2019

Sustainable Energy in America

Factbook

Natural Gas + Renewable Energy + Energy Efficiency

GROWTH SECTORS OF THE U.S. ENERGY ECONOMY

BloombergNEF

The Business Council for Sustainable Energy®

GET THE FACTS

www.bcse.org

Overview

The 2019 Sustainable Energy in America Factbook is the seventh in a series documenting the revolution in energy production, delivery and consumption in the U.S. This installment documents the events of 2018 – a year in which faster U.S. economic growth rippled through nearly every aspect of the energy sector and volatile weather conditions impacted consumption patterns.

The U.S. economy in 2018 expanded at its fastest pace in five years and for the first time in several years, energy consumption actually grew at a faster clip than GDP, based on data through the first 10 months of the year. Extreme weather boosted demand for both heating and cooling in the buildings sectors as the U.S. set a record for the most "cooling-degree days" (as defined by the Energy Information Administration) since at least 1990. CO2 emissions rose 2.5% but would have grown faster had the power sector not continued cutting its carbon intensity. Energy consumption related to transportation also rose, but at a more modest pace.

A boom in natural gas power plant completions – the largest single-year addition in 14 years – allowed natural gas to reach 35% of the nation's electricity mix, a record. Generation from renewables rose 5.1% in absolute terms, as output from new wind and solar farms offset a modest contraction in hydroelectric output. Renewables including hydro now provide 17.7% of U.S. power. Coal's role in U.S. energy waned again in 2018, dropping to only 27% of the power generation mix – the lowest share in the post-war era.

States in 2018 continued to take the lead in establishing policies to support the growth of sustainable energy by establishing new, ambitious clean energy targets and regulations. At the federal level, agencies sought to provide financial support to uneconomic coal and nuclear units, announced plans to roll back efficiency and emissions standards across various sectors, and proposed to freeze vehicle fuel efficiency standards at 2020 levels. The administration auctioned off offshore wind development leases along the east coast. Congress extended tax credits supporting some sustainable energy technologies.

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 2018 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 **seventh edition** (first published in January 2013)

What's new?

- **New coverage:** This year's report contains additional content not shown in last year's edition, including data on corporate actions on renewable energy and energy efficiency, renewables-plus-storage projects, and green bonds. It also contains an expanded sustainable transportation section, plus more data on natural gas markets and carbon capture and storage. Finally, it includes updates to energy efficiency data sets, including LED lighting penetration, state codes, and others.
- **Updated analysis:** Most charts have been extended by one year to capture the latest data.
- **2018 developments:** The text in the slides highlights major changes that occurred over the past year.
- **Format:** The emphasis of this 2019 edition is to capture new developments that occurred in the past year. For those looking for more context on any sector, the 2014 edition[(1)] can continue to serve as a reference.

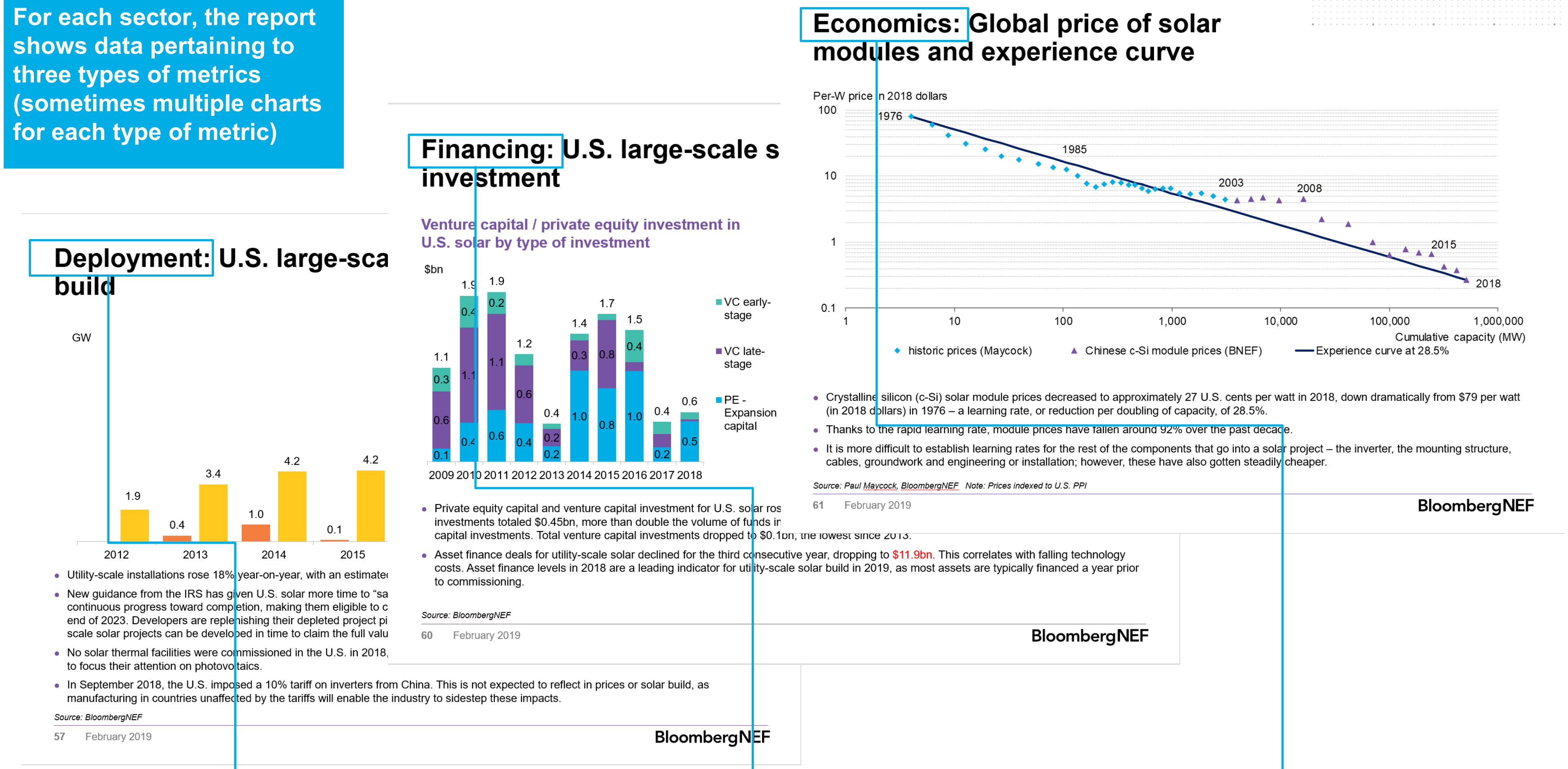
Note: The 2018 Factbook can be found at https://www.bcse.org/wp-content/uploads/2018-Sustainable-Energy-in-America-Factbook.pdf

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 (aluminum) • 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	• Industrial efficiency (other industries)	

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

Financing: captures the amount of investment entering the sector

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

  BloombergNEF

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: Ameresco, the American Gas Association, the American Wind Energy Association, Capital Power, The Christian Coalition, The Copper Development Association, The Corn Refiners Association, Covanta, CRES Forum, Enel Green Power North America, First Solar, Inc., Ingersoll Rand, Johnson Controls, JP Morgan Chase & Co., Jupiter Oxygen Corporation, McKnight Foundation, National Grid, The National Hydropower Association, The Polyisocyanurate Insulation Manufacturers Association, Sacramento Municipal Utility District, Schneider Electric, Sempra Energy, The Solar Energy Industries Association, U.S. Green Building Council, Young Conservatives for Energy Reform.

Executive summary (1 of 6)

After a decade of mostly modest growth, the U.S. economy kicked into a higher gear in 2018. These new conditions rippled through nearly every aspect of the energy sector including overall demand, power generation, project build, energy prices, and CO2 emissions.

2018 affirmed many of the key trends documented in previous editions of the Sustainable Energy in America Factbook. But the year also raised questions about whether U.S. energy can continue on a lower-carbon pathway when economic growth is strong but federal policy support is weak.

Longstanding trends which continued in 2018:

- **Natural gas boomed.** The most new gas-fired power-generating capacity was added in 14 years propelling it to a record 35% of the country's power generation. At the same time, natural gas production hit record highs.
- **Renewables grew in volume and importance, while grid reliability was maintained.** Installations of new mostly wind and solar capacity in 2018 hit 19.5GW. Hydropower closely followed by wind are the largest sources of zero-carbon, renewable generation in the U.S.
- **Wind is the largest single source of zero-carbon power-generating capacity in the U.S.** Total wind installations are essentially level with nuclear in terms of capacity.
- **Coal's decline continued.** Its contribution to overall power generation fell to 27%, the lowest in the post-WWII era. Meanwhile, another 13GW of existing plants announced or completed retirement, the second most in U.S. history.
- **The power sector continued to de-carbonize.** Renewables + natural gas growth - coal = a less carbon-intensive U.S. power sector. Total electricity consumed in the U.S. rose 2.2% in 2018 while CO2 emissions from power plants rose just 0.6%.
- **Energy remained affordable.** Households continue to spend near-record lows of personal income on electricity and natural gas bills. In many major regions, weighted-average retail power prices fell 1-3% though they did rise in some regions.
- **US energy jobs grew.** The U.S. energy sector employs approximately 6.5 million Americans, up 2 percent in 2017 from 2016 (the most recent data available), with energy efficiency, renewable energy and natural gas sectors employing 3.4 million Americans in 2017.
- **The U.S. retains a competitive advantage on industrial power prices.** The U.S. is second only to Canada with the lowest industrial electricity prices among the G7 nations.
- **The popularity of electric vehicles grew.** EVs accounted for only 1.3% of total vehicles sold in the U.S in the 4th quarter of 2017. By third quarter 2018, that had nearly doubled to 2.5%, then hit 3% by the fourth quarter.

Executive summary (2 of 5)

- **Battery storage costs fell further**. Lithium-ion battery prices dropped another 18% year- on-year, boosting both EVs and stationary storage applications and encouraging electric utilities to sign power purchase agreements pairing storage with solar and wind.
- **Corporates continued to drive demand for sustainable energy.** Retailers, major technology firms, and even an oil major contracted record volumes of renewable power through direct contracts. Others pledged to double energy productivity or to green their vehicle fleets, with electric, fuel cell and renewable natural gas power vehicles.
- **States and localities again led the charge on sustainable energy policy-making**. California promised to achieve 100% renewables while Nevada, New Jersey and New York also upped the ante on their renewables, efficiency, and battery deployment pledges. Florida agreed to allow third-party PV installers to operate in the state.

Key questions that 2018 raised:

- **Can the U.S improve energy productivity when economic growth accelerates?** Energy productivity is a comparison of energy consumption and GDP. U.S. energy consumption, which had been relatively flat over the past ten years, grew by 3.3% in 2018, outpacing GDP growth of 2.9%, resulting in an energy productivity decline of 0.4% percent. The numbers suggest a potential departure from what had appeared to be a ‘decoupling’ between energy use and economic growth in the U.S, although extreme weather also played a role. A ten-year look back shows that energy consumption grew by 7.5% while GDP expanded by 22%. Over that same period, energy productivity increased by 14%.
- **Can U.S. greenhouse gas emissions be kept in check without concerted federal government efforts?** As energy consumption expanded, so too did the U.S. CO2 footprint. Greenhouse gas emissions rose an estimated 2.5% in 2018, driven by large year-on-year increases in the buildings and industrial sectors. The power sector continues to decarbonize thanks to the growth in natural gas and renewables generation at the expense of higher-emitting coal. The transportation sector for the second year accounted for the largest share of CO2 emissions but has potential for CO2 reduction, particularly if federal efficiency rules can take effect. Meanwhile, state and municipal governments continue to make important efforts to address climate change. Still, it remains to be seen if the U.S. can fully do its part to address global climate change if its federal government declines to make an effort.

Executive summary (3 of 6)

Each of these trends is discussed at a high level below and then in far greater depth graphically in the Factbook slides.

Economic growth, along with extreme weather, pushed energy demand to an all-time high in 2018.

The U.S. economy in 2018 grew at its fastest pace in five years, posting an annualized GDP expansion rate of 2.9%. For the first time in several years, energy consumption grew at a faster clip than GDP, rising 3.3% over the same time period. Seasonal factors played an important role, as extreme weather boosted demand for both heating and cooling in the buildings sectors. The U.S. set a record for the most "cooling-degree days" (as defined by the Energy Information Administration) since at least 1990 causing Americans to use more air-conditioning to remain comfortable. The number of "heating degree days" bucked a long-term declining trend to hit their highest level since 2014.

Meanwhile, the increase in overall energy use belied slower growth in transportation consumption (up 0.7%), as Americans continued to buy larger, less fuel efficient cars, but vehicle miles traveled leveled off. Electricity demand as measured in terawatt hours grew at a slower pace of 2.2%. In other words, although overall energy productivity declined in 2018, the U.S. continued to grow more productive and efficient in its use of electricity. Even so, the increase was enough to push electricity sales to a projected all-time high of 3,950 terawatt-hours, a 1.2% increase over the previous record set in 2014.

Rising electricity demand pushed generation levels to new highs while the fuel mix continued to transition away from coal and toward natural gas and renewables.

Coal's role waned again, dropping to only 27% of the mix – the lowest share in the post-war era. In the past year, coal generation has shrunk by 6.3% as the grid retired nearly 13GW of coal-fired units, second only to 2015's record of 15GW retired. Coal units are struggling to compete with low-priced natural gas, increasing renewable penetration and state-level support for ailing nuclear units. Increasingly, large utilities are re-evaluating coal plants and electing to retire early in favor of low-cost renewables, gas, and energy storage.

A boom in natural gas build – the largest single-year addition in 15 years – helped push natural gas to 35% of the electricity mix, a record. Nuclear held steady at 19%, but renewables are closing the gap: in 2018, renewable generation rose 5.1% in absolute terms, as output from new wind and solar farms offset a modest contraction in hydroelectric output. Renewables including hydro now provide 17.7% of U.S. power, with hydro representing 7% and non-hydro renewables 10.7%.

Installations of new renewables assets rose slightly in 2018 to 19.5GW. Wind build stayed steady at approximately 7.5GW bringing its total cumulative capacity effectively level with nuclear. (Due to higher capacity factors, the nuclear fleet and hydropower generate more power overall.) At the same time, several Northeastern states held requests for proposals (RFPs) for offshore wind projects, a first for an industry that has seen significant levels of build and interest in international markets.

Executive summary (4 of 6)

After a bumpy start to 2018, solar build rebounded with the installation of 11.7GW across large- and small-scale segments. Continued uncertainty over solar and metals tariffs weighed on purchasing decisions in the first half of the year; meanwhile, developers are replenishing pipelines following 2016's 14.1GW and before the step-down of the federal Investment Tax Credit. Residential solar installations remained roughly level year-on-year, as falling costs only partially mitigated the impact of the roll-off of net metering regimes in several states.

In terms of other renewable energy technologies, hydro added 142MW, biomass, biogas and waste to energy added 83MW, and geothermal added 53MW. None of these technologies benefitted in 2018 from federal tax credit support.

As energy consumption expanded, so too did the U.S. carbon footprint.

Greenhouse gas emissions rose an estimated 2.5% in 2018 above 2017 levels, driven by large year-on-year increases in the buildings (ie, residential and commercial segments) and industrial sectors. Total climate-warming emissions now sit approximately 10% below 2005 levels, or roughly two-fifths of the way to the Obama Administration's abandoned Paris Agreement target of 26% below 2005 levels by 2025.

A cleaner electricity mix dulled the impact of rising electric load, with power-sector greenhouse gas (GHG) emissions increasing only 0.6%. In the transportation sector, emissions rose an estimated 0.9%. Transportation remains the single largest source of greenhouse gases in the U.S. Total miles traveled by Americans in vehicles rose slightly while the average fuel efficiency of vehicles sold remained flat at 25 miles per gallon for 2017, the last year for which data is available.

The federal government continued to ease regulations on carbon emissions, proposing weaker fuel efficiency standards for light-duty vehicles as well as higher allowable thresholds for emissions from new coal-fired power plants.

Prices remained low by historical standards, offsetting the impact of rising demand on consumers.

Although total energy consumption rose, households continue to spend near-record lows of personal income on electricity and natural gas bills, tapping in at 1.3% and 0.4%, respectively, of outlays in 2018. A slight decline in average retail prices underlies this trend: in many regions of the U.S., weighted-average retail prices fell between 1-3%.

On the other hand, natural gas prices, while remaining low by historic averages, were volatile in 2018, at times pushing wholesale electricity prices up in tandem. Wholesale power prices escalated as much as 35% in Texas and 27% in New England as natural gas prices hit their highest levels in four years. Lack of natural gas delivery infrastructure has at times created regional delivery bottlenecks and boosted prices.

Executive summary (5 of 6)

Falling battery prices helped drive record electric vehicle sales, as well as non-hydro energy storage build.

Sales of electric vehicles leapt higher in 2018, spurred by the full launch of the Tesla Model 3. Customers received 138,000 units of Tesla's new lower-cost, long-range battery electric vehicle in a rush to capture the federal electric vehicle tax credit before it begins to phase down for Tesla in 2019. Battery electric and plug-in hybrids accounted for just over 106,000 units in the third quarter of 2018, double the number of vehicles sold in the same quarter in 2017. This represented or 2.5% of total sales for the quarter, overtaking hybrid sales for the first time. In the fourth quarter, sales of such vehicles jumped again, to 132,000 units.

As electric vehicle sales drive down lithium-ion battery prices, the economics of batteries for stationary storage continues to improve. An estimated 292MW of non-hydropower energy storage was commissioned in 2018, compared to an average of 200MW annually over the prior three years. California remains the market leader, with 345MW of cumulative installations. Meanwhile, batteries are being deployed for a more diverse suite of applications, including for meeting resource adequacy requirements in California, pairing with solar and wind to help increase dispatchability in the Southwest and Hawaii, and offsetting demand charges on commercial and industrial power bills. The use of batteries for these applications has pushed the average duration of deployed project up to nearly two hours, from only one hour in 2012.

Overall deployment of non-hydro energy storage remains small in comparison to pumped hydro projects, which tally to nearly 23GW. There have been no new pumped hydro projects built since 2012, but as of October 2018, the Federal Energy Regulatory Commission was considering licenses for 2.3GW of new projects, mostly in New England and the Pacific West.

States continued to act as a counterweight to federal policy, raising clean energy goals at the same time that the federal government sought to roll back environmental regulations.

Federal policy set up roadblocks to the ongoing transformation of the energy sector, as the White House sought ways to provide financial support to uneconomic coal and nuclear units and announced plans to rollback efficiency and emissions standards across various sectors. In the transport sector, the Environmental Protection Agency released a rulemaking proposing to freeze vehicle fuel efficiency standards at 2020 levels, as well as revoke California's waiver to set more stringent targets. The move likely sets up a protracted legal battle between the Trump Administration and California's government. If implemented as proposed, it could impact future sales of battery, plug-in hybrid and fuel-cell electric vehicles. The ongoing trade dispute with China led to tariffs on steel and aluminum imports, metals which are critical inputs into all types of energy assets.

Executive summary (6 of 6)

On a positive note for clean energy development, the Administration through the Bureau of Ocean Energy Management successfully auctioned offshore wind development leases off the east coast, paving the way for what are anticipated to be the first U.S. large-scale offshore projects. Congress and the Trump Administration also passed a number of energy related tax measures at the beginning of 2018 including extension of the ITC for fuel cells, combined heat and power, small wind, and geothermal and reform to 45Q to incentivize carbon capture and storage.

On a state level, California set a number of new, ambitious targets and regulations. A spring 2018 ruling by the state's energy commission will require solar on almost all new homes built beginning in 2020. Legislation passed in September now mandates that the state source 100% of its power from zero-carbon energy by 2045, and an executive order will aim for the state's entire economy to be carbon neutral by the same year. New Jersey's updated renewable portfolio standard – which now targets 50% renewables by 2030 – also raised the target for distributed solar to 5.1% by 2021, at the same time that it made plans to eventually phase out net metering. New York transitioned commercial customers to an innovative 'value of distributed energy' tariff.

Not all the news out of the states was positive, however, as some made plans to scale back net energy metering or renewable energy credit programs that promote rooftop solar build. Maine, Connecticut, Michigan, Indiana and Utah all enacted or announced net metering program suspensions.

Large energy consumers are growing even further engaged, taking steps to reduce and green their footprints.

Globally, 158 corporations have now pledged to source 100% of their electricity needs from renewable energy under the RE100 Initiative. In the U.S., corporate interest in clean energy blew through previous records: large energy buyers signed contracts for 8.6GW of wind and solar, over twice the previous record of 3.4GW contracted in 2015. Procurement reached into new markets, as companies such as Facebook, Google and Walmart worked together with vertically integrated utilities in New Mexico, Georgia and Tennessee (among others) to build new wind and solar projects. New aggregation models also arose, allowing smaller energy buyers like Etsy and Adobe to combine their demand to sign onto an individual project, thereby leveraging economies of scale previously only open to large consumers.

Corporate activity stretched beyond electricity consumption, with pledges to the EP100 campaign – under which they seek to double energy productivity by 2030 – nearly tripling in 2018. 37 companies including H&M, Hilton and Swiss Re are members of the initiative, up from only 13 in 2017. Additionally, a new campaign called the EV100 garnered 31 corporate pledges. Companies like IKEA, HP and Unilever promised to ramp up integration of electric vehicles into their corporate fleets and to assist employees in transitioning to cleaner transportation.

Finally, back on the electricity delivery side, 2018 saw some key announcements from U.S. utilities regarding sustainable energy. Minneapolis-based Xcel Energy, which operates utilities in eight states, said it would deliver only carbon-free power to all its customers by 2050. Ohio-based AEP, which serves customers in 11 states, said it will cut its CO_2 emissions 80% by 2050 (vs. a 2000 baseline).

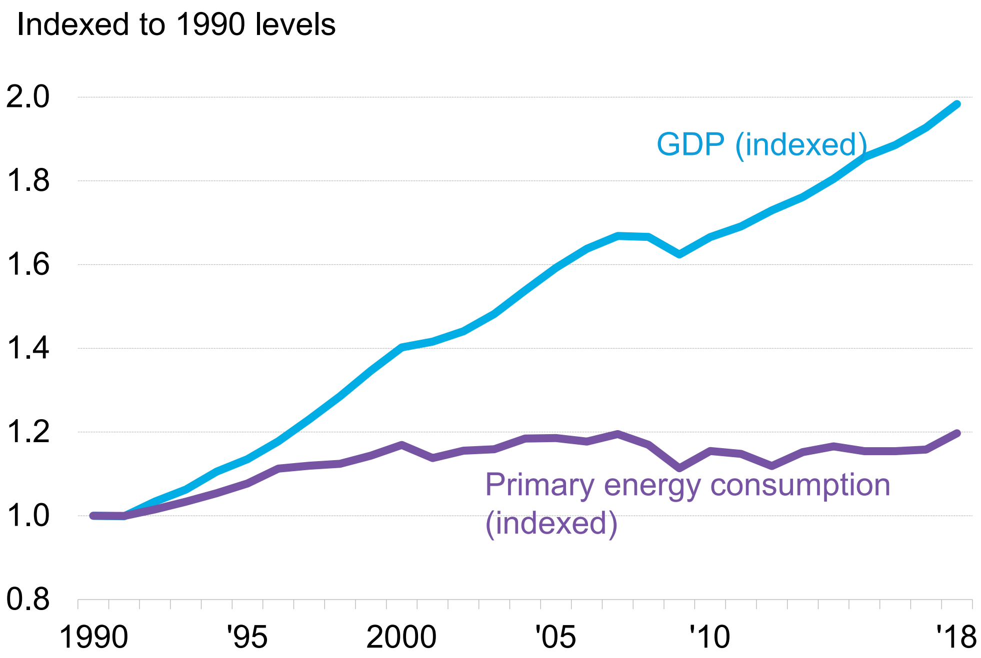
The 2019 Factbook in the context of previous editions

- **First edition (January 2013):** The inaugural edition of the Sustainable Energy in America Factbook, published in January 2013, captured a period of rapid de-carbonization of the U.S. energy sector. From 2007 to 2012, electricity generated from natural gas grew from 22% to 31% and total energy use fell 6%, driven largely by advances in energy efficiency. Power from renewables including hydropower grew from 8% to 12% of total electricity output, with generation from non-hydro renewable sources more than doubling during that time.
- **Second edition (February 2014):** This edition detailed the continuation of long-term growth in natural gas, small-scale solar, energy efficiency and electric vehicle uptake.
- **Third edition (February 2015):** This edition highlighted the surge in natural gas investment and infrastructure to enable that fuel's market upswing and the growing share of renewables in the nation's generation capacity.
- **Fourth edition (February 2016):** This edition summarized a year in which U.S. renewables capacity surged while frameworks for supporting a clean energy future emerged at both the international and domestic levels, and it detailed how natural gas achieved a record-high share of generation at the expense of coal.
- **Fifth edition (February 2017):** This edition affirmed sustainable energy as the "new normal" in the U.S., where record growth in renewable energy helped to drive power-sector emissions to their lowest point in 25 years. It also chronicled how natural gas became a significant driver of American export trade even as domestic demand rose and prices fell.
- **Sixth edition (February 2018):** This edition noted that 2017 saw economic growth accelerate while electricity and total primary energy demand fell, capping a four-year run in which GDP and energy consumption were "decoupled." It reported that renewable power generation hit a record 18% of the U.S. total, a record, at the same time that U.S. consumers devoted less of their personal expenditures to electricity bills than at any other time on record.
- **This (seventh) edition** finds continuing expansion of natural gas consumption and exports, wind and solar installations, state energy efficiency targets and the popularity of electric vehicles. It also observes that 2018 saw a break with a multi-year period in which the economy grew while power demand and greenhouse gas emissions declined. It is highly likely that new federal policy support will be needed if the U.S. is to maintain economic growth while reducing harmful greenhouse gas emissions.

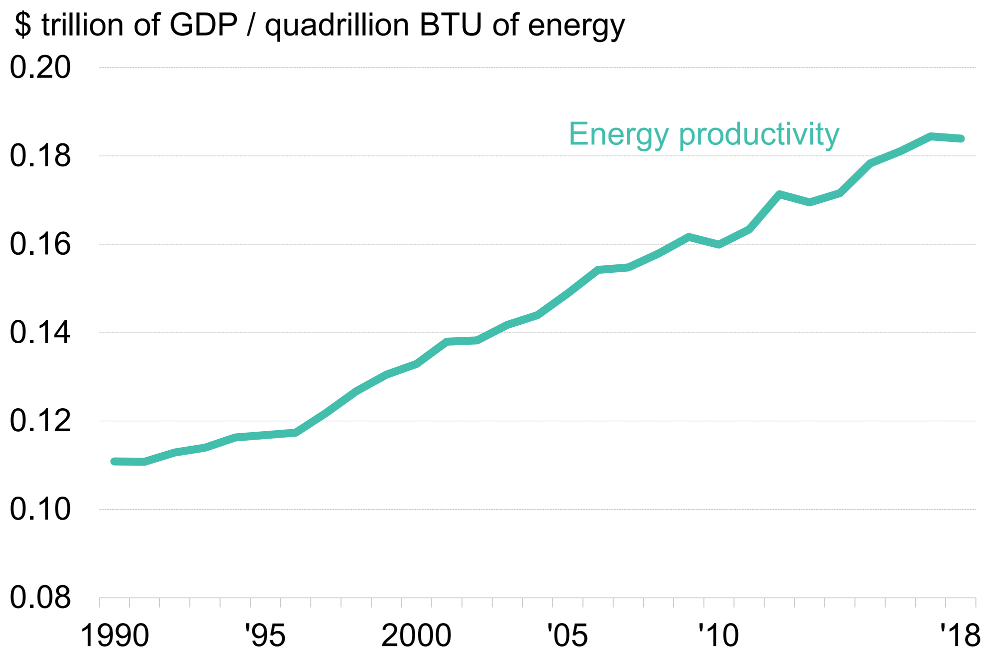
Table of Contents

U.S. energy overview: Economy's energy productivity

U.S. GDP and primary energy consumption



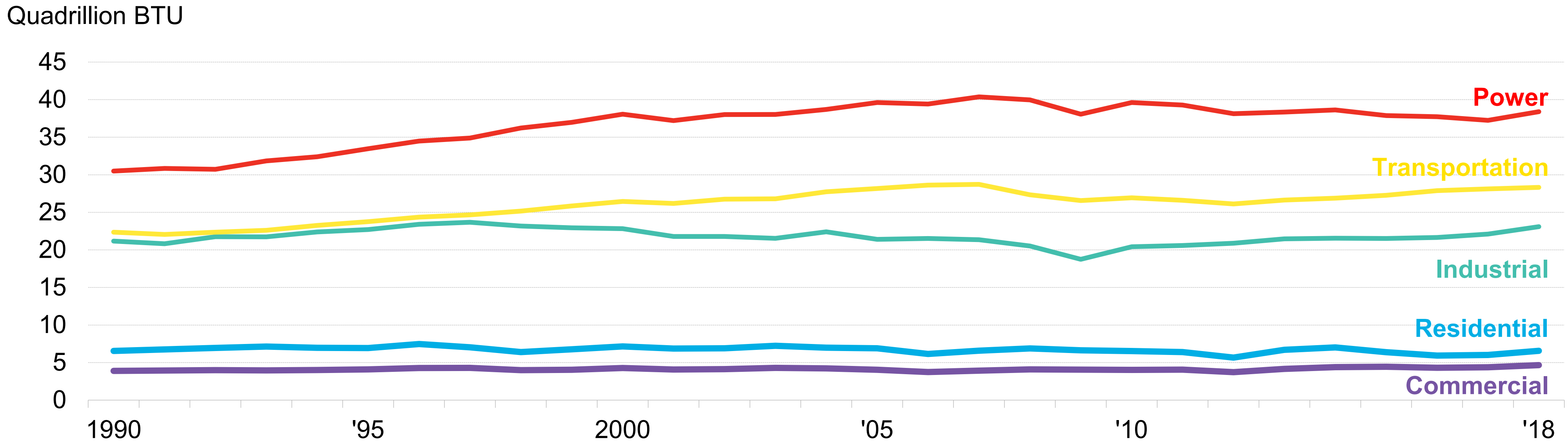
U.S. energy productivity



- The U.S. economy expanded by 2.9% in 2018, the fastest annual growth since 2005 with the exception of one year. Primary U.S. energy consumption grew by 3.3% marking the first time it has outpaced GDP expansion since 2013.
- Still, U.S. economic growth has broadly 'decoupled' from energy use, as reflected in improvements to energy productivity: within the past decade, GDP has climbed 22% while primary energy consumption has grown only 7.5%.
- The year-on-year growth in primary energy consumption can be attributed to a combination of faster economic growth and weather conditions.
- Since 1990, the U.S. economy has nearly doubled as measured in GDP, while primary energy consumption has increased only 20%. This represents a 66% improvement in U.S. energy productivity.

Source: Bureau of Economic Analysis, EIA, Lawrence Berkeley National Laboratory, BNEF   Notes: Values for 2018 are projected, accounting for seasonality, based on latest monthly values from EIA (data available through October 2018). 2018 GDP estimate is a projection from economists compiled at ECFC <GO> on the Bloomberg Terminal.

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

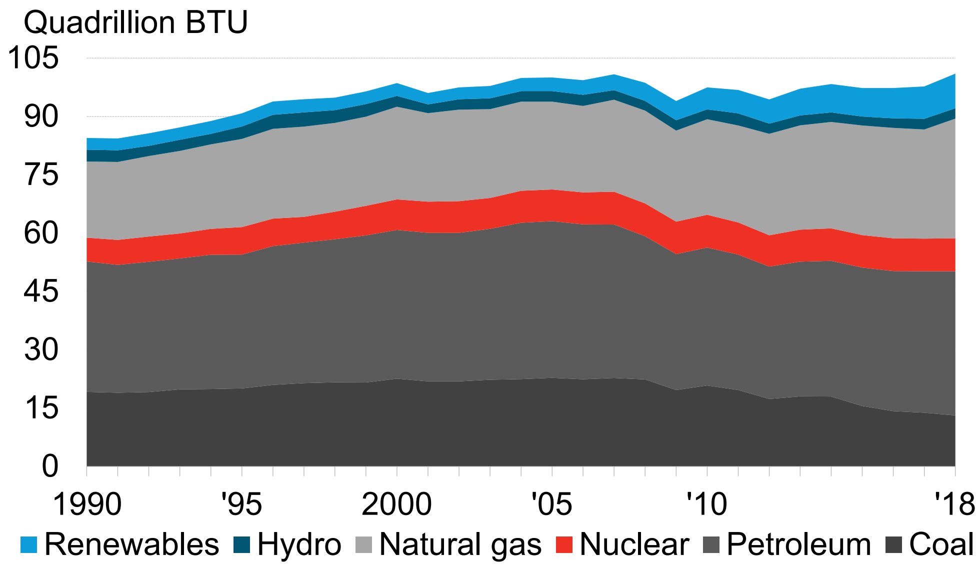


- Growth across all sectors helped fuel the increase in energy consumption in 2018, although some sectors grew at a faster clip than others.
- On a percentage basis, the residential and commercial sectors exhibited the largest growth, consuming 10.7% and 7.4% more *primary* energy, respectively. Primary energy is primarily 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 bears this out: heating degree-days, a measure of cold weather, rose 10.5% through October 2018 compared to the same period in 2017, to return to the ten-year average. In contrast, the winters of 2016-17 were significantly warmer than average, meaning that heating demand was relatively low.
- At the same time, hotter summer weather also boosted primary energy use in the power sector, which rose 3.3% year-on-year. Cooling degree-days (which indicate warm weather) rose 11.6% year-on-year through September, sitting at 24% above their ten-year average.
- More extreme weather was not the only factor. Higher levels of industrial activity also contributed to higher primary energy demand. Industry consumed 4.7% more energy in 2018 than in 2017.
- The transportation sector experienced the smallest year-on-year growth on both a relative and absolute basis, demanding only 0.7% more energy or 0.2 quadrillion British thermal units (BTUs) above 2017's level.

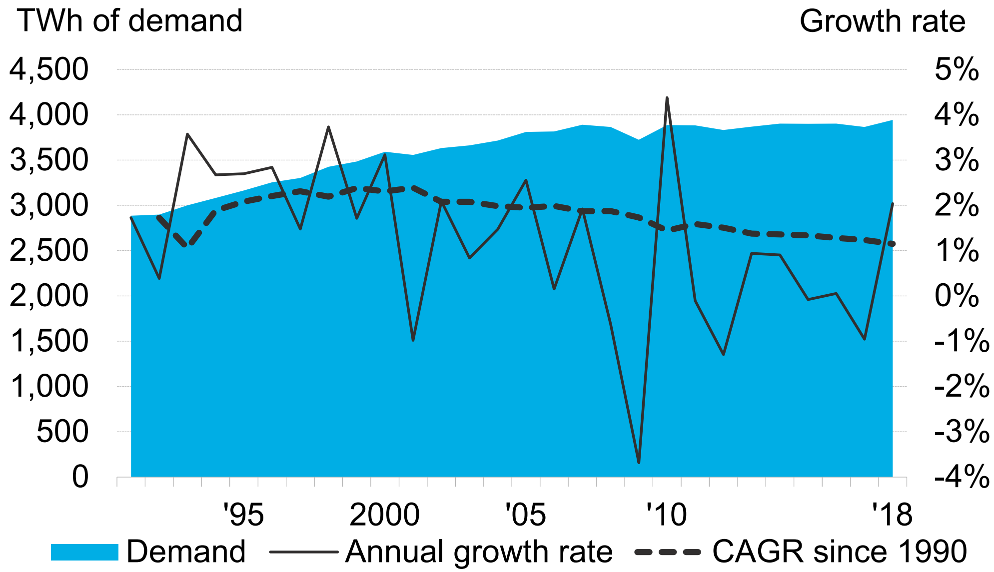
Source: EIA, BNEF Notes: Values for 2018 are projected, accounting for seasonality, based on latest monthly values from EIA (data available through September 2018)

U.S. energy overview: Energy and electricity consumption

U.S. primary energy consumption by fuel type



U.S. electricity demand



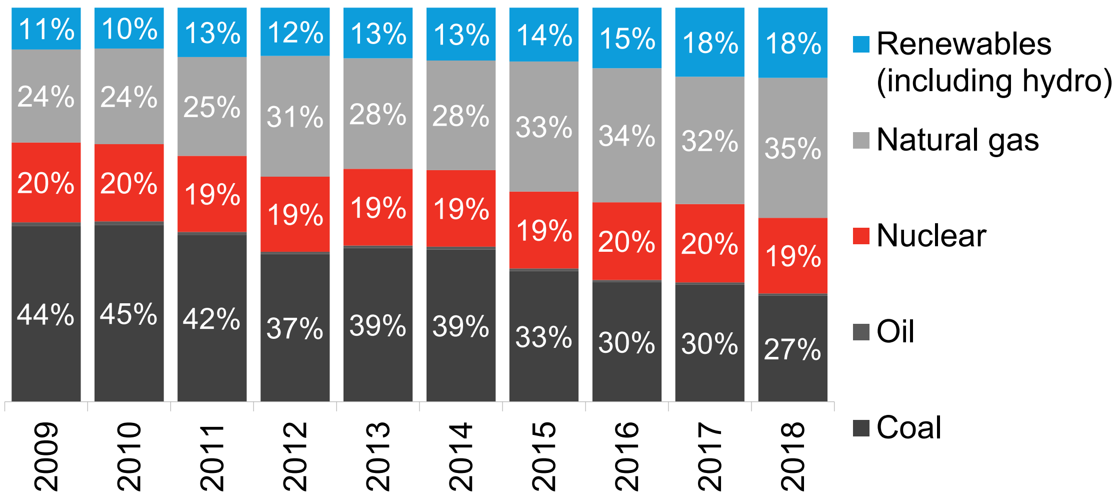
- U.S. total energy consumption advanced 3.3% to 101 quadrillion BTU in 2018. Consumption of coal sank by 4.9% as a near-record volume of coal-fired power plant capacity was retired. Hydro generation declined 3.3% after a drier year in the West. Coal consumption hit its lowest level since the mid-1970s, at only 13.2 quadrillion BTU, down 42% from its peak of 22.8 quadrillion BTU in 2005.
- Natural gas and non-hydro renewables saw the largest gains, increasing by 10.4% and 7.4%, respectively. The surges came as both sources saw near-record levels of installations in the power sector and demand for power rose.
- Petroleum use advanced 1.8%, and nuclear output rose 0.4%.
- Retail electricity demand climbed 2.2% year-on-year (excluding contributions from distributed, small-scale facilities). Compound annual electricity growth has been steadily declining, from 5.9% over 1950-1990, to 1.4% over 1990-2009, to 0.7% since 2009.

Source: EIA, BNEF Notes: "CAGR" on the right hand side graph is compound annual growth rate. Values for 2018 are projected, accounting for seasonality, based on the latest monthly values from EIA (data available through September 2018). BTU stands for British thermal units.

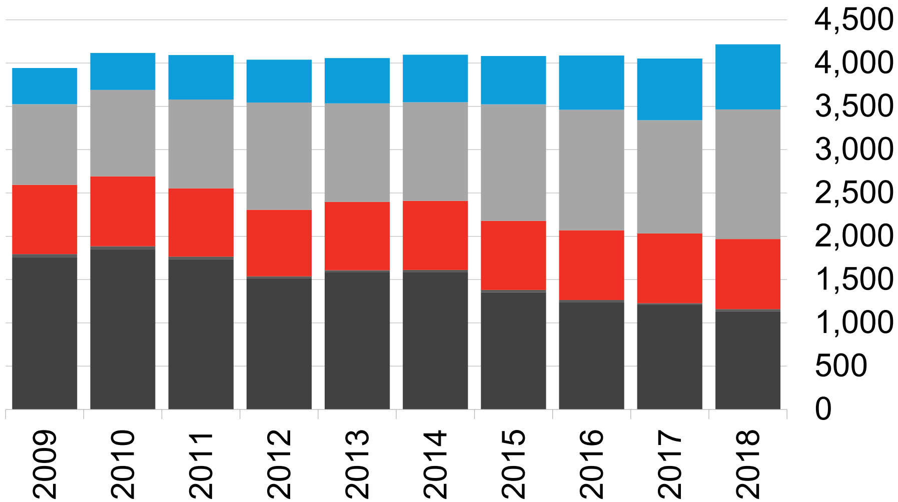
BloombergNEF

U.S. energy overview: Electricity generation mix

U.S. electricity generation by fuel type (%)



U.S. electricity generation by fuel type (TWh)

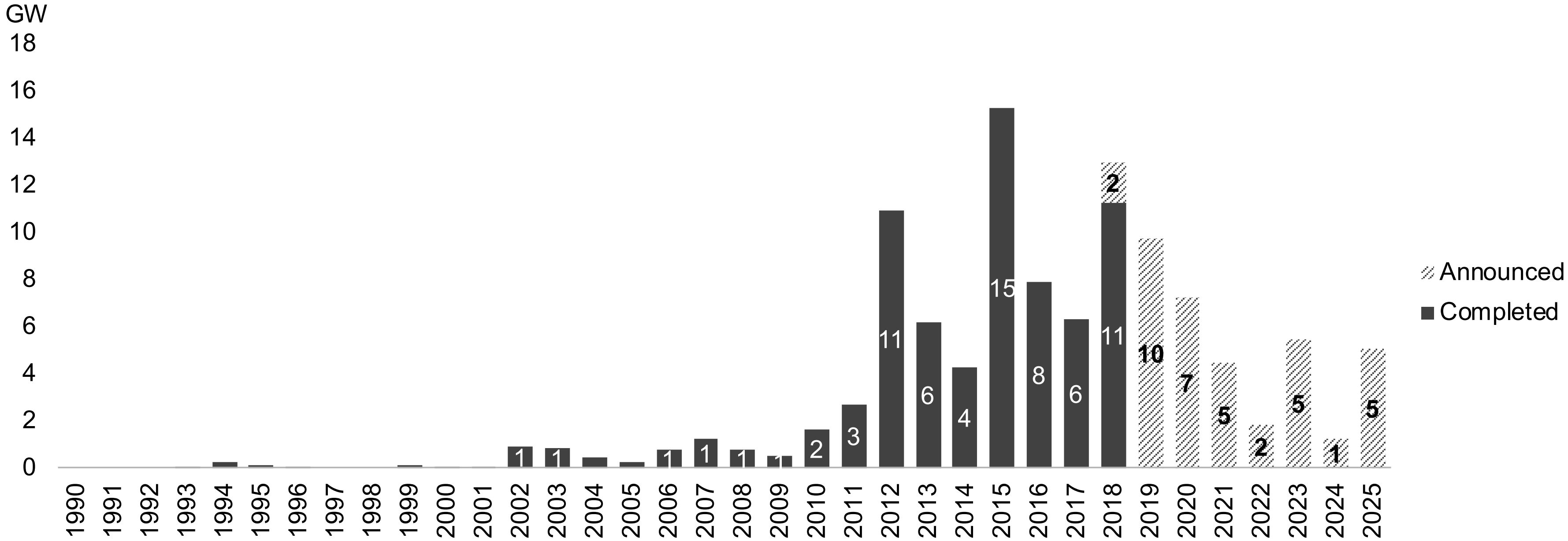


- Natural gas generation surged in 2018 after a down year in 2017, cementing its position as the largest source of U.S. electricity. It reached 35% of power generation, equivalent to nearly 1,494TWh, up 14% from last year's levels.
- Coal saw its role wane further, dropping to only 27% of the mix – the lowest share in the post-war era. In total, coal produced an estimated 1,145TWh of electricity in 2018, the lowest value in absolute terms since 1979 and a 5% decline from 2017.
- Renewables generation (including hydropower) grew 5.1% year-on-year in 2018, as a 13% increase in output from a rapidly growing wind and solar fleet was partly offset by a small decline (-2.7%) in hydropower output. In absolute terms, renewables generation rose 36TWh to land at 747TWh, closing the gap with the nation's nuclear fleet, which held steady in 2018. Nuclear output rose 0.4% but its share eased back modestly to 19.2% of the total mix due to overall demand growth.
- Over the past decade, renewables inclusive of large hydro and natural gas have grown from 35% to 53% of total power generation.

