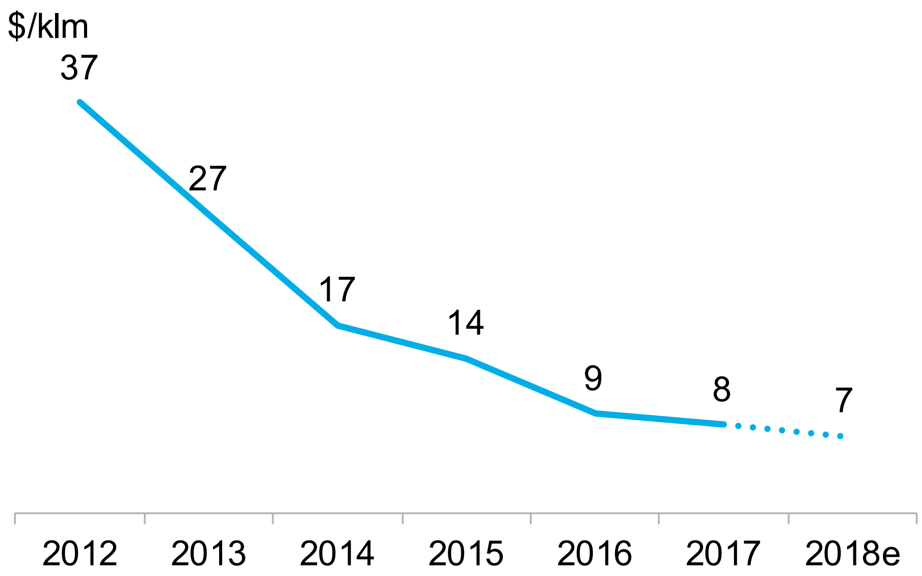


- Of the products above, laptop computers had the highest Energy Star rate of certification at 82% as of 2018 (the last year for which complete data are available). This is in contrast to desktop computers at 63%. Since 2017, the number of Energy Star-certified laptops has fallen while the number of Energy Star desktops has risen. Consumer preferences and demands for high functioning laptops may be behind the changes.
- Televisions also saw a dip in Energy Star-certified products, from 58% in 2017 to 43% in 2018.
- Air conditioning products have lower certification rates than other products, but made significant improvements in 2018. Central air conditioning was at 29% Energy Star certified in 2018 from 22% the year prior. Room air conditioning was at 42% in 2018 from 34% in 2017. Meanwhile, residential boilers and furnaces were at 53% and 26% Energy Star certification in 2018, respectively.
- Penetration rates can rise year to year due to factors such as increases in the number of Energy Star-certified products. They can fall with the introduction of new, more stringent certification standards or the introduction of new products that are not yet certified.

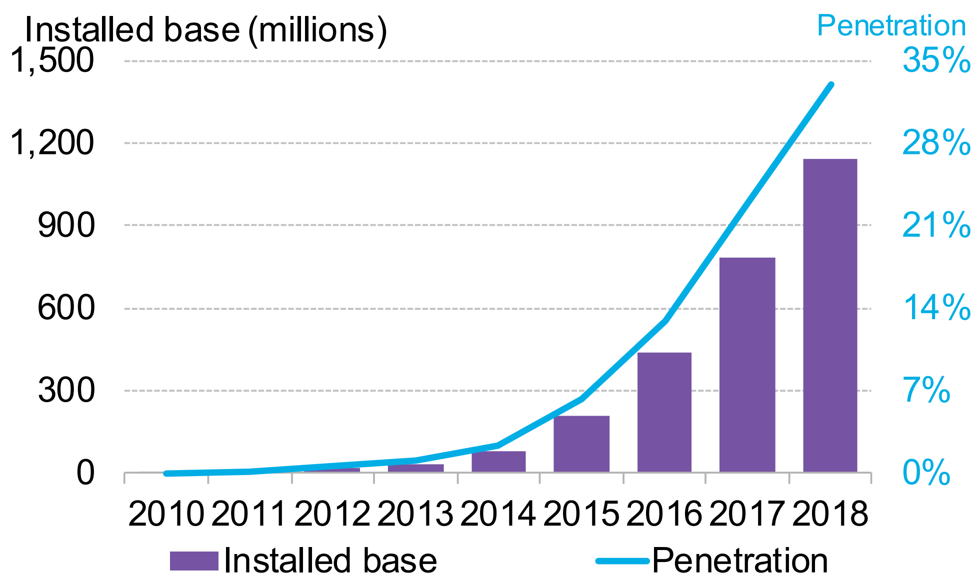
Source: Energy Star, BloombergNEF Note: Non-exhaustive selection of appliances; share of certified appliances sold is based on sales data compiled by Energy Star.

Deployment: Light-emitting diodes (LED)

LED price, A-type lamps



LED installed base and penetration, A-type lamps

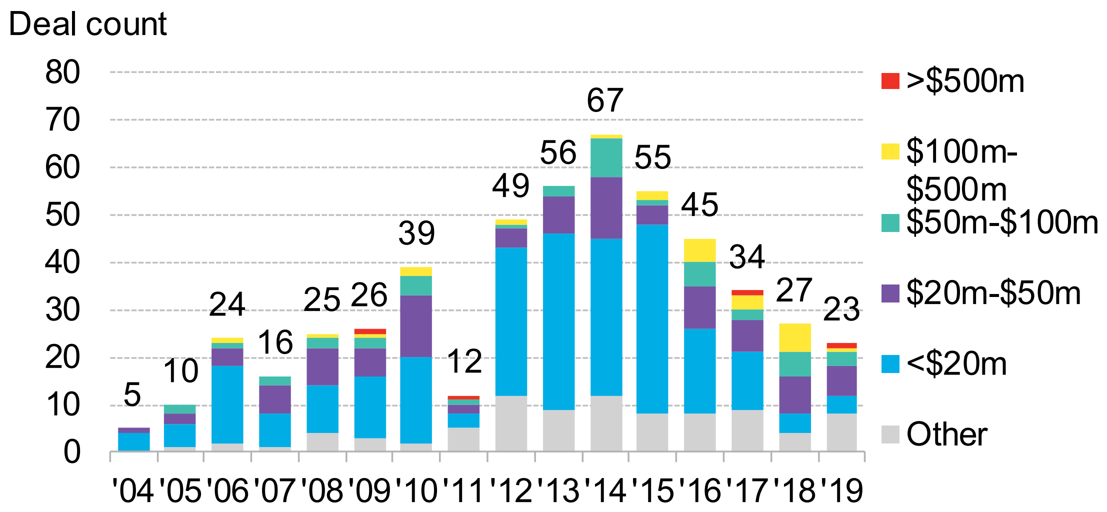


- The light-emitting diode (LED) is a technology that displaces incandescent bulbs, while providing longer lifetimes and significant energy savings for consumers. The A-type LED is the classic lamp used in most household applications. The installed base of LEDs has accelerated rapidly in recent years, climbing to 1.1 billion A-type units at the end of 2018, the latest year for which data are available. With an estimated 3.5 billion A-type lamps installed in the U.S., this represents a 33% penetration.
- As deployment has picked up, costs have fallen dramatically. Costs per kilo-lumen (klm) fell 75% from 2012 to 2017. Based on the installed base of 1,144 A-type lamps, BNEF estimates A-type lamp price to be $6.8/klm in 2018.
- Federal efficiency policies, utility energy efficiency programs (many, in turn, promoted by state policy) and federal R&D initiatives have helped spark LED uptake. LEDs also offer efficiency enhancement for connected and networked devices and “smart” buildings.

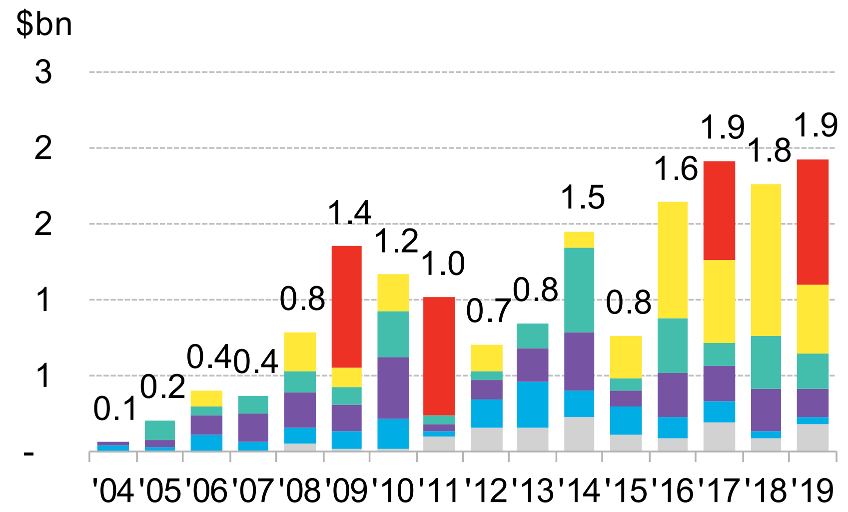
Source: Department of Energy. Note: Luminous flux differs from power (radiant flux) in that radiant flux includes all electromagnetic waves emitted, while luminous flux is weighted according to a model (a "luminosity function") of the human eye's sensitivity to various wavelengths.

Policy: U.S. federal energy efficiency contracts

Number of deals



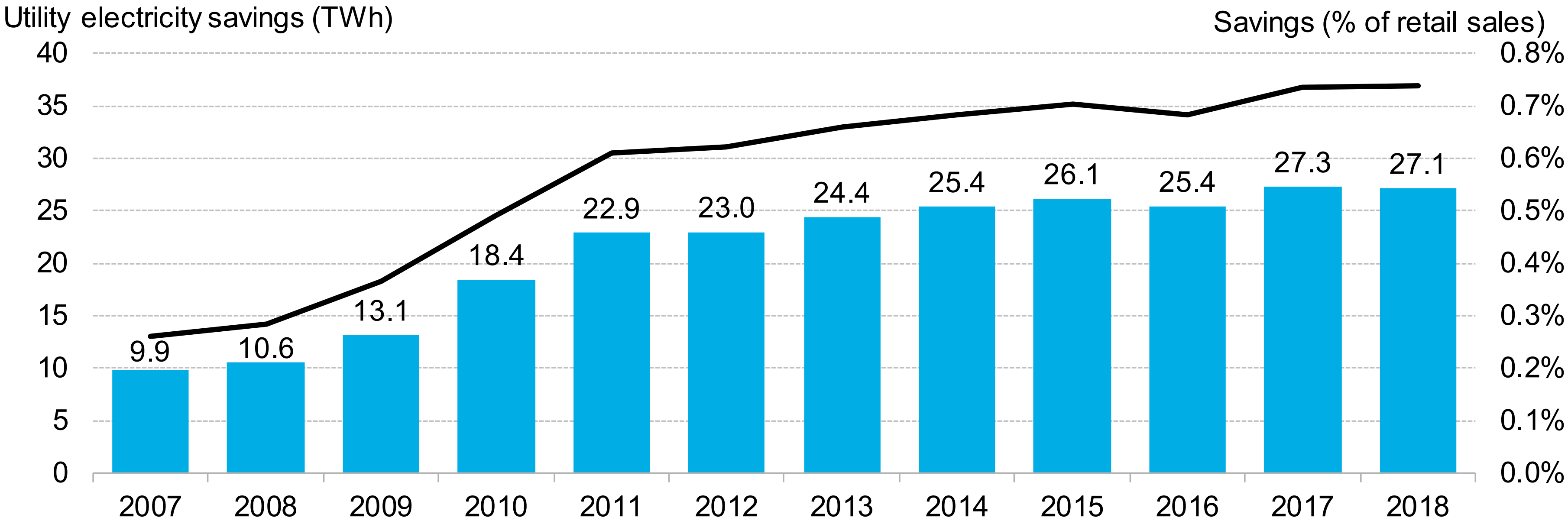
Total contract values



- Federal government entities signed $1.9 billion of energy efficiency contracts in 2019. These charts contain the most up-to-date energy service performance contract (ESPC) and utility energy service contract (UESC) data accounted for and made available by the federal government.
- Federal ESPCs and UESCs have average lifetimes of 16 and 15 years, respectively. These long time horizons (as compared to those under contracts in the commercial sector) are typical for government agencies.
- President Obama's efficiency targets set in 2014 marked a shift towards larger projects, particularly for ESPCs. While a third of the number of deals were struck in 2019 compared to 2014, the average deal size increased almost four-fold. Larger deals included more comprehensive energy efficiency retrofits, touching on multiple sectors of the energy economy.
- The largest project in 2019 was a nearly $830 million lighting, water and energy generation and distribution upgrade at a U.S. Navy base in Cuba.

Source: Federal Energy Management Program (FEMP), U.S. Department of Energy (DOE), USACE, BloombergNEF Notes: Totals here are summed in terms of calendar years in order to facilitate comparison with government targets, as opposed to DOE sources which commonly sum over fiscal years. The figures are the most comprehensive provided by the federal government but do not include data for every federal agency.

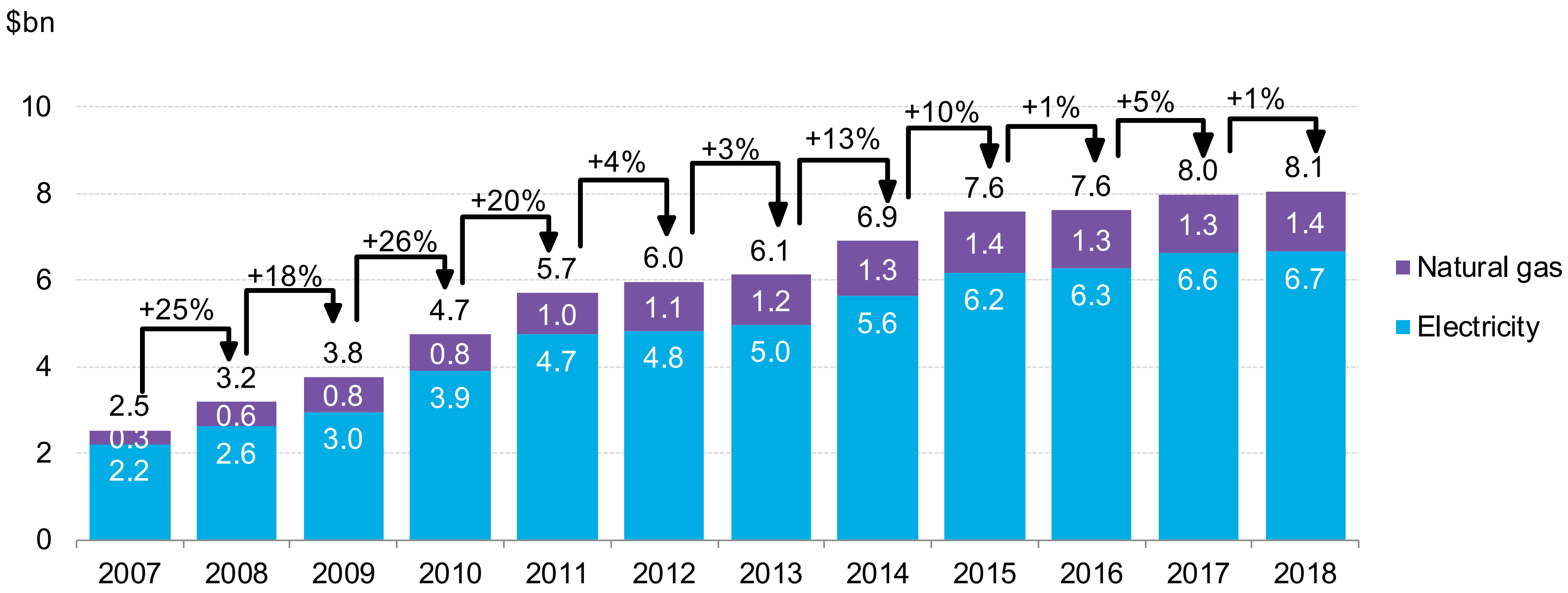
Deployment: Incremental annual energy efficiency achievements by electric utilities to date



- The years leading up to 2011 saw a growing number of states introducing Energy Efficiency Resource Standards (EERS) mandating utilities to invest in energy savings among their customer-base. There was a corresponding increase in investment in utility energy efficiency programs.
- Since 2011, the number of states with EERS policies in place has grown modestly, along with investment. 2018 utility energy efficiency savings decreased slightly by 1% from the previous year.
- As funding decreased, so did utility electricity savings. In 2018, of the 28 states that decreased their efficiency program spending, 19 states also saw a decrease in their electricity savings. The largest program reduction came from Kentucky, which cut $60m from its efficiency spending and had a 224GWh decrease in electricity savings.
- The ACEEE, which collects these data, attributes the difference to adjustments in its qualifying criteria for utility energy efficiency savings, rather than a decrease in energy efficiency activity.