Source: EIA, BNEF Note: Values for 2018 are projected, accounting for seasonality, based on latest monthly values from EIA (data available through October 2018)

BloombergNEF

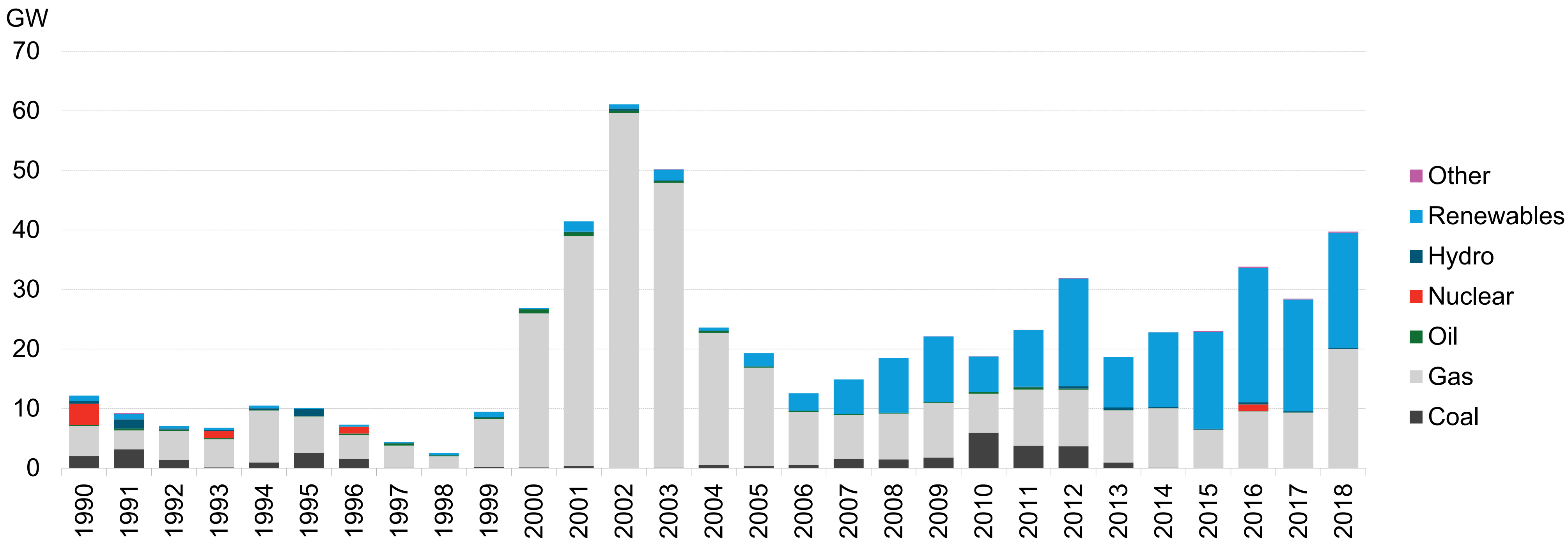
U.S. energy overview: Completed and announced coal-fired plant retirements



- Coal-fired power plants retirements accelerated in 2018, reaching 13GW and nearing the record 15GW set in 2015. The pipeline of future retirements has grown as well. Companies now plan to retire another 17GW over 2019-20. As of end of 2017, they had projected just 4GW of closures.
- The coal fleet has shrunk 19% from its peak of 303GW in 2011. Persistently low gas prices and flat load have contributed to lower run-times and revenues. Meanwhile, 20GW of new gas-fired capacity came online in 2018. Much of this is located atop the prolific Marcellus and Utica gas shales in Appalachia, a region also known for coal production. The new gas units may put further economic pressure on coal-fired plants.
- Increasing renewable energy penetration and state-level support for ailing nuclear plants also play a role in some regions. But even in states where these factors are absent, utilities are announcing plans to retire coal in favor of lower cost renewables, gas 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 2018. All capacity figures represent summer generating capacity.

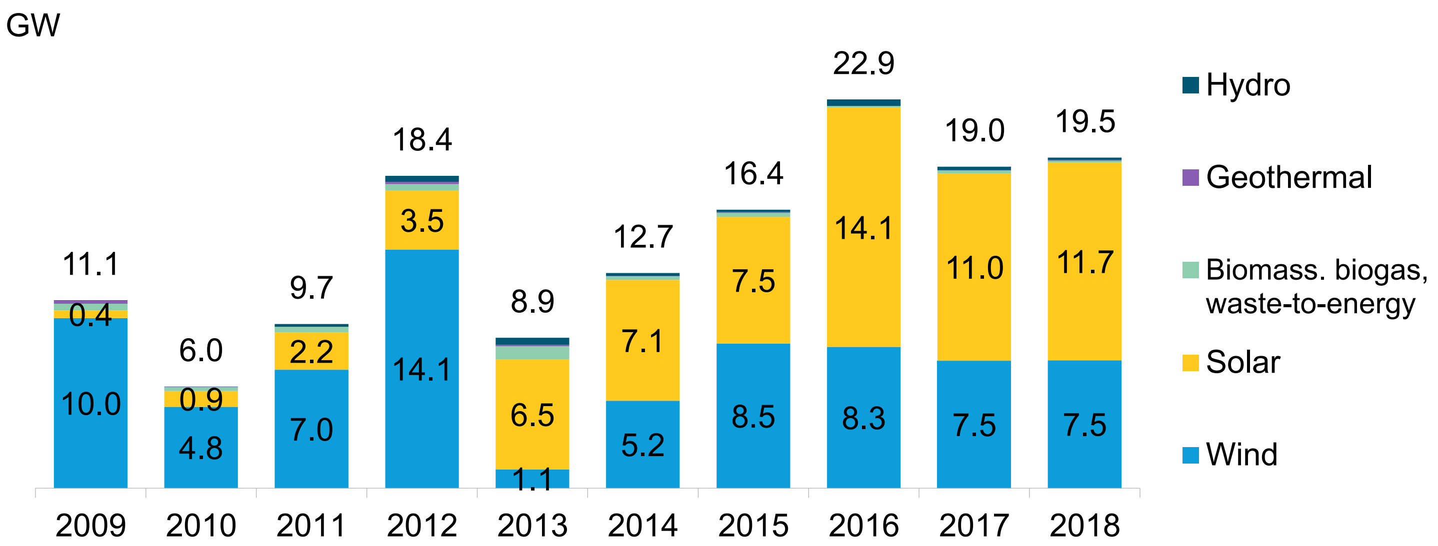
U.S. energy overview: Electric generating capacity build by fuel type



- 2018 represented another boom year for electric generating capacity additions, with just under 40GW added – the most in 15 years.
- Natural gas build soared as developers installed 20GW, seeking to take advantage of persistently low gas prices, particularly in the mid-Atlantic region. The 2018 build was more than double the capacity added in 2017.
- Non-hydro renewable energy annual build was its second highest of all time. Since 2006, these technologies (wind, solar, biomass, geothermal, others) have accounted for over half of cumulative additions.
- In total, gas, renewables and hydro have accounted for over 94% of all U.S. capacity additions in the past 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 2018, as well as BNEF projections.

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



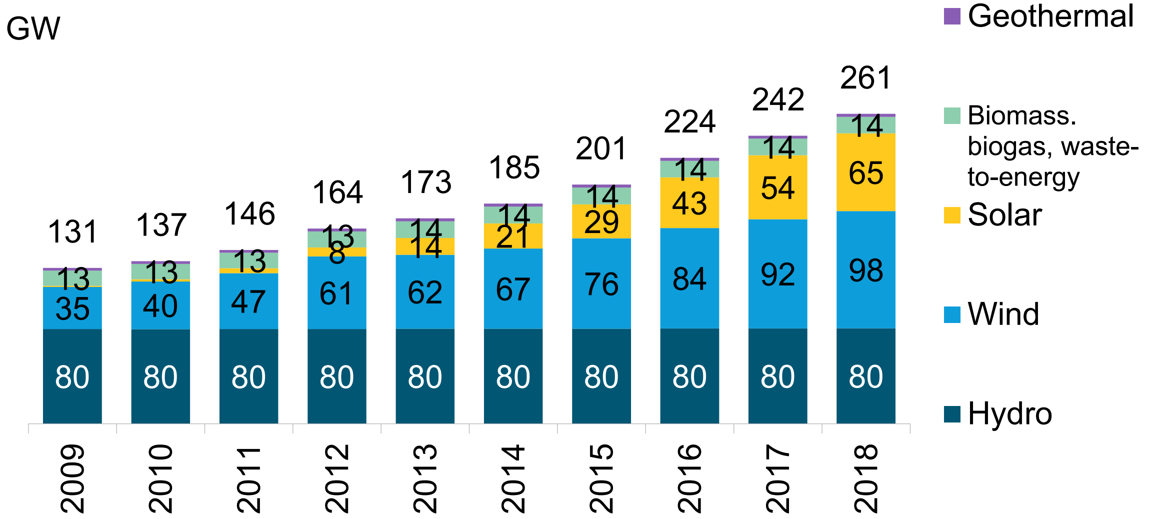
- The U.S. installed an estimated 19.5GW of renewables and hydroelectric capacity in 2018, a moderate uptick from 2017 and the second-highest year on record. The increase came amid uncertainty surrounding the impact of corporate tax reform, solar and metals tariffs, and a generally deteriorating trade relationship with China.
- Wind build maintained 2017 levels as developers rushed to monetize the federal Production Tax Credit (PTC). Meanwhile, several Northeastern states held requests for proposals (RFPs) for offshore wind projects, a first for an industry that has seen significant levels of build in Europe but relatively little activity in the U.S. so far.
- The solar industry rebounded after 2017's down year, despite continued uncertainty over solar and metals tariffs weighing on purchasing decisions. Like their counterparts in wind, solar developers are replenishing project pipelines before the step down of their key tax credit, the federal 30% Investment Tax Credit (ITC). However, the ITC's step-down begins after the PTC's, lending less urgency to the solar sector.
- Build was muted in other sectors: hydro added 142MW, biomass and waste-to-energy added 103MW, and geothermal added 53MW. Policy support for these sectors has been shorter term and less consistent, in general, than for the wind and solar industries.

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 2018, as well as BNEF projections.

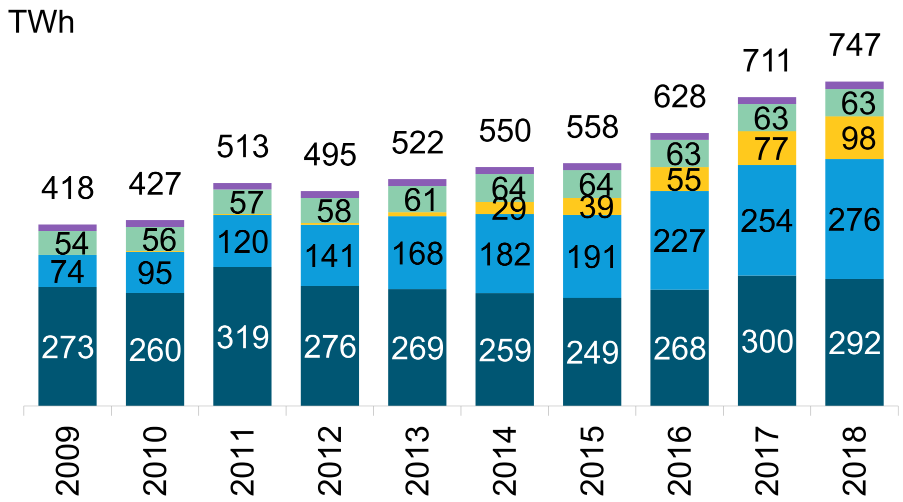
BloombergNEF

U.S. energy overview: Cumulative renewable energy by technology

U.S. cumulative renewable capacity



U.S. renewable generation by technology



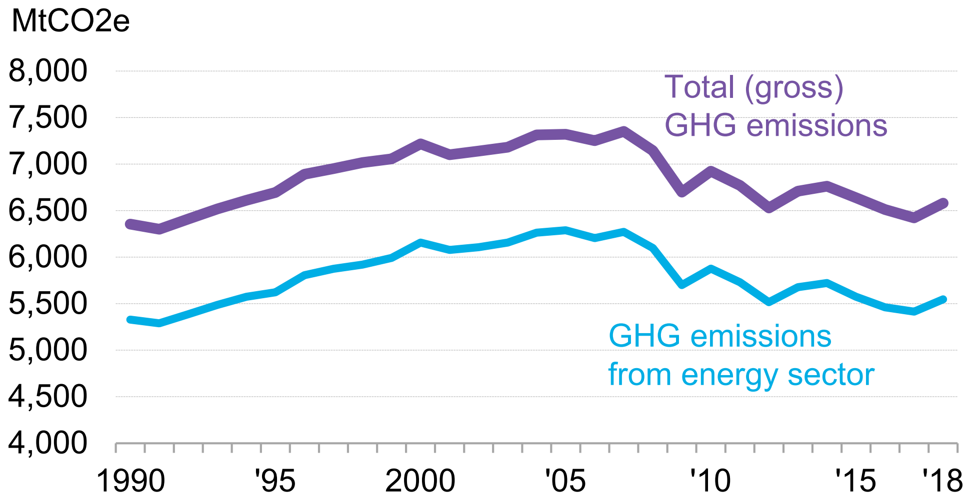
- Total renewable energy capacity has doubled within the past decade, reaching 261GW (excluding hydro pumped storage facilities) from 131GW in 2009. Wind and solar have represented nearly all new additions, helped along by strong policy support and rapidly falling costs.
- Wind capacity totaled 98GW in 2018 and is essentially tied with nuclear as the largest zero-carbon source of capacity in the country. Meanwhile, solar capacity now exceeds an estimated 65GW, nearly 70 times its installed capacity only a decade ago.
- As a result of the strong additions of wind and solar, renewable generation rose 5.1% to 747TWh in 2018. Wind experienced the largest year-on-year growth, adding an estimated 22TWh, a 8.5% increase. Wind and hydro production are now nearly neck-and-neck accounting for 37% and 39% of total renewable output, respectively.
- Solar generation increased 21TWh, or 27% and exceeded 100TWh for the first time.

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 2018 are projected, accounting for seasonality, based on latest monthly values from EIA (data available through October 2018)

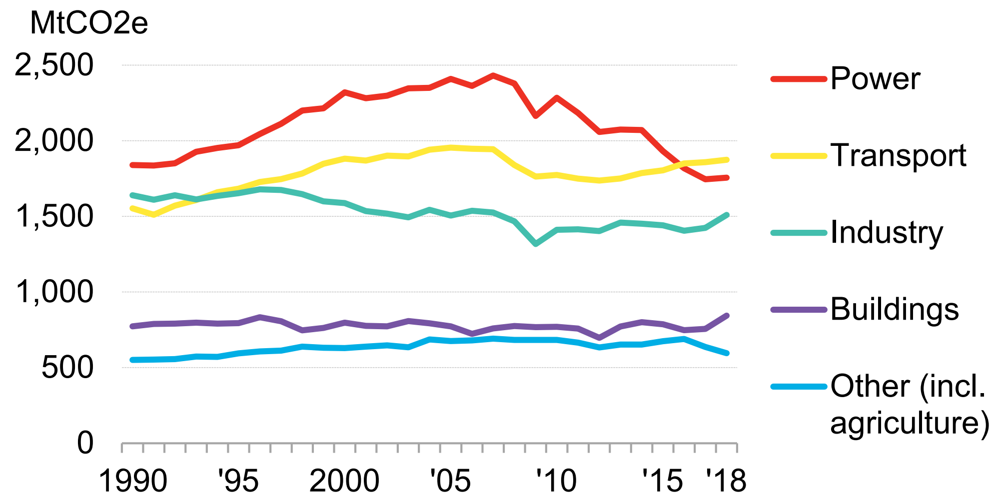
BloombergNEF

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

Economy-wide and energy sector emissions



Emissions by sector

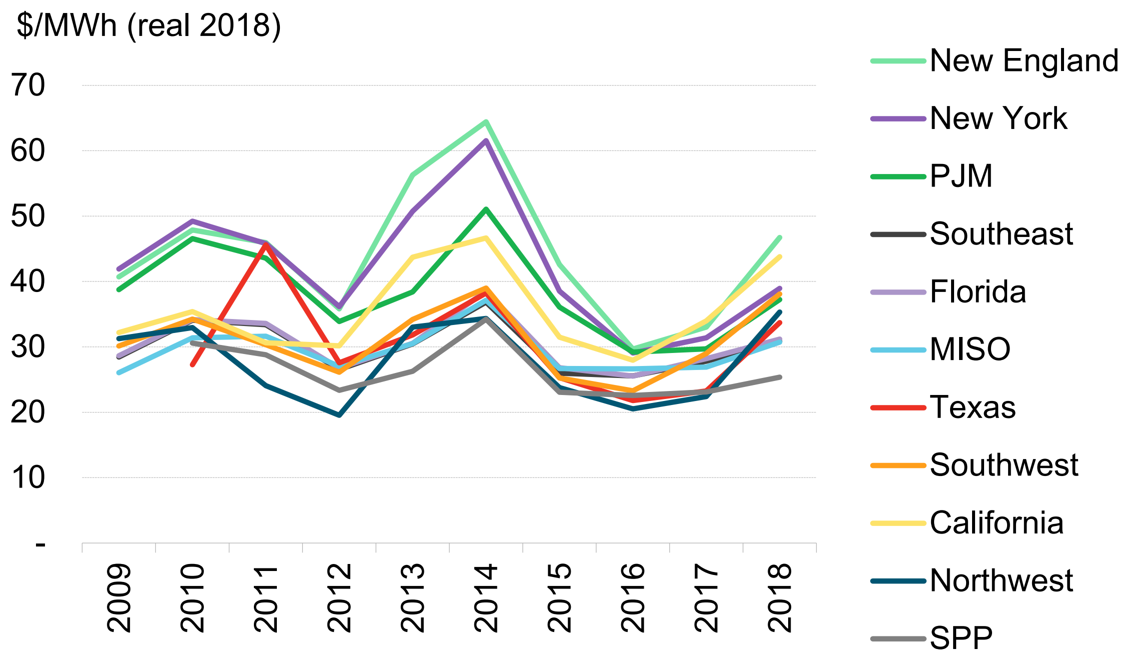


- U.S. GHG emissions rose for the first time in several years, increasing by a projected 2.5% as energy demand escalated in the buildings and industrial sectors and, to a lesser extent, in power and transport. Total gross greenhouse gas emissions now sit at roughly 6,574Mt or approximately 10% below 2005 levels. This represents roughly two-fifths of the way to the U.S's abandoned Paris Agreement target of 26% below 2005 levels by 2025.
- A cleaner electricity mix mitigated a rise in power-sector demand, with power-sector emissions climbing only 0.6% despite a 3.3% increase in primary energy consumption by power plants. The U.S. grew its production from natural gas and wind and solar as higher-emitting coal-fired power plants retired in near-record numbers.
- Transport emissions rose 1% year-on-year, as gasoline consumption grew modestly. The transportation sector remained the largest single source of climate-warming emissions for the third consecutive year, widening its gap with the power sector to 128Mt.
- Federal progress on climate change took another step back in 2018, as the Trump Administration reiterated its intent to withdraw from the Paris Agreement and announced weaker efficiency standards for vehicles and emissions standards for new coal-fired power plants.

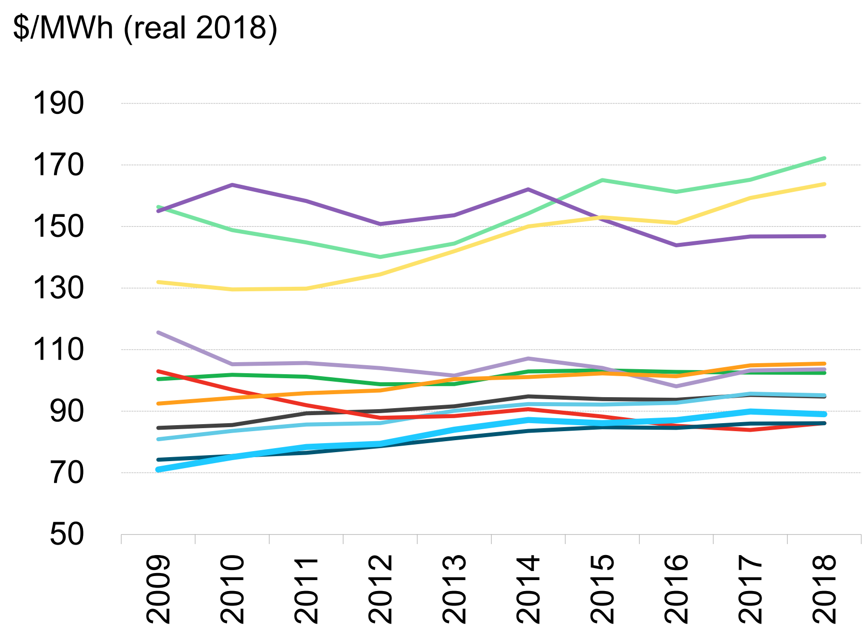
Source: BloombergNEF, EIA, EPA Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2016 Notes: "Sinks" refer to forests and green areas which absorb carbon dioxide. Values for 2018 are projected, accounting for seasonality, based on monthly values from EIA available through September 2018.

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

Wholesale power prices



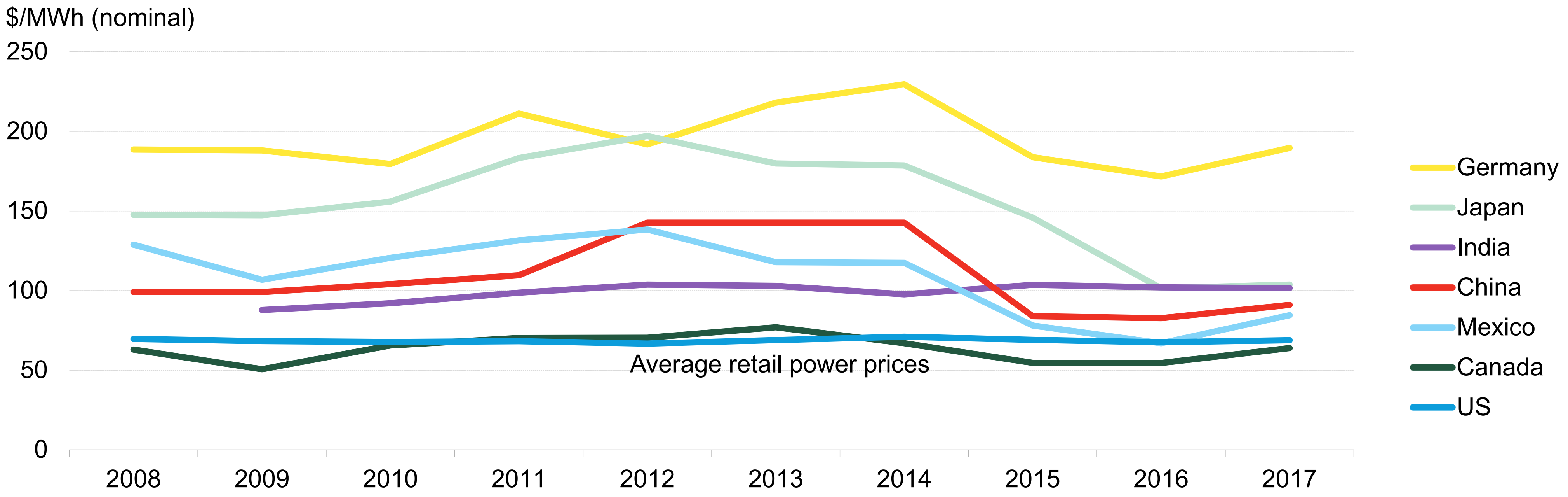
Average retail power prices



- Wholesale power prices continued their ascent in 2018, but they remain historically low in real terms. A rise in average Henry Hub natural gas prices helped boost wholesale prices across the board relative to 2017 levels. Year-on-year, average wholesale prices rose as much as 58% in the Northwest, 45% in Texas (ERCOT), 41% in New England and 31% in the Southwest. Prices rose 14% in the Midwest (MISO).
- Wholesale prices generally remained below their 2014 peaks in real terms. However, Northeast prices did top their 2014 peak by 3%.
- Retail prices fell by more than 2% in the Northwest, Midwest (MISO) and Southeast. Prices fell between 0.5% and 1% in the Southeast, MISO and SPP regions. Prices rose in New England by 4.2%, in California by 2.8% and Texas by 2.6%. The New York, PJM and Florida regions had very minor retail price changes. Retail prices overall in the U.S. rose by 2.5%.

Source: BloombergNEF, EIA, Bloomberg Terminal Notes: Wholesale prices are taken from proxy power hubs in each ISO and are updated through end-2018. 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 2018.

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

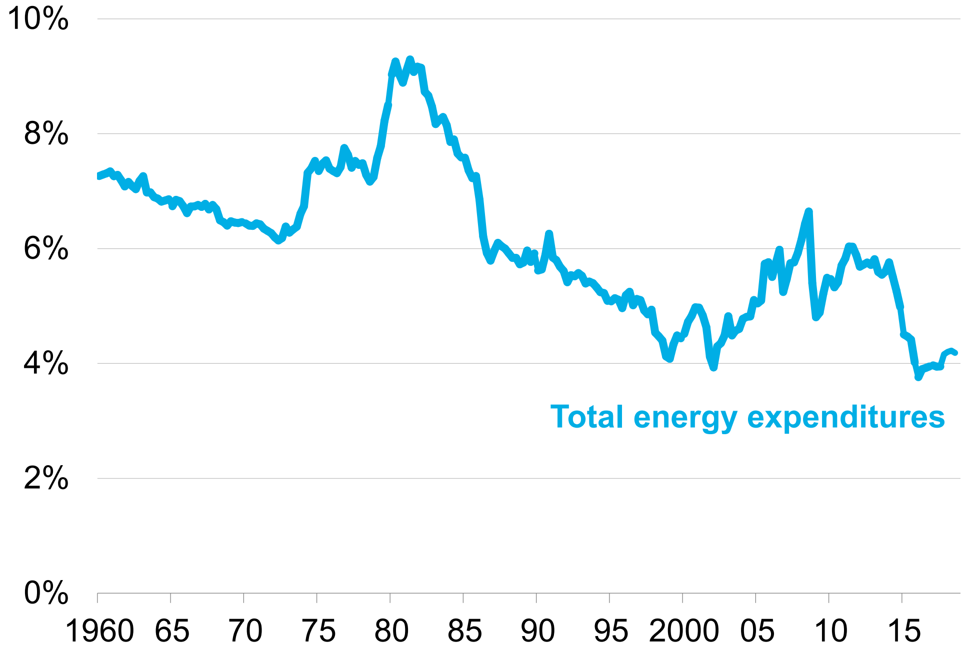


- The U.S. – and North America in general – has among the lowest electricity costs in the world for industrial customers. Among G-7 nations, the U.S, with an average price of 6.88¢/kWh in 2017, is second only to Canada.
- Prices increased in Germany, Canada, Mexico and China from 2016 to 2017. Rising prices for fuel oil and natural gas likely contributed, as well as exchange rate movements. In Mexico, government changes to the power pricing formula also impacted prices.
- Japanese power prices for commercial and industrial customers remained low in 2017. The liberalization of retail electricity markets had the spillover effect of driving up competition among commercial and industrial electricity providers.

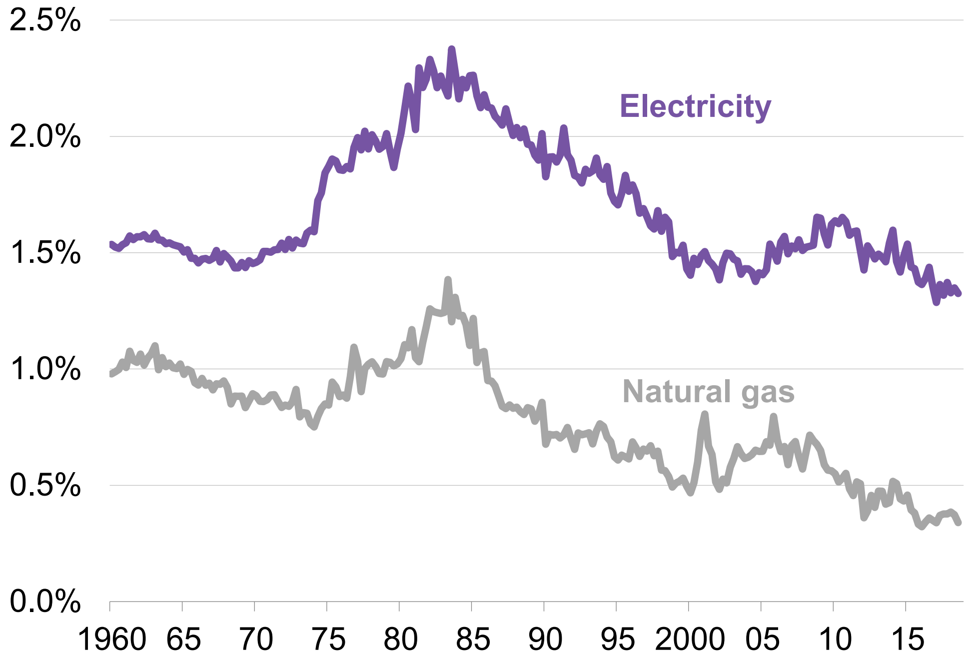
Source: BloombergNEF, government sources (EIA for the U.S.) Notes: Prices are averages (and in most cases, weighted averages) across all regions within the country. Japanese data is for the C&I segment and 2016 figures come from a different source than preceding years.

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

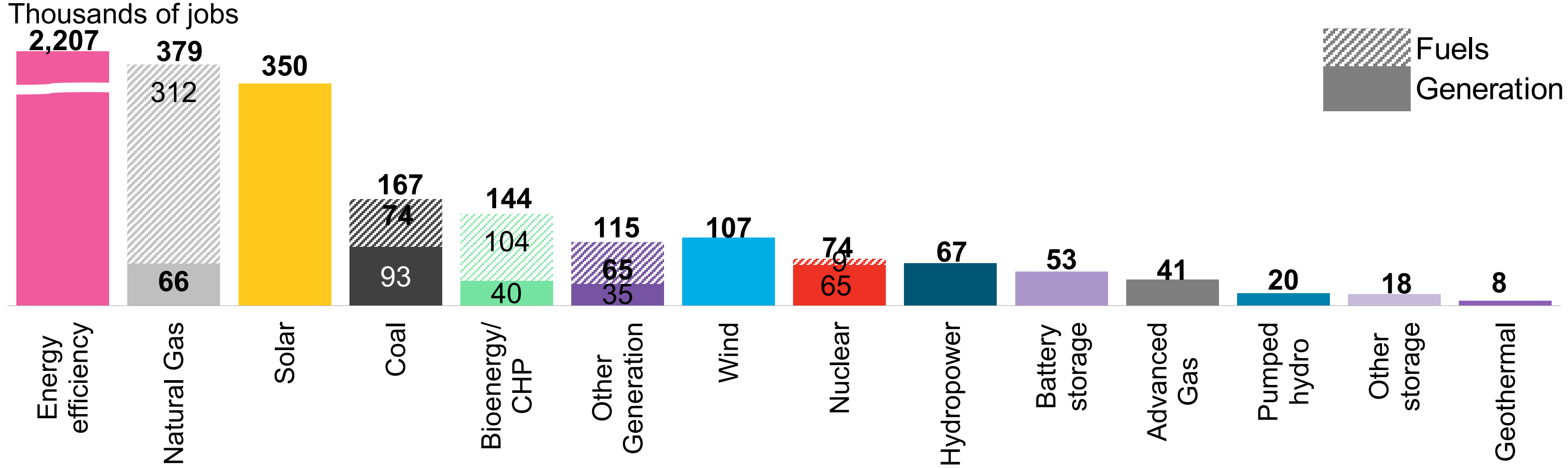


- Energy spending amounted to 4.2% of total U.S. personal consumption expenditures in 2018, up modestly from 2017 levels as gasoline prices rose. Consumers still devote a relatively small share of total spending to energy compared to historical levels, helped along by falling natural gas costs, energy efficiency measures, and technological change.
- Although the share of total energy outlays rose, consumers continued to dedicate the lowest percentage ever to electricity and natural gas: only 1.7% of household expenditures paid electric and gas bills in 2018, tied with 2017 levels. This breaks out to roughly 1.3% on electricity and 0.4% on natural gas.

Source: Bureau of Economic Analysis, BNEF

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

Jobs in select energy segments, 2017



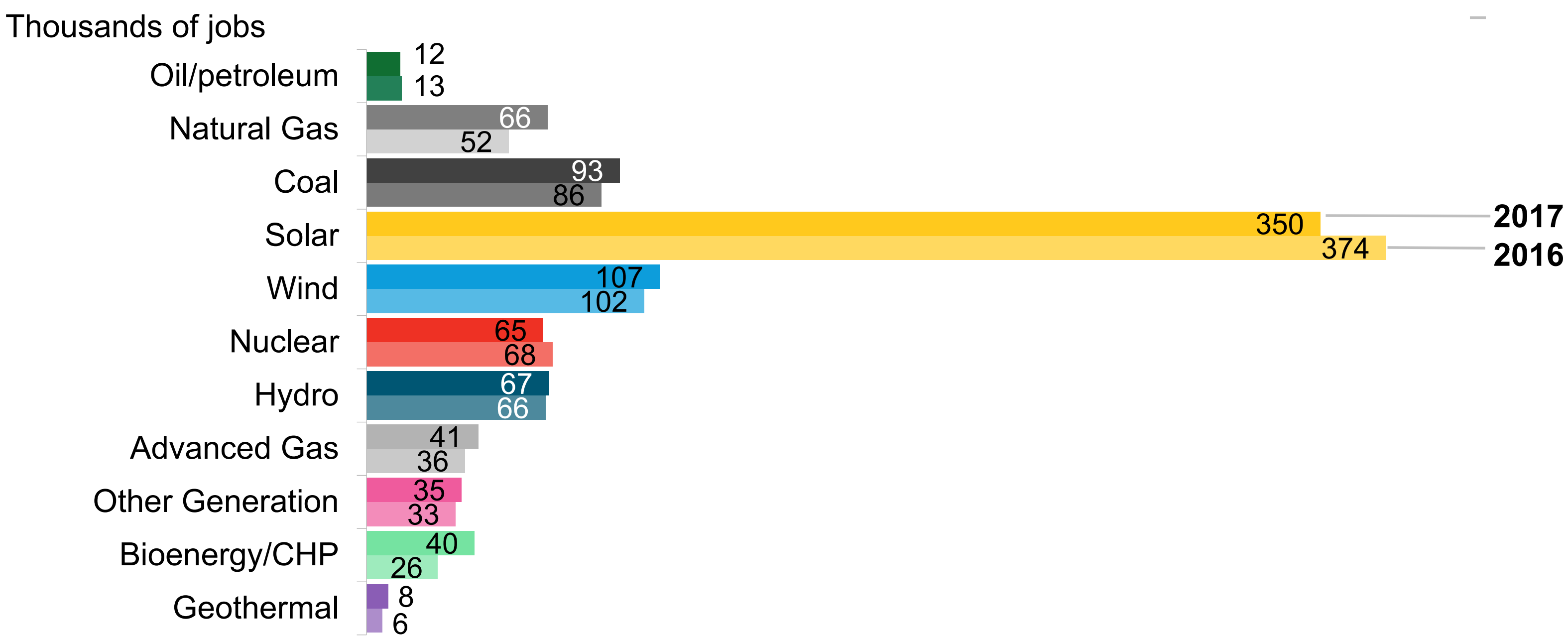
Sustainable energy jobs, 2017

- The renewable, energy efficiency, and natural gas sectors employed an estimated 3.4 million Americans in 2017, according to the U.S. Energy and Employment Report. This number increased from approximately 3.3 million in 2016. Energy efficiency alone supported 2.2 million jobs, while natural gas supported roughly 379,000 jobs and solar 350,000 jobs.
- While renewable sectors like solar, wind, hydropower and geothermal do not require upstream processing or extraction of a fuel, fossil-fired generation does. Adding in fuel-related jobs notably boosts the total employment by fossil-fired generation and bioenergy. As of 4Q 2017, 74% of the jobs associated with the natural gas sector came from fuel supply. Coal employed 167,000, with 44% in coal production and supply.
- Energy efficiency jobs related to construction often hire people who also work on other types of construction tasks (20% of the 1.3 million employees in this category spend only the minority of their time on efficiency).

Source: The U.S. Energy Employment Report, NASEO and EFI. Notes: The data provided relies on thousands of data points provided via survey. Transmission, distribution, and oil/petroleum jobs not included as available data does not break out the portion of those jobs relevant to the electricity sector. See footnote on next slide for details on the definition for "Advanced Gas."

  BloombergNEF

U.S. energy overview: Jobs in electricity generation



- The graph above describes employment within electricity generation (excluding upstream fuel extraction). The solar sector was the single largest employer in electricity generation for 2017, supporting an estimated 350,000 jobs. Fossil fuels (coal, gas, and oil combined) were the next largest category at 172,000, followed by wind with 107,000.
- Solar and nuclear were the only two sectors to shrink year-on-year, as the solar industry experienced its first contraction in new installations (due partly to the boom year in 2016, which had boosted employment significantly) and as nuclear units retired. Fossil fuels exhibited the strongest growth, predominantly in the natural gas sector as the industry added significantly more gas-fired power plants.
- Solar employees often work part-time in other sectors. Of the 350,000 solar industry employees counted by the Department of Energy in 2017, around 30% spent the majority of their time employed in other, non-solar sectors.

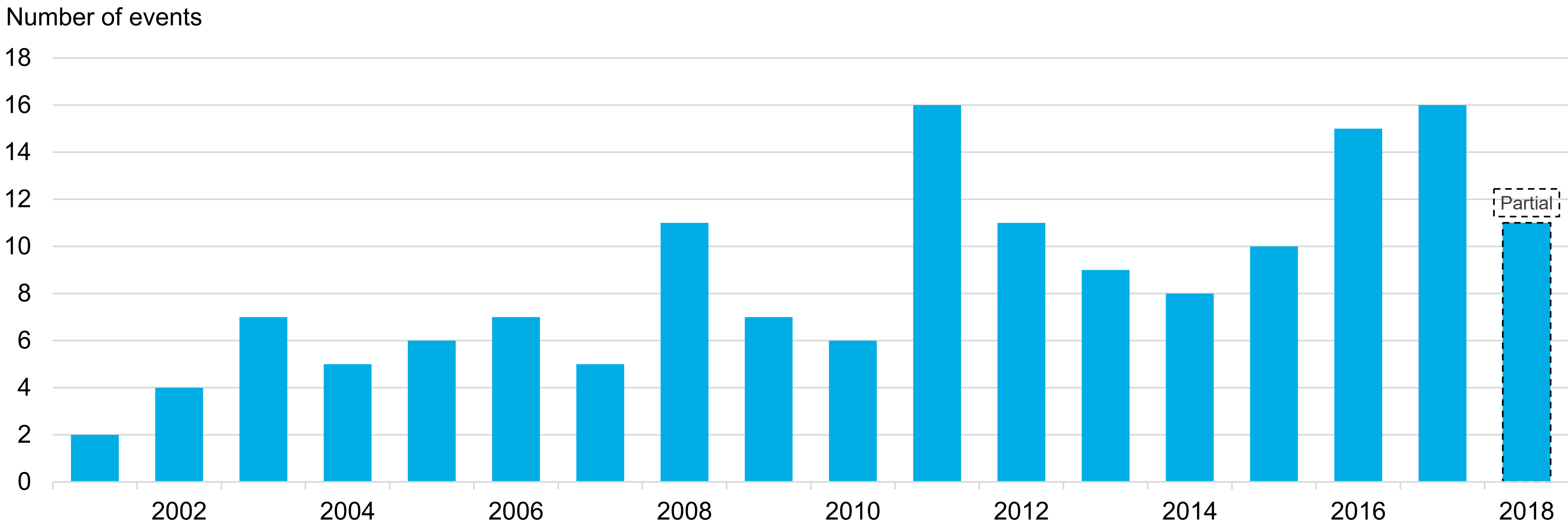
Source: The U.S. Energy Employment Report, NASEO and EFI. Notes: 2016 data is from Q1 2016, 2017 data is from 2Q 2017. "Advanced gas" uses a variety of technologies including high efficiency compressor systems, advanced low NOx combustion technology, first application of closed loop steam cooling in an industrial gas turbine, advanced turbine blade and vane materials, high temperature tbc and abradable coatings, advanced row 4 turbine blades, 3-d aero technology, or advanced brush seal.