Source: ACEEE Note: The ACEEE Scorecard points to caveats in the energy efficiency savings data reported by states. ACEEE uses a standard factor of 0.9 to convert gross savings to net savings for those states that report in gross rather than net terms.

Financing: U.S. utility energy efficiency spending

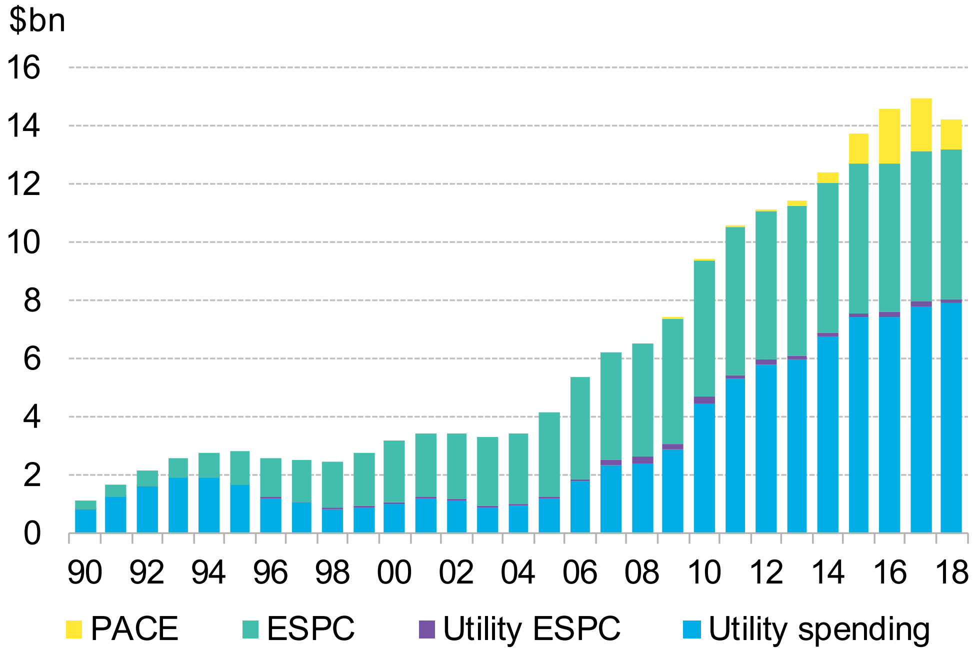


- In 2018, utility spending on energy efficiency kept pace at $6.65bn for electricity and $1.4bn for natural gas. Total spending was just 1% higher than the previous year.
- While investment stayed steady nationwide, the picture was more dynamic at the state level. California invested the most in both natural gas, $380 million, and electricity, $1.4 billion. New York saw the largest jump in electric program spending by $183.4 million (+41%), and California saw the largest jump in gas program spending, $75.9 million (+27%).
- 11 states cut their efficiency budgets by more than 10% in 2018. Kentucky was the largest, dropping its by $25.4 million (-70%). It was followed by Alabama (down $5.4 million, -68%), Tennessee (-$24.3 million, -59%) and Mississippi (-$18.8 million, -37%).

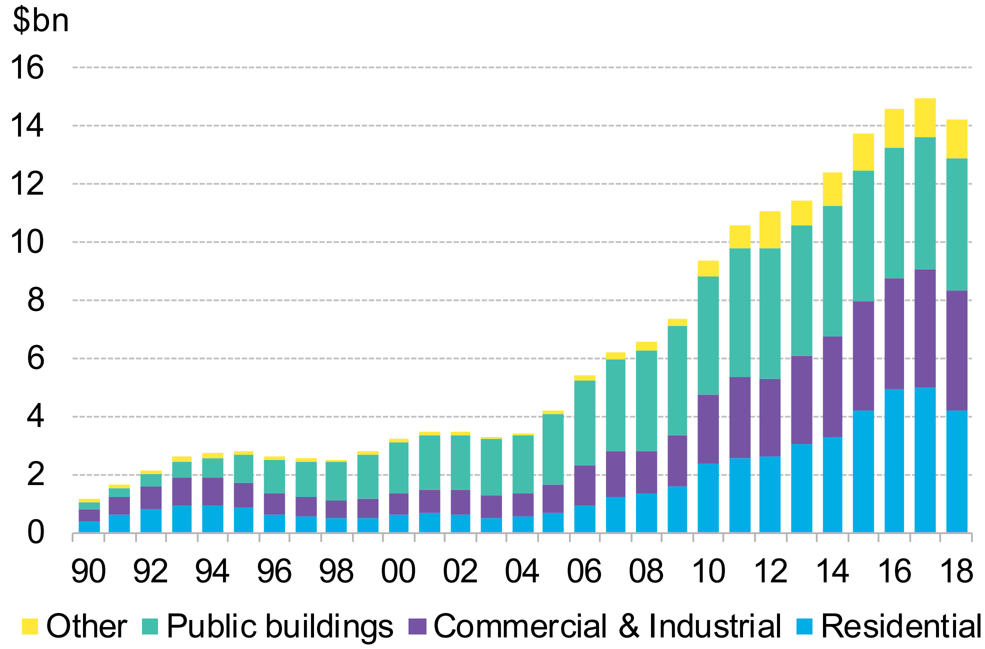
Source: CEE, ACEEE, BloombergNEF. Note that data for 2010-14 were sourced from CEE, and for 2006-2009 and 2015-19 from the ACEEE.

Financing: U.S. estimated investment in energy efficiency through formal frameworks

By framework



By sector



- Total U.S. spending on energy efficiency through formal frameworks fell to an estimated $14.2 billion in 2018, 5% off 2017's peak.
- Utility spending and Energy Savings Performance Contracts (ESPC) remain the most important frameworks. The Property Assessed Clean Energy (PACE) mechanism had been the fastest source of growth from 2013-2016. The 2018 PACE drop was partially offset by a 1% boost in utility spending on energy efficiency.
- While our estimate for ESPC investment has leveled off in recent years, there is a certain amount of extrapolation involved due to the lack of detailed data on the market.

Source: ACEEE, NAESCO, LBNL, CEE, IAEE, PACENation, BloombergNEF Notes: The values for the 2015-18 ESPC market size shown are estimates. The most recent data from Lawrence Berkeley National Laboratory report revenues of $5.3bn in 2014. The 2015-18 estimates are based on a continuation of 2011-14 growth rates.

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Table of Contents

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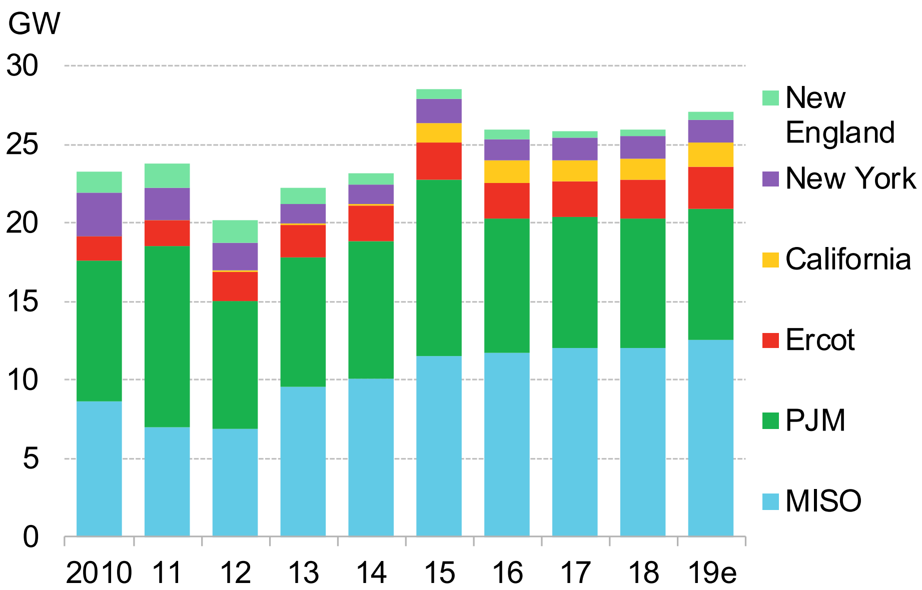
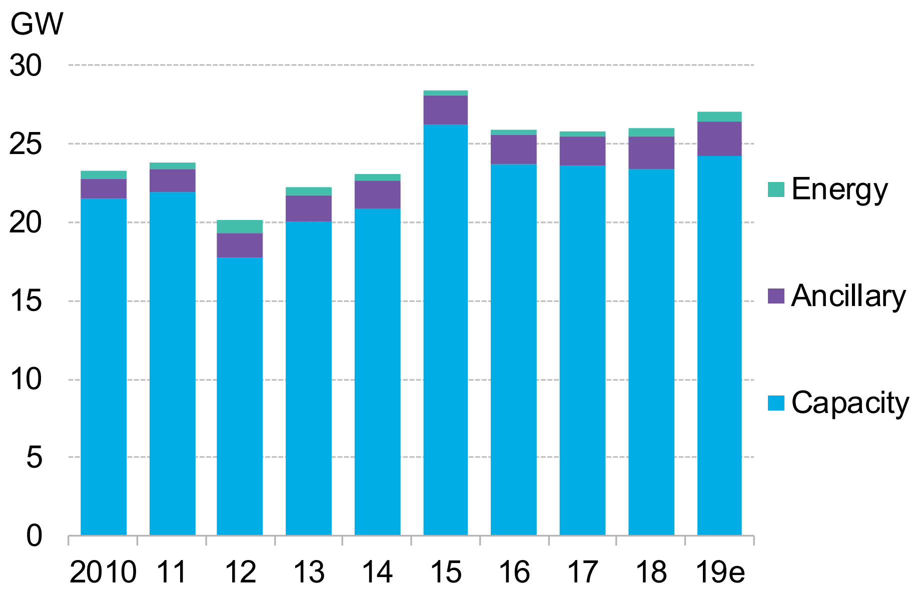
Deployment: U.S. wholesale demand-response capacity

By market



By application



- Demand response (DR) capacity in U.S. wholesale markets grew in 2019 for the second straight year. There were gains in MISO, PJM, Ercot, California and New England, which more than offset a decline in New York. In California, the demand response auction mechanism more than doubled to 373MW. Ercot increased the cap on DR in its reserve market from 50% to 60%. Interruptible load programs managed by utilities in MISO grew in size.
- The vast majority of wholesale demand response is concentrated in capacity markets and reliability mechanisms. Even in Ercot, which has no formal capacity market, 991MW of DR has been contracted through its capacity-style Emergency Response Service. Ercot accounts for 75% of the DR capacity providing ancillary services in U.S. wholesale markets and all of its growth. After two years of growth, 1.7GW of demand response provides reserves and frequency regulation in Ercot.

Source: BloombergNEF. Note: Demand response was only formally integrated with the CAISO market in 2015.

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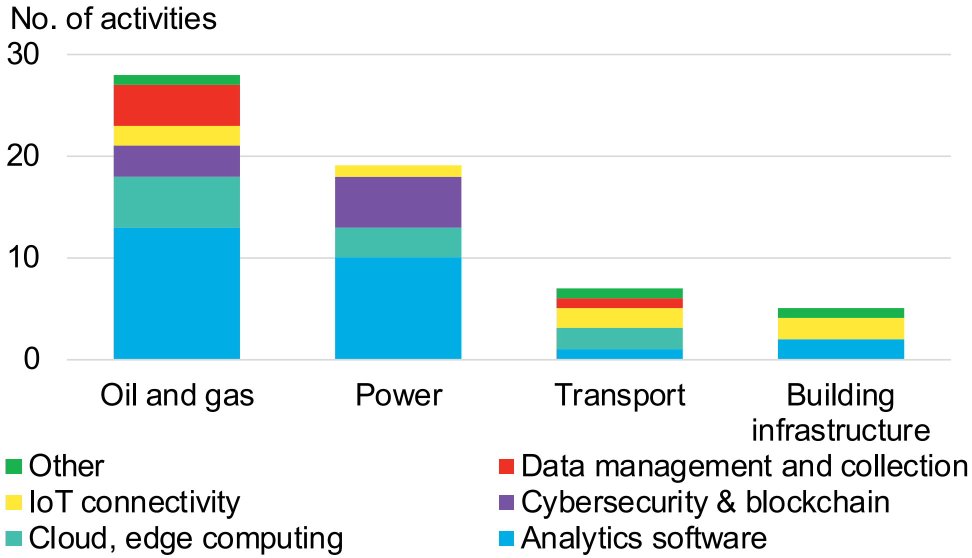
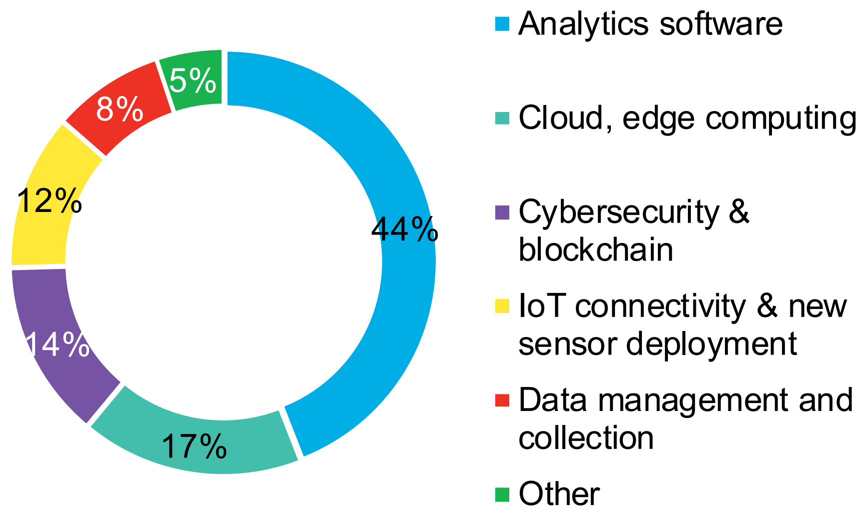
Deployment: Progress in the digitalization of the energy sector

Industrial digitalization activity by sector and technology, 2019



Most common technologies adopted in U.S. industrial digitalization for energy, 2019

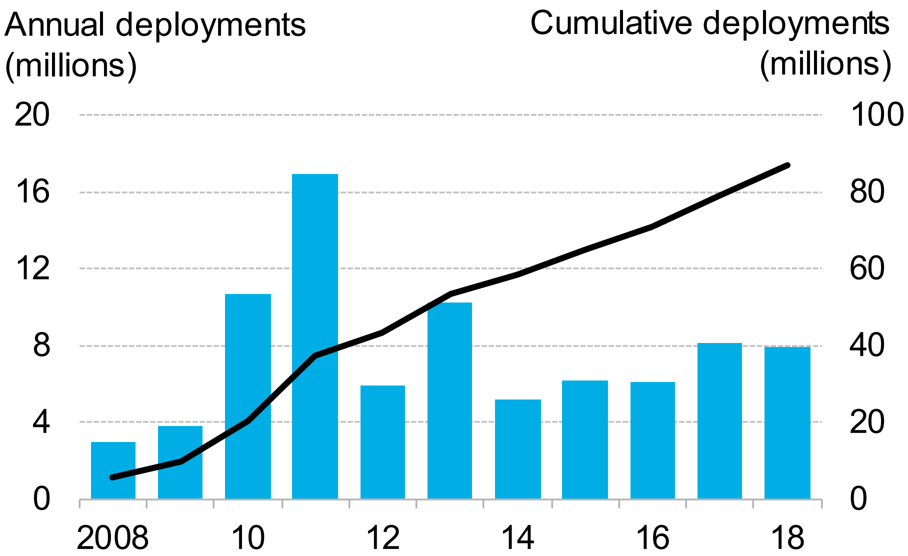


- Microsoft, Schlumberger and Honeywell were the top three companies announcing the highest number of digital projects and partnerships in 2019.
- The oil and gas sector was the most active in 2019, reflecting a global trend. In the U.S., energy companies are fast adopting smart meters, IoT sensors, analytics platforms, cloud computing, drones and other technologies. While oil companies such as Chevron and Exxon are behind their European peers, they are still looking to digital technologies to improve upstream profits and reduce oil refinery downtime. In the power sector, utilities such as Edison, Ameren, Southern and NYPA are all building smart grid technologies and working with software providers like GE, Schneider Electric, Siemens, and startups to reap the benefits of reduced operating costs, less outages, and fewer truck send-outs.
- However, regulated utilities have not been the most active corporations in announcing new projects because they cannot as yet rate-base any cloud computing or other software purchases, making them slower to adopt large digital projects compared to European and Asian peers.