Table of Contents

BloombergNEF

Policy: Infrastructure and resilience

U.S. billion-dollar weather and climate disasters

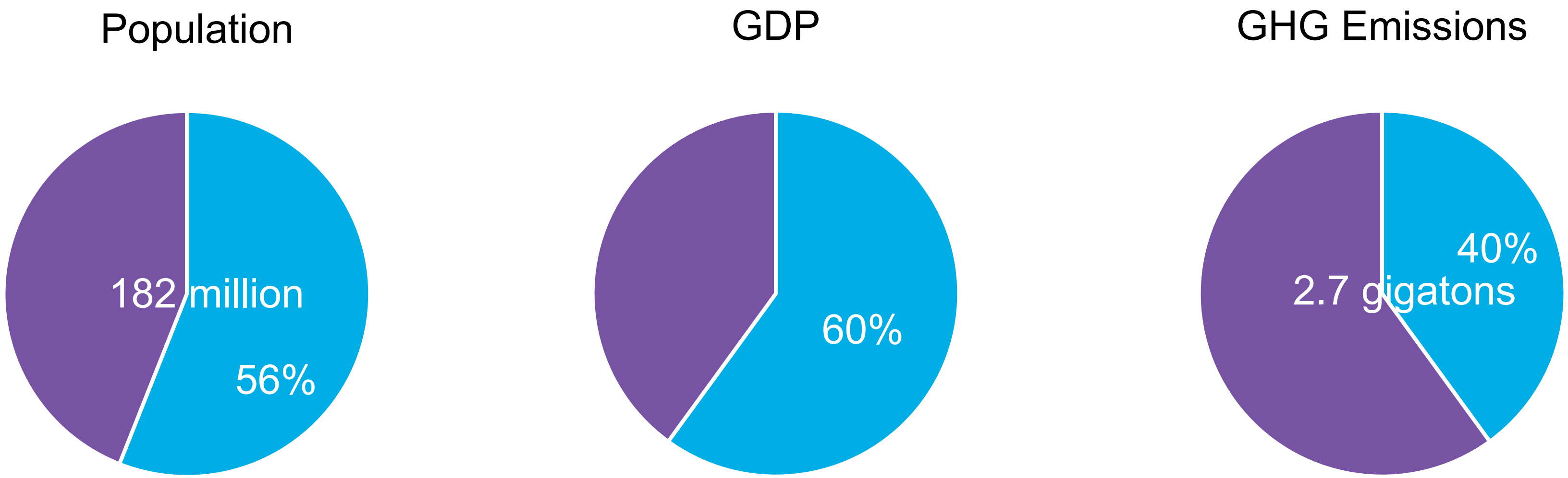


- The Disaster Recover Reform Act, signed by President Trump on October 5, 2018, sets a new formula for pre-disaster mitigation funding. The likely result based on historic disaster costs is that billions of federal dollars annually will help prepare and defend states and localities.
- DRRA also strengthens building code enforcement (including energy codes), identifies qualifying mitigation activities for natural disasters and directs infrastructure repaired or constructed using Stafford Act funds to be built to the most recent code or standard.
- The McCain National Defense Authorization Act, signed on August 13, 2018, gives the Department of Defense the ability 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, 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. 2018 count shown was as of October 9, 2018.

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 (2016)

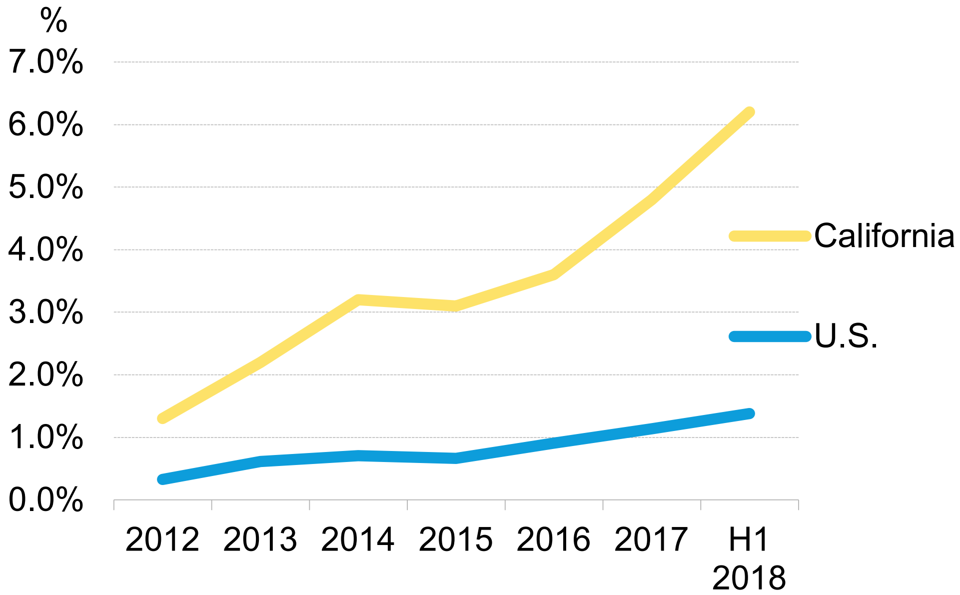


- "Real economy actors" that have pledged support for the Paris climate agreement now represent more than half the U.S. population, more than half the American economy and more than one-third of nationwide GHG emissions, according to a 2018 report from Fulfilling America's Pledge, a coalition of U.S. state and local governments, businesses and other organizations funded by Bloomberg Philanthropies.
- One example of municipal action has come in Los Angeles, which in partnership with a unit of France's Bolloré Group, launched BlueLA, the nation's first all-electric carshare service aimed at serving low-income citizens. The service is funded by the city, Bolloré and revenue from California's cap-and-trade program. BlueLA placed stations in the city's most disadvantaged areas and employs residents of those areas.

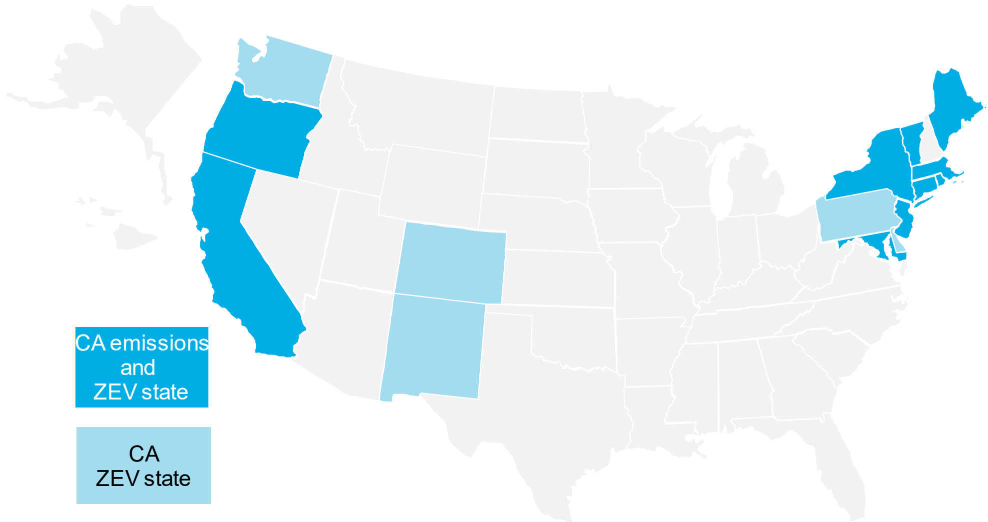
Source: America's Pledge, BloombergNEF

Policy: vehicle fuel economy standards

EV share of light duty vehicle sales in California and nationwide



States that have adopted California's vehicle emissions standards

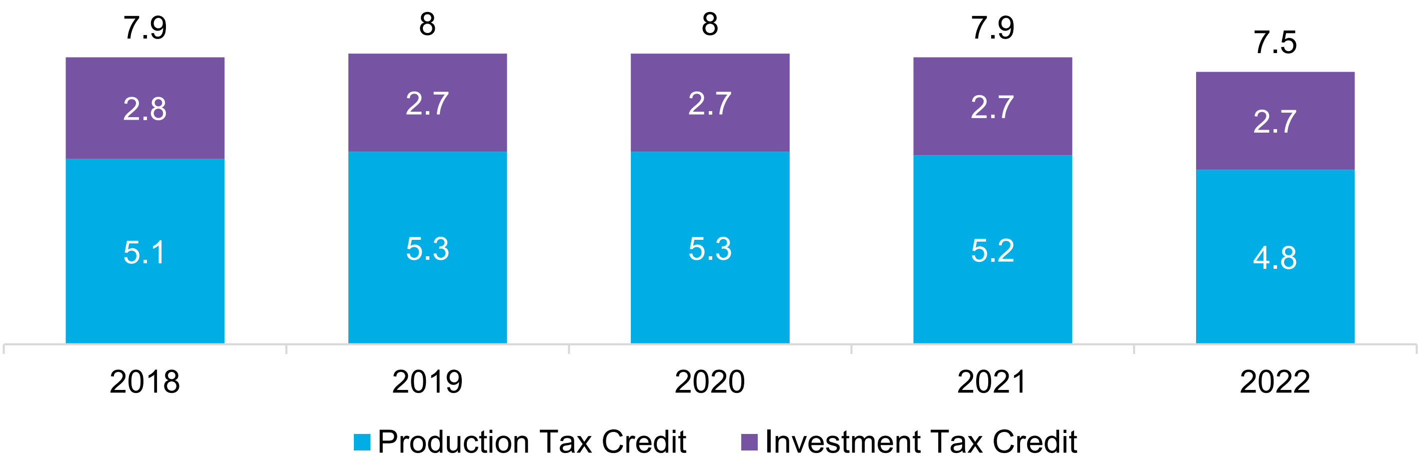


- The transportation sector is now the largest source of CO2 emissions in the U.S. Electric vehicle sales are growing but still represent a miniscule share of the on-road fleet.
- The Trump administration proposed to freeze Corporate Average Fuel Economy (CAFE) standards for model years 2021-2025 at 2020 levels, which by its own estimates would increase both motor fuel consumption and greenhouse gas emissions. The state of California declared that it will not freeze or dilute its CAFE standards, which have been adopted by 13 other states and the District of Columbia.
- 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 states that follow the California GHG standard are Colorado, Connecticut, Delaware, Maine, Maryland, Massachusetts, New Jersey, New Mexico, New York, Oregon, Pennsylvania, Rhode Island, Vermont and Washington, plus the District of Columbia.

Policy: Tax policy

Annual federal expenditures on renewable energy tax credits ($billions)

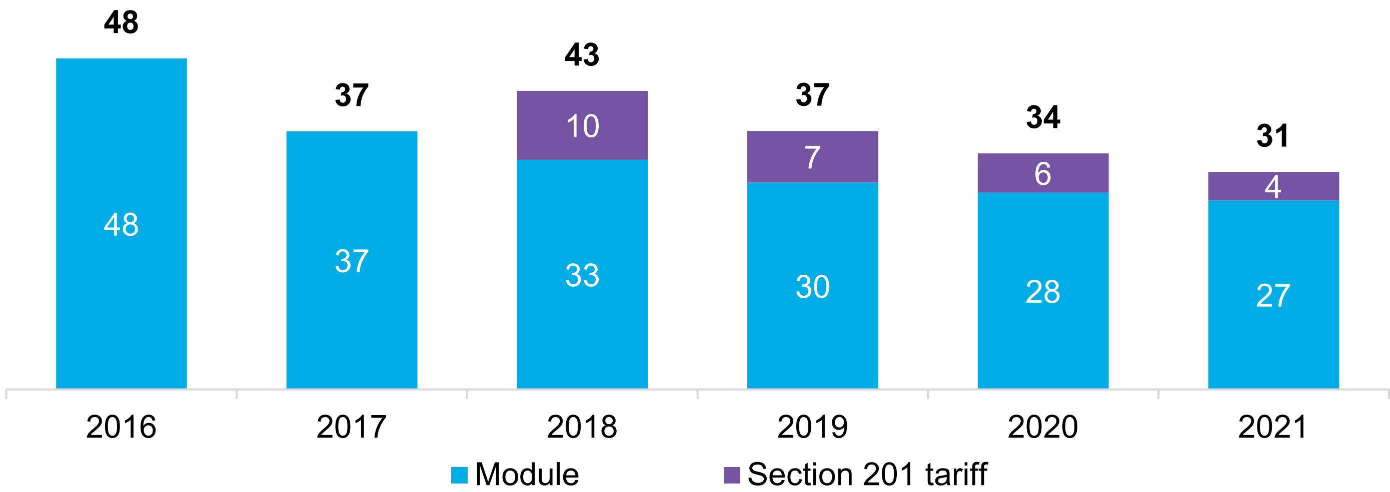


- Federal expenditures on the two main tax credits that support clean energy development will stay level then decline slightly in coming years, the Joint Committee on Taxation of the U.S. Congress has projected.
- The Bipartisan Budget Act of 2018 provided a long-term extension of the ITC for fuel cells, combined heat and power, small wind and geothermal. A number of other energy tax measures have not yet been extended, including several energy efficiency credits and the PTC for biomass, geothermal, landfill gas, waste to energy, hydropower, marine and hydrokinetic.
- Carbon capture and storage was a standout beneficiary of the budget bill. A tax credit for carbon captured, permanently stored and used for enhanced oil recovery or other industrial processes was raised from $10 per ton up to $35 per ton, depending on the process. A companion credit for carbon captured and permanently sequestered (with no further use) was raised from $20 up to $50 per ton.
- The budget bill also extended eligibility for the nuclear production tax credit past a looming 2020 deadline. That extension benefits the only major unfinished U.S. nuclear project, the Vogtle plant in Georgia, which would not have been able to meet the previous deadline.

Source: U.S. Congress Joint Committee on Taxation

Policy: Trade

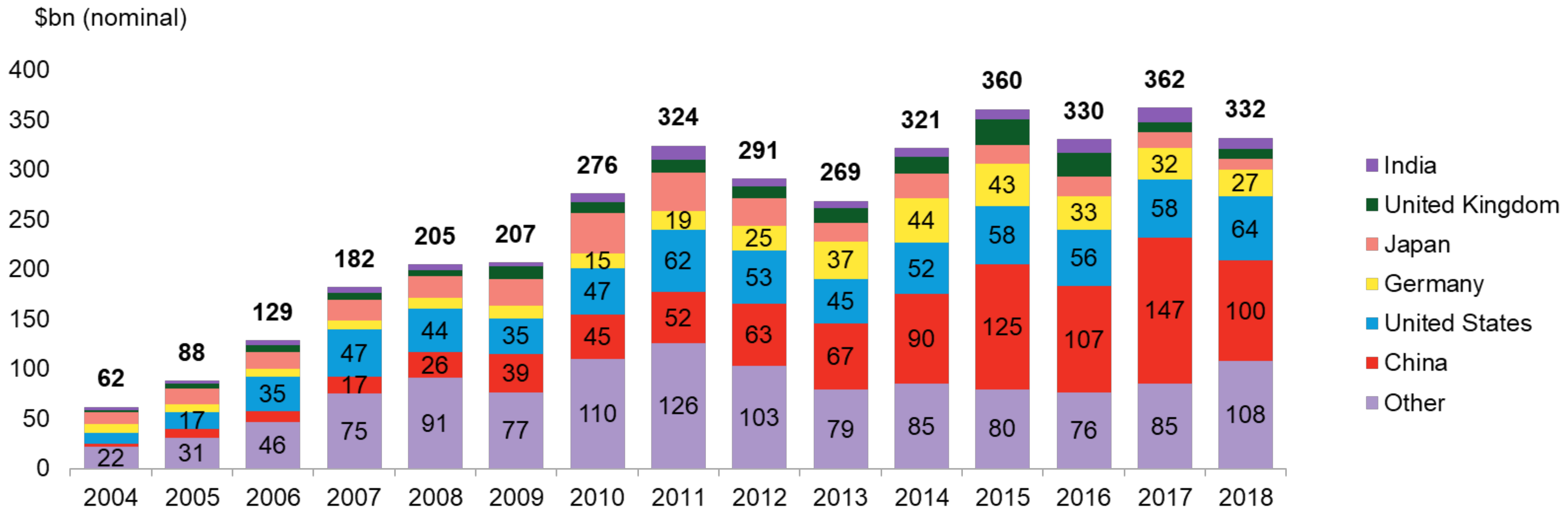
Estimated cost of Chinese solar modules delivered to U.S. (cents/Watt)



- In January 2018, President Trump imposed Section 201 “safeguard” duties on imported solar crystalline silicon cells and modules on grounds that they cause serious injury to American manufacturers. While the tariffs have served to raise the price of solar in the U.S., they were to some degree offset by declining PV equipment costs. BNEF projects further costs equipment declines through 2021.
- Citing a threat to national security, Trump in July 2018 imposed Section 232 duties on imported steel and aluminum products.
- Trump in September 2018 hit $50 billion in Chinese products with tariffs, citing Section 301, which allows the U.S. to use tariffs and other measures to respond to unfair or discriminatory trade practices.
- Bowing to Trump’s demands, Canada and Mexico agreed to replace the 28-year-old North American Free Trade Agreement, or Nafta. Unlike other trade policy moves by the president the Nafta successor, the United States-Mexico-Canada Agreement, must be approved by Congress.
- The Nafta replacement incentivizes more auto manufacturing in North America and requires that most work be carried out by employees making at least $16 per hour, which is much less than prevailing wages in Mexico.

Source: BloombergNEF

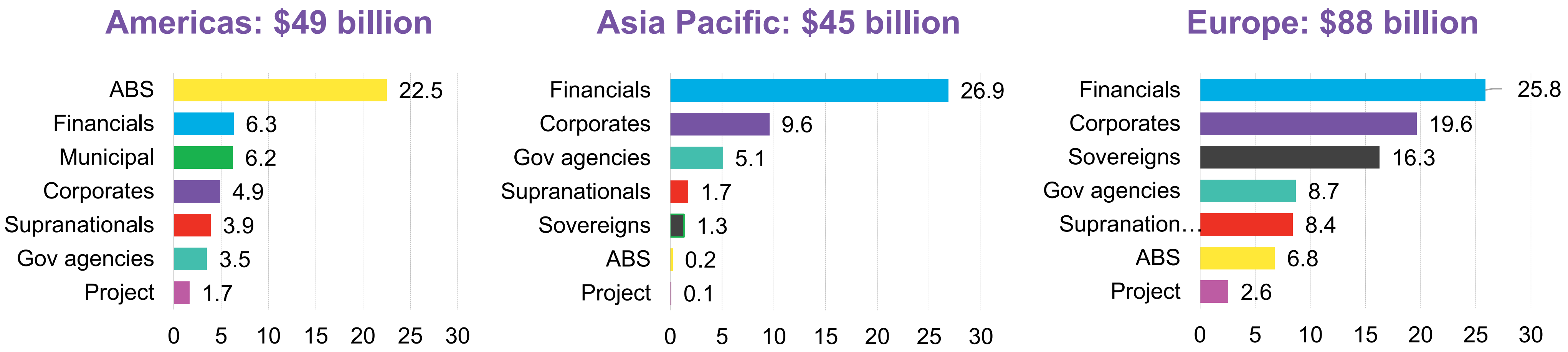
Finance: Total new investment in clean energy by country or region



- Global investment in clean energy reached $332 billion for 2018, the lowest annual total since 2013. This represents a 8.2% decrease from 2017 investment levels.
- Many countries experienced year-on-year declines, with significant falls in China (down 32% year on year), Germany (down 16%), and Japan (down 32%). However, the U.S. experienced an uptick of 11%.
- Solar was the largest single recipient of investor dollars in 2018. However, financing in this segment dropped 24% year on year to $131 billion. Financing for wind also dropped 22%. Falling costs for these technologies help explain these declines.
- The U.S. was the second largest market for clean energy investment, at $64 billion.

Source: BloombergNEF Notes: Includes new investment in wind, solar, biofuels, biomass, waste, energy smart technologies (such as electric vehicles and lithium-ion batteries), and other renewables/low carbon services.

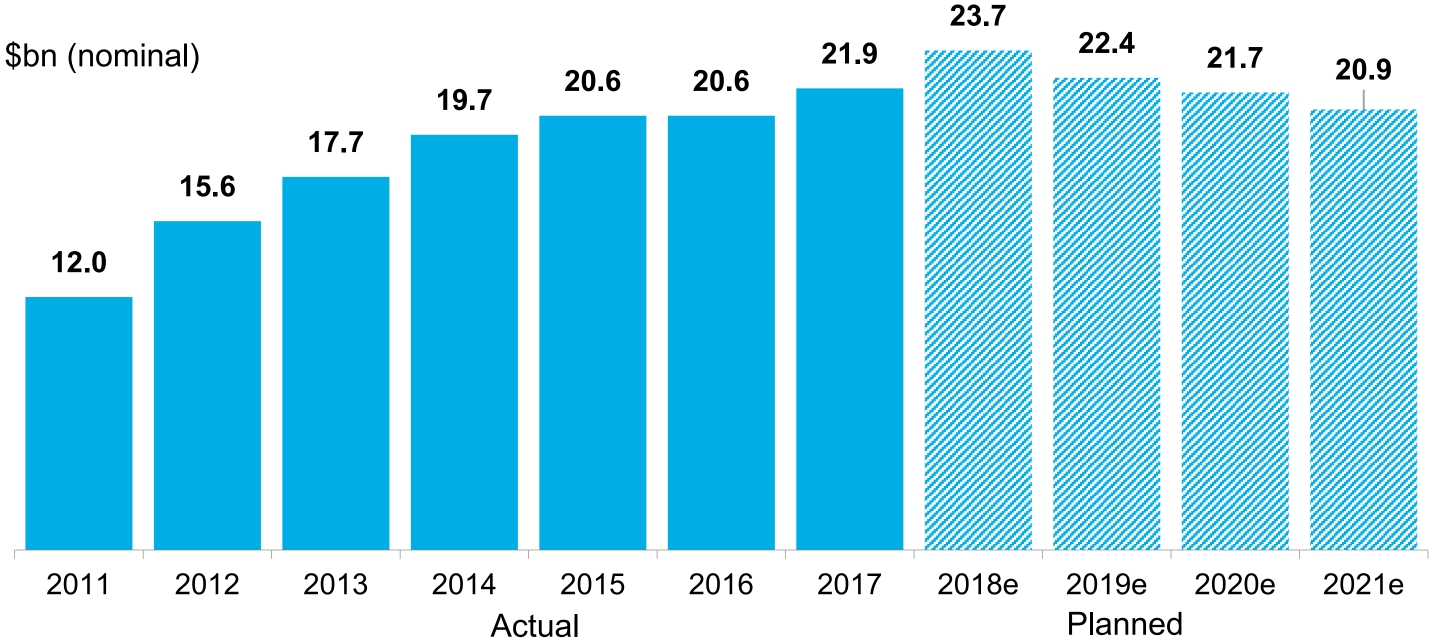
Finance: Global green bond issuance



- Europe was the most active region for green bond issuance in 2018, with $88 billion of green securities raised through the year, versus $45 billion in Asia-Pacific and $49 billion in the Americas.
- The European market was driven by major banks financing and refinancing renewable energy debt lending portfolios, as well as a surge in green sovereign debt. The government of Belgium joined France, Poland and Sweden with $16 billion in green sovereign debt sold in 2018.
- Asia's green bond market barely surpassed 2017's $44 billion total raised as debt lending restrictions and deleveraging initiatives impacted the wider market.
- The U.S. green bond market is almost entirely upheld by mortgage giant Fannie Mae. The enterprise's green mortgage program continues to expand, with over $22 billion of new commercial green pools sold into capital markets in the year. These securities finance efficiency-certified multifamily units throughout the country. U.S. municipal green debt slowed as many states and cities awaited updates on potential federal infrastructure legislation before selling bonds into the markets.

Source: BloombergNEF Note: ABS stands for asset backed securities (green mortgages, solar and EV auto loans)

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

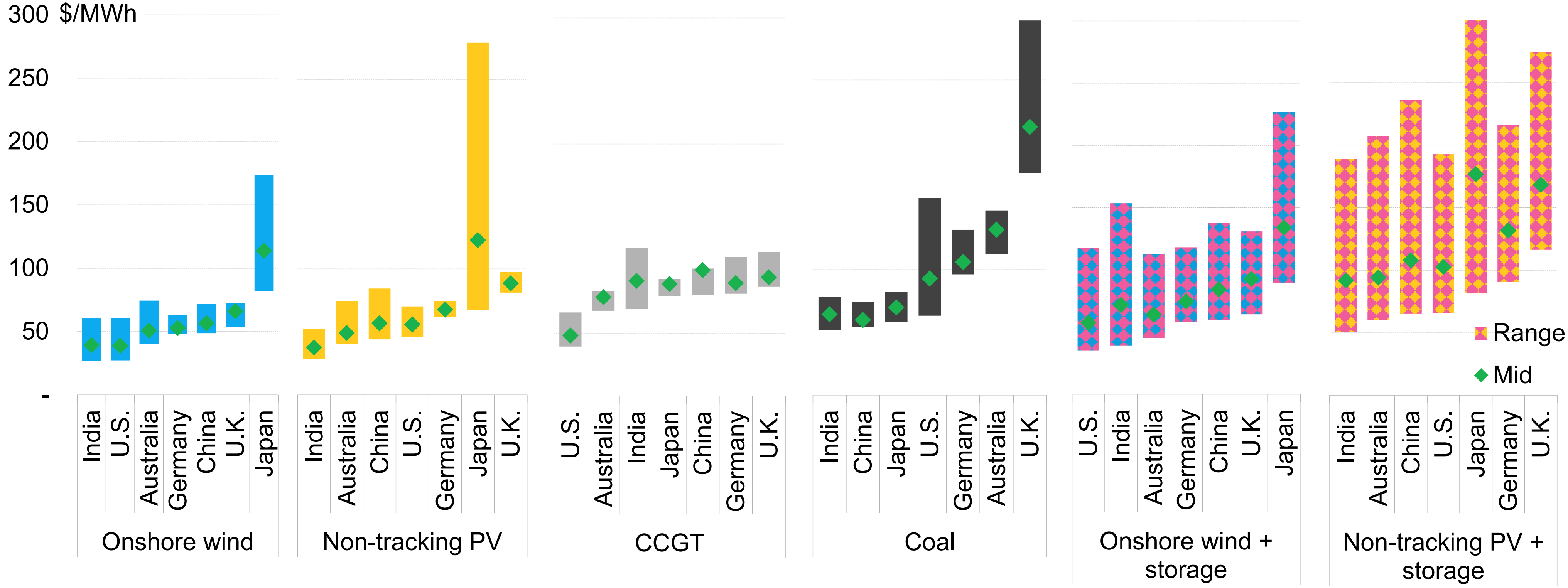


- Investor-owned utilities and independent transmission developers spent an estimated $21.9 billion on electric transmission in 2017, a new high, the Edison Electric Institute estimates. This is up 6% from 2016.
- Based on company reports, investor presentations and a survey conducted by EEI, transmission investment likely grew 8% in 2018 to $23.7 billion. Current capex plans suggest that investment will have peaked in 2018 and investment will slow in 2019 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 (updated December 2018), BNEF

BloombergNEF

Economics: Select country levelized costs of electricity (unsubsidized, 2H 2018)

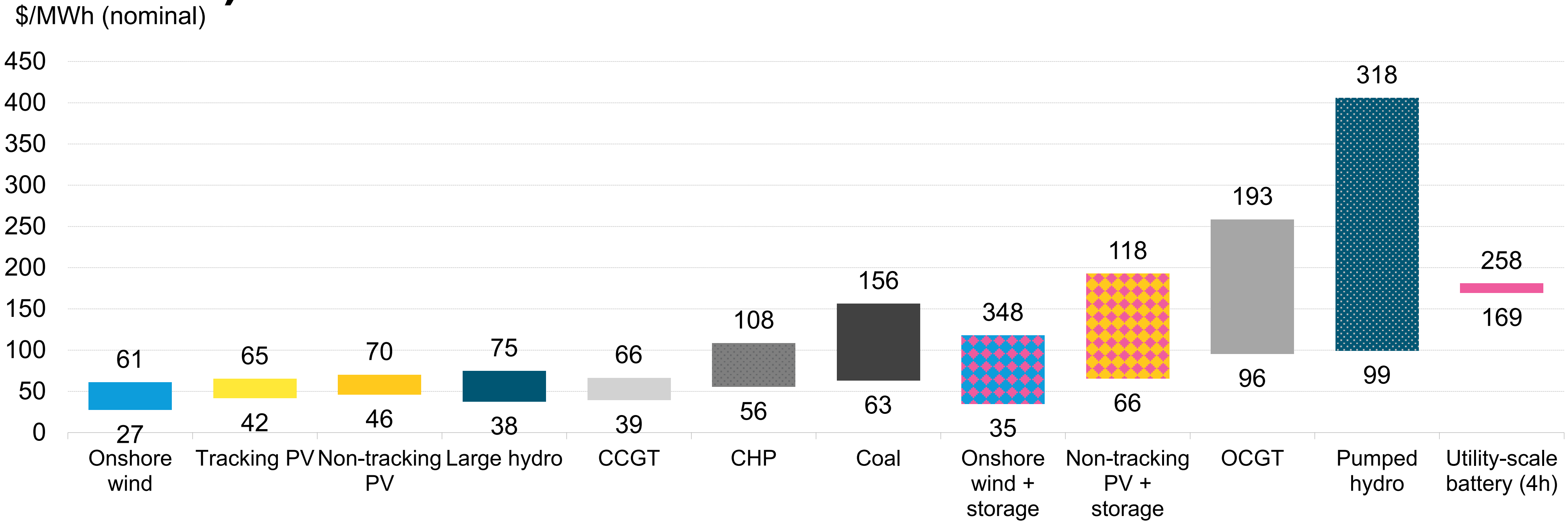


- Onshore wind is the cheapest source of new generation across geographies, with India and the U.S. boasting the lowest all-in costs at $27/MWh.
- India also features the world's lowest-cost solar, at an estimated $28/MWh for non-tracking photovoltaic (PV).
- The U.S. sees the least expensive combined-cycle gas turbines (CCGTs) due to cheap, abundant gas resources and no nation-wide carbon price. Carbon pricing and relatively poor resources in the U.K. and Germany push up the costs for both gas and coal build.

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 2018)

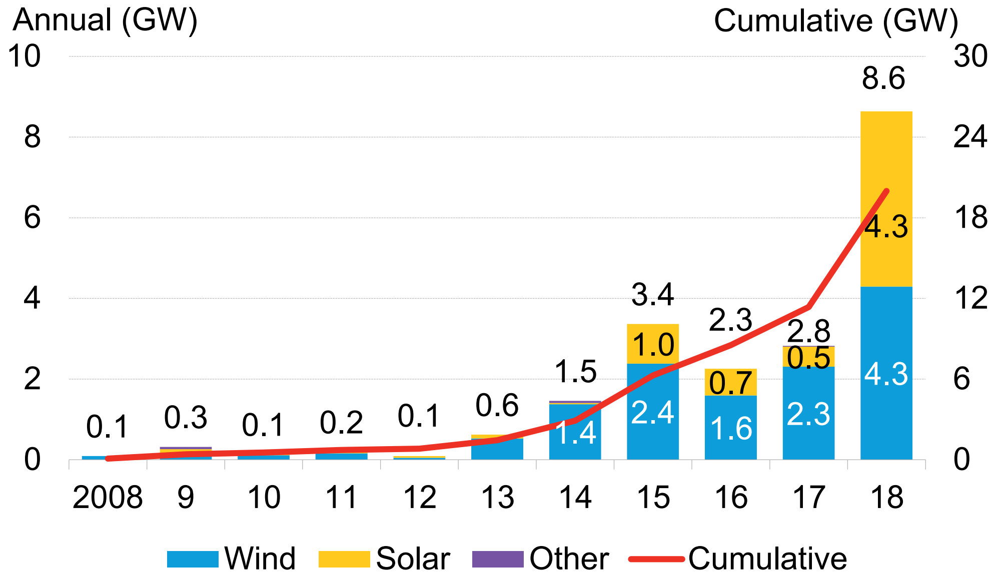


- Levelized cost of electricity (LCOE) is a metric for comparing the relative costs of different generating technologies. It measures the all-in, lifetime costs of operating a plant, accounting for upfront costs as well as anticipated ongoing expenses.
- At $27-$61/MWh *without accounting for tax credits*, the LCOE for onshore wind is lower than for new gas-fired plants for bulk electricity generation in many areas of the U.S. Meanwhile, combined-cycle gas turbines (CCGTs) offer the lowest cost *dispatchable* power in the U.S., with an LCOE of $39-$66/MWh.
- Photovoltaic (PV) systems outfitted with mechanisms to track the sun's progress across the sky offer an LCOE of $42-$65/MWh and are nearly at parity with new CCGTs. PV without tracking is getting cheaper, with an LCOE of $46-$70/MWh.
- The levelized cost of paired onshore wind-plus-battery (with four hours of storage) systems ranges from $36-$118/MWh, while solar-plus-battery (four hours) is $57-$169/MWh.

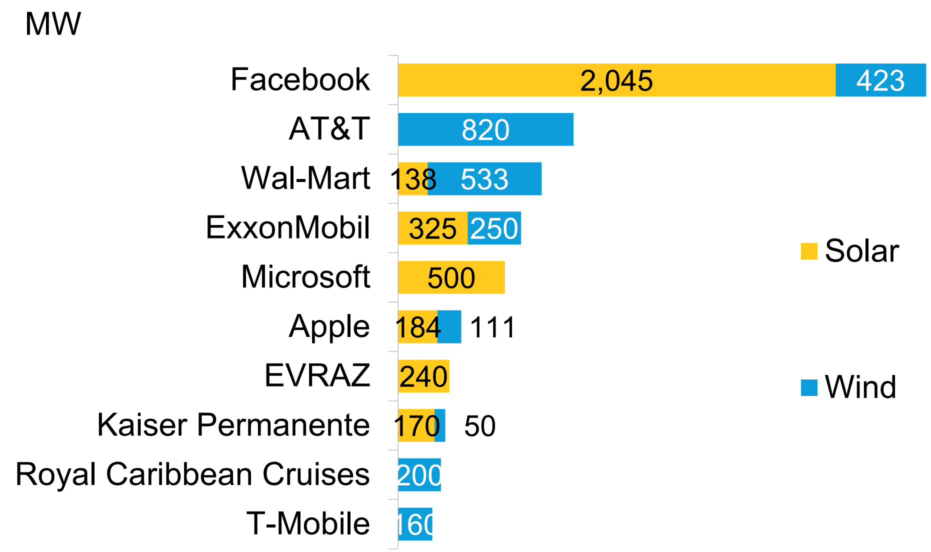
Source: BloombergNEF. Note: LCOE range represents a range of costs and capacity factors. Battery storage systems (co-located and stand-alone) presented here have four-hour storage. In the case of solar- and wind-plus-battery systems, the range is a combination of capacity factors and size of the battery relative to the power generating asset (25-100% of total installed capacity). All LCOE calculations are unsubsidized. Categorization of technologies is based on their primary use case. Nuclear not included due to insufficient data and lack of project development. Large hydro projects are those greater than 50MW of capacity.

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

Renewable capacity contracted by corporations, by technology



Largest corporate offtakers, 2018



- New power purchase agreements (PPAs) signed between buyers of clean energy and generators spiked to a new record of 8.6GW in 2018, up from 2.8GW in 2017. Facebook contracted nearly 2.5GW of U.S. clean energy in 2018, more than any other corporation. It has worked closely with regulated utilities such as Pacific Power and PNM Resources through green tariff programs. ExxonMobil is the first oil and gas major to lock into a long-term clean energy contract to power its own operations. It signed two deals to purchase 575MW of solar and wind from Orsted.
- Some buyers that previously signed contracts are feeling remorse as wholesale prices have remained low. As a result, corporations seeking new PPAs are now asking for shorter terms on their deals. Average corporate wind PPA lengths dropped from 17 years in 2014 to 14 years in 2018.
- Smaller companies are increasingly aggregating their load to take advantage of the economies of scale of larger clean energy projects. This has opened the door for companies such as Akamai, Adobe and Etsy to sign long-term contracts. Roughly 4.5GW of corporate PPAs signed since 2014 have come through aggregated purchasing.

Source: BloombergNEF   Note: Charts show offsite PPAs only

Finance: Corporate procurement of clean energy and energy efficiency

Key players: corporate clean energy procurement

Retail

Financial & Insurance

Tech

Manufacturing

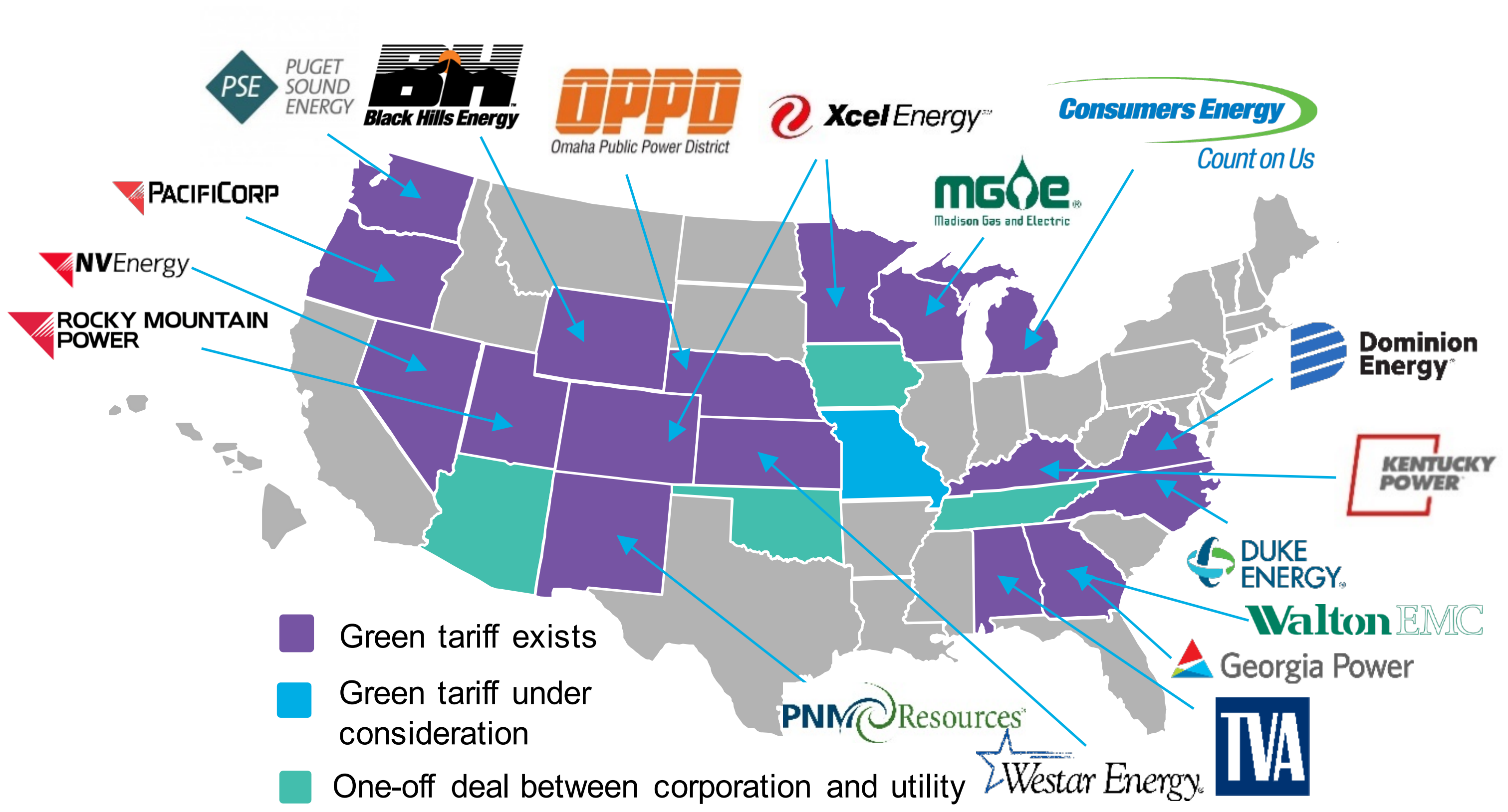
Key players: corporate vehicle electrification

Key players: corporate energy efficiency

- Corporations continue to establish targets to purchase clean energy. Through 2018, 158 companies have pledged to source 100% of their energy consumption from renewables by signing onto the "RE100" initiative; 32% of these firms are domiciled in the U.S. Financial, consumer staples and technology companies are the most common signees. 40 companies from 13 countries joined the RE100 in 2018.
- Through 2018, 37 companies have joined The Climate Group's EP100 campaign, up from 13 companies in 2017. Signatories pledge to double their energy productivity by 2030, while also cutting energy waste and owning and operating energy-smart buildings. Salesforce, Hilton and Schneider Electric are notable members to join the initiative in 2018.
- The Climate Group's EV100 campaign is also gaining momentum. Companies make a public commitment to integrate electric vehicles (EV) into their fleet or support EV charging infrastructure at their operations by 2030. IKEA, HP and Unilever spearhead a group of 31 companies that have joined the campaign through 2018.

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

Deployment: Corporate procurement of clean energy through green tariffs



- Corporations are increasingly working with utilities in regulated U.S. markets to purchase clean energy, through programs known as green tariffs. Through green tariffs, corporations aim to limit their exposure to plummeting wholesale power prices and purchase clean energy locally.
- Through 2018, 17 regulated utilities in 17 states offer green tariff programs for corporate customers.
- Companies purchased 2.7GW of clean energy through green tariffs in 2018, quintupling the record 500MW of activity in 2017.
- 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 program.