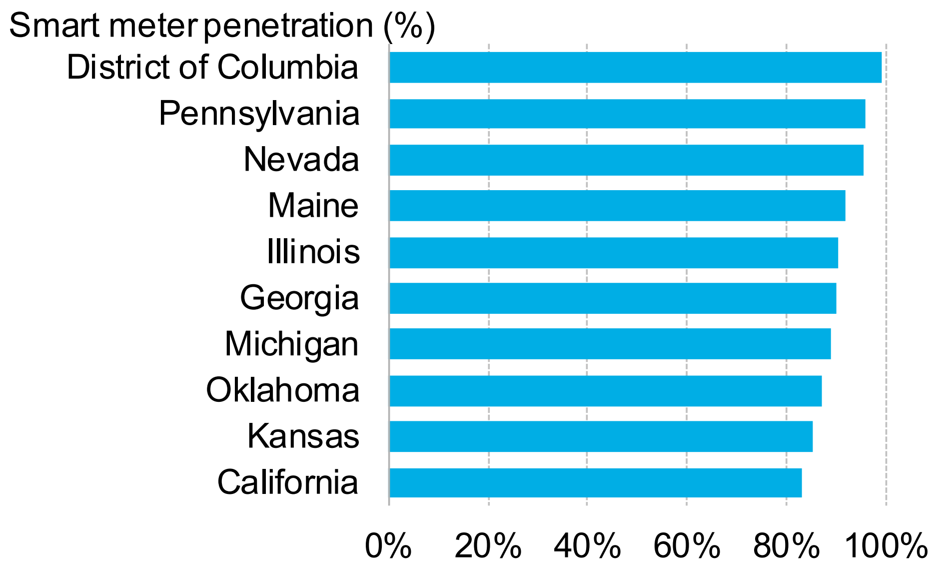
Source: BloombergNEF

Deployment: U.S. smart electricity meter deployments

U.S. smart meter deployments



Top 10 states by penetration, 2018



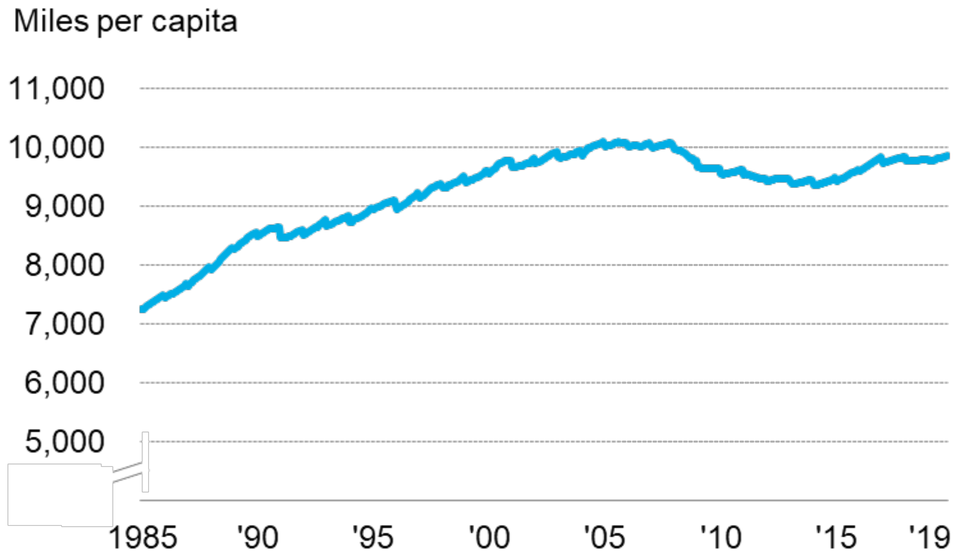
- Smart meter installations hit a peak in 2011, supported by stimulus funding awarded in 2009. Many of the largest U.S. utilities took advantage of the Smart Grid Investment Grant to roll out smart meters across their territories. As grant funding dried up, deployments slowed, hitting a trough in 2014. Smart metering activity has since picked up though it remains well below the peak of 2011.
- At the end of 2018, 56% of U.S. electricity customers had a smart meter, but with enormous regional variation. The top 10 states all had penetration greater than 80% whereas 20% or fewer customers had smart meters in the bottom 10 states. In 2018, smart metering markets in North Carolina, Pennsylvania, Illinois, Washington, Oregon and Ohio saw the most action, each deploying over a half a million.

Source: BloombergNEF, EIA. Note: there is a 10-month lag in official smart meter statistics.

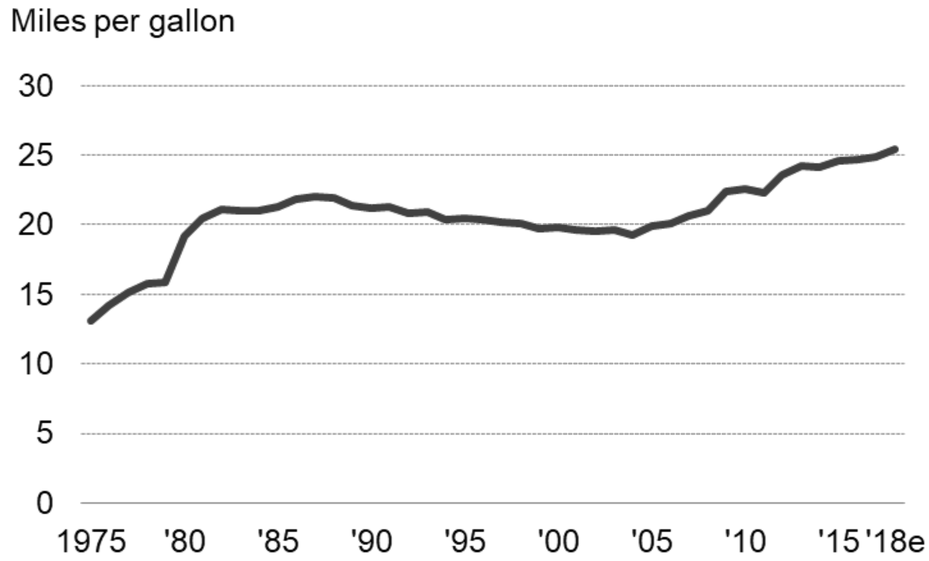
Table of Contents

Deployment: U.S. gasoline consumption and fuel economy

U.S. vehicle miles traveled, per capita



U.S. light-duty vehicle real-world fuel economy

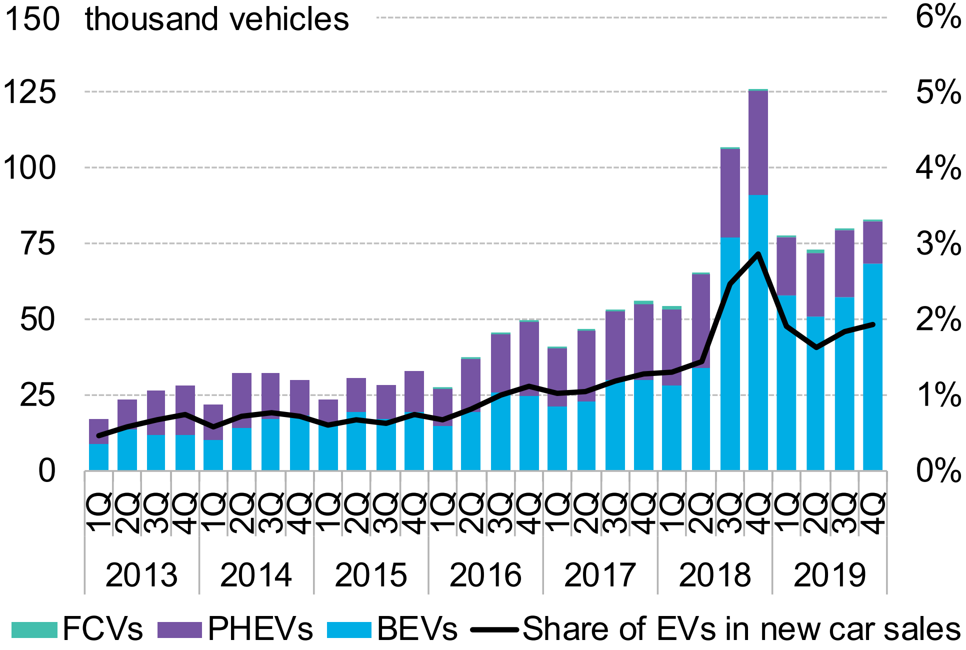


- Vehicle miles traveled per capita held fairly steady in 2019. Americans are driving 2% less than 2004's record, but total miles traveled have risen 5.2% from the trough hit in 2014. Lower fuel prices have helped spur the increase: gasoline prices in November 2019 sat 10% below their recent 2014 peak of $3.00/gallon, and 35% below the all-time high reached in 2008 of $4.11/gallon.
- Average U.S. light-duty vehicle fuel economy was expected to hold flat at around 25 miles per gallon (mpg) in both 2017 and 2018. Despite 2018 gas prices hitting their highest levels since 2014, Americans continued to purchase heavier, less fuel-efficient vehicles. Sport-utility vehicle sales increased 8.4% from 2017 to 2018, on top of increasing 5.8% from 2016 to 2017. Meanwhile, large, medium and small passenger car sales fell in both of those time frames.