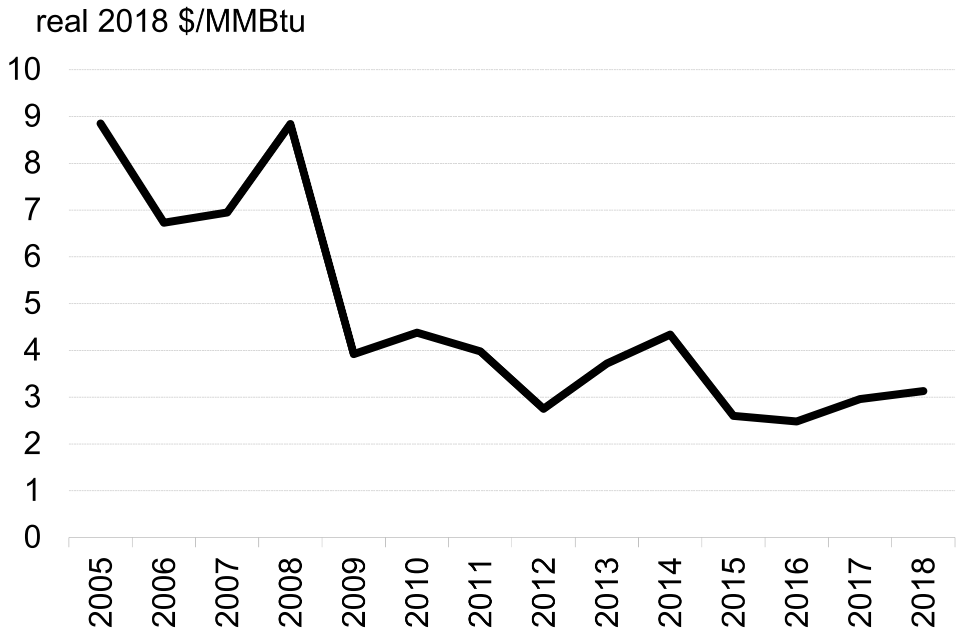
Source: BloombergNEF, World Resources Institute

Table of Contents

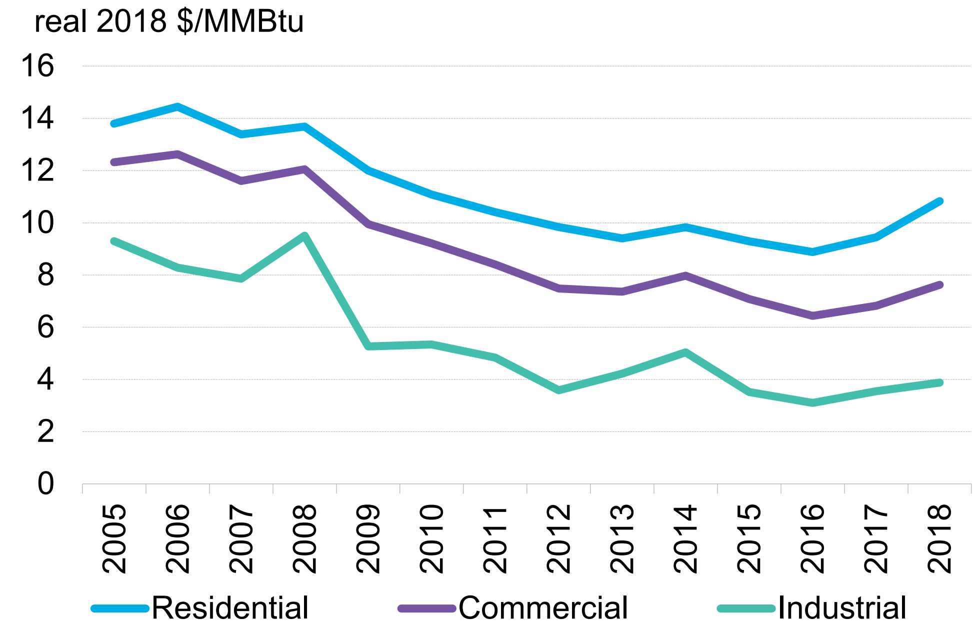
BloombergNEF

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

Natural gas spot prices



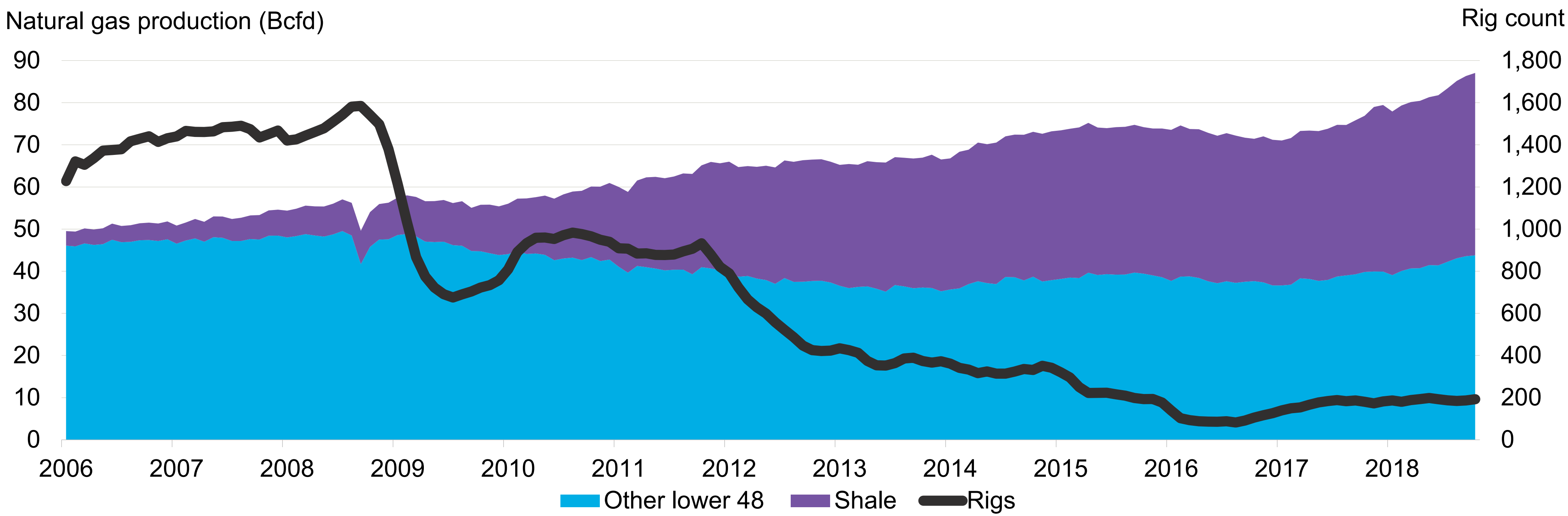
Natural gas prices to end users



- The price of natural gas has fallen dramatically since a decade ago. In 2018, the average price ticked up to $3.20/MMBtu. That marked a 29% increase from 2016's low. The recent rise is being driven by weather, increased demand for power generation and increased liquefied natural gas (LNG) exports. All combined to tighten inventories, which influence market sentiment and prices.
- The growth of U.S. gas supply has pushed down costs to industrial, commercial and residential users. Over the last 10 years, industrial gas prices have fallen 59%, commercial gas prices have declined 37% and residential gas prices slid 21%.
- All customer groups saw gas prices rise in 2018, however. Industrial, commercial, and residential prices lifted to $3.88/MMBtu, $7.62/MMBtu, and $10.82/MMBtu, respectively.

Source: BloombergNEF, EIA; Note: Natural gas prices derive from Henry Hub annual spot prices. Values for 2018 are projected, accounting for seasonality, based on latest monthly values from EIA (data available through October 2018).

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

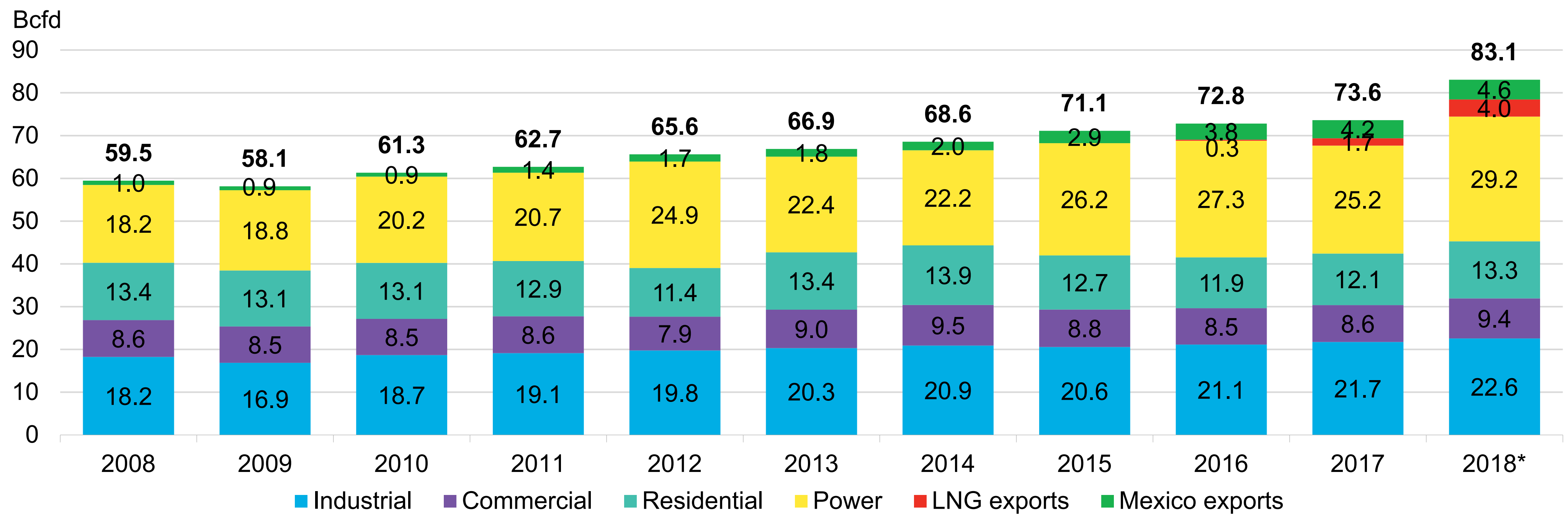


- Gas production has been improving in efficiency over the last decade. Between September 2008 and September 2018, the U.S. gas-directed rig count collapsed nearly 90% from a monthly average of 1,585 to 187. But at the same time, total production rose 56%, driven by the explosive growth in shale gas production.
- In 2018, the number of gas-directed rigs in operation remained flat throughout the year, yet production experienced the biggest yearly increase since 2014. New production came from Appalachia, which saw improved prices as the region was de-bottlenecked through capacity additions, and from the Haynesville.
- New gas production also came from oil-directed wells in the Permian. The Permian has seen a growth in oil production, particularly as oil prices rose through much of 2018. This resulted in an increase in associated gas production from the region.

Source: Bloomberg Terminal, EIA, Baker Hughes Note: Data is through October 2018

BloombergNEF

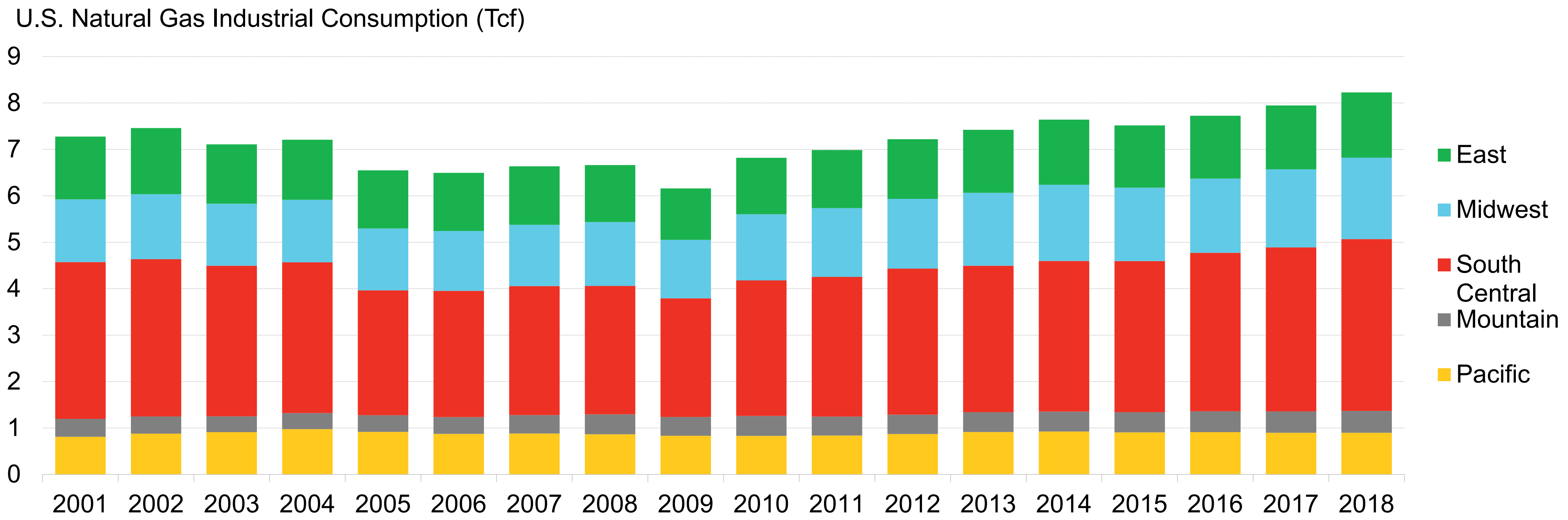
Deployment: U.S. natural gas demand by end use



- Total U.S. annual gas demand has grown 40% over the past decade and spiked 13% from 2017 to 2018 to hit a new record of 83.1Bcfd.
- The growth was primarily driven by power sector demand, which increased by 4Bcfd (16%) from 2017, but all sectors saw growth in gas consumption. Power-sector gas consumption resumed its growth trend after a 8% dip in 2017 due to strong production from competing large hydro power projects.
- Refinery expansions along the Gulf Coast as well as new chemical facilities – mainly in Appalachia – led to the uptick in industrial demand.
- Residential and commercial consumption increased with cooler temperatures in the winter, reaching levels not seen since 2014.
- LNG exports grew by 2.3Bcfd (up 135% year-on-year) as Sabine Pass expanded its export capacity and two new terminals, Cove Point and Corpus Christi, began operations in 2018. Pipeline flows to Mexico and Canada also grew as new export capacity additions came into service.

Source: BloombergNEF, EIA. Note: Values for 2018 are projected, accounting for seasonality, based on latest monthly values from EIA (data available through October 2018).

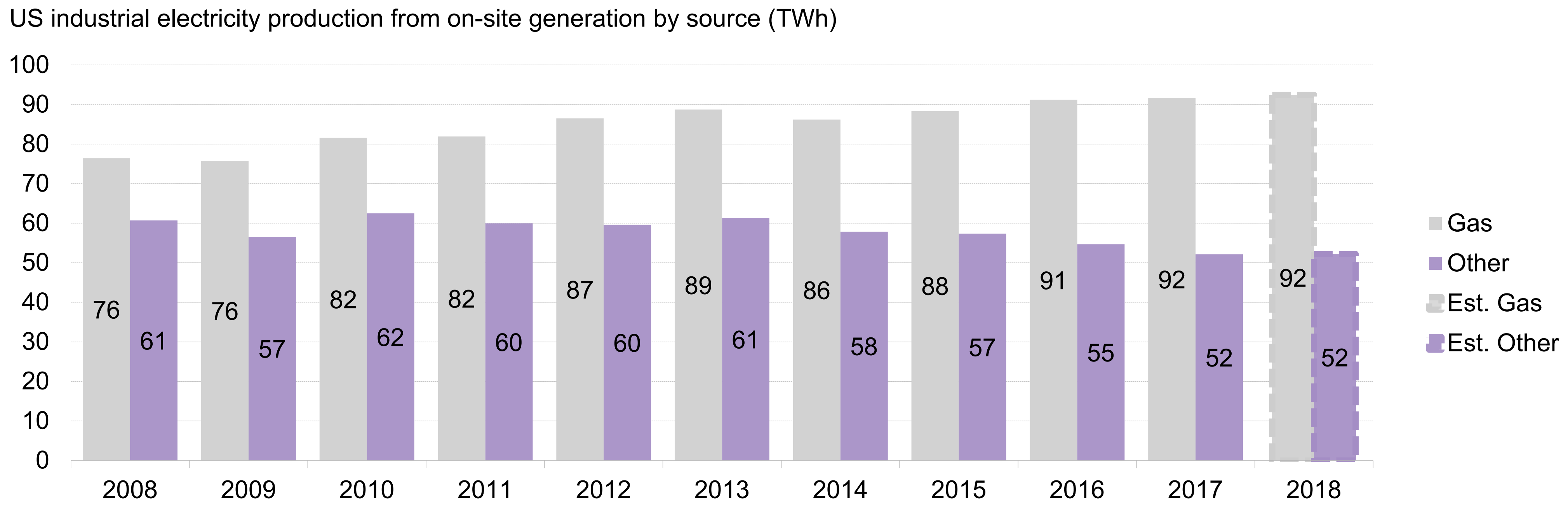
Deployment: industrial gas demand by region



- In the past decade, overall natural gas consumption has increased 23% from 2008 levels, helped by lower natural gas 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 8.2Tcf in 2018, of which 3.7Tcf was consumed in the South Central region, 1.7Tcf in the Midwest, 0.5Tcf in the Mountain region, 0.9Tcf in the Pacific and 1.4Tcf in the East.
- Industrial gas consumption rose 3.5% in 2018 from the year prior. Consumption increased in most regions, but by varying amounts: the East was up by 2%, the Mountain region by 2%, the Midwest by 4% and the South Central by 5%. Consumption in the Pacific did not change.
- There has been a long-term decrease in gas consumption in the Pacific region, where demand peaked in 2014 at 0.92Tcf and has declined nearly every year since.

Source: BloombergNEF, EIA; Note: Values for 2018 are projected, accounting for seasonality, based on latest monthly values from EIA (data available through October 2018). 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

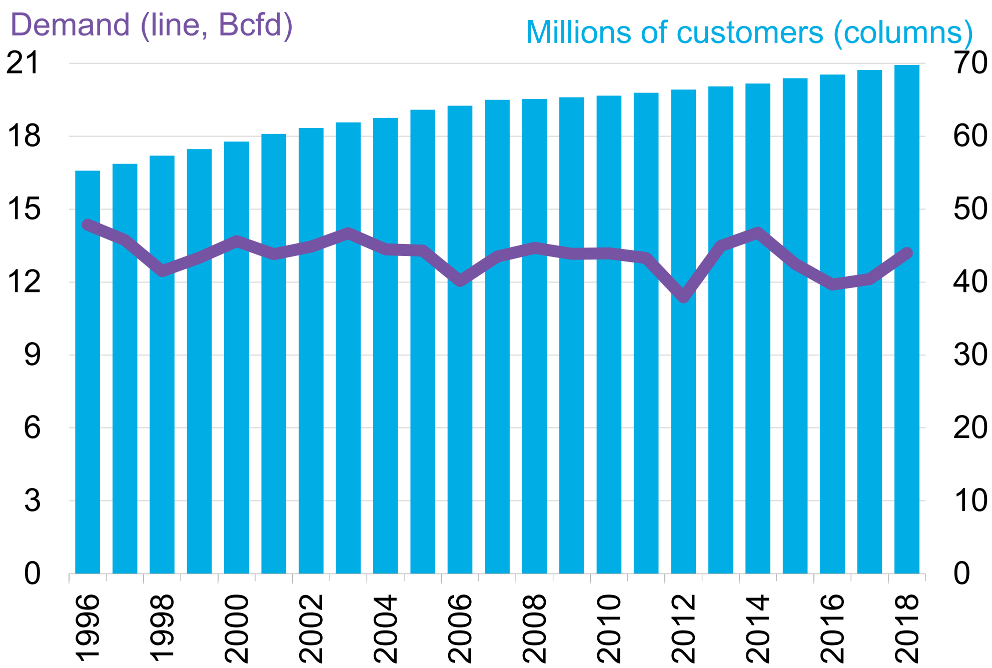


- On-site power generation in the industrial sector is when electricity is produced on the premises of the industrial plant rather than being imported from the grid.
- In 2018, natural gas was responsible for an estimated 92TWh of on-site generation at industrial facilities, with 52TWh provided by other sources, unchanged from 2017's levels.
- Despite total industrial sector on-site generation decreasing by 2TWh since 2016, gas based generation has increased by 1TWh by displacing other fuels through low prices.
- The percent of on-site generation provided by gas has increased significantly in the last decade, from 54% in 2008 to 64% 2018.

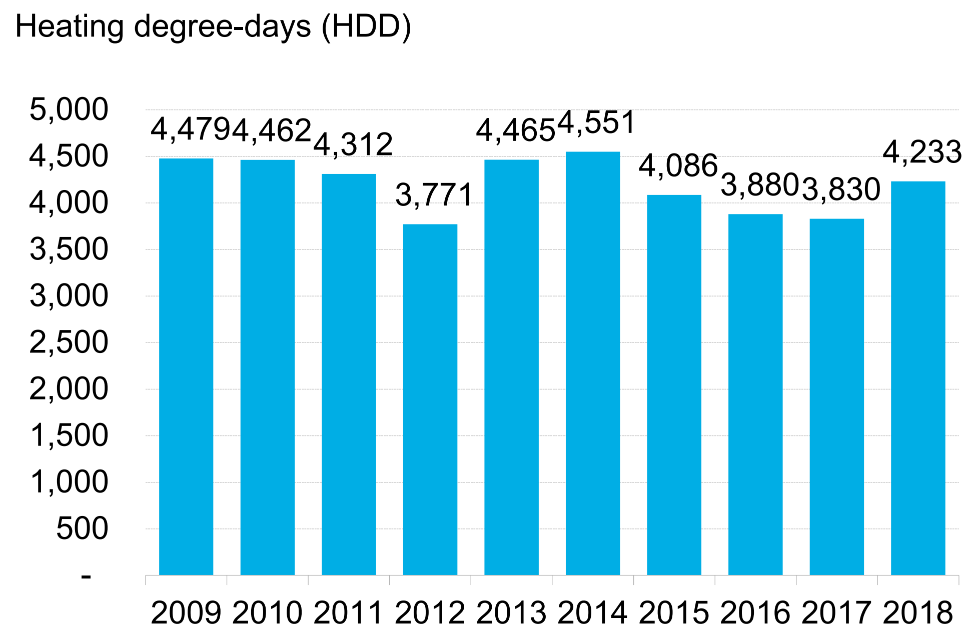
Source: BloombergNEF, EIA; Note: Values for 2018 are projected, accounting for seasonality, based on latest monthly values from EIA (data available through September 2018)

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

Residential demand vs. consumption



Heating degree-days

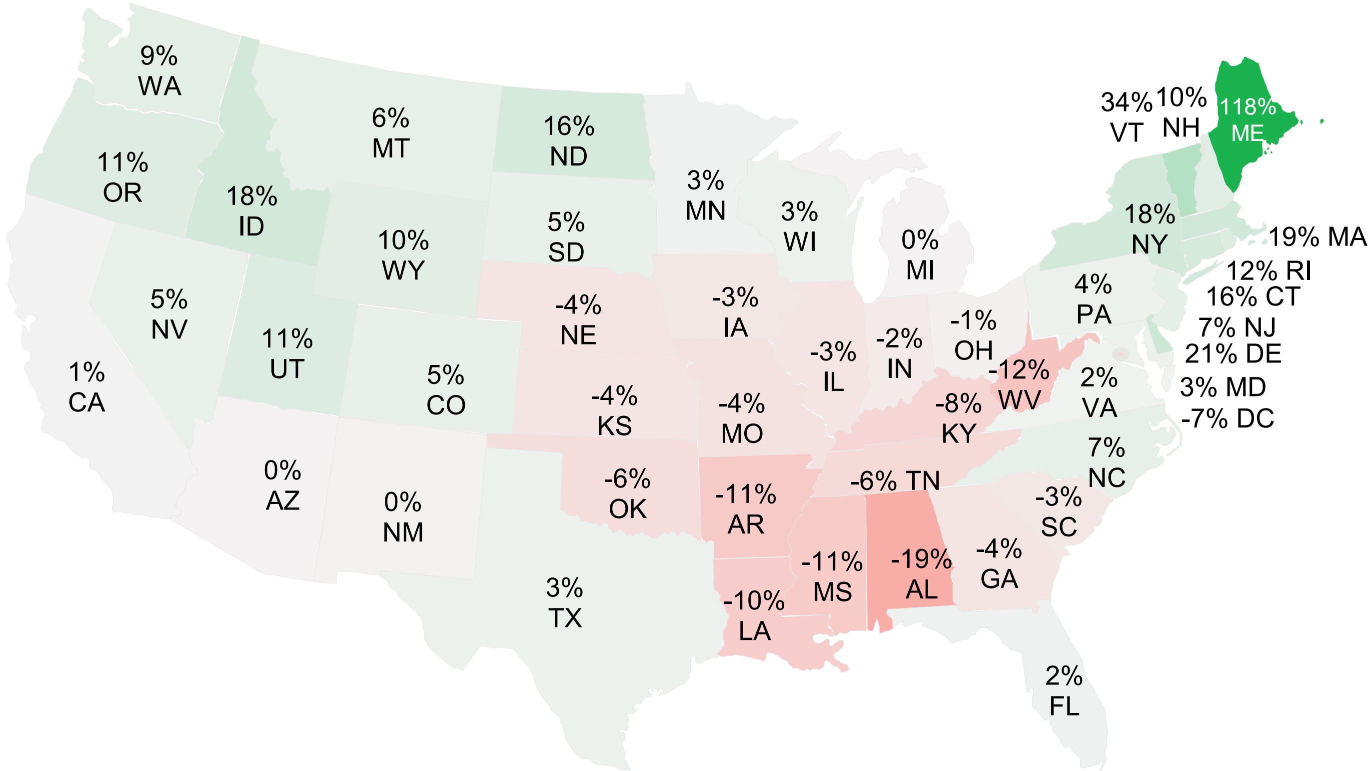


- Due to energy efficiency efforts, residential gas consumption expanded at a slower rate than the number of customers. The customer base for residential gas expanded by 12.7 million, or 22%, over the past 20 years. Meanwhile, residential consumption has remained largely flat over the same time period.
- 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% decrease 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, 2018 will see a 9% rise in demand, partly due to colder weather early on in the year.

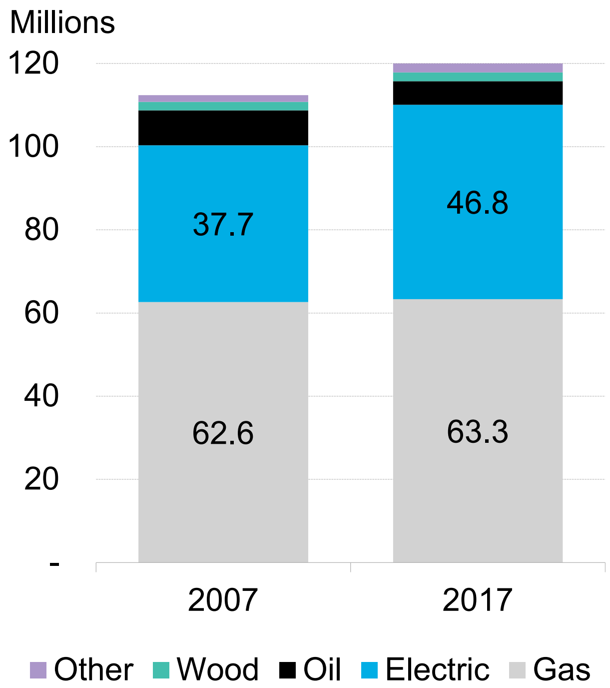
Source: BloombergNEF, EIA Notes: Values for 2018 are projected, accounting for seasonality, based on latest monthly values from EIA (data available through October 2018). Heating degree-days are through mid-December 2018.

Deployment: heating demand for natural gas

Change in percent of households using natural gas for heating, from 2007 to 2017



Primary heating source by household



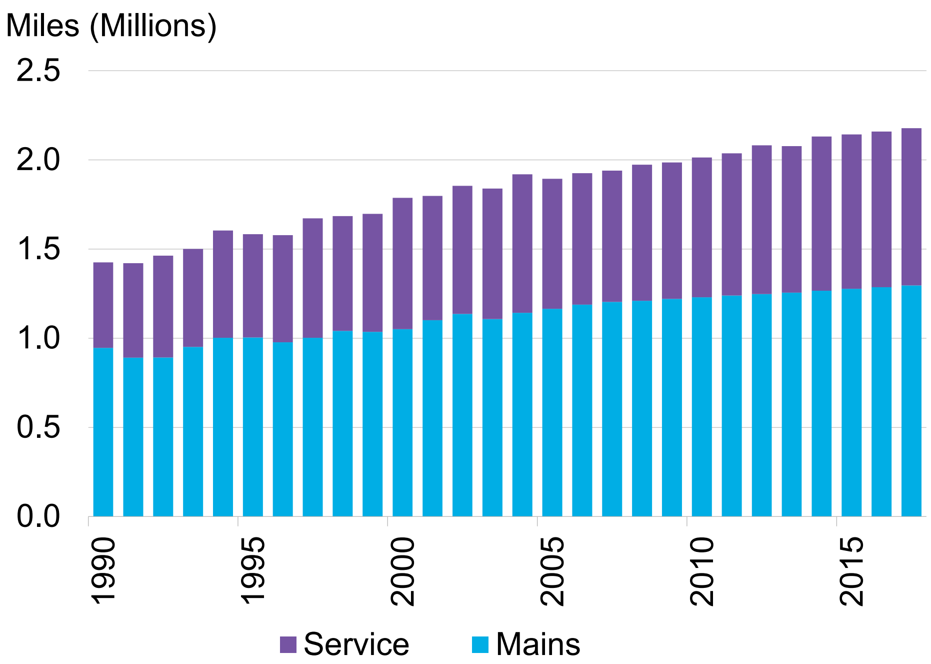
- Natural gas is the largest heating source in the residential sector, with close to 70 million households connected to the national gas distribution system. In total, 63.3 million homes are heated with utility natural gas or bottled propane. That is equivalent to 53% of U.S. households.
- In absolute terms nationwide, the total number of households using natural gas for heating has risen slightly since 2007.
- However, changes have varied substantially by region. Usage grew swiftly on a percentage basis in the New England states as consumers moved away from burning more costly home heating oil. Gas usage also grew in the Northwest states, while declining in the Southeast.

Source: BloombergNEF, US Census Bureau

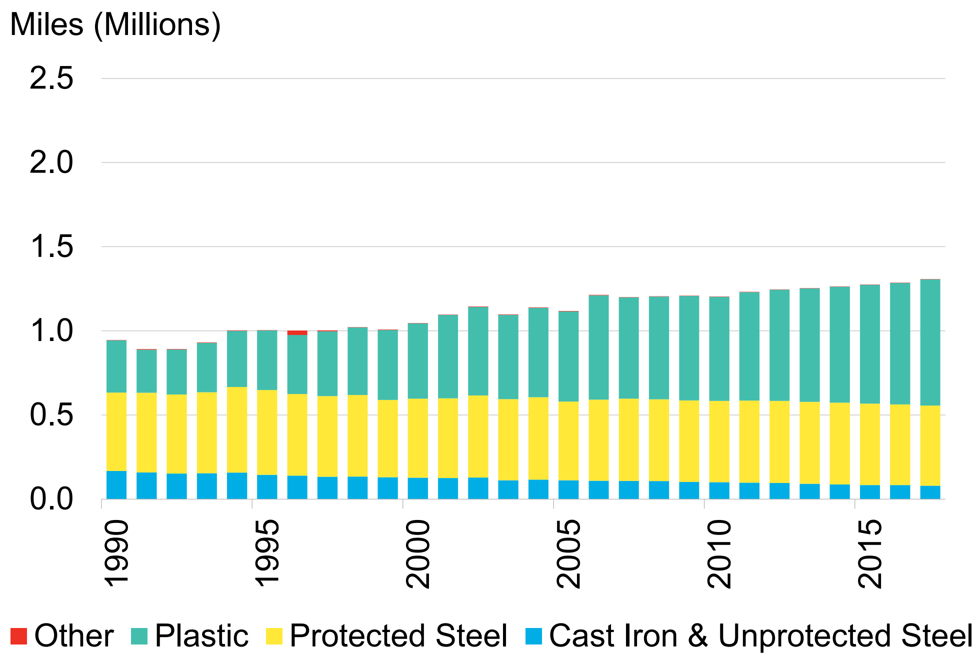
BloombergNEF

Deployment: U.S. natural gas pipeline installations and materials

U.S. existing natural gas distribution pipelines



U.S. natural gas distribution mainline material

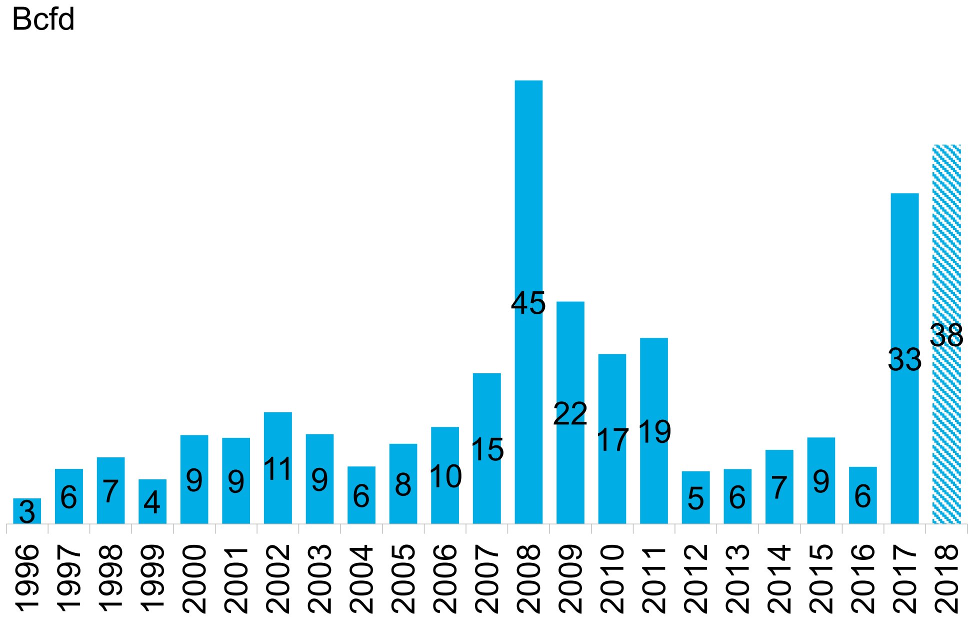


- Service and distribution pipelines that bring gas from transmission lines to end-users continue to rise incrementally, with growth averaging 1% per year over the past decade.
- Plastic is the material of choice for replacement and expansion efforts as U.S. pipelines are upgraded with more modern materials. Companies are removing older networks, which are made from cast iron and unprotected steel, and replacing them with newer plastic or protected steel pipes, which are less susceptible to leaks. At the same time, more miles of pipeline are being added to connect under-served and previously un-served customers.

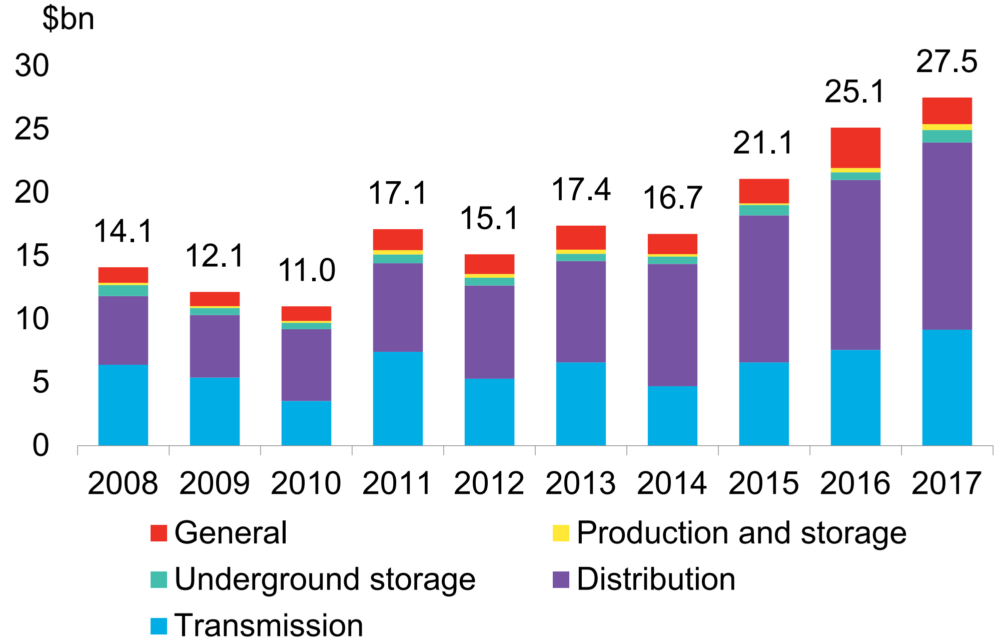
Source: American Gas Association, U.S. Department of Transportation

Deployment: U.S. midstream infrastructure capacity and investment

U.S. transmission pipeline capacity additions



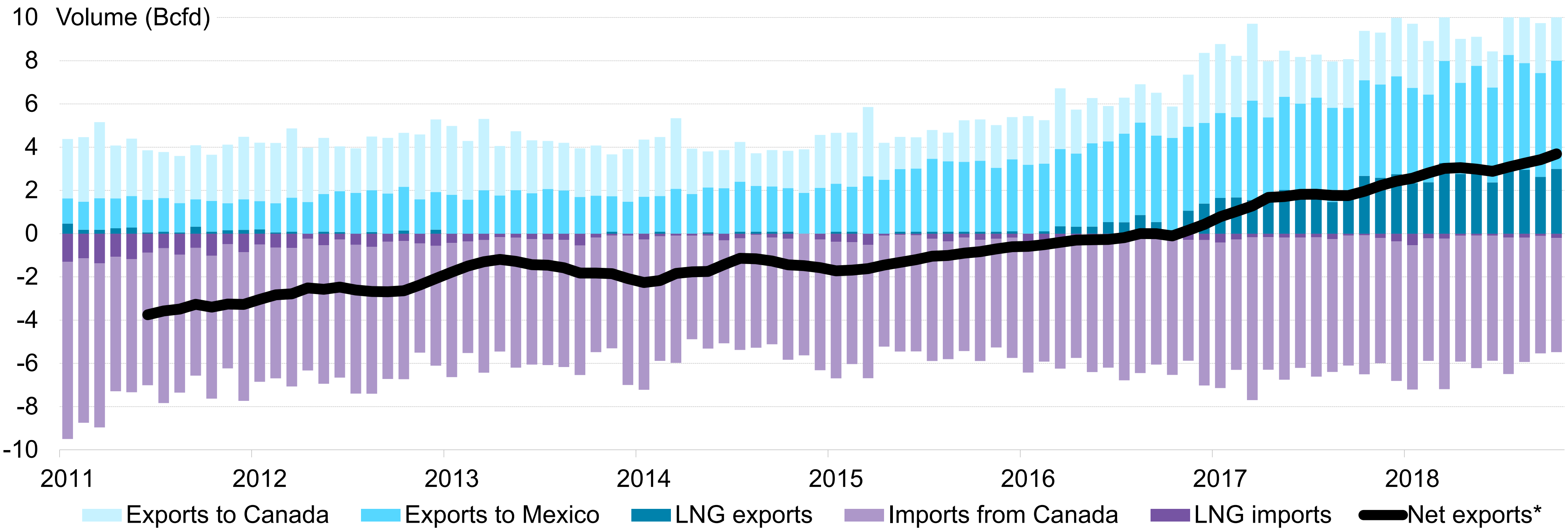
U.S. midstream gas construction expenditures



- Pipeline companies had plans to complete 38Bcfd of capacity additions by the end 2018, up slightly from the 33Bcfd constructed in 2017 and the largest single-year addition in capacity since 2008. Much of this capacity addition is a result of the need to disseminate record-setting amounts of gas production to end users in the U.S and to across the border to Mexico.
- Midstream expenditures continued a trend since 2015 of rising, posting a 9.4% jump from 2016 to 2017, the last year for which complete data exists. The majority of this was spent on transmission and distribution pipelines, connecting gas to consumption centers.

Source: BloombergNEF, American Gas Association, EIA Notes: EIA data include both first-mile takeaway capacity and pipeline additions that do not impact takeaway capacity. 2018 transmission capacity is a BNEF 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

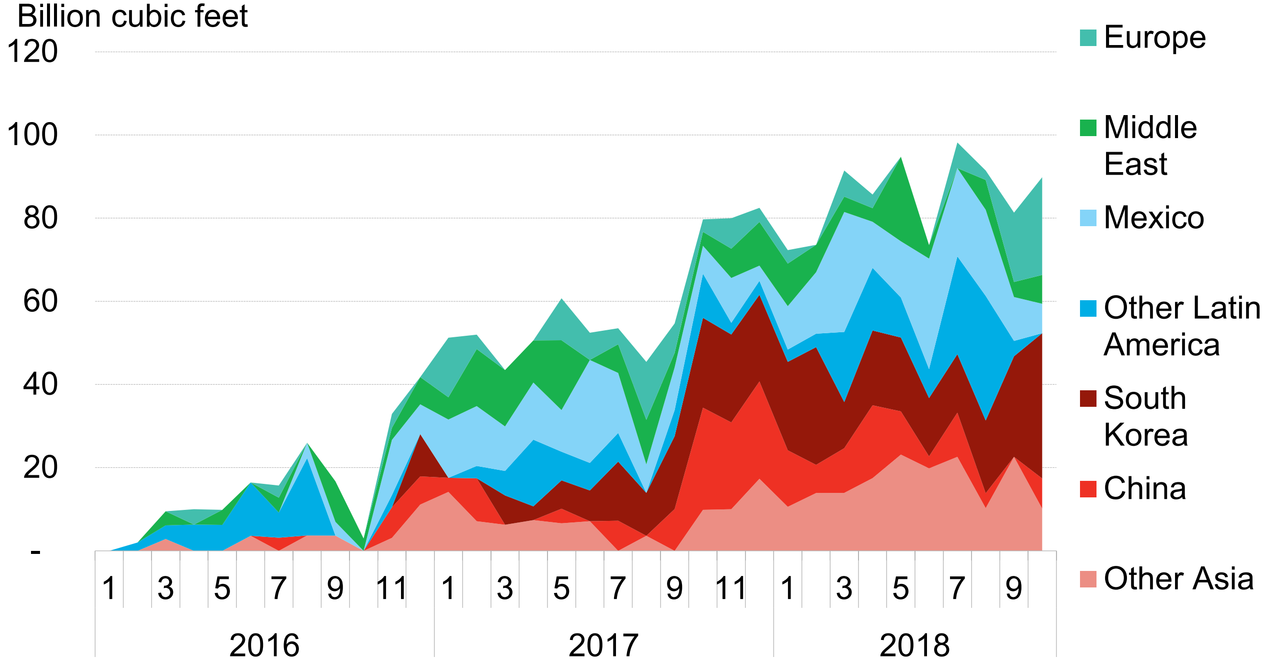


- The U.S. became a net exporter of gas for the first time in November 2017, and it strengthened that position throughout 2018. Net exports were positive for every month of the year, and on average U.S. exports exceeded imports by 2.6Bcfd.
- LNG exports grew by 1.8Bcfd when Cove Point shipped its first cargo to Japan in April and by 3.5Bcfd as Sabine Pass increased capacity at its facility on the Texas-Louisiana Border. In addition, Corpus Christi exported its first LNG cargo in December, adding another 645MMcfd (4.5MMtpa) to U.S. export capacity.
- U.S. pipeline exports to Mexico have also been increasing, but the U.S. is waiting for pipelines to be completed both on the Mexican side of the border and within Mexico in order to further boost its exports south. Currently, the pipelines from south Texas are operating at capacity, creating a bottleneck in the region. This should be relieved once the 2.6Bcfd Sur de Texas (and connecting interior pipelines) comes online early 2019.