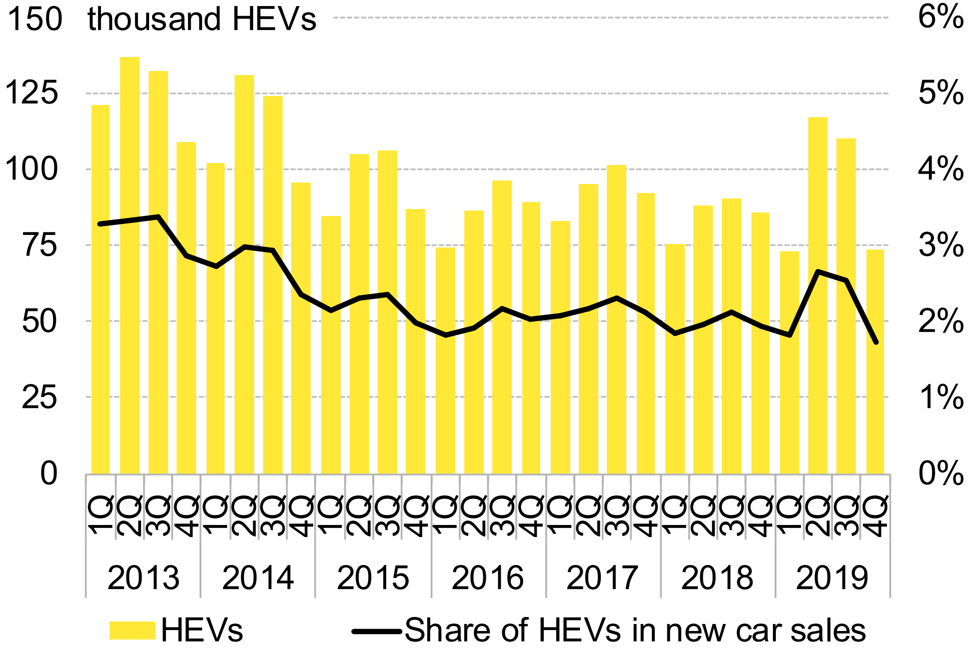
Source: Federal Highway Administration, Census.gov, EPA, DOE, Marklines, BloombergNEF   Note: Miles per gallon are estimated real-world fuel economy as calculated by the EPA.

Deployment: Electric vehicle and hybrid electric vehicle sales in the U.S.

U.S. electric vehicle and fuel cell vehicle sales



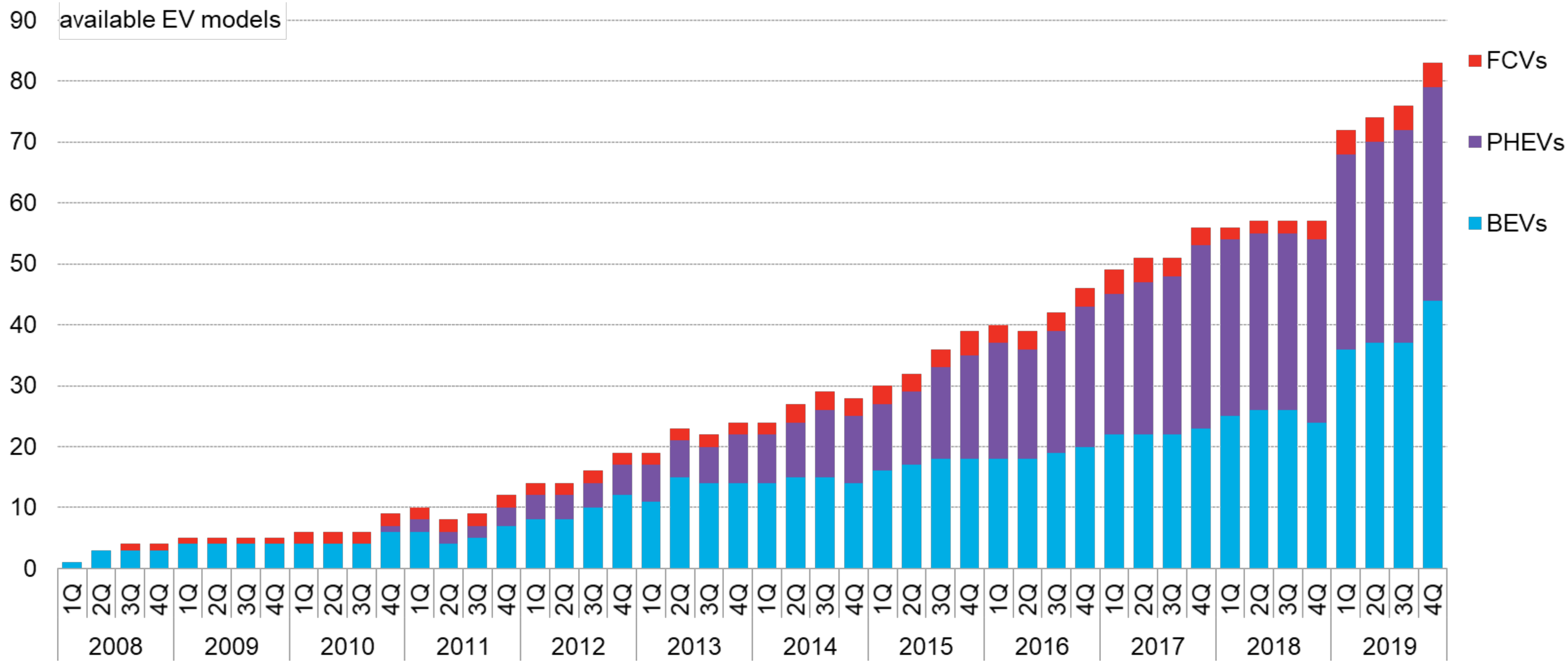
U.S. hybrid-electric vehicle sales



- Annual sales of electric vehicles (EVs) – a category that includes battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs) – slipped 11% in 2019, falling from 350,000 units in 2018 to 311,000 units. EVs accounted for 2% of total vehicle sales in 2018 and 1.8% in 2019.
- The Tesla Model 3, which sold 146,000 units, was the top-selling EV by a wide margin, and Tesla – which sold 179,000 BEVs in total – accounted for nearly 58% of overall U.S. EV sales in 2019.
- BEV sales rose 2% year-over-year to approximately 235,000 units in 2019 but PHEV sales fell 36% year-over-year to 76,000 units.
- Sales of hybrid electric vehicles (HEVs) reached 373,000 units in 2019 – a 10% bump compared to 2018. Sales of fuel cell vehicles (FCVs), meanwhile, slipped 12% compared to 2018 to just 2,090 units.

Source: BloombergNEF, Bloomberg Terminal, Marklines, California Fuel Cell Partnership. Note: PHEV stands for plug-in hybrid electric vehicle, BEV stands for battery electric vehicle, HEV stands for hybrid electric vehicle and FCV stands for fuel cell vehicle. EV includes BEVs and PHEVs. FCV sales data not available prior to 2016. FCV sales numbers too low to be visible.