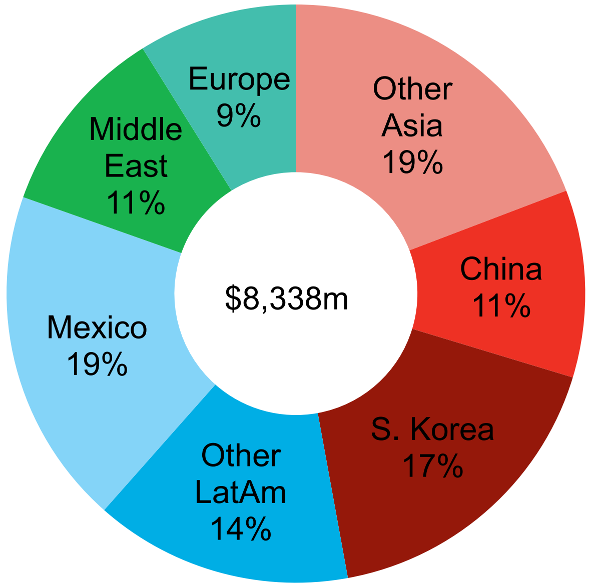
*Source: Bloomberg Terminal, EIA Note: *Net export line shows the six-month rolling average.*

Deployment: liquefied natural gas exports by value and destination

Monthly LNG exports from Sabine Pass and Cove Point, by country



Total value of LNG exports, 2016 – Oct 2018

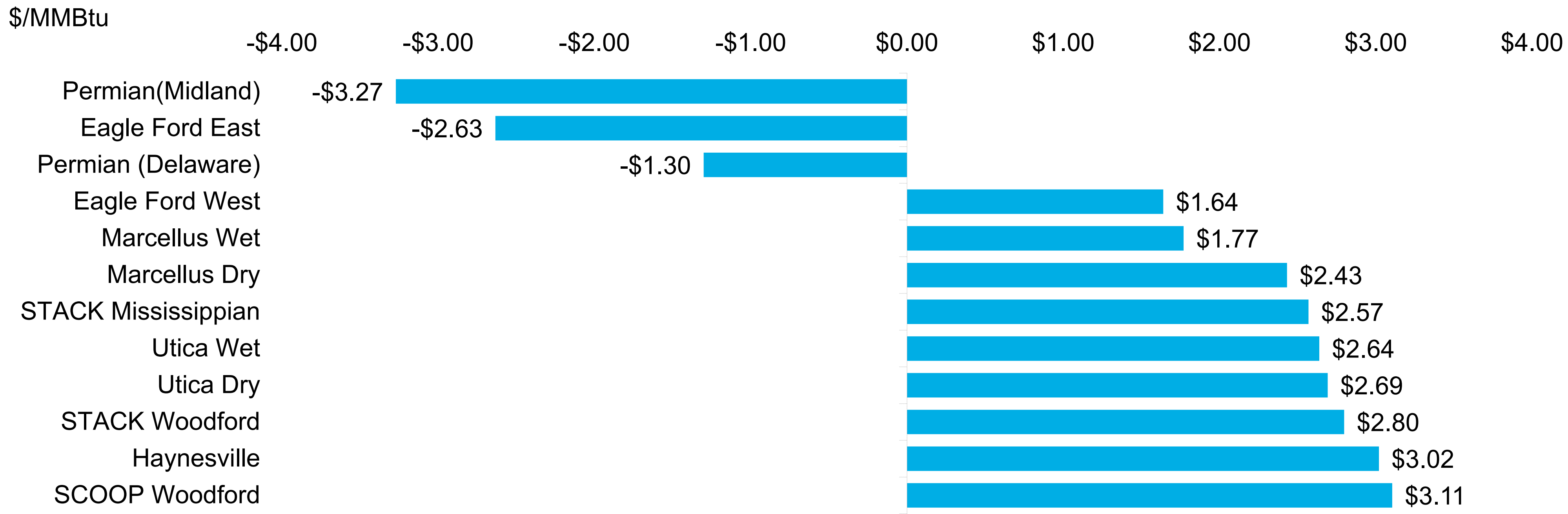


- Following the 2016 commissioning of the U.S.'s first large-scale liquefied natural gas export facility, Sabine Pass, U.S. exports of LNG have accelerated rapidly. Additional capacity at Sabine in 2017 and the commissioning of Dominion's Cove Point terminal in April boosted LNG exports further, to an average of 85 billion cubic feet (Bcf) per month in 2018.
- The pool of buyers has diversified as capacity has expanded. Sabine Pass and Cove Point have sent cargoes to 29 countries to date. First-time importers in 2018 included Panama, France, Israel, and Colombia.
- Mexico is the single-largest destination by value, representing 19% or $1.53bn of revenues and 13% of total exports. Asia is by far the largest regional market for U.S. LNG, making up 47% of total export value from 2016 to October 2018.

Source: BloombergNEF, Department of Energy. Notes: Data through October 2018; dollar values represent the price at export point, times the value exported.

BloombergNEF

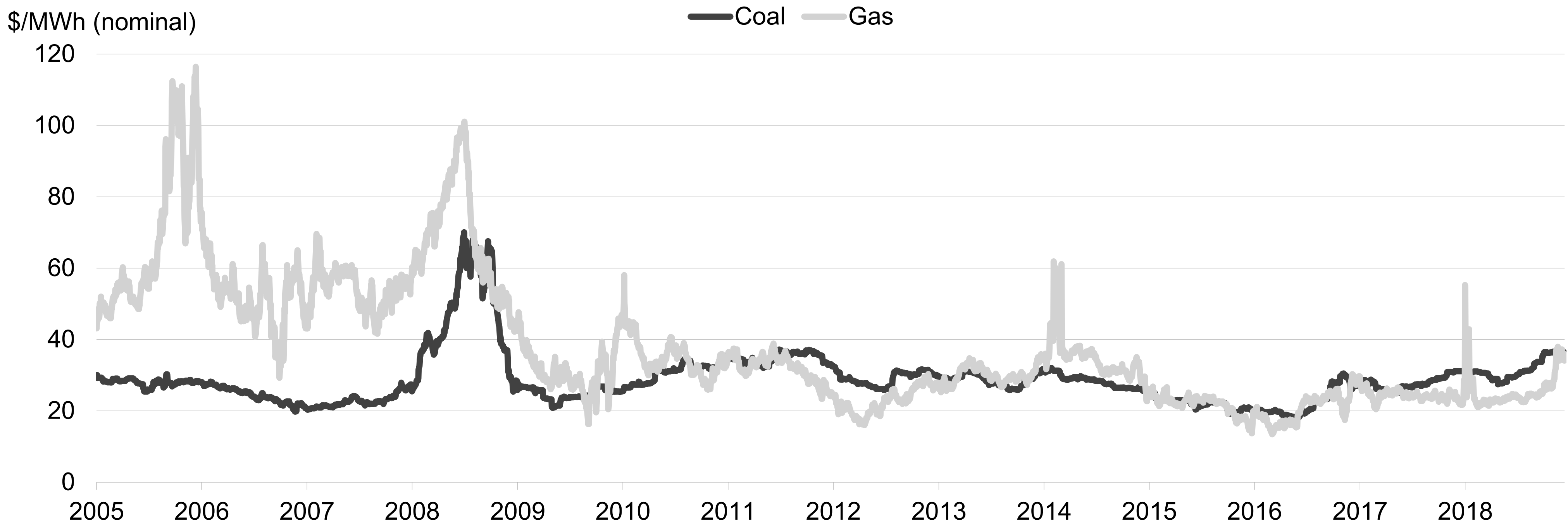
Economics: Gas wellhead breakevens by basin



- Wet plays such as the Eagle Ford and Permian, which produce gas as a byproduct of oil drilling, show negative breakeven costs. This is because oil and natural gas liquids have a higher economic value than gas on a heat content basis. As a result, producers in these regions can virtually give gas away and still be profitable.
- Wet and associated plays offer superior returns than their dry counterparts; however, they are too few in number to satisfy demand. Thus, the marginal costs of dry plays set the market price.
- The forward curve has gas prices at $2.5-3/MMBtu over the next couple of years, yet most dry wells need $2.85-3.2/MMBtu gas to be profitable. This suggests the forward market could be underpricing the true economic costs of production.

Source: BloombergNEF Note: The STACK play name is derived from "Sooner Trend Anadarko (basin) Canadian and Kingfisher (counties)". Breakevens account for transportation costs.

Economics: Cost of generating electricity in the U.S. from natural gas vs. coal

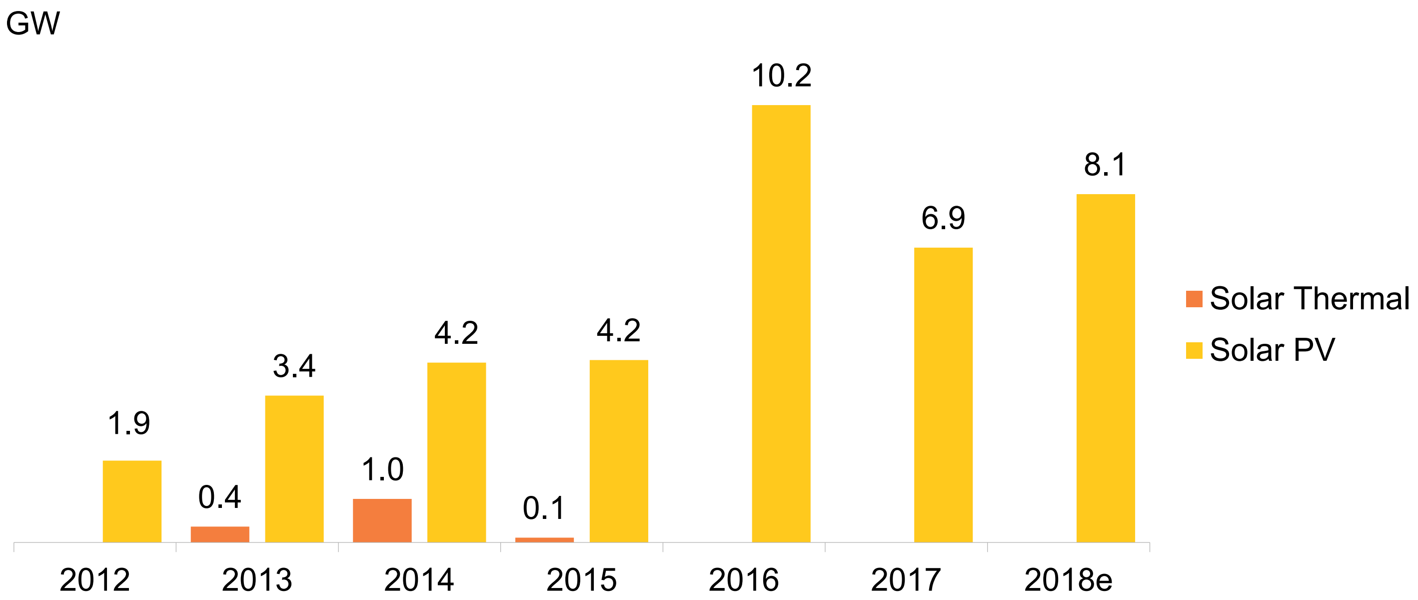


- Power has served as the primary source of price elasticity for gas demand in the U.S.: when the price of gas falls below that of coal, gas burn rises until the differential (in $/MWh) between the two fuels closes.
- The U.S. observed this switching in 2012 and it has occurred fairly consistently since 2016. The U.S. grid was on track to replace 13GW of coal capacity with 18GW of net natural gas build in 2018. This would bring about another 1.3Bcfd of gas burn for power generation.
- Most of 2018 saw gas prices cheaper than coal, however, a surprisingly cold November and historically low inventory levels meant that a late surge in prices pushed some gas plants behind coal plants in the merit order in PJM, yielding some hours of generation for coal.

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

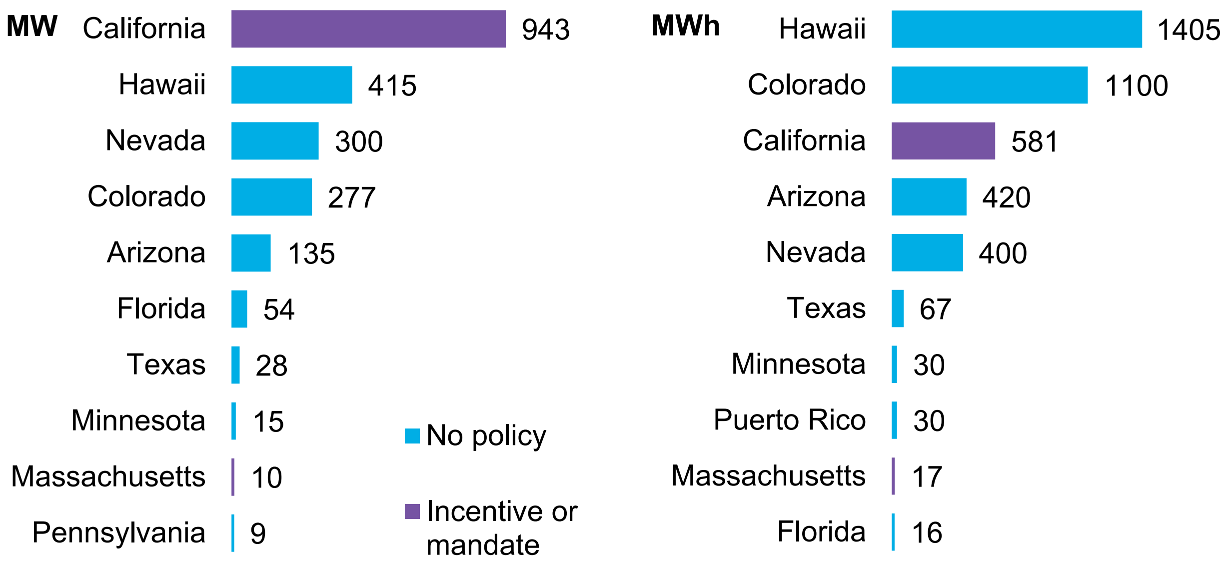


- Utility-scale installations rose 18% year-on-year, with an estimated 8.1GW installed in 2018. The new build was entirely represented by photovoltaics (PV).
- New guidance from the IRS has given U.S. solar more time to “safe-harbor” projects by beginning construction in 2019 and showing continuous progress toward completion, making them eligible to capture the full 30% Investment Tax Credit if they are commissioned by the end of 2023. Developers are replenishing their depleted project pipelines and looking for new state markets where the next generation of utility-scale solar projects can be developed in time to claim the full value of the ITC.
- No solar thermal facilities were commissioned in the U.S. in 2018, and none has been announced, either. Developers and financiers continue to focus their attention on PV.
- In September 2018, the U.S. imposed a 10% tariff on inverters from China. This is not expected to raise solar prices or reduce build, as manufacturing in countries unaffected by the tariffs will enable the industry to sidestep these impacts.

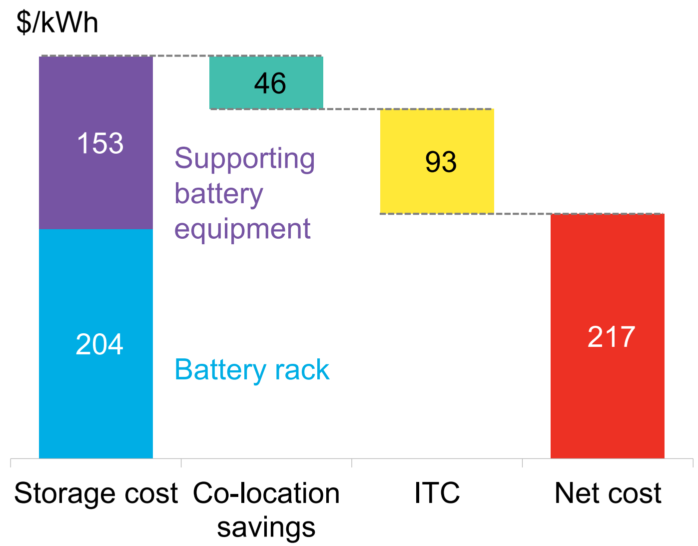
Source: BloombergNEF. Note: All solar capacity in the Factbook portrayed in GWdc.

Deployment: Solar + storage

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



Cost advantage to co-locating storage with solar

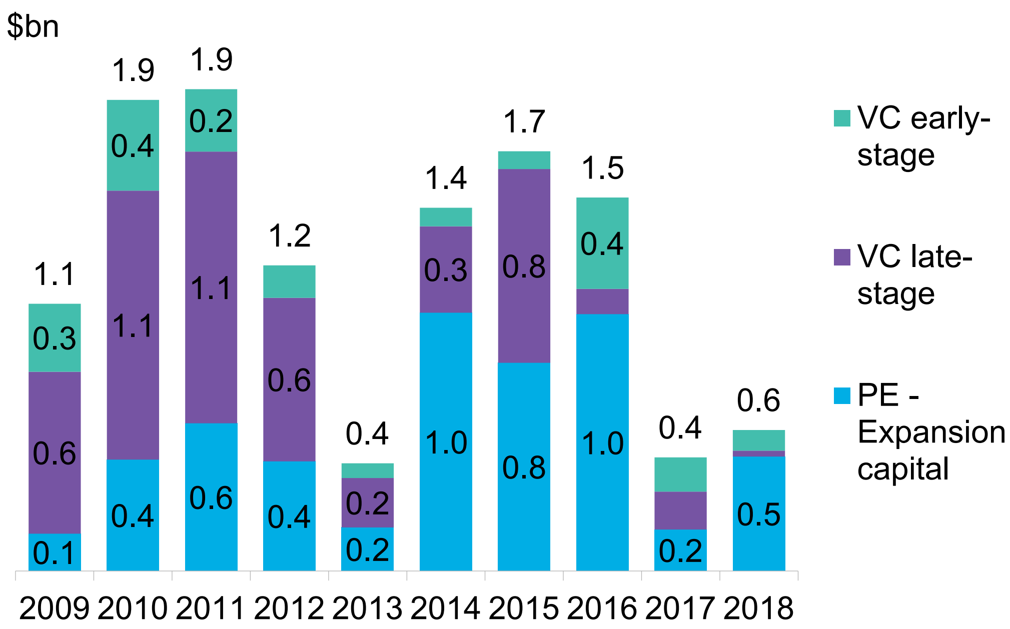


- Co-located photovoltaics and storage (PV+S) development activity jumped in 2018. California and Hawaii led the nation with total planned and commissioned projects of 943MW/581MWh and 415MW/1405MWh, respectively. Colorado recently issued a solicitation; BNEF estimates it will seek 1,100MWh through 275MW of storage co-sited with solar.
- The Southwest saw a surge in large-scale PV+S announcements, led by solar developers bidding into utility solicitations at prices that undercut other firm generation sources, including natural gas. Developers with solar-storage offerings have expanded opportunities compared to those that only have solar products, as solicitations that explicitly call for firm resources or electricity delivery after sunset are now open to them as well.
- Battery storage systems that function as supporting equipment to solar projects, through co-location, are eligible for the ITC worth 30% of their upfront capital cost. Co-located systems are also able to share interconnection, hardware and operation costs. Together, these cost savings are worth nearly 40% of the cost of a standalone system.

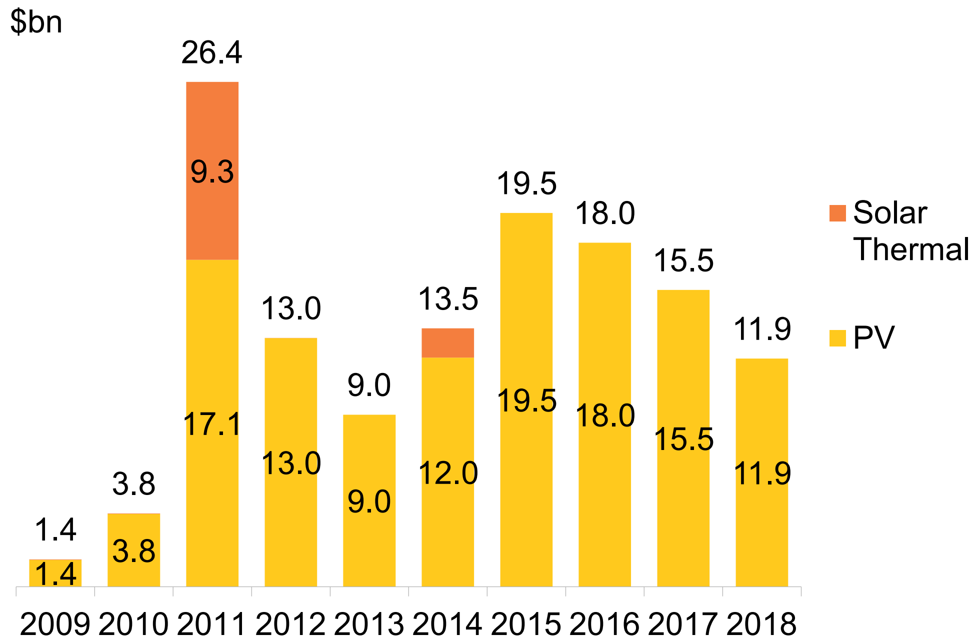
Source: BloombergNEF. Note: Storage capacity uses two metrics: MW which signifies power output (based on the inverter capacity) and the MWh which specifies the energy storage capacity and relates to the duration the input/output can be sustained for (ie, a 10MW/40MWh system can sustain 10MW for 4 hours).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

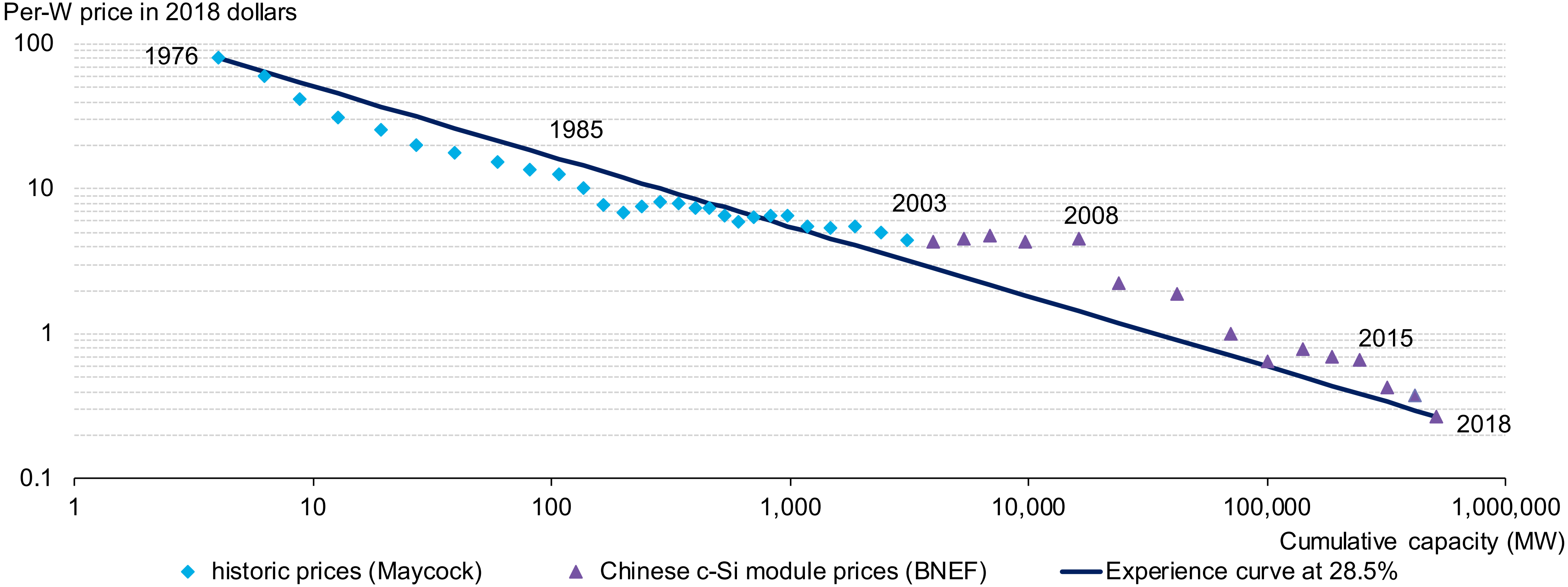


- Private equity capital and venture capital investment into U.S. solar rose overall in 2018 compared to 2017. Private equity investment totaled $0.45 billion, more than double 2017's total. This was enough to offset the fall of $0.18 billion in venture capital investments. Total venture capital investments dropped to $0.1 billion, the lowest since 2013.
- Asset finance deals for utility-scale solar declined for the third consecutive year, dropping to $11.9 billion. This correlates with falling technology costs. Asset finance levels in 2018 are a leading indicator for utility-scale solar build in 2019, as most assets are typically financed a year prior to commissioning.

Source: BloombergNEF

BloombergNEF

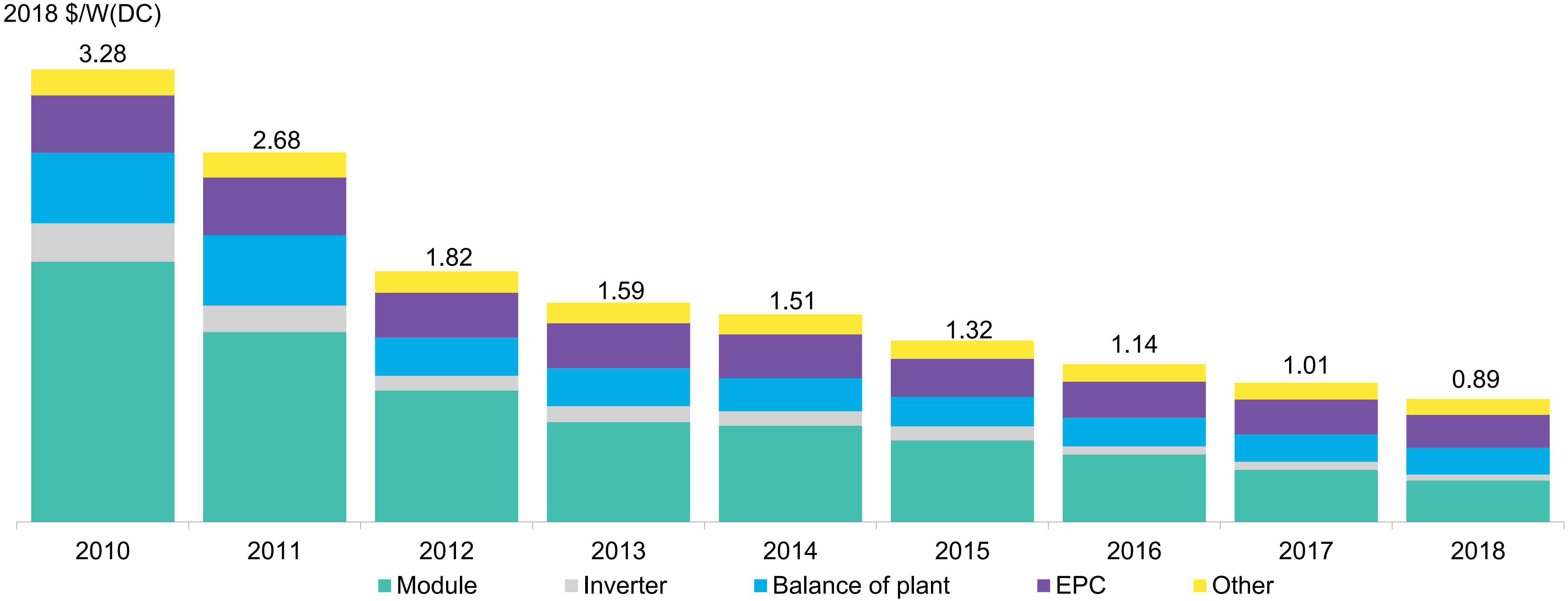
Economics: Global price of solar modules and experience curve



- Crystalline silicon (c-Si) solar module prices decreased to approximately 27 U.S. cents per watt in 2018, down dramatically from $79 per watt (in 2018 dollars) in 1976 – a learning rate, or reduction per doubling of capacity, of 28.5%.
- Thanks to the rapid learning rate, module prices have fallen around 92% over the past decade.
- It is more difficult to establish learning rates for the rest of the components that go into a solar project – the inverter, the mounting structure, cables, groundwork and engineering or installation; however, these have also gotten steadily cheaper.

Source: Paul Maycock, BloombergNEF   Note: Prices indexed to U.S. PPI

Economics: Global benchmark capex for utility-scale solar PV

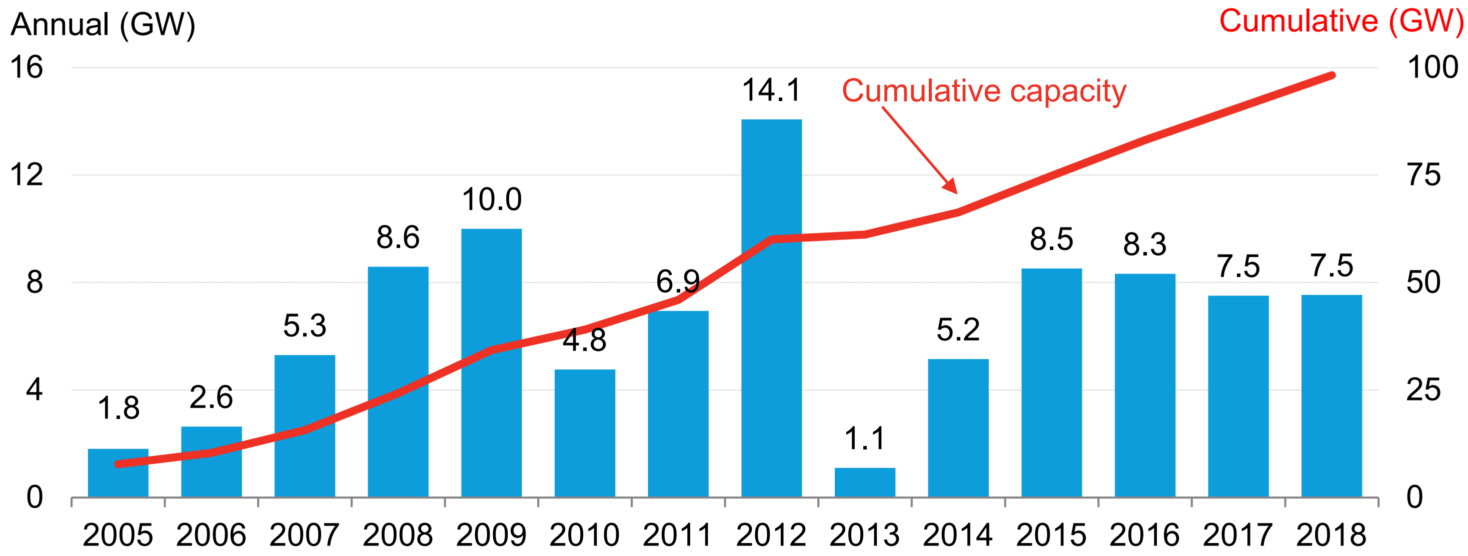


- The cornerstone of the U.S. Department of Energy's Sunshot Initiative was achieved three years ahead of schedule when utility-scale PV costs fell below $1/watt in the second half of 2017. Costs continued to fall through 2018, although they can be higher in locations where higher land, labor, or margins exist.
- The cost of building a utility-scale PV facility declined dramatically from 2010 to 2012 (based on the global benchmark for mature markets) before leveling off to more modest annual cost reductions from 2012 to 2017. Costs continue to fall due to both technology improvements and industry productivity.

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

Deployment: U.S. large-scale wind build

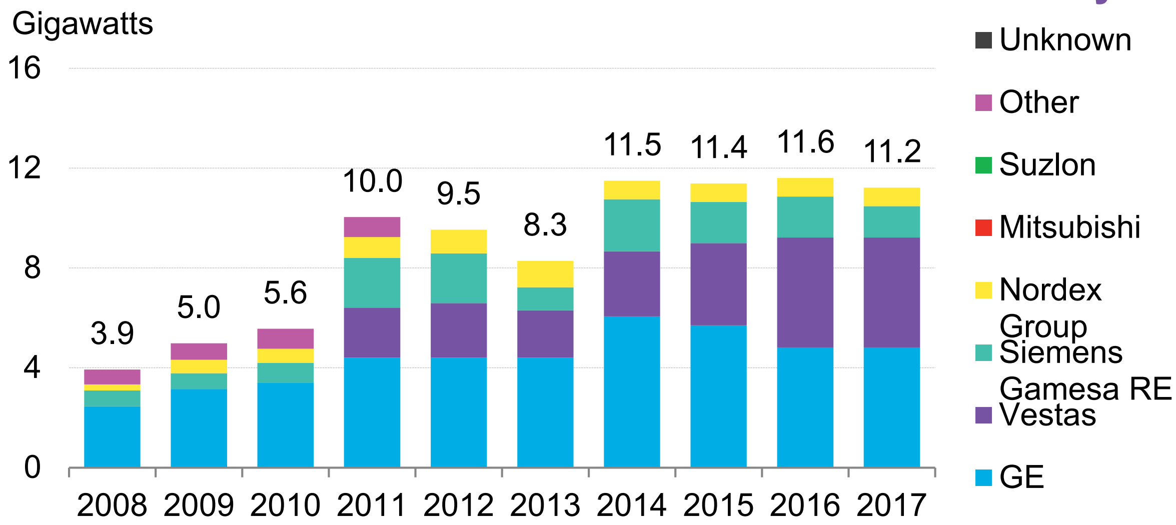


- The U.S. utility-scale wind market added about 7.5GW of new capacity in 2018. In advance of the upcoming phase-out of the Production Tax Credit (PTC), developers continue to rush build and commission safe-harbored turbines. Small- and medium-scale wind continue to struggle: the U.S. added only 5.8MW total across both categories in 2017.
- The PTC extension in December 2015 applies to projects commencing construction through 2019, with a phase-out for projects beginning after 2016. A four-year build window to qualify means projects that broke ground in 2016 have until 2020 to complete construction and still qualify for the full value of the credit. Even for projects unable to commission by their prescribed deadline date, the IRS gives generous exceptions for projects experiencing a “non-exclusive” list of construction disruptions.
- The extension has provided certainty and stability for the wind industry in the past few years, allowing it to see consistent new wind build in the realm of 7-8GW annually.
- A majority of the 2018 additions were in Texas and the U.S. wind belt, thanks to high capacity factors and low costs to build. However, despite Texas’ affordability (subsidized levelized costs there are estimated to be as low as $19/MWh for wind), growing congestion in the region is sending developers north towards MISO. MISO is also enabling more wind with new transmission capacity.

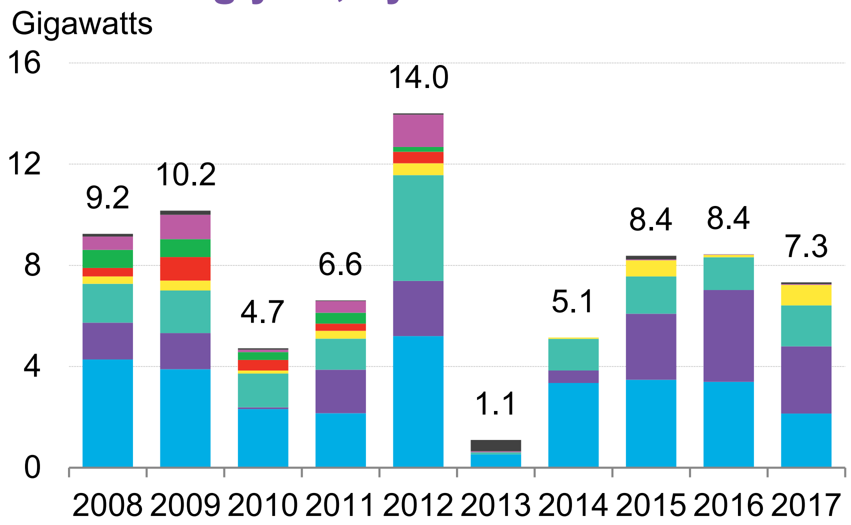
Source: BloombergNEF. Notes: Includes all utility-scale wind development, excluding partially commissioned projects and including distributed turbines that are above 1MW (BloombergNEF threshold for utility-scale).

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

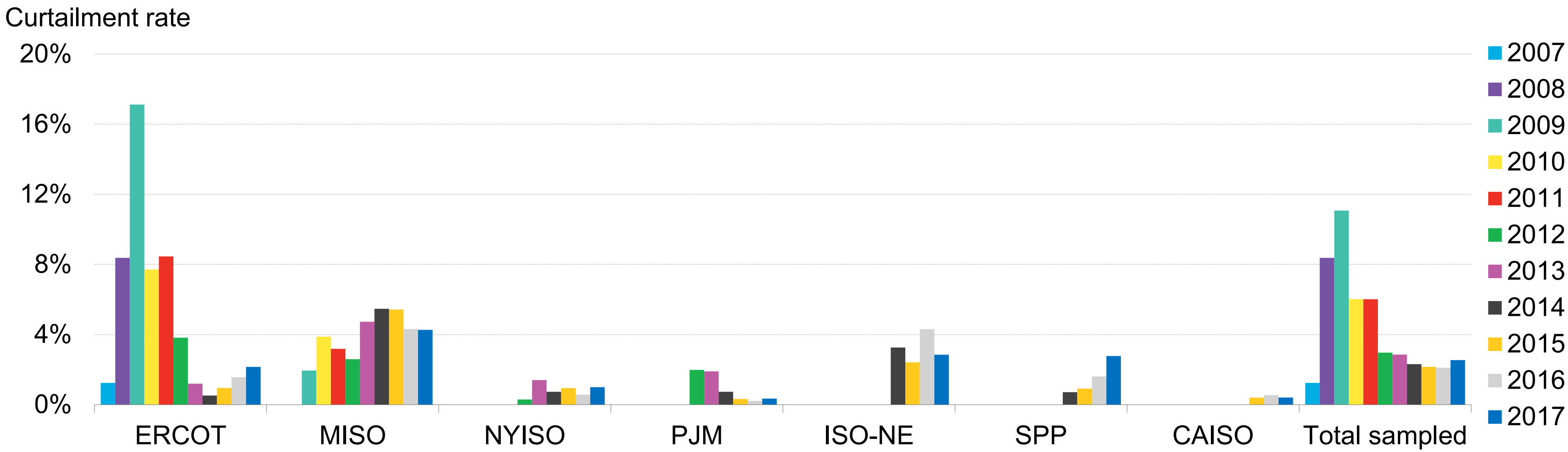


- There has been a global trend in the wind manufacturing space towards market consolidation and the U.S. is no exception. This trend became quite noticeable in 2016, when global wind build hit the second-highest level on record, and the top-10 manufacturers broke away from the remaining smaller players to dominate 75% of new capacity additions. Over the past few years, four manufacturers have emerged as market leaders in the U.S.: GE in the lead, followed closely by Vestas, Nordex, and Siemens Gamesa RE
- In 2017, Vestas supplied turbines for 2.7GW of the 7.3GW of wind commissioned in the U.S. in 2017. GE came in second behind Vestas, supplying 2.1GW. Meanwhile, Siemens Gamesa (with 1.6GW) and Nordex Group (0.8GW) increased their market shares and intensified the competition faced by the two market leaders.
- 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 U.S.-based, compared to only one-quarter for Vestas.

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

BloombergNEF

Deployment: U.S. wind curtailment

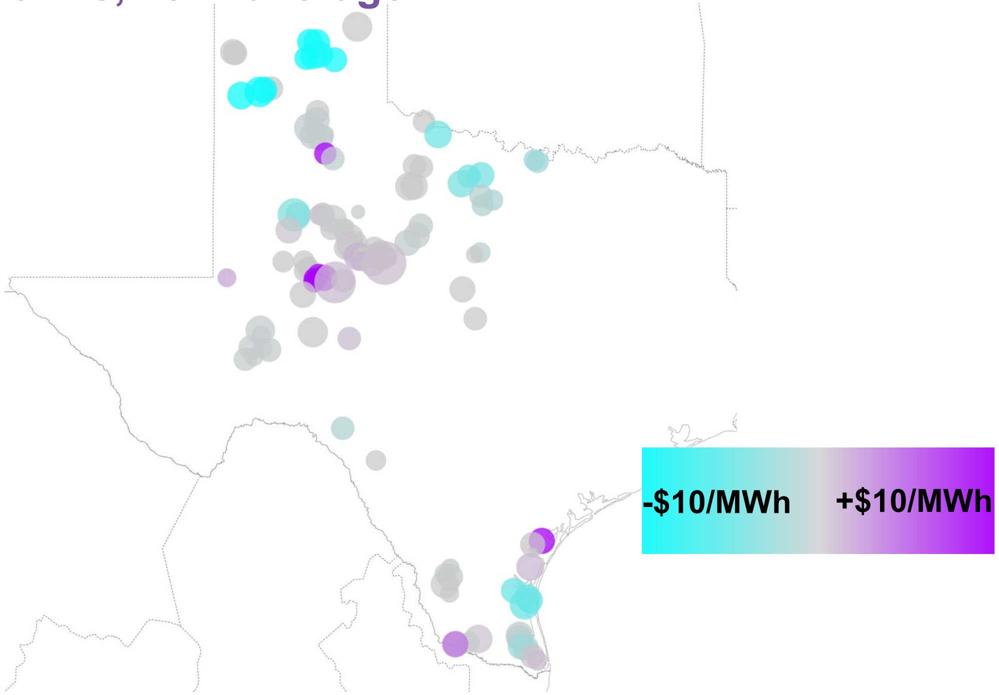


- Curtailment can occur due to transmission constraints, inflexibilities in the grid and environmental or generation restrictions.
- This was a significant problem in ERCOT (Texas) from 2008-2013, but the build-out and upgrade of the Competitive Renewable Energy Zone (CREZ) transmission lines and increased efficiency in ERCOT's wholesale electricity market lessened this concern in the short-term. Curtailment in this region fell to only 0.5% in 2014, down from a peak of 17% in 2009; however it has been slowly rising since 2015 as build continues, with about 2.2% curtailment observed in 2017.
- For the past three years, PJM experienced the lowest curtailment of any region, at 0.2%. MISO continued to experience a curtailment rate of over 4%, the highest out of all the regions sampled. However, MISO's wind curtailment dropped 27% from 2015 to 2017, as transmission build began to alleviate congestion; most of MISO's MVP transmission projects should be online by 2019. New England reined in its curtailment levels from 2016, down 33% in 2017 to under 3%. CAISO curtailment remained small (0.4%) while SPP's crept up to 2.78%, likely due to wind additions in the region.
- Total U.S. curtailment has shrunk since 2009. However, time-varying influences also played a role: in 2015, for example, the western and interior U.S. experienced below-normal wind speeds, reducing generation and therefore the need to curtail in constrained regions.

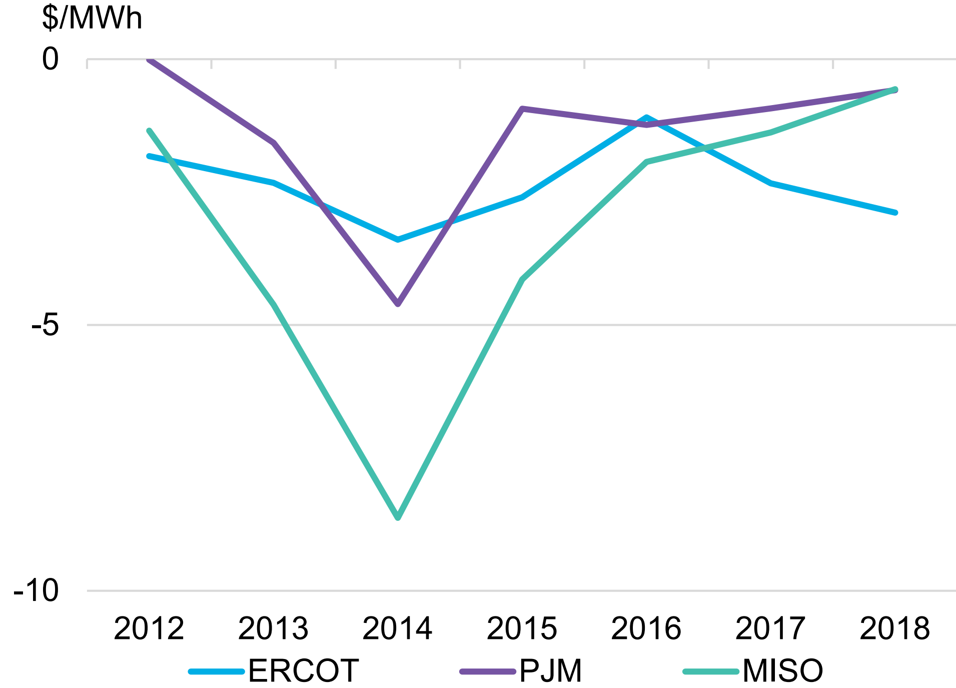
Source: BloombergNEF, Department of Energy. Note: All curtailment percentages shown in the figure represent both forced and economic curtailment. PJM's 2012 curtailment estimate is for June through December only. Department of Energy sourced data from ERCOT, MISO, CAISO, NYISO, PJM, ISO-NE, SPP.

Deployment: Transmission congestion in Texas, the Midwest and Mid-Atlantic

Congestion costs for Texas (ERCOT) wind farms, 2017 average



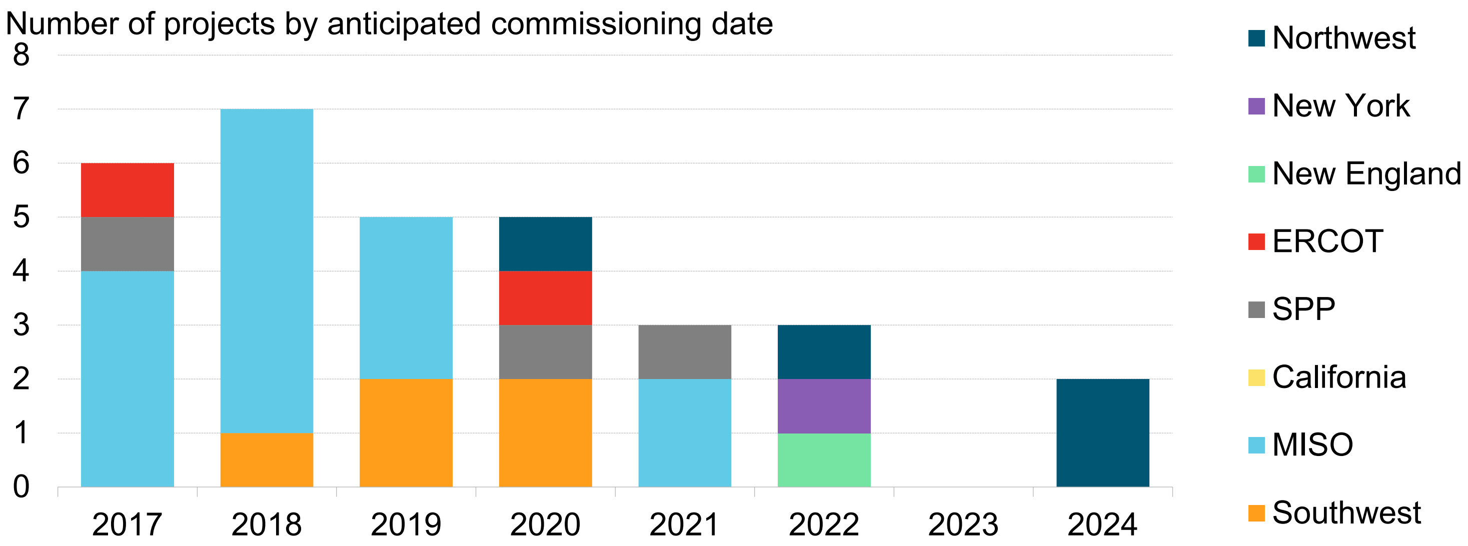
Average congestion across wind fleets



- Transmission congestion for remotely located wind farms can diminish what the plants earn in wholesale markets. Texas (ERCOT) is currently home to one-quarter of America's installed wind capacity, with well over half of that capacity clustered in the western part of the state.
- To alleviate congestion in West Texas, the state invested in the Competitive Renewable Energy Zone (CREZ) transmission lines, which connect West Zone and Panhandle wind to load centers in the East. This relieved $2/MWh of congestion pricing between 2014 and 2016. Those gain are being reversed as build persists in the West Zone. (Negative pricing in the graphs above represents congestion costs.) Congestion bit roughly $3/MWh on average out of ERCOT wind revenues in 2018.

Source: BNEF, EIA, NOAA, Genscape Note: 'Congestion' is calculated as the difference between the node at which the wind farm is located and the hub at which most power is traded, also known as 'basis'.

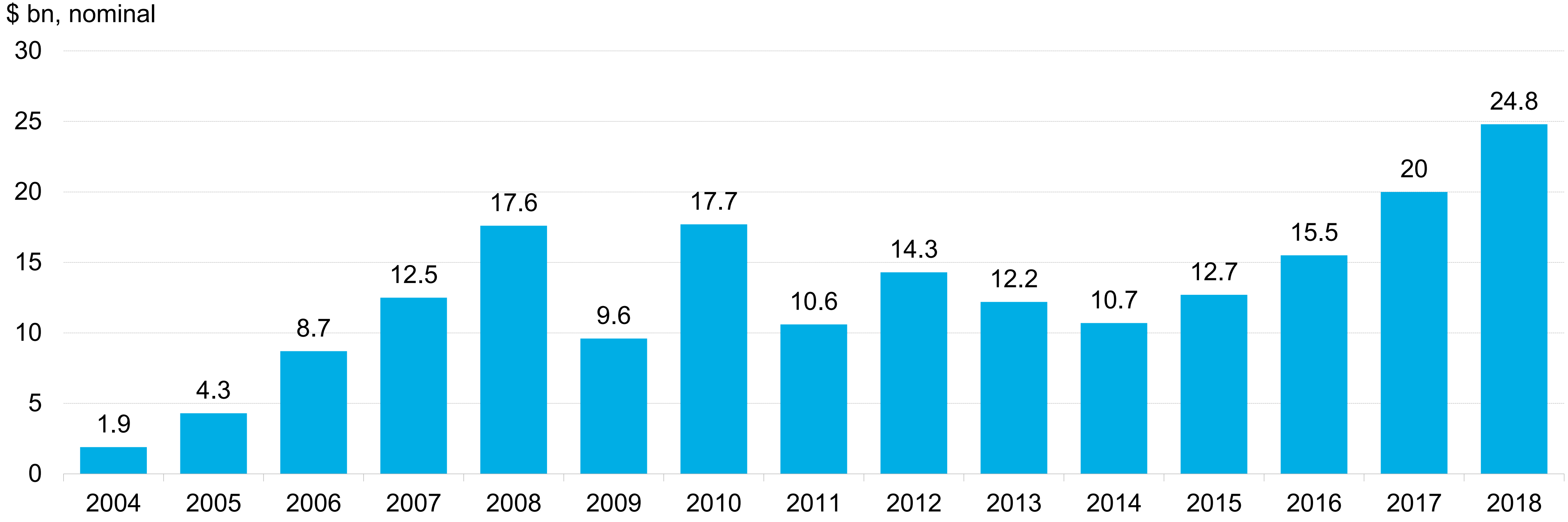
Deployment: Commissioned and planned transmission lines serving wind



- Wind tends to be one of the first sources to be curtailed when transmission congestion occurs, and congestion tends to rise as more units 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 potentially enable 52GW of new wind capacity between 2017 and 2024.
- MISO led the way in 2018 with six projects brought in service, as part of their Multi-Value Project ("MVP") portfolio. Another three projects are due to come online in 2019. In its planning process, MISO predicted that the benefits of adding transmission are between 2.6 and 3.9 times greater than the costs.
- Several other regions have lines planned over the coming years, including five in the Southwest from 2018-20. Many of the proposed transmission projects have yet to begin construction, and projects may be delayed or canceled. Generally, transmission build 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.

Source: BloombergNEF, AWEA Note: two projects, Centennial West line through NM, AZ and CA, and Rock Island line through IL and IA don't yet have in service dates set and are not included. Graph includes 320, 345, 500, and 600kV lines.

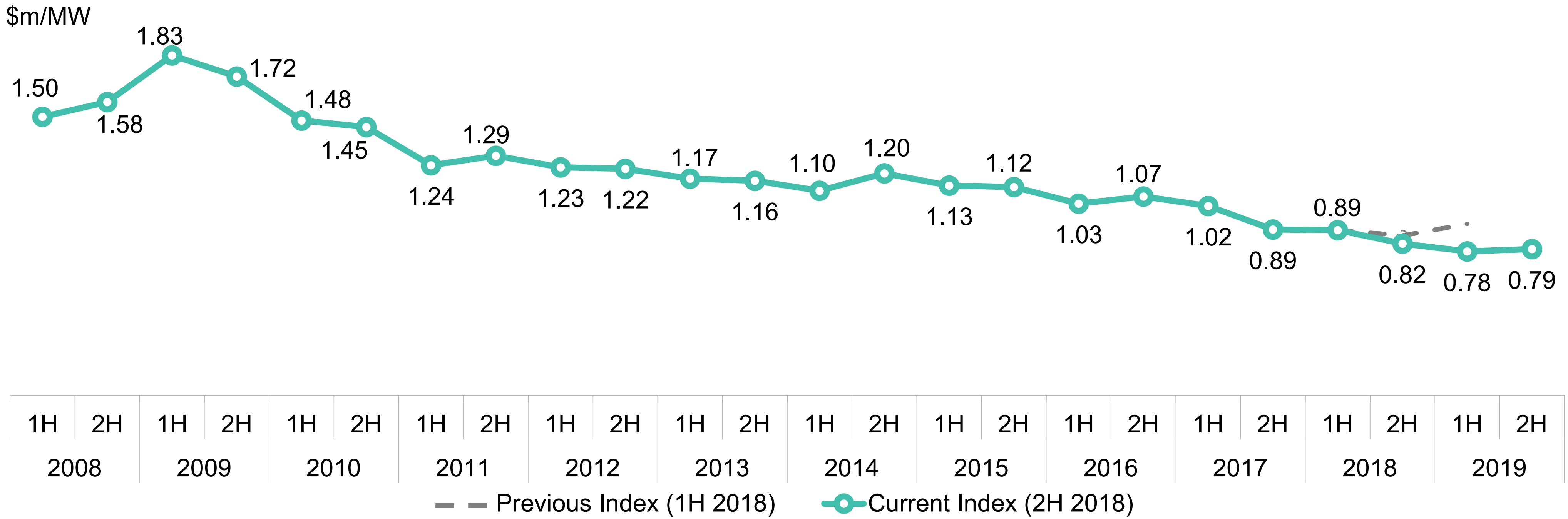
Financing: Asset finance for U.S. large-scale wind projects



- The 2019-20 wind pipeline is very healthy: a large portion of the $19.2 billion in financing secured in 2017 and the $19.6 billion secured in 2018 is for wind projects to be commissioned in 2019-2020.
- 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 that started construction in 2016; projects that start construction later will receive a phased-down credit.

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.

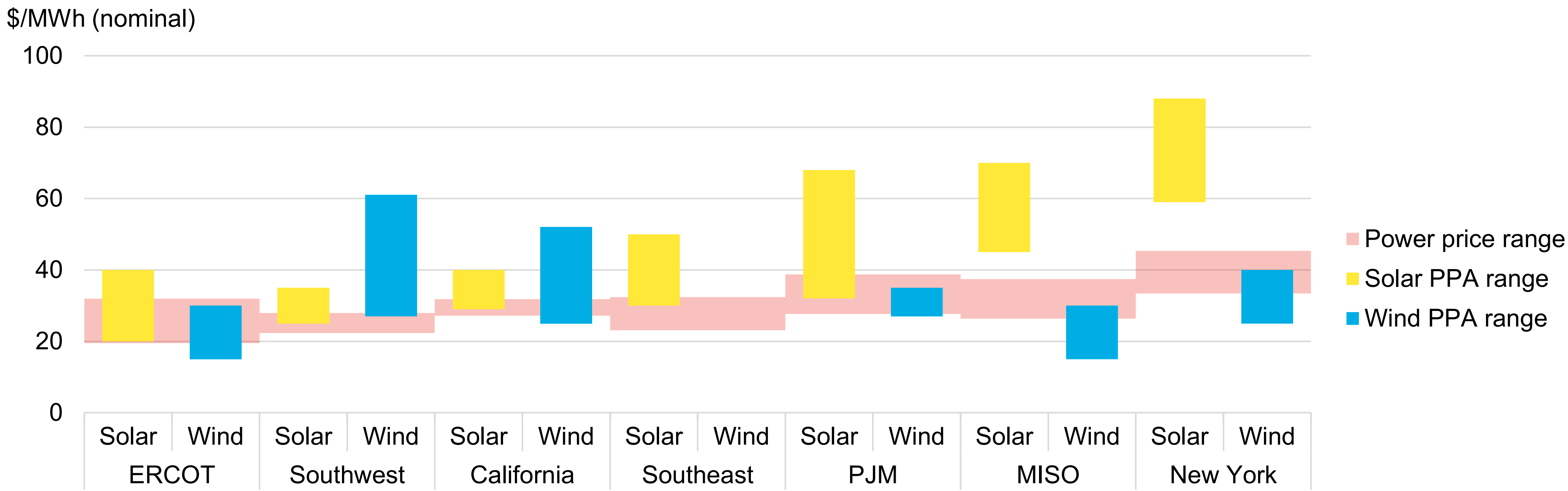
Economics: Global wind turbine price index by delivery date



- Since 2009, turbine prices have fallen 55% to $0.82 million/MW. Global oversupply continues to suppress prices.
- The price for U.S. wind turbines delivered in 2H 2018 dropped well below the global average price. Fierce competition between turbine manufacturers to maximize their share of surging orders drove the rapid U.S. pricing plunge. In 2016, turbine and equipment orders ballooned to 11GW, a direct result of developers rushing to qualify as many projects as possible in time for this final opportunity to gain 100 percent of U.S. wind's main federal subsidy.
- In addition to dwindling turbine prices, taller turbines and improved capacity factors have also contributed to lower levelized costs for wind.
- Based on current turbine contracts signed for delivery in 2019, prices will continue to drop this year by about another 5% from 2H 2018 levels.

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.

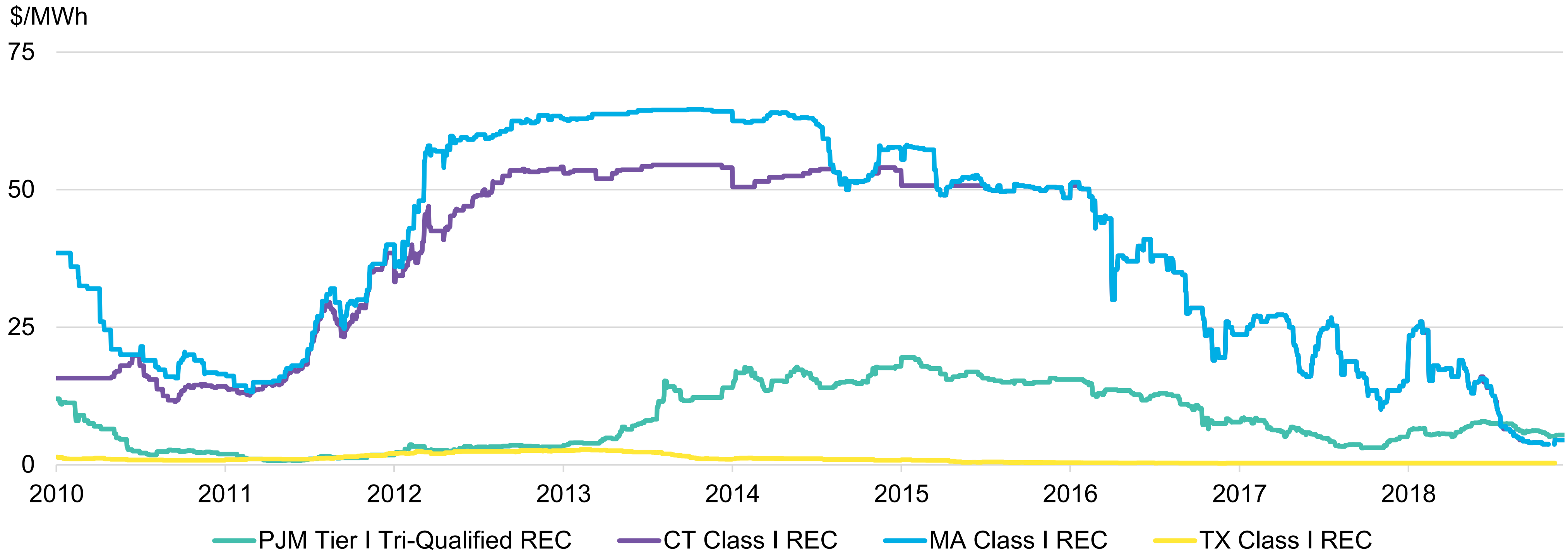
Economics: U.S. wind PPA prices compared to wholesale power prices



- 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. 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 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 continued in more recent years, with an additional 2.3GW contracted in 2017 and 4.1GW in 2018.

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: ‘Class I’ REC prices in select U.S. state markets



- In areas with Renewable Portfolio Standards (RPS), Renewable Energy Credits (RECs) are given to eligible renewable generators for each MWh of electricity they supply to the grid. Credit generators can sell their RECs for additional revenue. When REC prices are high, renewable energy investment sees a higher rate of return and new renewable build is encouraged.
- Over 2018, many major RPS markets boosted targets. California adopted SB100, which stipulates an RPS target of 60% by 2030. Connecticut raised its RPS target to 48% by 2030 and New Jersey raised its RPS target to 50% by 2030. REC price futures in both markets rose substantially as the new targets stand to reduce oversupply.

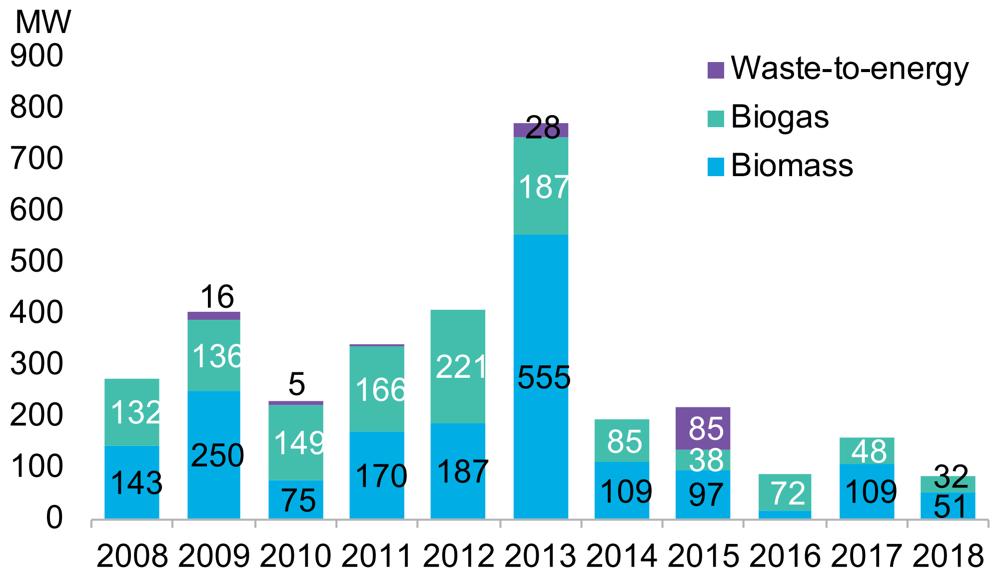
Source: BloombergNEF, ICAP, Evolution, Spectron Group   Notes: “Class I” generally refers to the portion of REC markets that can be served by a variety of new renewables, including wind. The “Class I” component is usually the bulk of most states’ renewable portfolio standards. Solar REC (SREC) are not Class I. Data in the charts above is the sole property of ICAP United, Inc. Unauthorized disclosure, copying or distribution of the Information is strictly prohibited and the recipient of the information shall not redistribute the Information in a form to a third party. The Information is not, and should not be construed as, an offer, bid or solicitation in relation to any financial instrument. ICAP cannot guarantee, and expressly disclaims any liability for, and makes no representations or warranties, whether express or implied, as to the Information's currency, accuracy, timeliness, completeness or fitness for any particular purpose.

Table of Contents

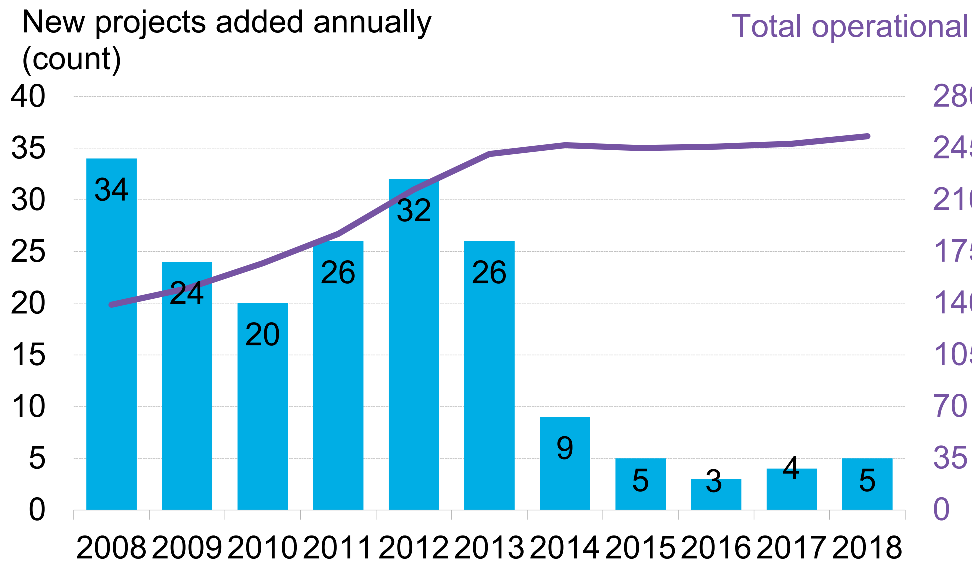
BloombergNEF

Deployment: U.S. bioenergy and anaerobic digester build

Annual build: large-scale bioenergy



Annual build: farm-based anaerobic digesters

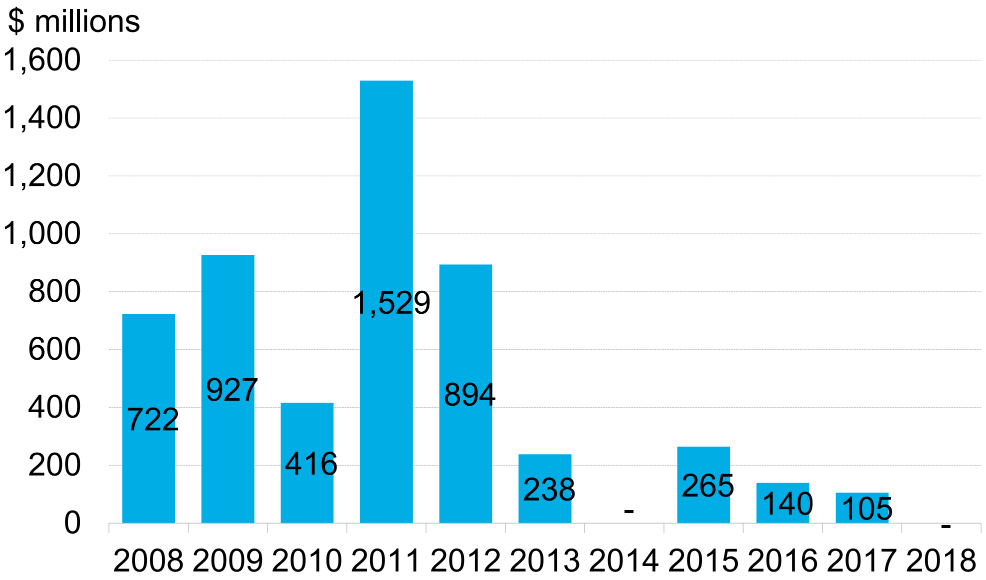


- In 2018, the U.S. installed 51MW of biomass and 32MW of biogas projects. Bioenergy build has tapered since 2013, when the Production and Investment Tax Credits, as well as the 1603 Treasury program, encouraged nearly 800MW of new installations.
- Waste-to-energy technology has seen more growth in countries such as China, where capacity rose 300% to an estimated 4,100MW in 2016, from approximately 970MW in 2009. China’s burgeoning economy has brought with it an explosion in the amount of solid waste, which has prompted the government to invest in waste-to-energy facilities. The U.K., too, has provided more supportive policies for waste-to-energy, encouraging nine new facilities in 2016.
- Five new anaerobic digesters were added in 2018. The total count of operational projects (accounting for retirements) has held fairly flat since 2014. In addition, there were 623 operational landfill gas energy projects not shown in the graphs above.
- BNEF tracked no major investment in biomass plants in 2018. But 12 new biogas plants representing potentially 22MW of capacity did get under construction in 2018, according to AcuComm, an alternative data provider. These represented $316 million in new investment.

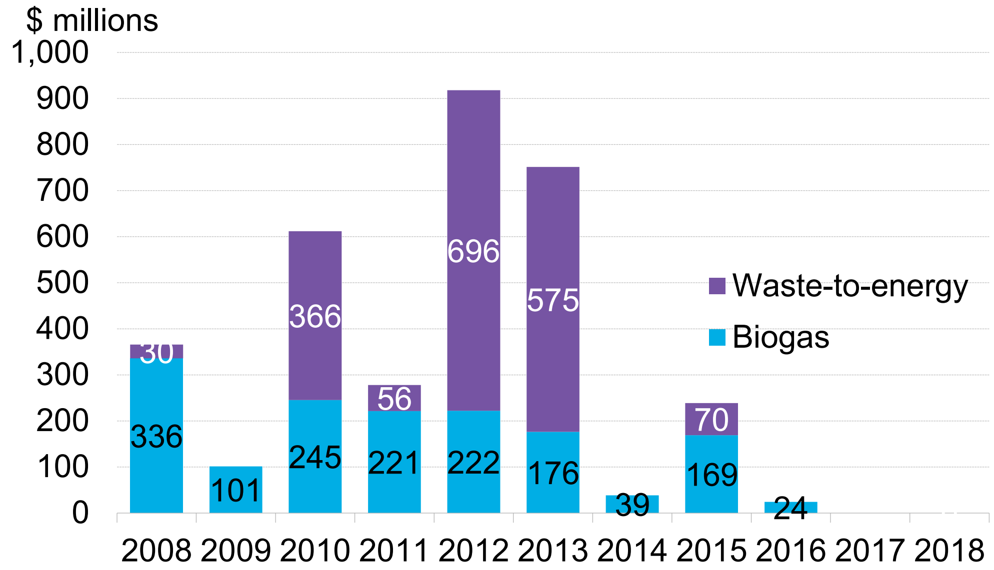
Source: BloombergNEF, EIA, company announcements, EPA AgSTAR database, AcuComm Notes: Biomass includes black liquor. Biogas includes anaerobic digestion (projects 1MW and above except wastewater treatment facilities). The graph on the right reflects anaerobic digesters on livestock farms in the U.S.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



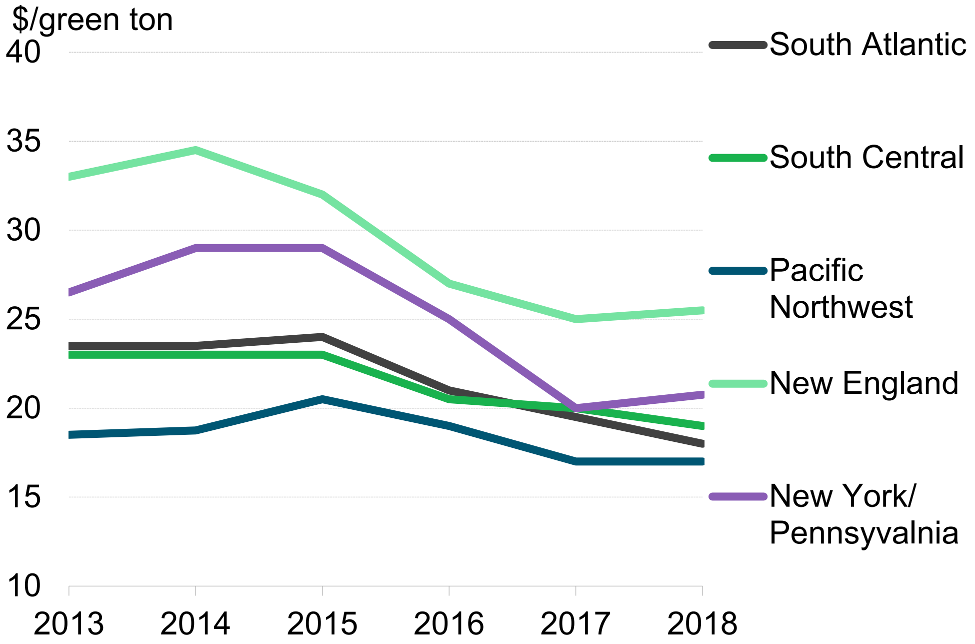
- Asset finance for new biomass and biogas build continues to dwindle. In 2018, BNEF did not track any major investment into large biomass, biogas or waste-to-energy projects. However, there was some new capacity added during the year.
- Low investment in the past five years for all these technologies 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.

Source: BloombergNEF, EIA, company announcements 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.

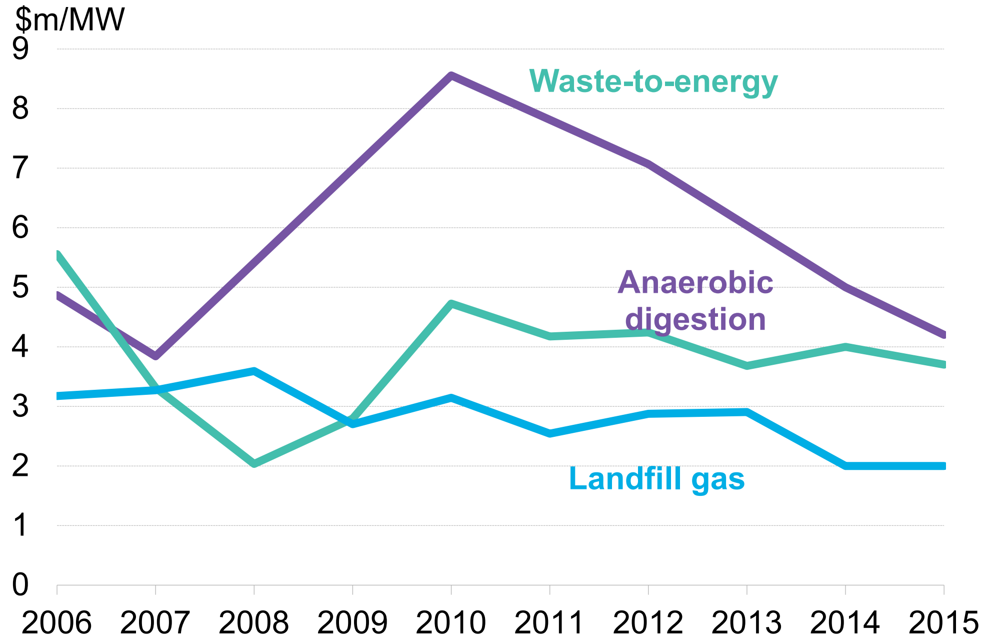
BloombergNEF

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

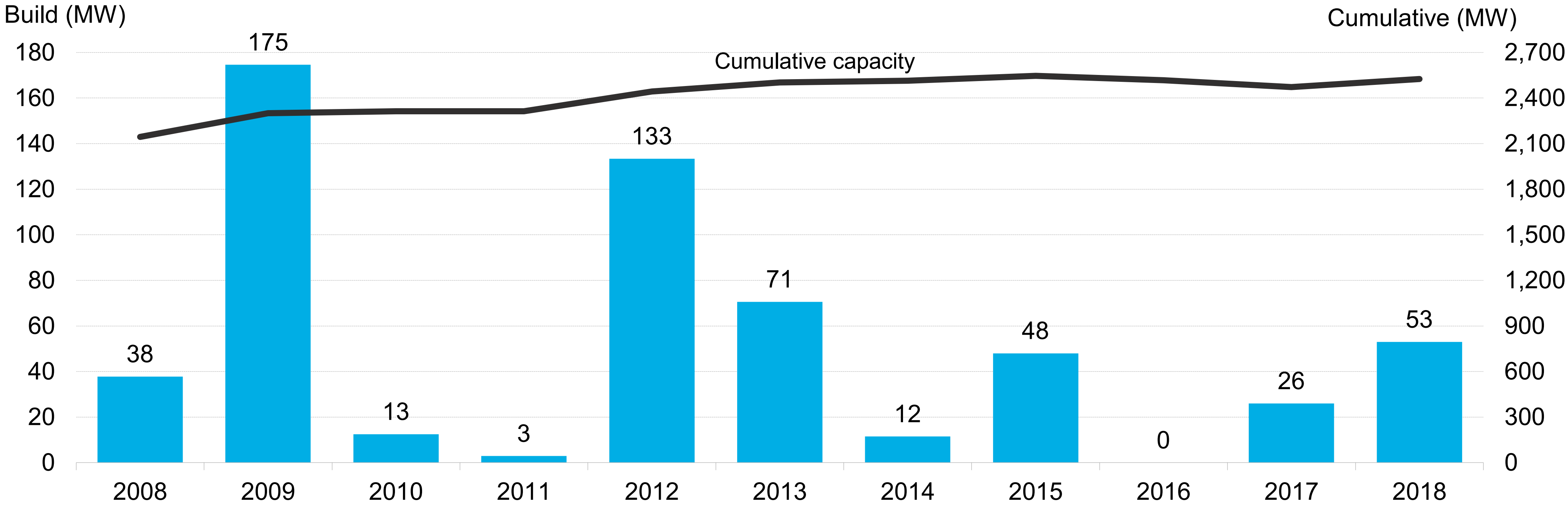


- Biomass feedstock prices continued to dip in the South Atlantic and South Central regions of the U.S. in 2018. Pacific Northwest plateaued at $17/green ton. New England and New York prices increased by less than 5% to $25.5/green ton and $20.8/green ton, respectively.
- Capex for waste-to-energy and anaerobic digestion both fell slightly in 2015. There are few projects under development domestically using these technologies, so the annual changes in capex figures are 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.

Table of Contents

Deployment: U.S. geothermal build



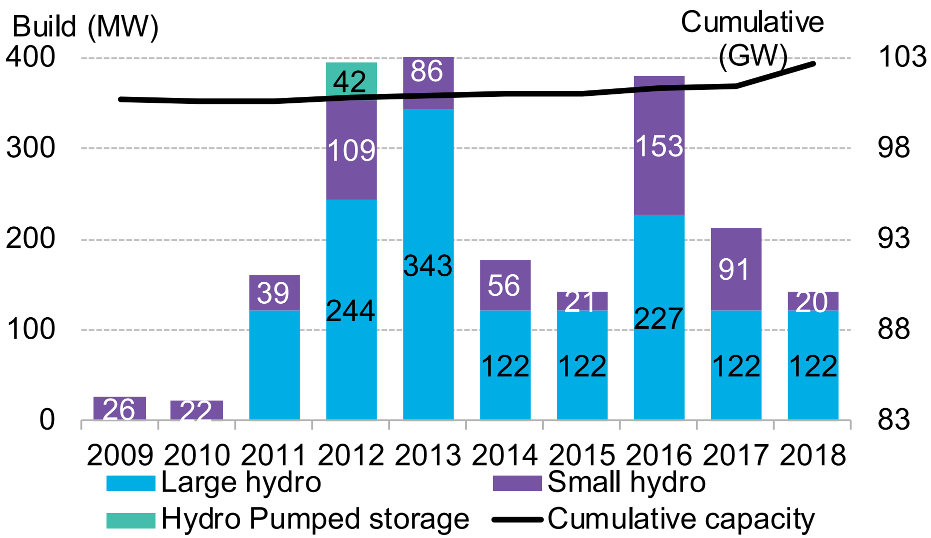
- U.S. geothermal build doubled in 2018 from 2017 levels. Of the 53MW completed, 37MW was accounted for by new development, McGinness Hills 3, in Lander, Nevada. The remaining 16MW came from the expansion of Herber Geothermal in Imperial, California. Unlike many other renewable resources, geothermal 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 contribute to the low build volumes.
- The 55MW project at the Geysers facility in Sonoma, California retired in 2018.
- New innovations in geothermal energy are emerging. Enel Green Power began operating two geothermal hybridization facilities in 2016. Geothermal hybridization is the combination of geothermal with another technology to enhance output. Outside of utility-scale electricity assets, geothermal may also be used for heating and cooling on a residential scale.

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

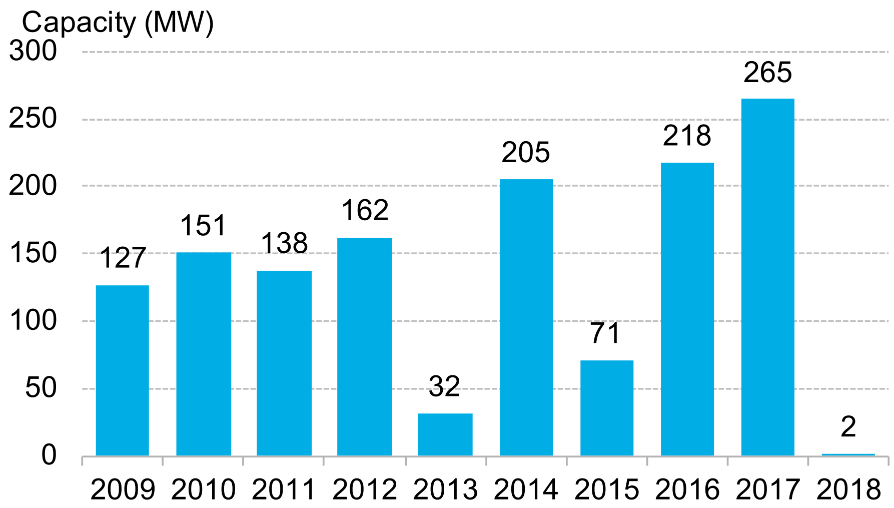
Table of Contents

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



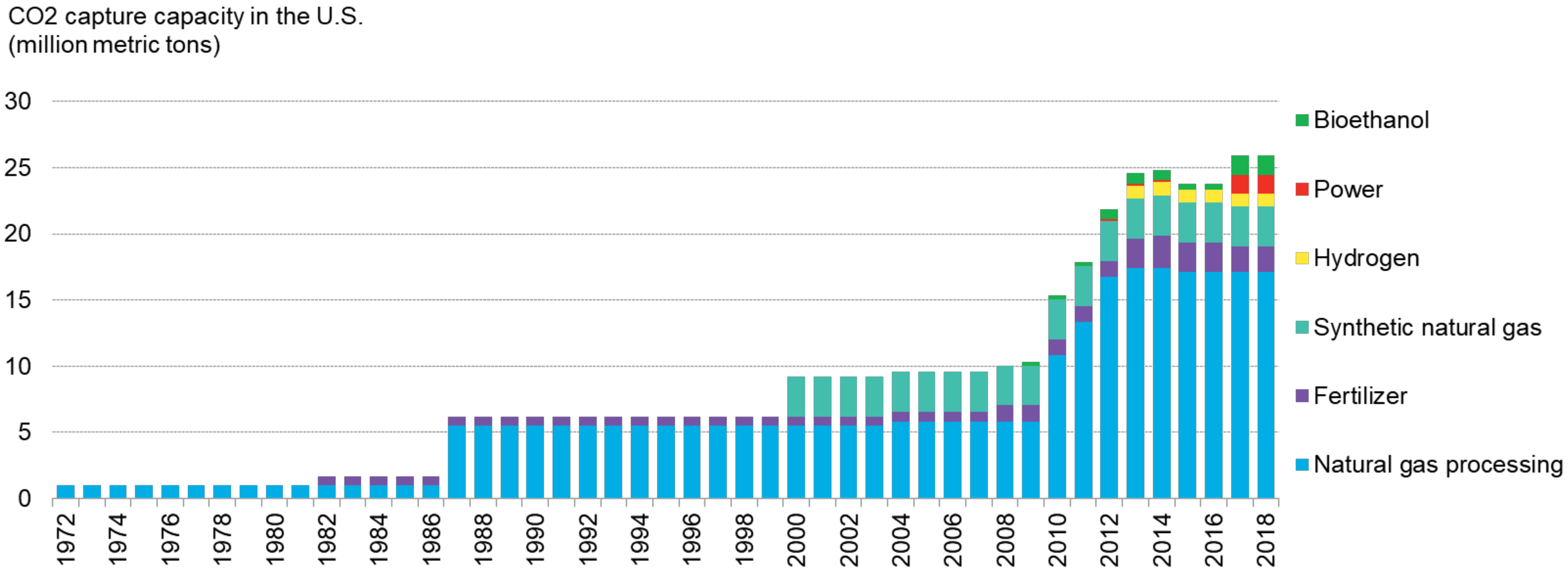
- Fewer megawatts of hydropower capacity were commissioned in 2018 than the previous year marking a two-year trend. Of 142MW of new build, 122MW came from the continued repair effort at the Wanapum dam in Washington. The remaining 20MW came from small hydro projects, the most sizable of which was the 6MW Hancock Creek Hydroelectric project in King, Washington.
- Only 2MW of new hydropower capacity, a proposed expansion at the Missouri-Madison project from 303MW to 305MW, were licensed by FERC from January to October 2018. Hydro projects that began construction before December 31, 2017, were retroactively eligible for the PTC thanks to the 2018 Bipartisan Budget Act. However, 2018 hydropower build was not eligible for the PTC.
- Total exemption applications and issuances have trended down since 2013, partly reflecting migration towards the simpler qualifying pathway for conduit projects that meet the necessary requirement of being smaller than 5MW with nonfederal owners. Since this pathway first became available in 2013, 105 conduit projects totaling 33MW have been deemed eligible for construction by FERC. (None are included in this chart.)

Source: BloombergNEF, EIA, FERC Notes: Hydropower build and cumulative 2018 values are projected, accounting for seasonality, based on latest monthly values from EIA (through October 2018) . Licenses data are from the Office of Energy Projects' (OEP) Energy Infrastructure Update in November 2018. 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.