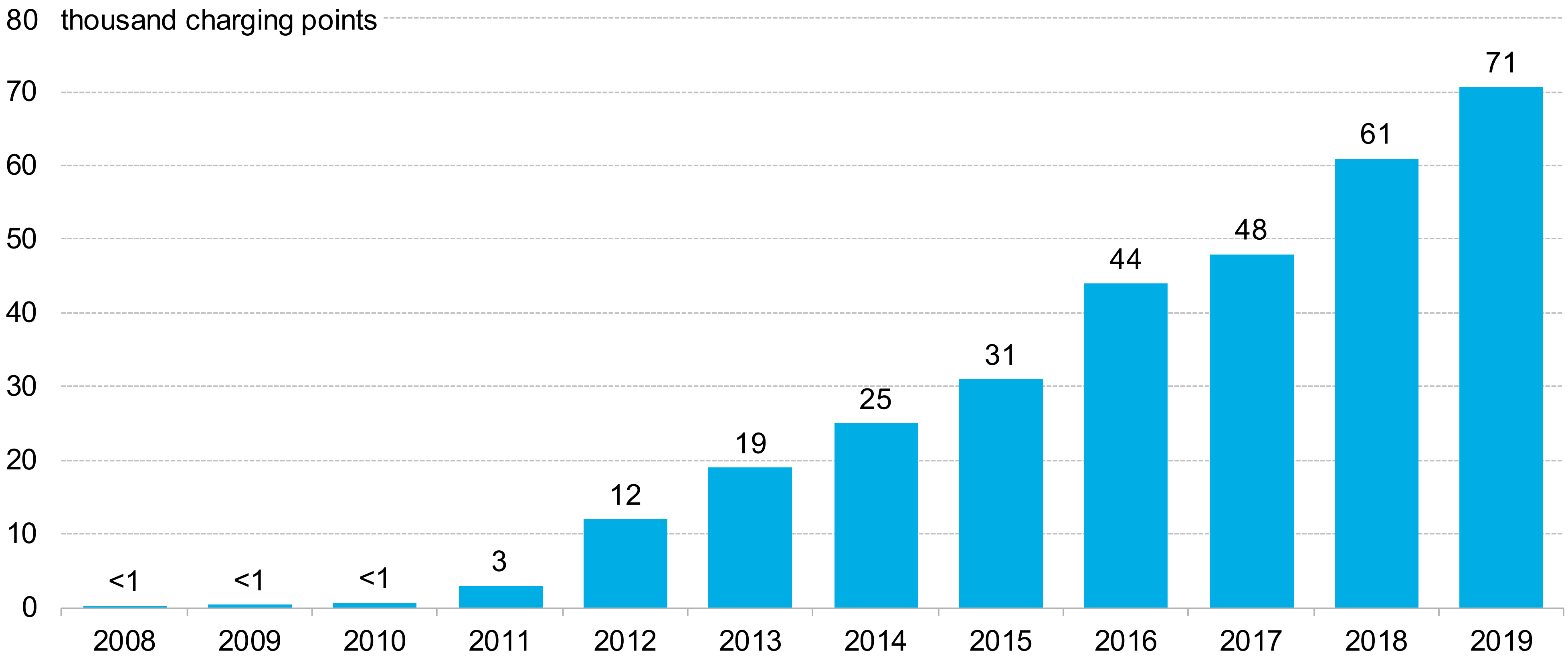
Deployment: EV and FCV model availability in North America



- By year-end 2019, North American consumers could choose from four FCV, 35 PHEV and 44 BEV vehicle models.
- The availability of BEVs has more than doubled in absolute terms, growing from 18 in 1Q 2016 to 44 in 4Q 2019. Having taken market share from PHEVs, BEVs now account for over half of all EV and FCV models on offer.
- New EVs launched in 2019 included the Kia Niro (BEV), Hyundai Kona (BEV), Audi e-tron (BEV) and Subaru Crosstrek (PHEV).

Source: BloombergNEF, Marklines. Note: EV includes BEVs and PHEVs. FCV stands for fuel cell electric vehicle, PHEV stands for plug-in hybrid electric vehicle and BEV stands for battery electric vehicle. Data as of November 26, 2019.

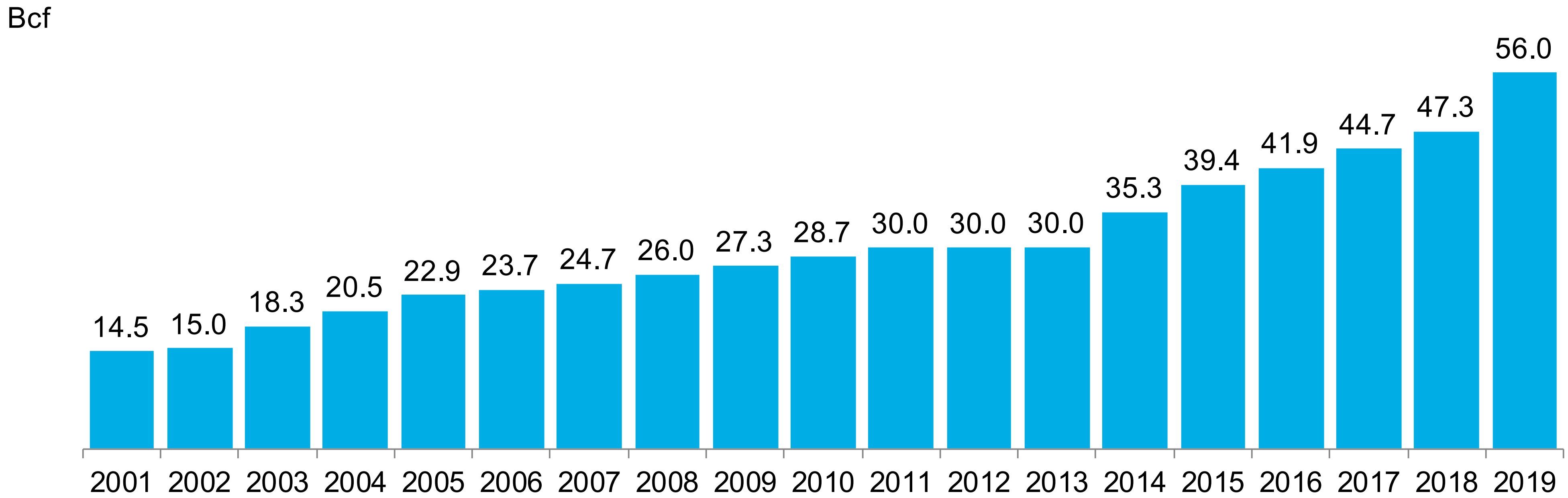
Deployment: Public EV charging points in the U.S.



- As of year-end 2019 there were approximately 71,000 public and workplace EV charging points in the U.S., an increase of nearly 17% over 2018. About 81% of these EV charging outlets are Level 2. Another 17% are fast or ultra-fast and the remaining 2% are Level 1.
- As in 2018, about one third of the EV charging outlets are in California. The number of EV charging outlets is much lower in other states.
- Consumers still regularly cite range anxiety as a barrier to purchasing electric vehicles. However, the majority of EV charging in the U.S. continues to take place at home, usually with Level 1 or Level 2 chargers.

Source: BloombergNEF, U.S. Department of Energy. Note: Data do not include residential EV charging infrastructure.

Deployment: Natural gas demand from natural gas vehicles on U.S. roads

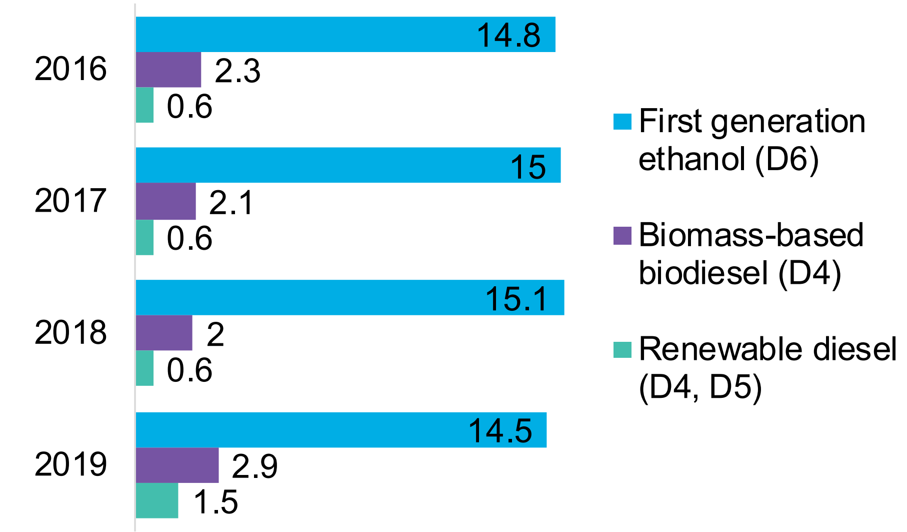


- Natural gas use in vehicles has grown steadily since 2013, and jumped 18% in 2019 from the year prior to reach 56Bcf. This represents a 7.5% compound annual growth rate over the last decade. A consumption uptick in 2014 coincided with the start of a period of low natural gas prices across the U.S. Natural gas accounts for about 3% of total transport fuel consumption in the U.S.
- Compressed natural gas (CNG) remains more widely used than liquefied natural gas (LNG), and this is reflected in the amount of fueling infrastructure available for each technology. As of October 2019, there were 1,591 CNG stations across the U.S., compared to 119 LNG stations (including public and private stations).
- The number of CNG stations shrank by 4% from 2018, and the number of LNG stations fell by an even steeper 13%. Comparatively, there are currently 3,118 propane fueling stations in the U.S., 818 of which are primary propane stations.

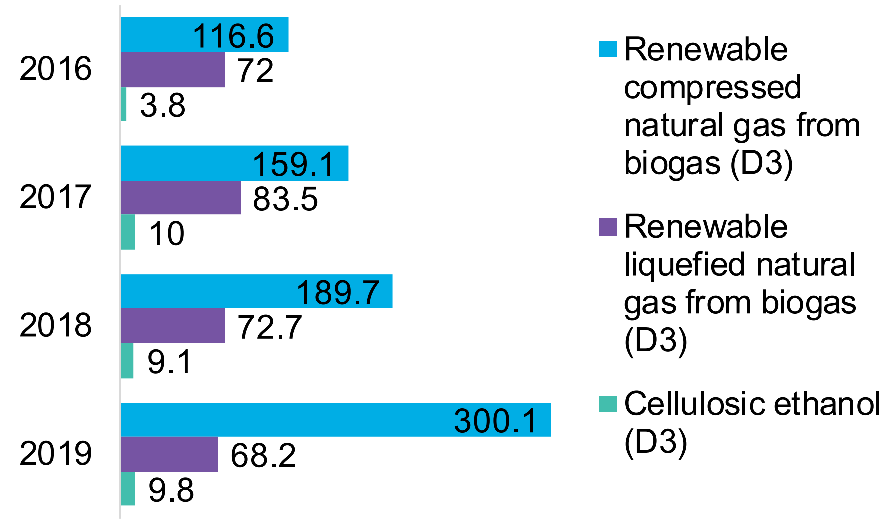
Source: EIA, natural gas monthly Notes: Values for natural gas demand in 2019 are projected, accounting for seasonality, based on latest monthly values from EIA (data available through September 2019). Data exclude gas consumed in the operation of pipelines.

Policy: Volumes of biofuels blended under the federal Renewable Fuels Standard

First generation biofuels (billion gallons)



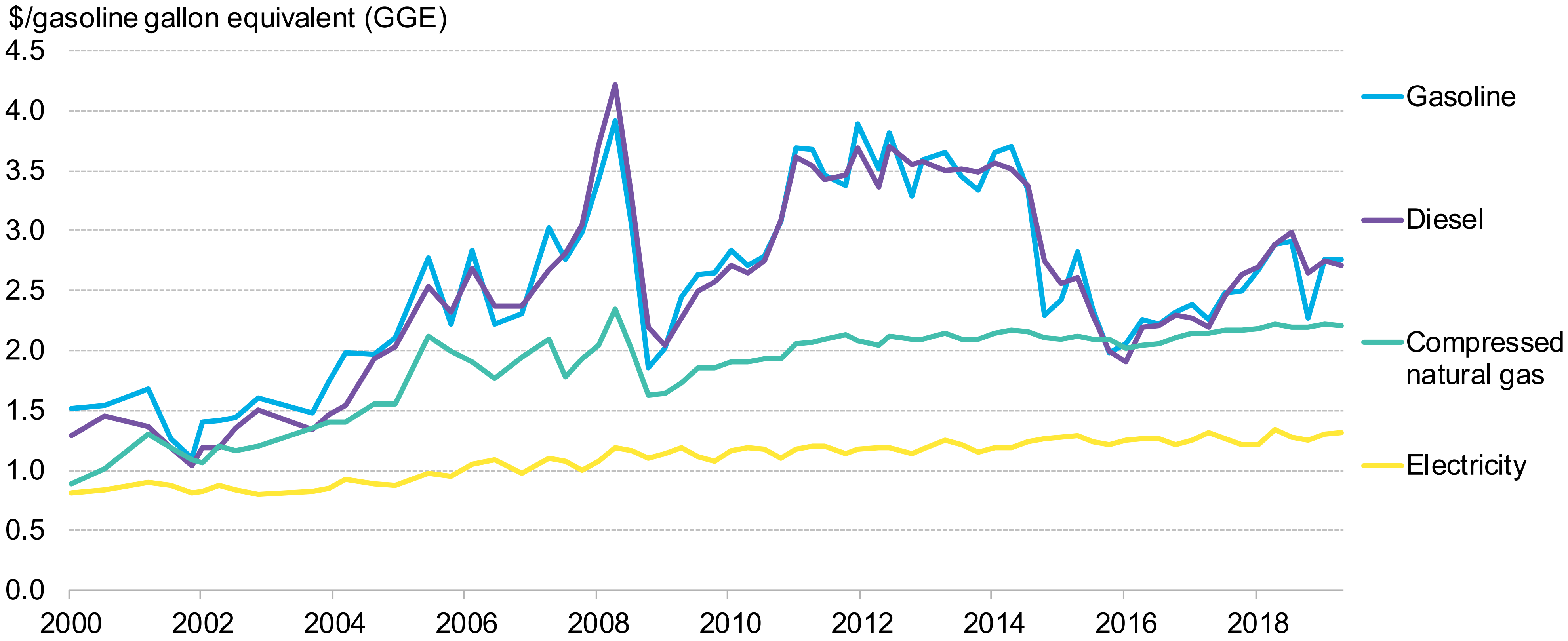
Next generation biofuels (million gallons)



- Biofuel blending into gasoline and diesel is mandated by the Renewable Fuel Standard 2 in the U.S., which currently has targets set through 2022. The EPA administers the program and sets annual blending targets split by fuel type.
- Each gallon of biofuel receives a renewable identification number (RIN) upon blending, which the blender can count towards annual mandated targets or sell to other blenders who otherwise would not meet targets. In 2019, prices for biomass-based diesel and advanced biofuel RINs peaked at about $0.64 per gallon in November before declining sharply in December on oversupply concerns
- Of higher value are cellulosic or “next generation” biofuels: cellulosic ethanol, diesel and biogas (including renewable natural gas), which are made from non-food feedstocks and possess low carbon footprints. Cellulosic RINs (D3) averaged more than $1.10 per gallon in 2019.
- The biofuel mandate for 2020 includes a 590-million gallon target for cellulosic biofuels, a sharp increase from 2019’s level, while conventional biofuels remain unchanged.

Source: BloombergNEF, EPA Notes: Fuels under the RFS2 are categorized by fuel type. D3 stands for cellulosic biofuels, D4 for biomass-based diesel, D5 for advanced biofuel, D6 for renewable fuel. See the EPA's website for more information.

Economics: Average gasoline, diesel, natural gas and electricity prices for vehicles in the U.S.



- Electricity has been the most competitive fuel for transportation in the U.S. for over a decade, remaining well below gasoline prices. In 2019, this discount remained greater than 20%. This can help overcome the larger upfront cost of a battery-electric vehicle.
- Compressed natural gas (CNG) enjoyed a substantial discount to diesel and gasoline from 2010-2014, but falling crude oil prices erased this gap in 2015 and 2016. As of July 2019, CNG prices had around a 25% discount to diesel and gasoline prices.
- Electricity and CNG prices are generally less volatile than gasoline and diesel prices.

Source: BloombergNEF, U.S. Department of Energy. Note: Data as of July 1, 2019. Note: Under DOE methodology, electric prices are reduced by a factor of 3.4 because electric motors are 3.4 times more efficient than internal combustion engines.

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