Table of Contents

BloombergNEF

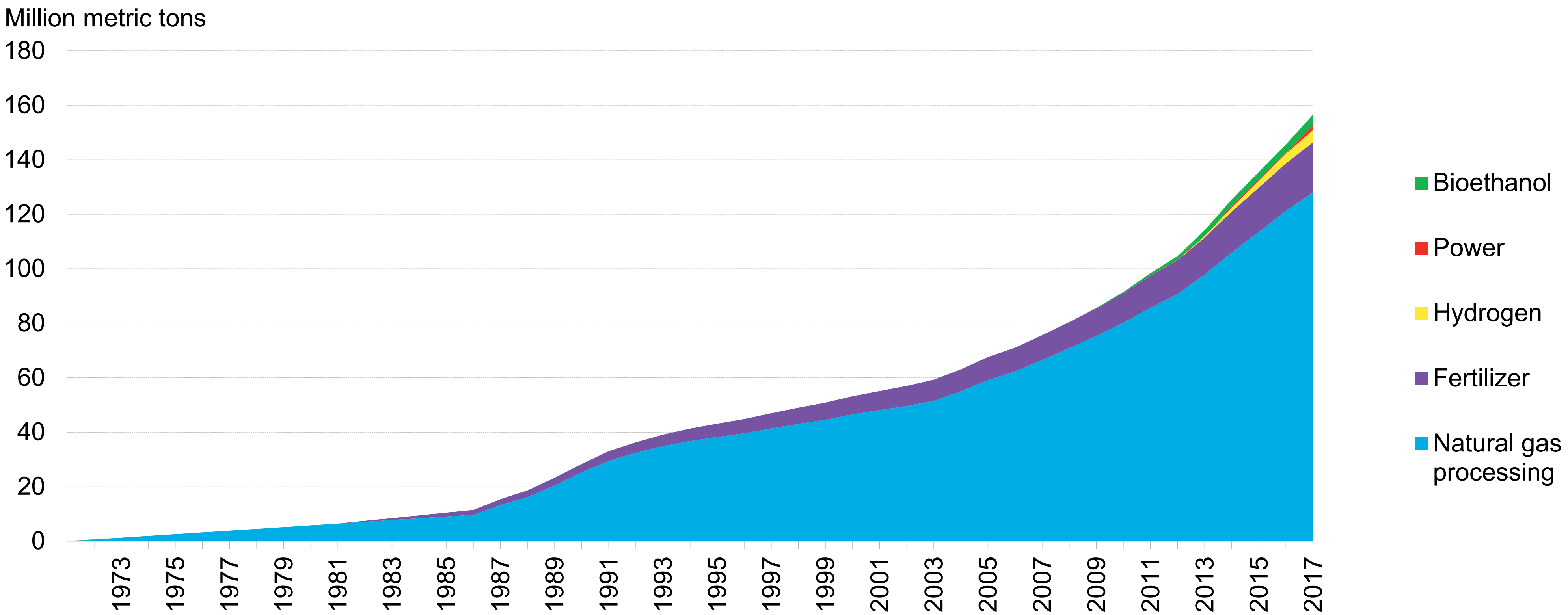
Deployment: Cumulative installed CCS capture rate in the U.S.



- 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 carbon capture and storage (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, with its capacity to store 1 million metric tons of CO2 a year, 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 carbon dioxide injection in the U.S.



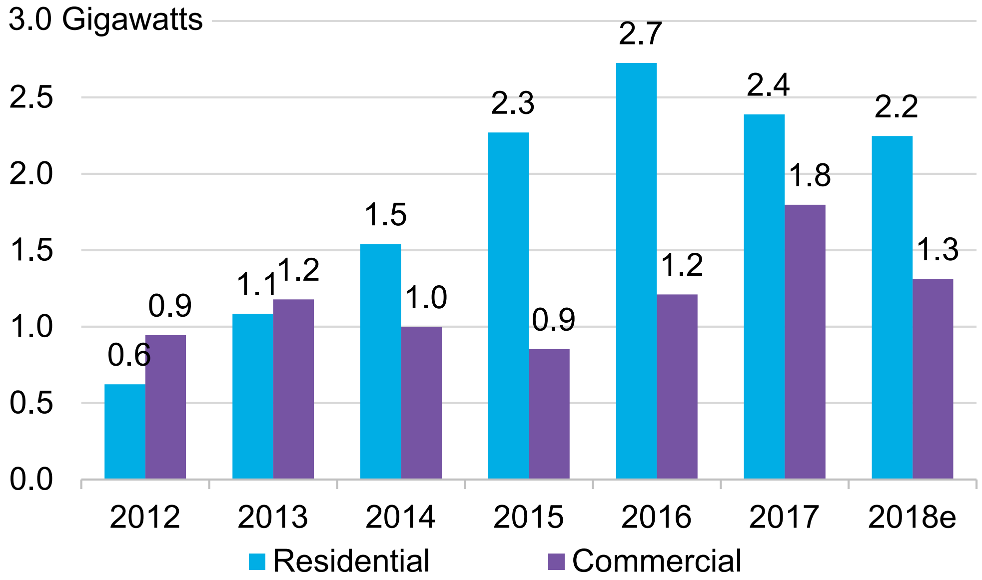
- Cumulative CO2 injection through U.S. carbon capture and storage projects continues to rise. In 2017-18, companies reached a number of milestones:
  - Great Plains Synfuels Plant, which produces synthetic natural gas, announced it has captured and transported over 35 million metric tons of carbon dioxide for enhanced oil recover (EOR) since 2000.
  - Air Products Steam Methane Reformer, a hydrogen production plant, hit a milestone of capturing and transporting 4 million metric tons for EOR in October 2017.
  - Petra Nova Carbon Capture announced in October 2018 that it had surpassed 2 million metric tons captured for EOR.

Source: BloombergNEF, Global CCS Institute

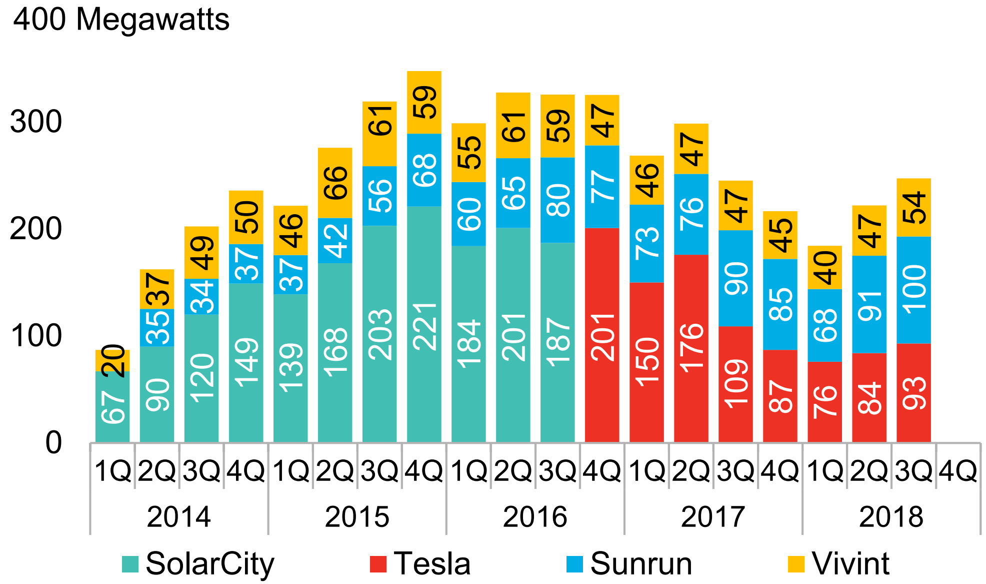
Table of Contents

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

Annual U.S. small-scale PV build



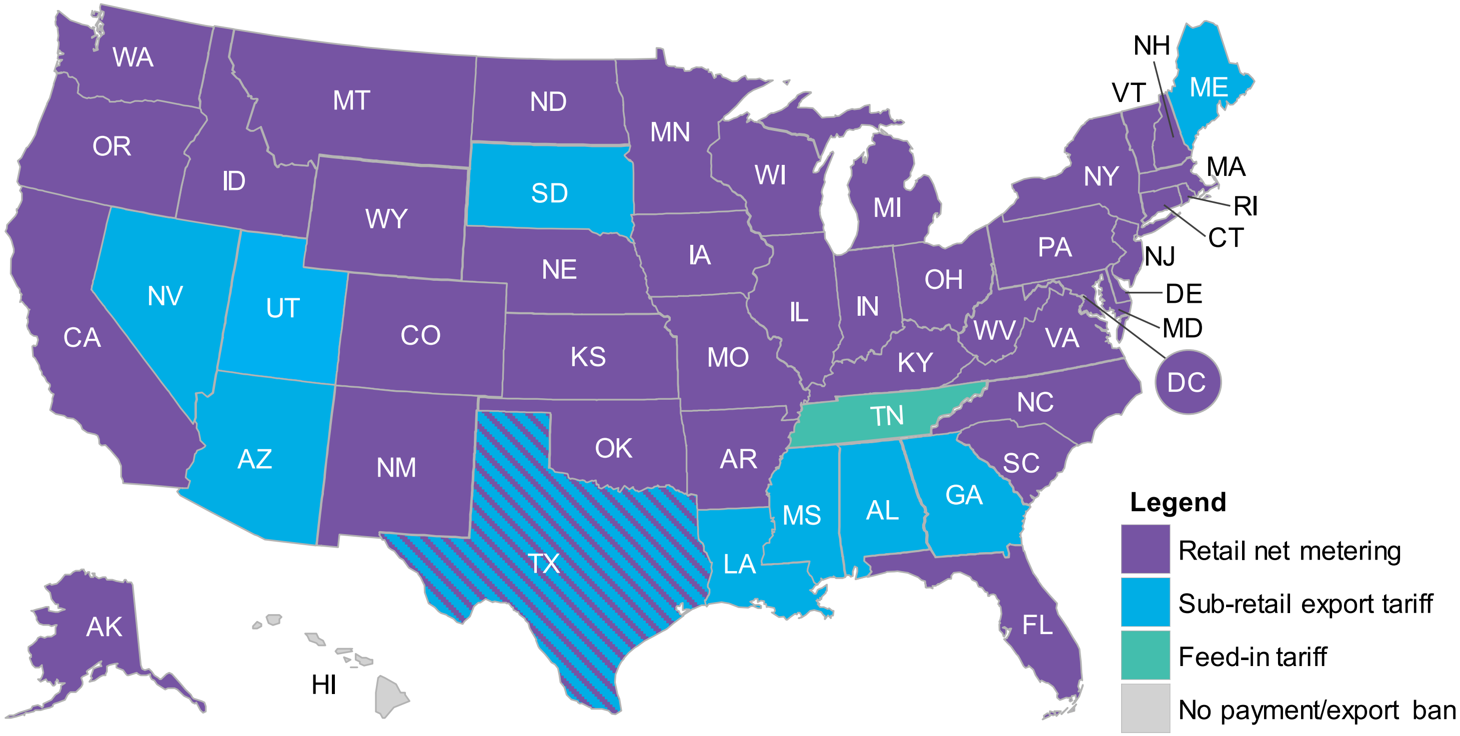
Installations of top three residential PV vendors



- In 2018, the U.S. residential and commercial solar market contracted for a second consecutive year. While there are signs that the California market is coming back to life, elsewhere the industry is facing headwinds as regulators dismantle net metering regimes at low penetration levels. Gains in Florida, Louisiana, Michigan, Nevada, Virginia, and the Carolinas couldn't offset slowing in more mature markets such as Hawaii, Maryland, Colorado, Pennsylvania, Utah, and Arizona.
- The current downturn is not terminal. Rather, it is the result of an overdue transition away from marketing-fueled growth to a more sustainable industry model. Tesla and Vivint Solar are growing again, having restructured over the past two years. The firms are recapturing ground lost to the new market leader, Sunrun, which continues to grow.
- Onsite commercial and institutional (C&I) solar build declined around 16% in 2018 after a bumper 2017 that was unlikely to be repeated. California, Colorado, Hawaii, Massachusetts, New Jersey, and Utah each experienced significant declines in commercial solar additions.

Source: BloombergNEF, company filings   Note: Q4 2018 data for individual vendors was not available at time of production.

Policy: Net metering state policies as of December 2018



- As of December 2018, net metering at the full retail rate was available to most customers within 38 states and Washington, D.C.
- The rooftop solar markets were once again threatened in 2018 by regulators' willingness to dismantle net metering regimes at low adoption levels. Maine became the first state in the Northeast to compensate residential solar generation below the retail rate. Several other states are set to follow. Connecticut, Michigan, and Utah are among the states that enacted suspensions or phase-outs in the past year.
- Net metering successor schemes vary widely. Several states, including Nevada and Maine, are phasing down the value of net metering credits over time; Arizona will compensate small-scale PV systems at the five-year-average utility-scale PPA price, and only for 10 years; and Indiana will only offer net metering to systems connected before 2022. New York's commercial PV market has transitioned from net metering to a *Value of Distributed Energy Resources* tariff that varies by location, system, and time of generation. NY mass market customers will transition to the complex scheme in 2020.

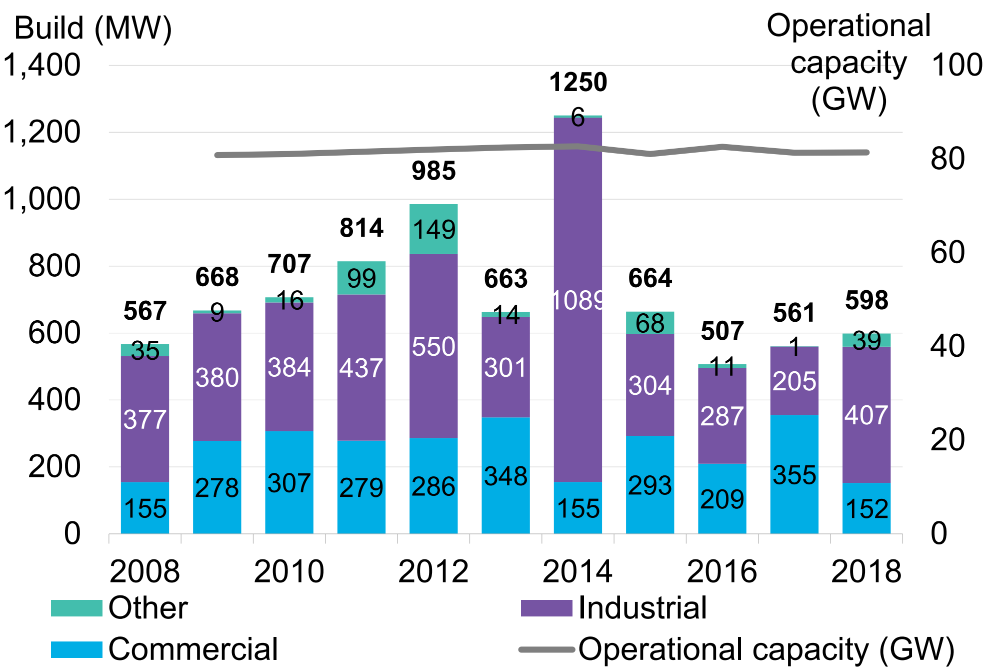
Source: BloombergNEF, DSIRE. Note: the map displays the mechanism offered to the majority of residential customers where the incentives vary within a state.

Table of Contents

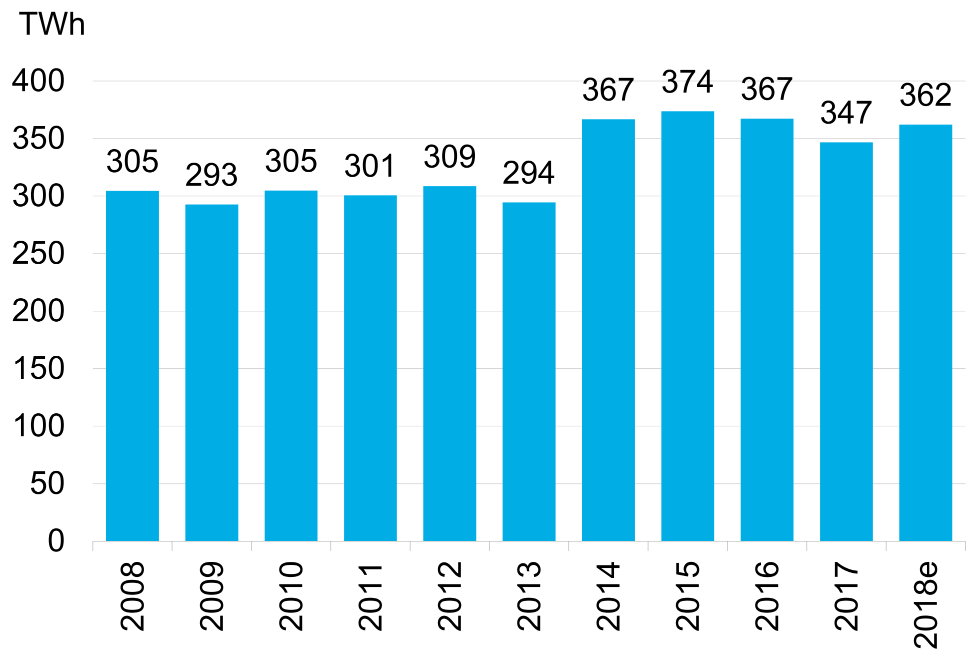
BloombergNEF

Deployment: U.S. CHP build and generation

U.S. CHP build and cumulative capacity



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

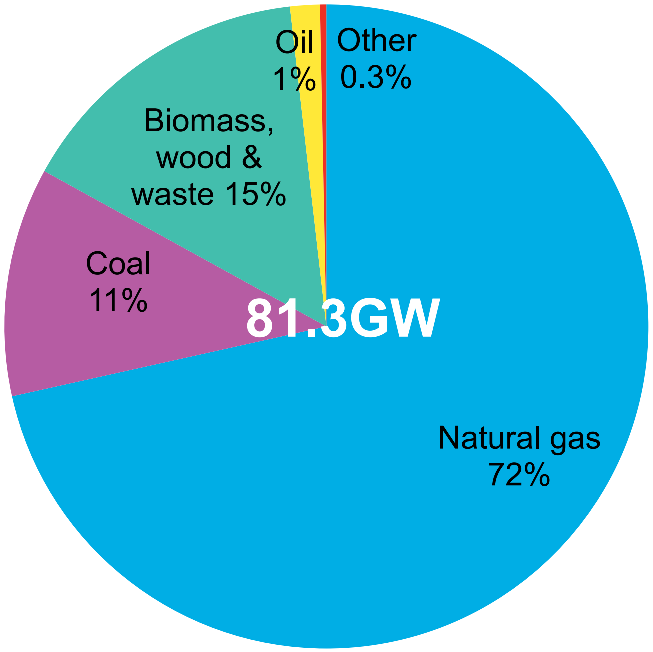


- CHP capacity additions increased slightly in 2018 to 598MW, from 561MW in 2016. The increase came as the sector saw the largest number of commercial CHP build in at least a decade.
- The total operational CHP capacity in the U.S. has remained relatively stable in recent years as new build has displaced older, retiring units.
- Generation from CHP plants rose slightly to an estimated 362TWh in 2018, a 4% increase over 2017 levels, as gas prices remained historically low throughout much of the year and older, less efficient units retired.

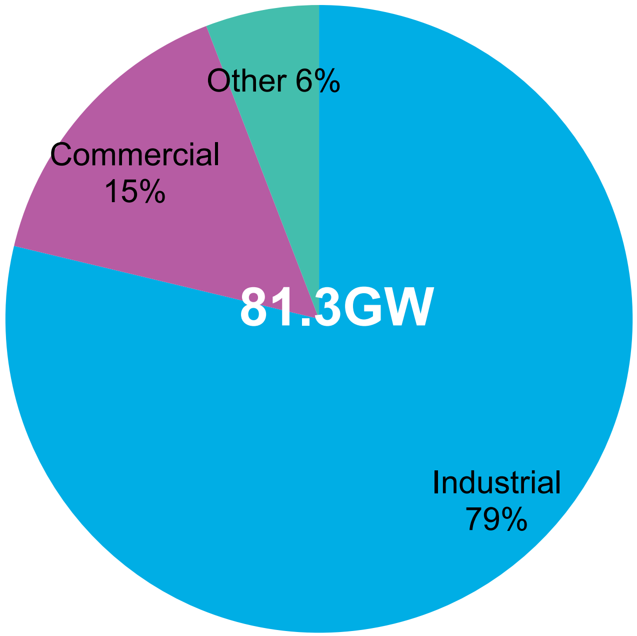
Source: BloombergNEF, DOE CHP Installation Database (maintained by ICF) Notes: EIA is the best available source for generation data, but is not comprehensive for CHP. The generation figures here are thus underestimated. Specifically, EIA does not collect data for sites <1MW and EIA categorizes some CHP systems as "electric power" rather than "industrial CHP," among other reasons. Values for 2018 are projected, accounting for seasonality, based on latest monthly values from EIA (data available through October 2018).

Deployment: U.S. CHP deployment by fuel and by sector, 2017

U.S. CHP deployment by fuel source



U.S. CHP deployment by sector

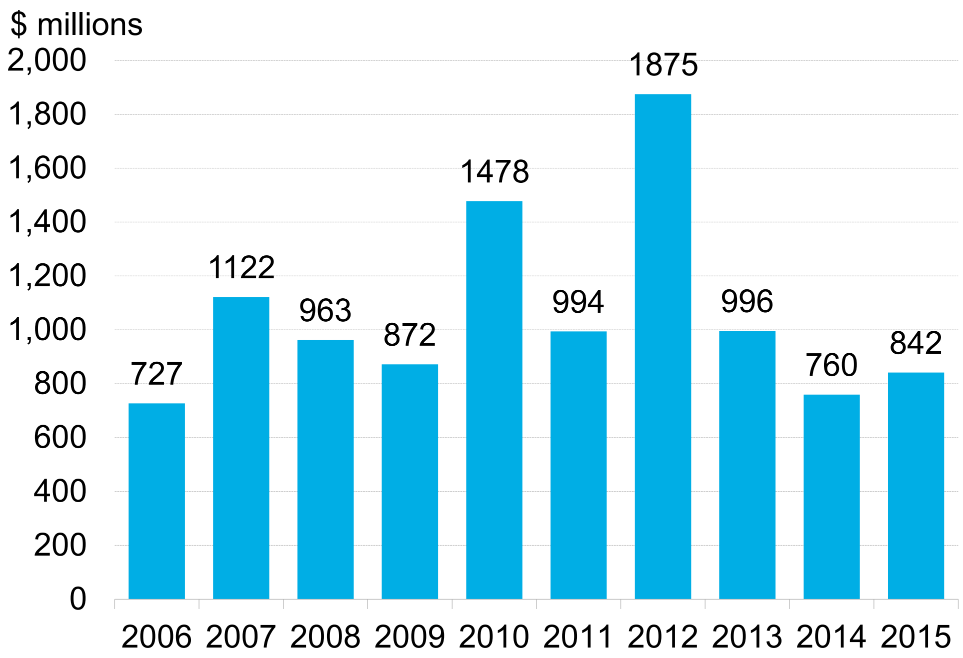


- Natural gas remained the dominant fuel source for CHP, providing 72% of CHP capacity. Units running on biomass, wood, or waste contributed 15% of total operational capacity, while units running on coal made up 11%, down from 13% the year prior.
- The industrial sector dominates CHP deployment at 64GW, or 79% of all operational capacity. Commercial users form the second largest share, at 15%.

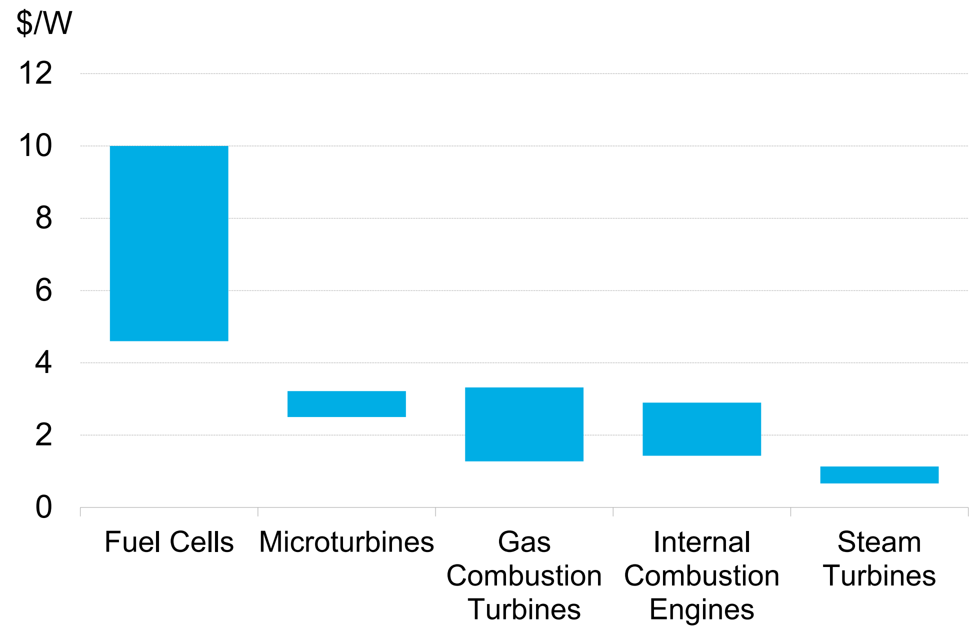
Source: BloombergNEF, DOE CHP Installation Database (maintained by ICF) Note: totals may not add to 100% due to rounding.

Financing and economics: U.S. CHP asset finance and capex

Asset finance for U.S. CHP



Capital cost of CHP by technology

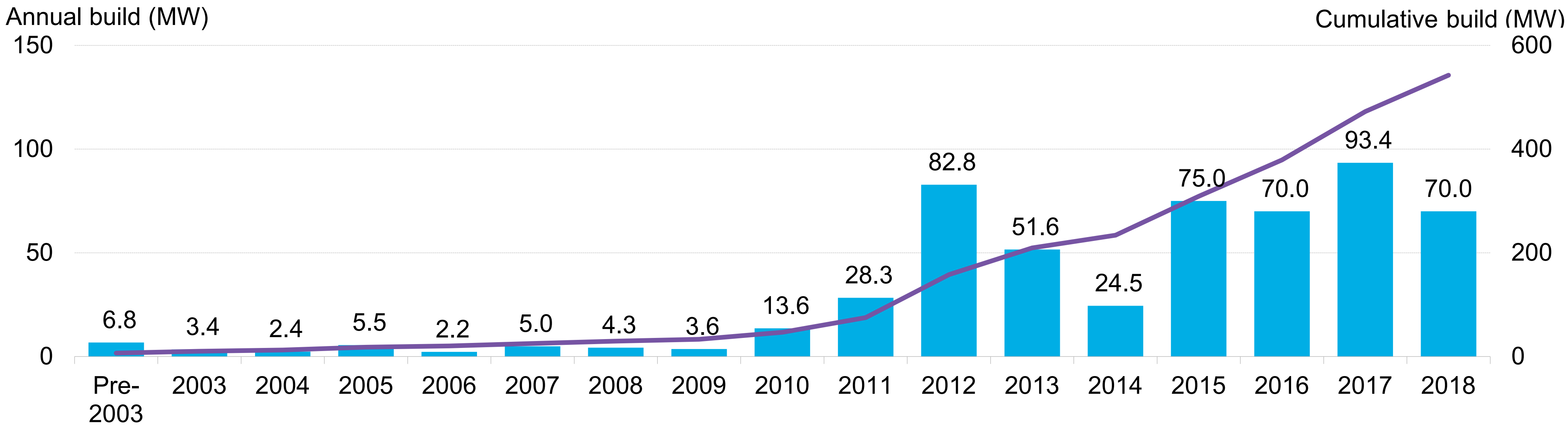


- Overall asset financing for CHP has declined as build tapered over the past few years. Note that financing figures assume a two-year lag between financing and deployment.
- Steam turbines, internal combustion turbines, and gas combustion turbines remain the more affordable CHP technologies in terms of capital cost.

Source: BloombergNEF; DOE CHP Installation Database (maintained by ICF); EPA Combined Heat and Power Partnership, Catalogue of CHP Technologies, prepared by ICF. Notes: ICF reports that CHP capex has remained fairly constant since 2008. BNEF data reflect capex for small CHP facilities powered by gas-fired reciprocating engines, gas turbines and microturbines and are based on an internal survey among industry participants. Asset finance values are estimated assuming a two-year lag between financing and deployment, and assuming a weighted average capex of $1.5m/MW from 2010 onwards to reflect a recent trend toward smaller systems. Financing figures are available through 2015 since deployment figures are only available through 2017.

Table of Contents

Deployment: U.S. stationary fuel cell build



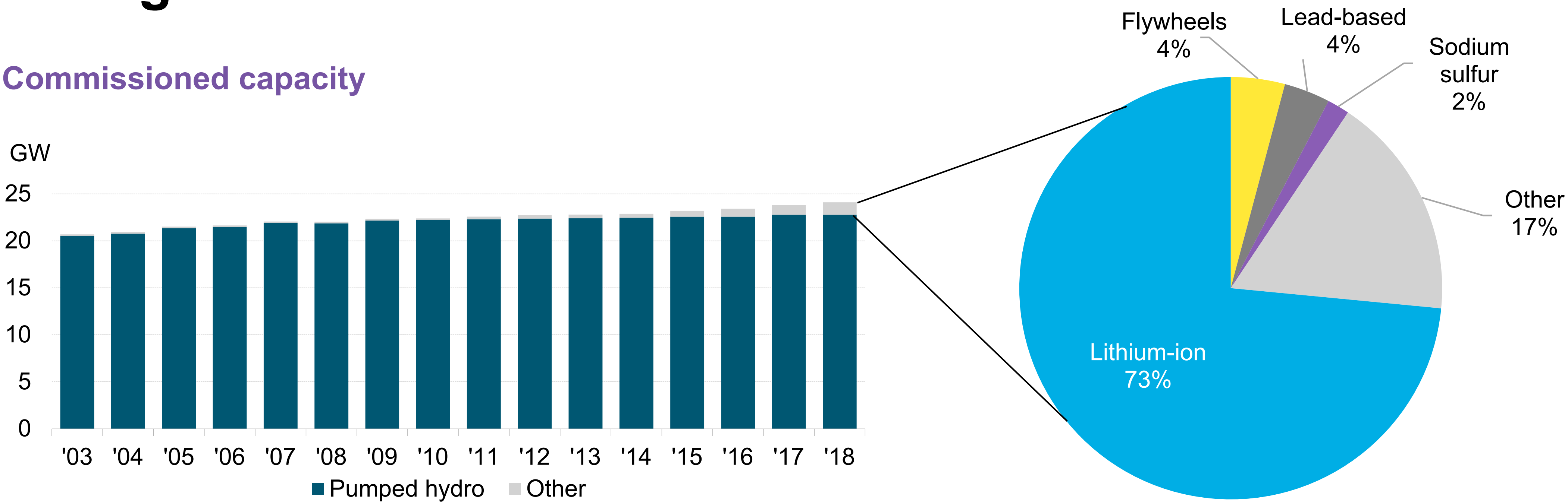
- The stationary fuel cell industry installed 70MW of systems in the U.S. in 2018, according to a survey conducted by the Fuel Cell and Hydrogen Energy Association of its members. This was down from 93.4MW in 2017.
- The U.S. is home to the world's largest manufacturers of stationary fuel cells. Despite lower deployment in the U.S in 2018, the industry saw significant exports of its products overseas. The industry also expanded its order backlog with projects and awards announced in 2018 that will enable future growth and deployment.
- In 2017, a federal Investment Tax Credit supporting the industry lapsed. The credit was then reinstated in February 2018, retroactive for 2017.

Source: E4tech Fuel Cell Industry Review 2017, Fuel Cell and Hydrogen Energy Association, SGIP, Bloom Energy, FuelCell Energy, BloombergNEF Notes: Fuel cells installed before 2003 are excluded due to the expected 10-year lifetime of these installations.

Table of Contents

Deployment: U.S. cumulative energy storage

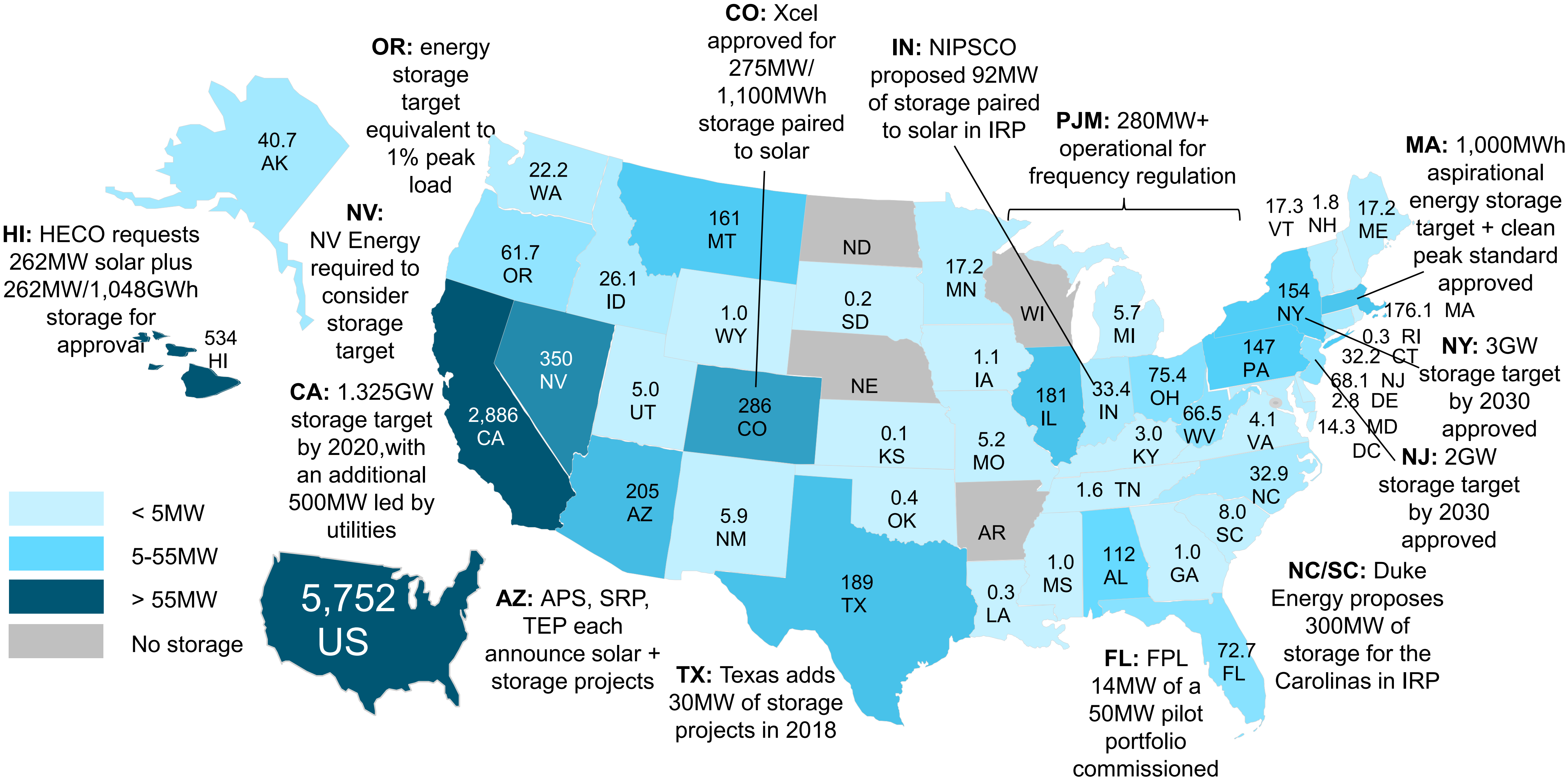
Commissioned capacity



- Pumped hydropower storage projects account for around 95% 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 2018, there were two pumped storage hydro projects with issued licenses (1,300MW Eagle Mountain in California and 400MW Gordon Butte in Montana). Additionally, there were pending licenses for five new projects totaling 2,138MW in new capacity.
- In February 2018, FERC issued Order 841 – a landmark rule that will enable energy storage to participate across all services in the wholesale markets. The rule aims to remove barriers to energy storage and to bring a measure of consistency to how these assets participate across organized power markets. Wholesale market operators have one year to implement the rule changes to comply with the regulation after they submit compliance filings (compliance filings were submitted to FERC in December 2018). The rule will ensure energy storage can compete fairly against other generators in the wholesale markets. This will encourage additional storage deployments and create new opportunities for energy storage to participate across multiple services.

Source: EIA, FERC, BloombergNEF

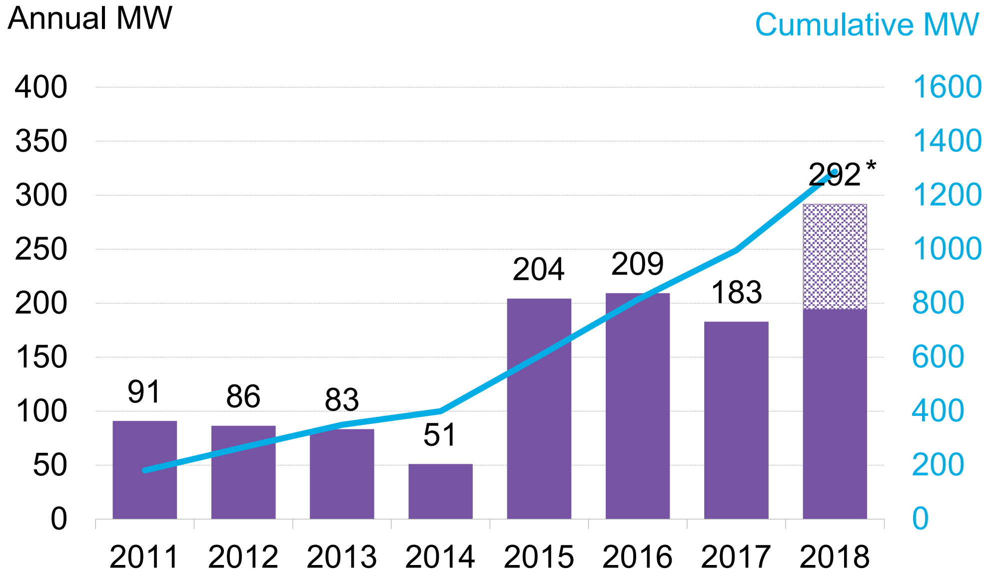
Deployment: U.S. announced and commissioned energy storage projects



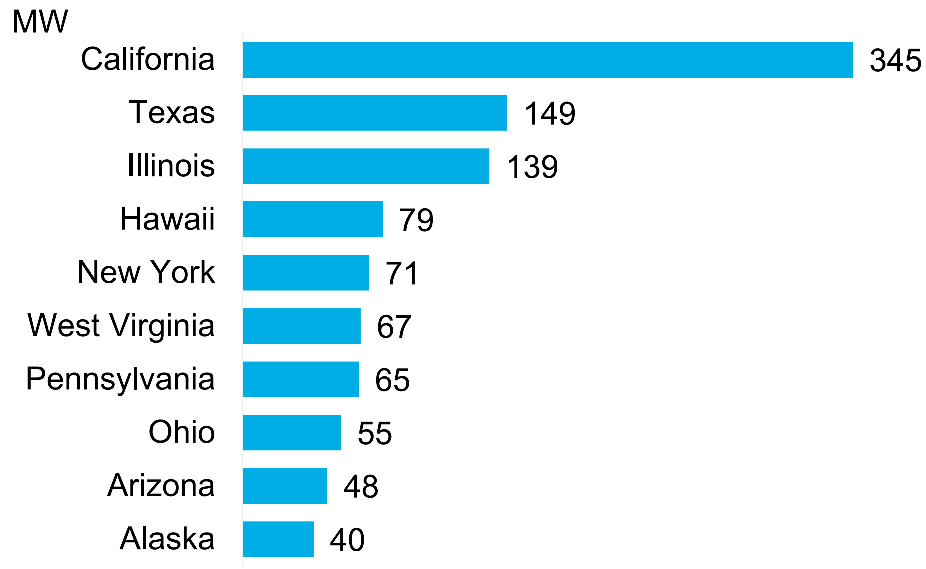
Source: BloombergNEF Note: Includes projects that are larger than 500kW/500kWh, have announced a specific location, and has been confirmed by the relevant company through public data. Indiana NIPSCO capacity not included in state capacity because individual project capacity is not yet disclosed.

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

Commissioned capacity



Installations by state (top 10 states in 2018)

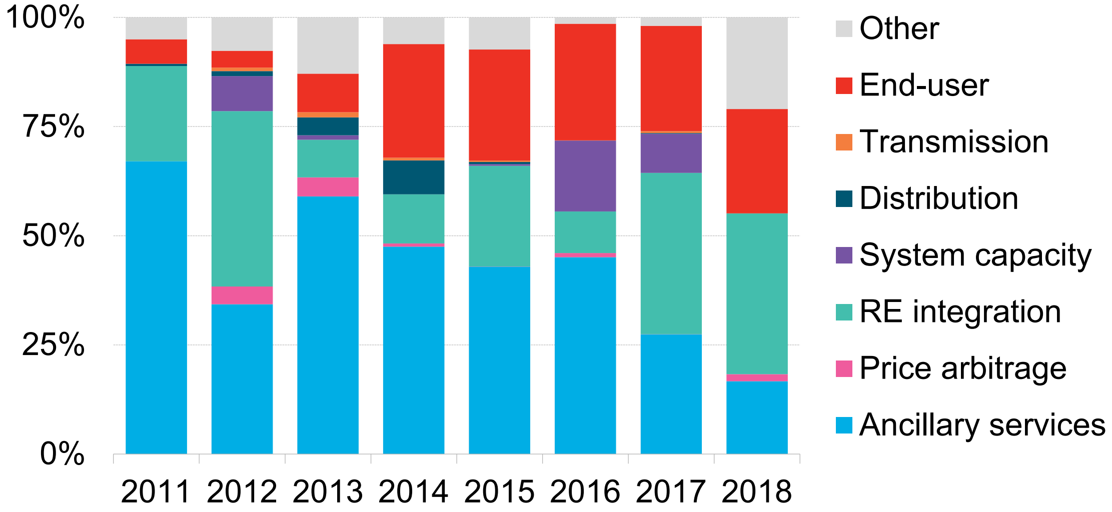


- Annual energy storage installations have increased significantly since 2014. Build ramped up in 2015 from projects seeking to participate in the PJM frequency regulation market – these assets represent most of the capacity in Illinois, West Virginia, Ohio and Pennsylvania.
- While PJM states are still, in aggregate, the biggest energy storage market in terms of commissioned capacity in the U.S., California is the largest single state market. California build surged in 2016 and early 2017 in response to emergency gas supply shortages expected from the Aliso Canyon gas storage facility leak-mitigation efforts.
- In 2018, markets began to expand beyond PJM and California. New Jersey, Texas, North Carolina, Illinois and Massachusetts each added more than 20MW of capacity.
- Falling lithium-ion battery pack prices have helped to lower costs for new stationary storage applications.

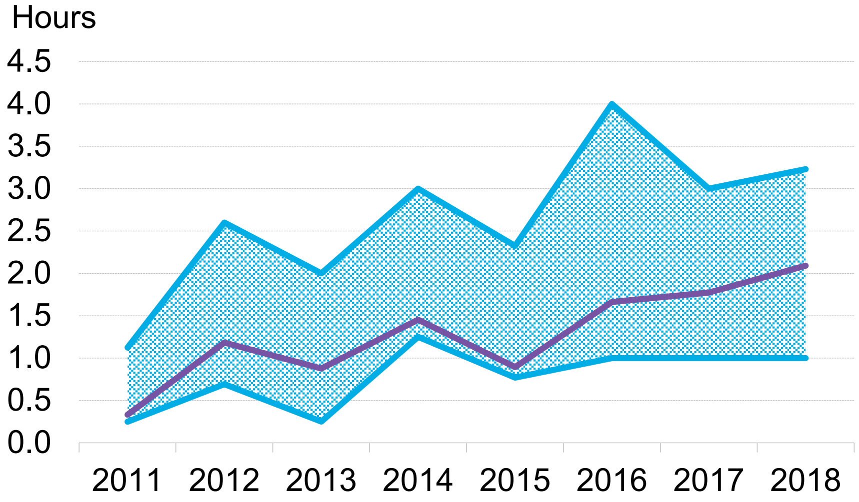
*Source: BloombergNEF Notes: *2018 includes expected but unconfirmed capacity as of December 5, 2018. Unconfirmed capacity is marked in white. Does not include underground compressed air energy storage or flooded lead-acid batteries. Minimum project size for inclusion in this analysis is 500kW or 500kWh. Cumulative capacity subtracts capacity that was decommissioned.*

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)



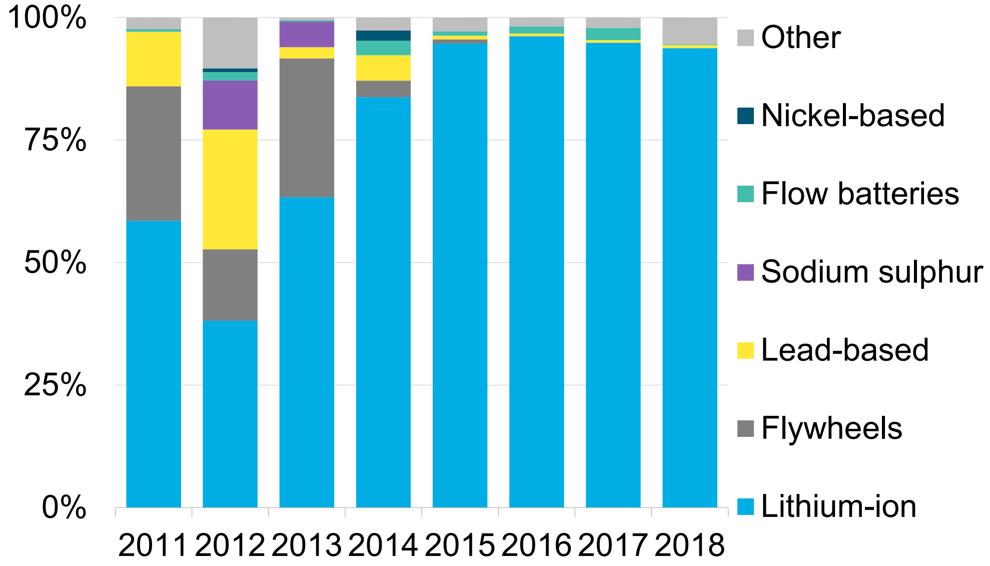
- Ancillary services (mainly frequency regulation) was the most common application for new storage systems installed between 2011 and 2016. Much of this was driven by deployments in PJM. However, the market for frequency regulation in PJM is now essentially saturated, and opportunities for this service in other territories are less attractive.
- System capacity rose in relevance in 2016 and 2017, driven by a wave of projects commissioned in California that are tied to Resource Adequacy contracts. These installations are required to be available for four hours whenever they are called upon. The shift from PJM frequency regulation projects to California Resource Adequacy projects explains the upward trend in average project duration, which increased from 0.9 hours in 2013 to 2.1 hours in 2018. Additionally, renewable energy integration increased in share in the last two years as more projects are co-sited with solar, helping to support additional renewable build across multiple markets.
- In 2018, the application mix became more diverse and more long-duration projects were in the pipeline. Examples include Hawaiian utility KIUC's solar-plus-storage PPA, which has a 5-hour duration battery; National Grid projects in Nantucket and Long Island featuring 8-hour duration batteries; and a Nextera project in East Hampton, New York.

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.

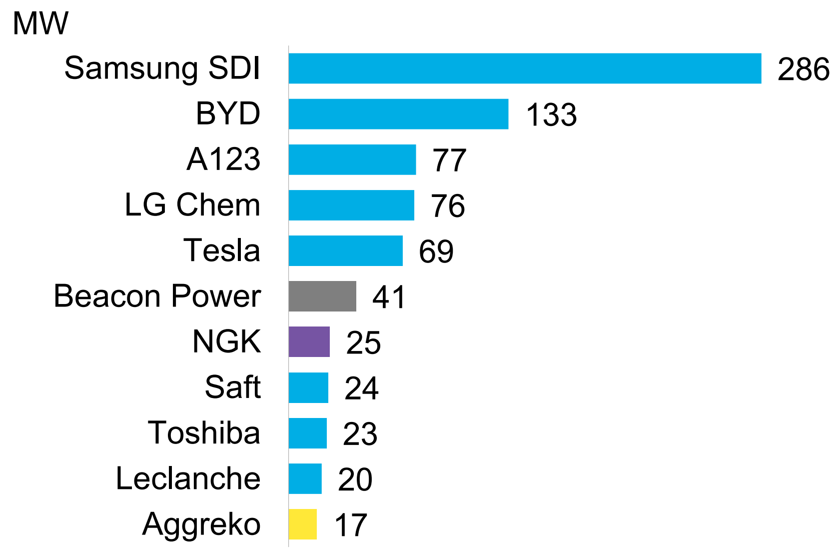
BloombergNEF

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

Technology (% by MW)



Top 10 storage technology providers

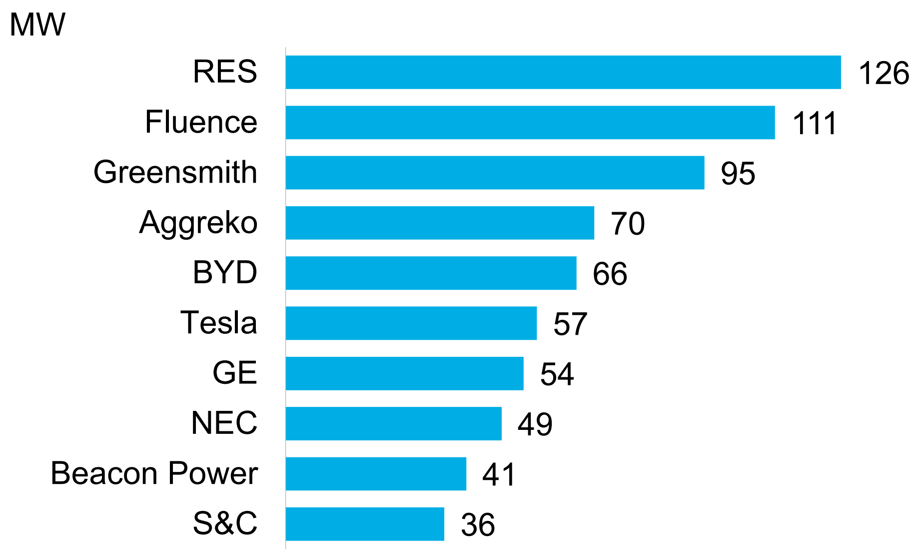


- The lithium-ion battery has been the technology of choice for developers of projects of all sizes, because:
  - It is widely available and mass produced all over the world;
  - It is modular and can be installed in multiple scales (from a few kW at residential scale to 100s of MWs for bulk system applications);
  - It can provide high power for short-duration applications (e.g. frequency regulation) and up to (and sometimes more than) four hours of energy capacity for longer-duration applications (e.g. investment deferral, arbitrage);
  - It has a long track record of reliability and high performance;
  - Projects using batteries produced by larger lithium-ion manufacturers such as Samsung SDI and LG Chem are more bankable due to the perceived risk of emerging companies; and
  - It is cheaper than other technologies on a turnkey basis, and its price is falling at a faster rate than other technologies. Cost reductions and scale are achievable because of the use of lithium-ion batteries in the transportation market, which is off-limits to most other technologies.

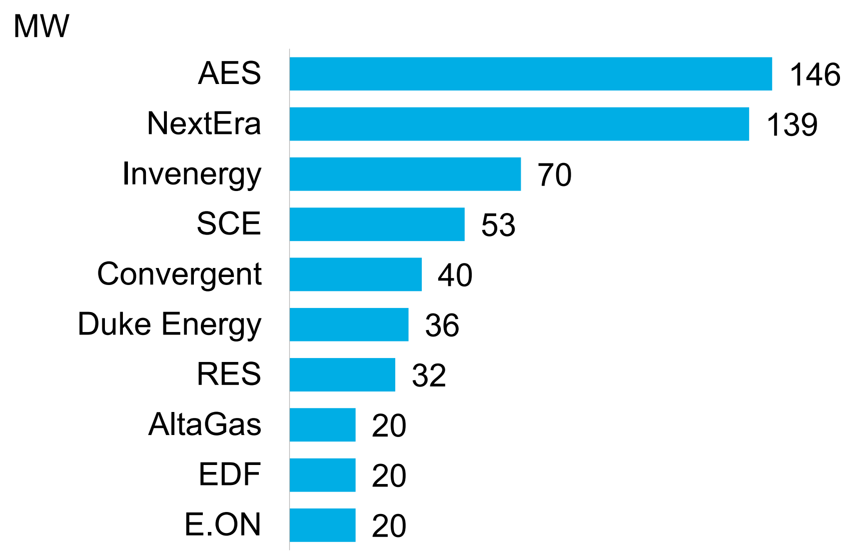
Source: BloombergNEF Notes: "Other" refers to applications not represented in the legend; many of these are government-funded technology testing or pilot projects to prove concepts. Top 10 based on commissioned capacity. Top 10 storage providers based on disclosed capacity at a project level, may exclude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

Deployment: U.S. non-hydropower energy storage, by integrator and owner

By system integrator



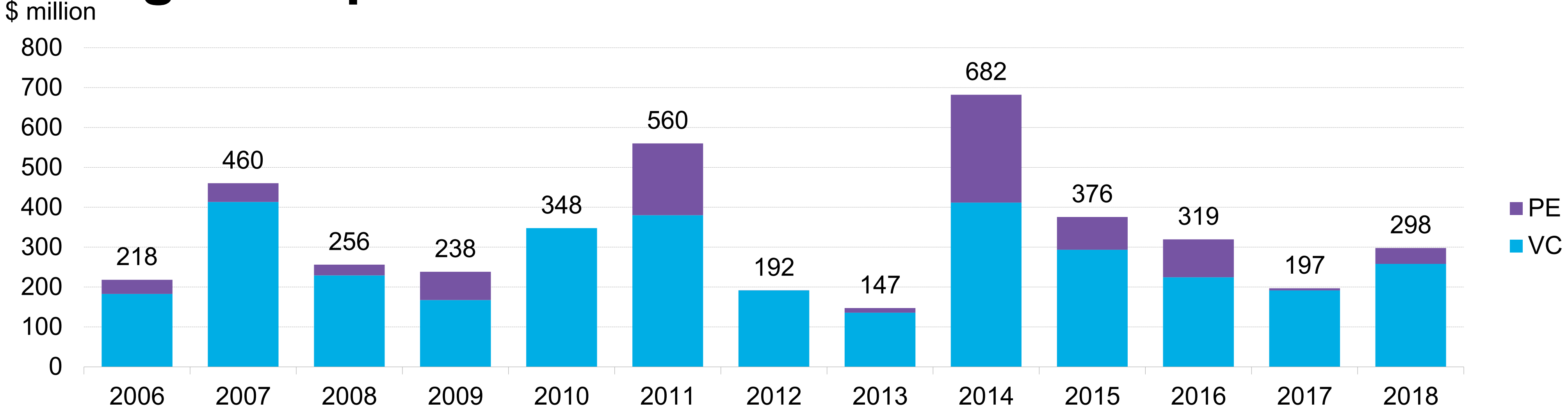
By owner



- System integrators are specialized companies that bring together the different components of an energy storage project – batteries, power conversion systems, the software that manages the whole system and other hardware components – and support its installation onto the final project site. While there is significant overlap between the top ten system integrators and owners, not all companies do both.
- Fluence Energy (joint-venture between AES Energy Storage and Siemens) has been the leading system integrator, while AES is the leading project owner.
- In the past two years, there has been consolidation among system integrators. Notable acquisitions included Wartsila's buyout of Greensmith and Aggreko's purchase of Younicos in 2017. Meanwhile, AES Siemens AG formalized Fluence. The deal gives AES access to Siemens's sales channel and after-sales services capability, cementing the company's transition from developer to services provider.
- Some utilities such as Indianapolis Power and Light (owned by AES), SDG&E (owned by Sempra), SCE and Imperial Irrigation District (IID) own projects that provide grid support to their distribution networks.

Source: BloombergNEF

Financing: Venture capital/private equity investment in U.S. energy storage companies



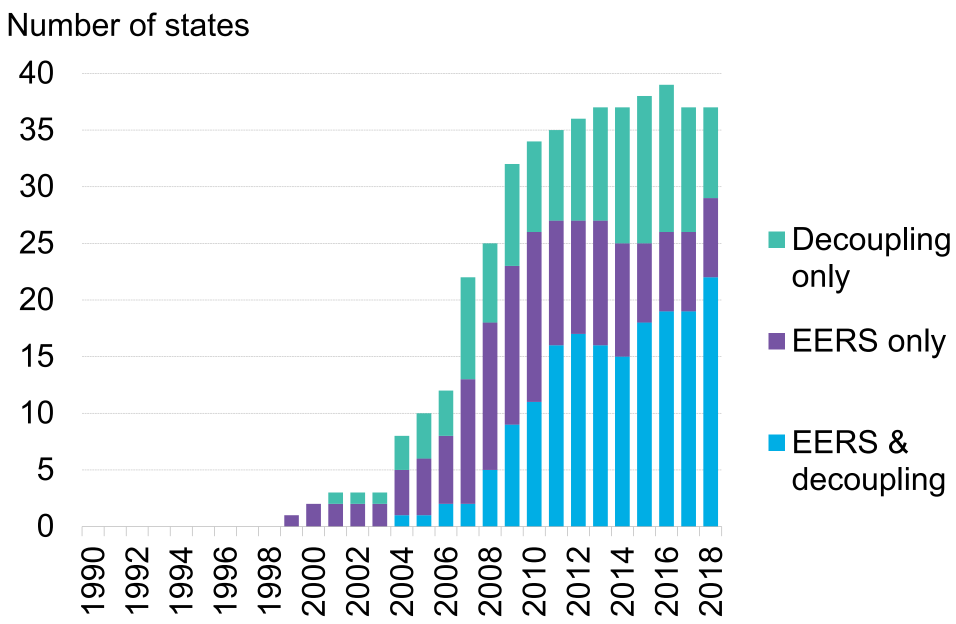
- There has been over $4.2 billion of venture capital and private equity investment in U.S. energy storage companies since 2006. Of this, $298 million came in 2018, according to the latest available data. The top disclosed investments for stationary storage in 2018 were:
  - $110 million for Stem, a California-based distributed storage turnkey system provider, from BNP Paribas, Magnesium Capital and others.
  - $65 million for Ionic Materials, a start-up company based in Massachusetts that has developed advanced materials for high-energy density batteries that would enable solid-state batteries. Investment was led by Hyundai CRADLE.
  - $20 million for Lionano, a developer of a cathode material to increase storage capacity and cycle life of batteries, led by WAVE Equity Partners, Helios Capital Ventures and NXT Ventures.
  - $20 million for Solid Power, a solid-state battery technology company, from Hyundai CRADLE, as well as Samsung Venture Investment, Sanoh Industrial, Solvay Ventures and A123 Systems.
  - Total VCPE investment in the sector had shrunk each year since 2014, but rose again in 2018. More confidence and consolidation of some key players have increased the number of acquisitions and third-party investment into projects, while decreasing the overall investment into earlier-stage energy storage companies. The new wave of investment is going into step-changes in energy storage technologies.

Source: BloombergNEF Note: Values include estimates for undisclosed deals. PE is private equity. VC is venture capital.

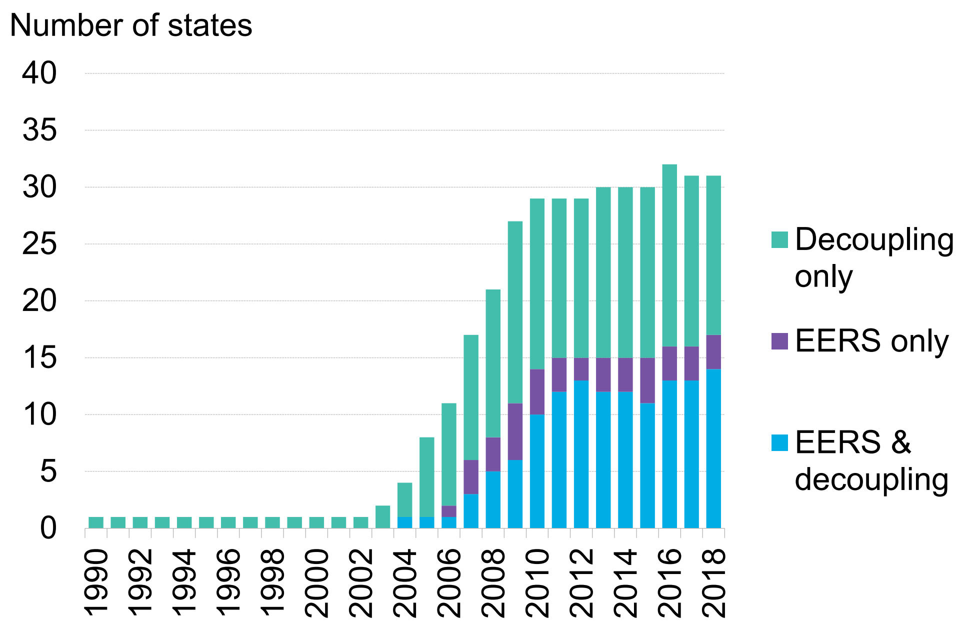
Table of Contents

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

Electricity



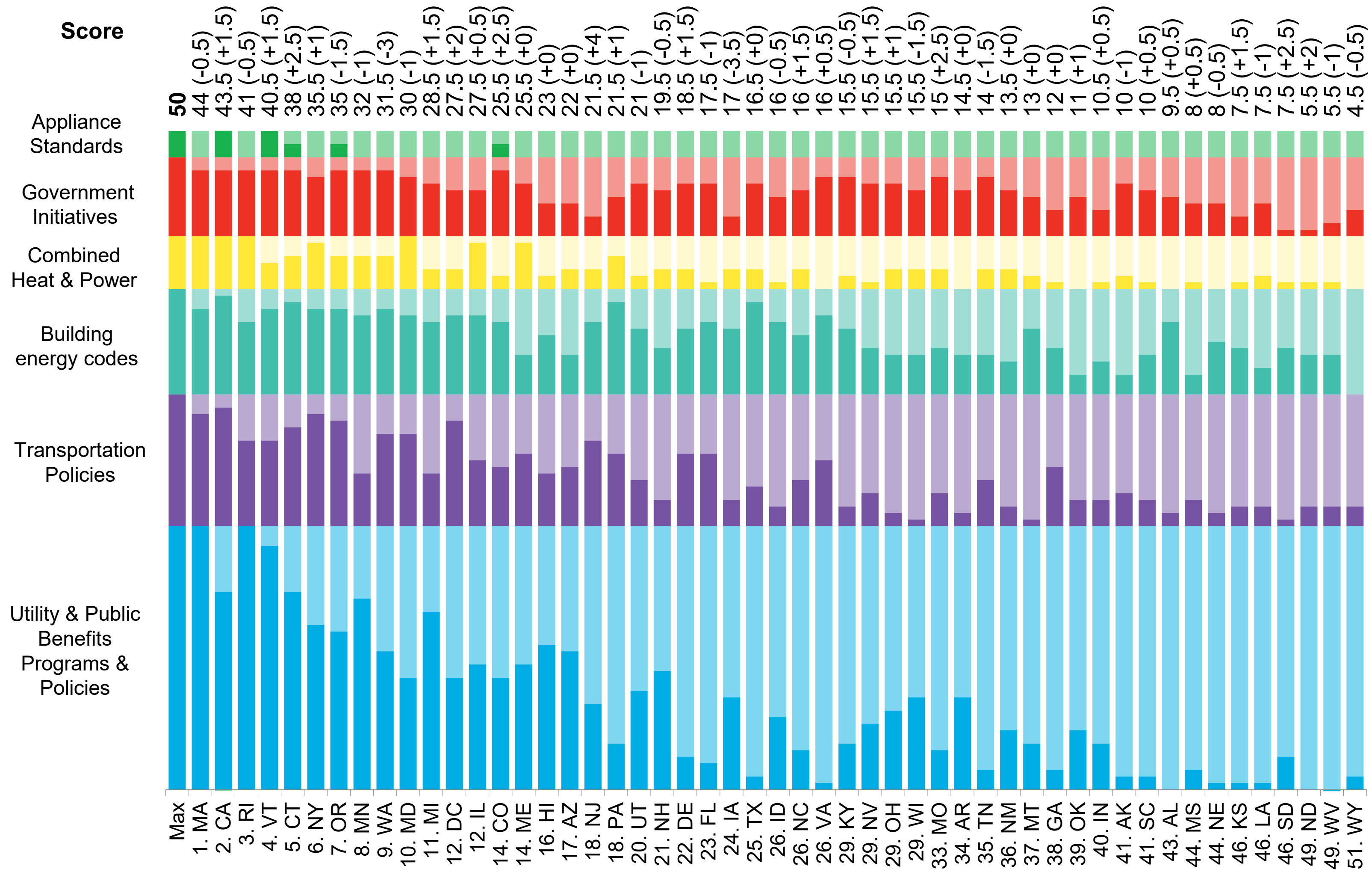
Natural gas



- Energy efficiency resource standards (EERS) are state-level policies that require utilities to invest in measures that improve end-user efficiency in order 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 but not on the volume sold. Decoupling removes the disincentive for utilities to invest in efficiency. Utilities are most likely to invest in energy efficiency in states with both EERS and revenue decoupling.
- The uptake of decoupling and EERS among states grew substantially from 2006 to 2010, accompanied by a dramatic increase in utility spending on end-user efficiency from $1.9bn to $4.7bn during that period. Although the number of states adopting legislation has slowed, spending has continued to rise as EERS targets have become more stringent.

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

Policy: ACEEE state-by-state scorecard for energy efficiency policies, 2017



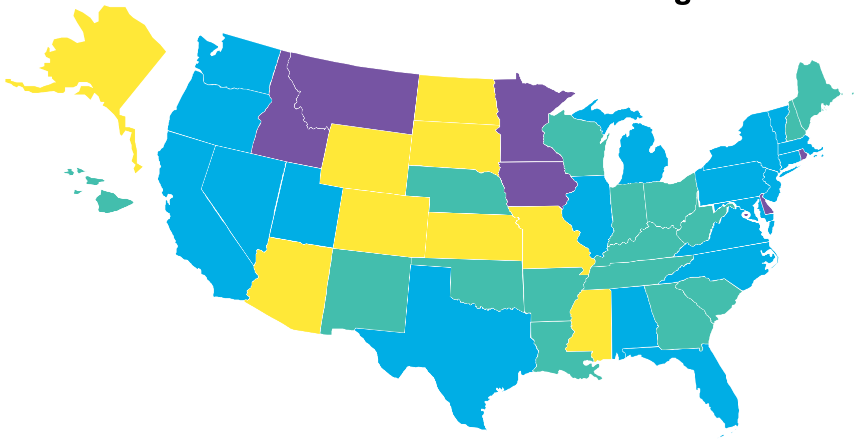
Source: ACEEE, EIA, BloombergNEF Note: Numbers in parentheses at the top denote the change in score from 2016 levels.

- Massachusetts retains its position as the highest-ranked state in 2018. With its fuel-neutral savings target and adequate utility funding it achieved record-high electricity savings equal to 2.7% of sales.
- Second-placed California scored maximum points across a number of categories, including building energy codes, state government initiatives and appliance standards, reflecting a number of major policy initiatives.
- New Jersey was a notable climber in the middle-rankings, moving from 23rd to 18th year-on-year due to increased utility spending on efficiency, new energy efficiency targets and RPS goals.
- Iowa fell the furthest in points for the second time in a row. New policies that deregulate efficiency requirements, cut efficiency spending, and set opt-out provisions have led to large drops in electricity energy and natural gas savings.

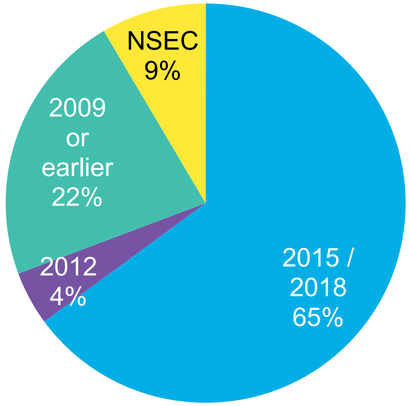
BloombergNEF

Policy: State adoption of building energy codes

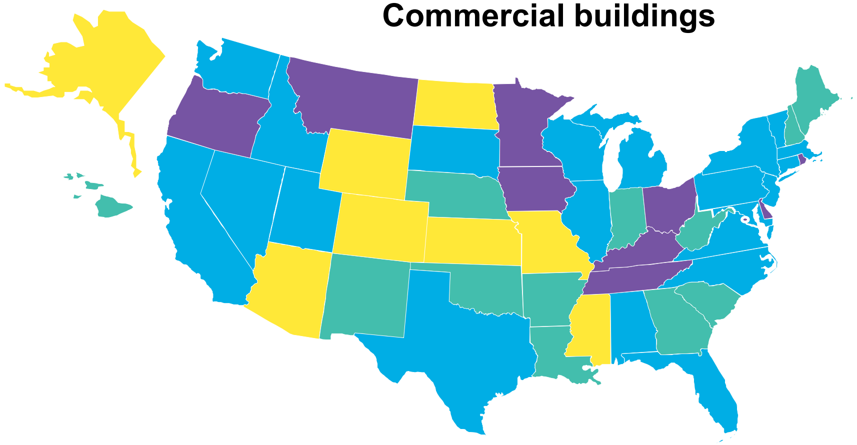
Residential buildings



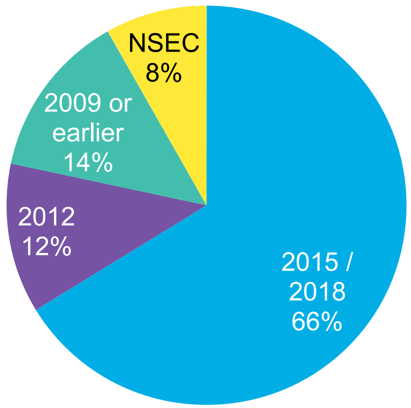
As a percentage of U.S. population



Commercial buildings



As a percentage of U.S. population

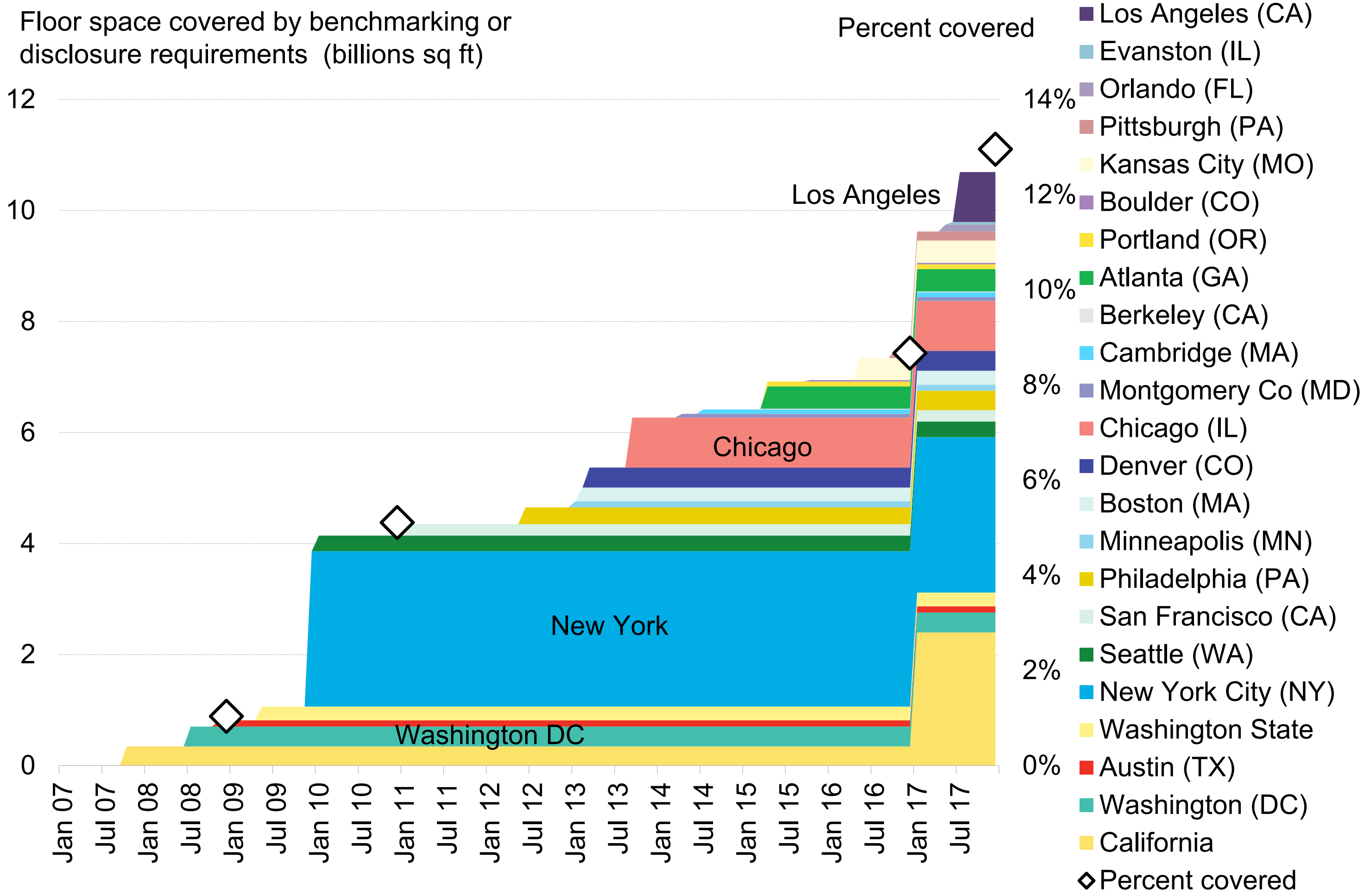


2015 / 2018 IECC | 2012 IECC | Earlier IECC | No state energy code

- 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,” some 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 programs in place.
- Adoption of the most recent versions of the IECC (i.e., 2015 and 2018) has increased from 46% of the U.S. population in January 2018 to 65% in January 2019.
- About a quarter of the U.S. population still lives in an area with an energy code that would be considered outdated (i.e., 2009 or earlier).

Source: U.S. Department of Energy, U.S. Census Bureau, BNEF. Note: 2015 IECC is 38 times more efficient than codes available in 2009.

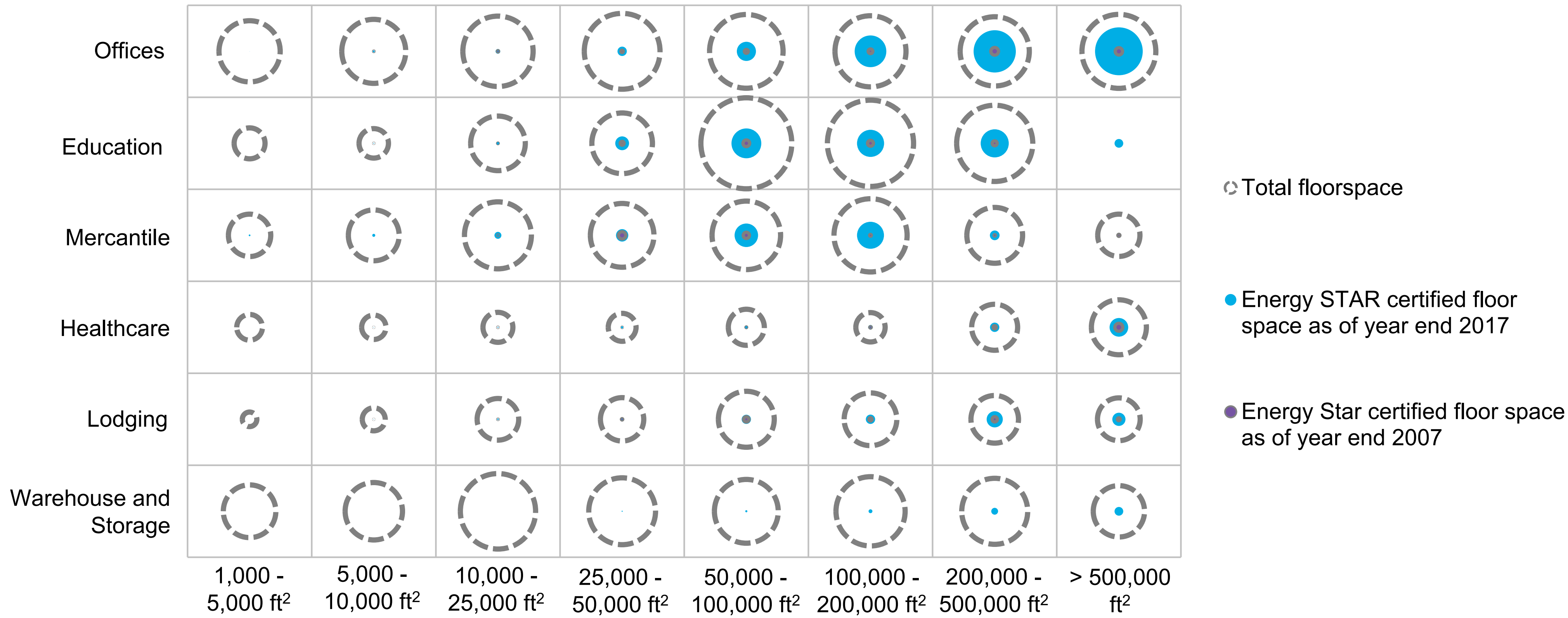
Policy: U.S. building floor space covered under state or local energy use benchmarking/disclosure policies



- In order to increase the 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 in 2017 from 9% to 13%.
- 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, Los Angeles passed new benchmarking laws that came into effect for public and non-residential buildings in July 2017.
- Similar laws for Evanston, Illinois and Orlando, Florida also came into effect mid-2017. Kansas City, Missouri passed a disclosure law that came into effect in May 2016.

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.

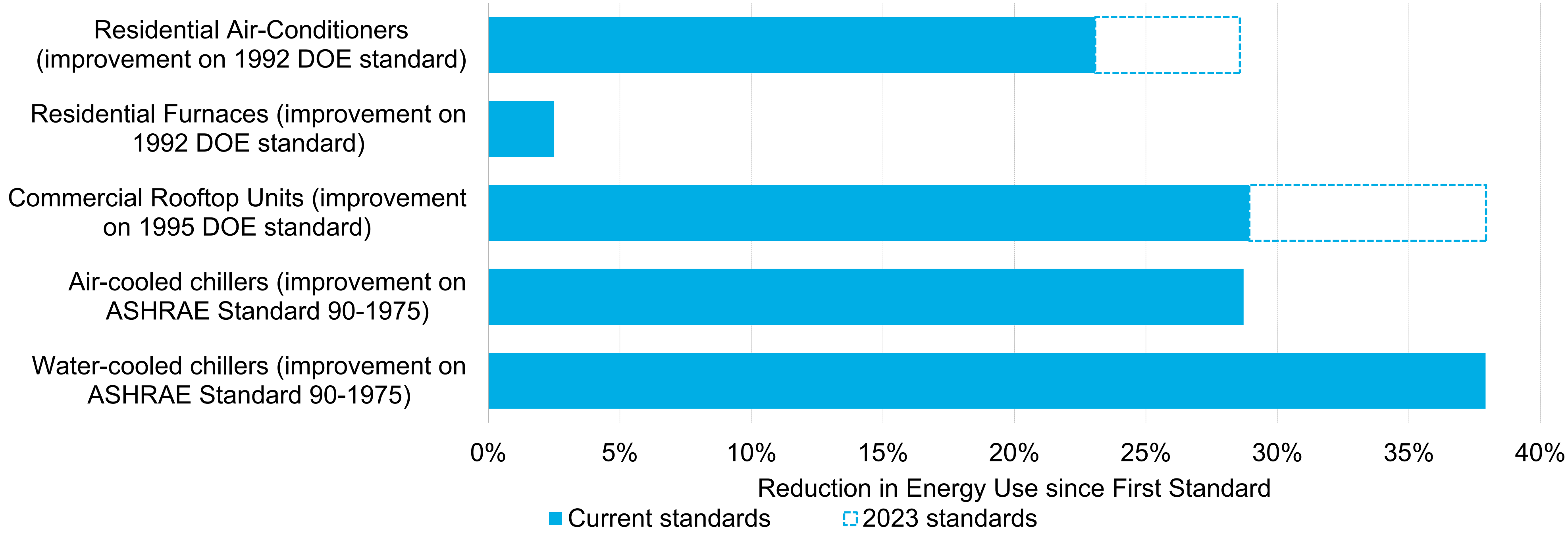
Deployment: Energy Star-certified floor space and total floor space for U.S. commercial buildings



- 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 same amount of effort 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. While lodgings and buildings for warehouse/storage currently have a low uptake in Energy Star certification, penetration is growing among the largest of these.
- The key 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 is insufficient data for total U.S. floor space of educational buildings in excess of 500,000ft^2.

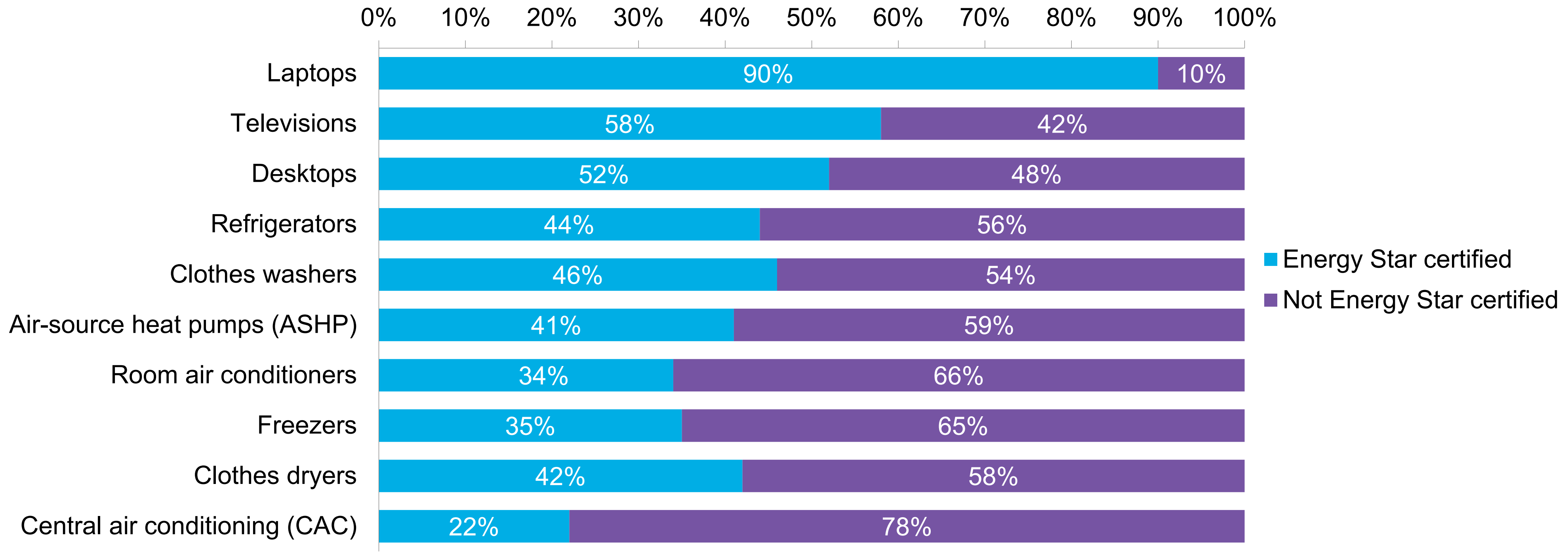
Policy: Reductions in energy use by HVAC equipment



- As technology advances, efficiency standards have tightened in order to continue driving building energy use reductions through innovation and other improvements. In 2018, a new commercial rooftop efficiency standard took effect, requiring a 29% improvement over 1995 levels. This is an increase over the 2010 standard that required a 19% efficiency improvement.
- Today, air conditioning equipment uses 20-40% less electricity to provide the same amount of cooling as when standards were first introduced.
- Potential remains for higher standards and further improvement to these systems, but relative efficiency gains will be incrementally smaller.
- Additional efficiency gains can come from optimizing these and other building systems through building energy codes and other "systems efficiency" approaches.

Source: © 1975 ASHRAE www.ashrae.org Note: 2023 standards reflect Department of Energy appliance standards to take effect in 2023.

Deployment: Energy Star-certified products sold by product type, 2017

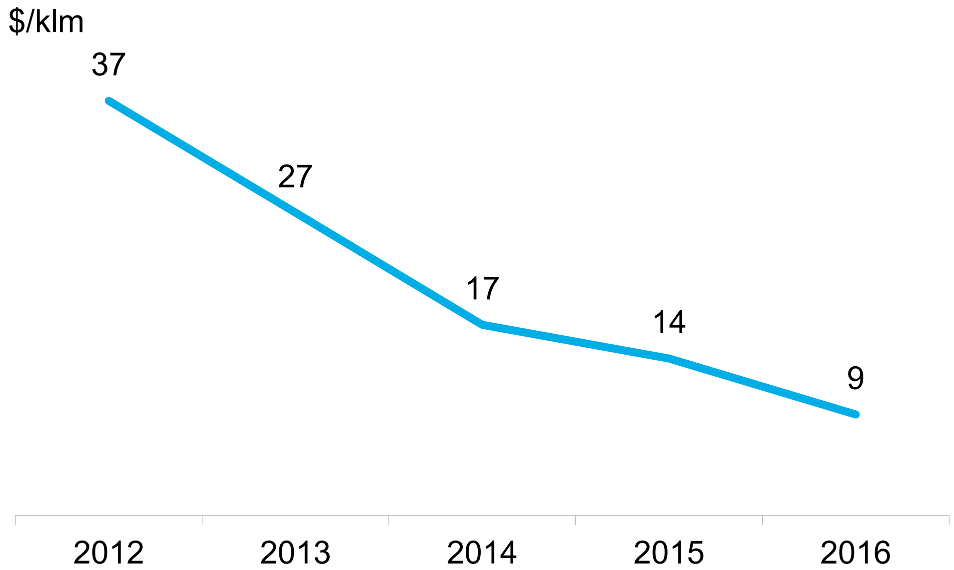


- Of the products considered, laptop computers have the highest rates of certification at 90%. This is in contrast to desktop computers, where the certification rate stands at only 52%. Because energy efficiency also impacts laptop battery life, there is an additional incentive for consumers to choose an efficient option. This is a likely explanation for the difference.
- Air conditioning products remains among the products with lower certification rates, with central air conditioning at 22% and room air conditioning at 34%.
- Clothes dryers have made significant improvements, jumping from 32% Energy Star certified in 2017 to 42% in 2018.
- Penetration rates can change year to year due to factors such as actual increases in the number of Energy Star-certified products, as well as falling penetration due to the introduction of new, more stringent certification standards or the introduction of new products that are not certified.

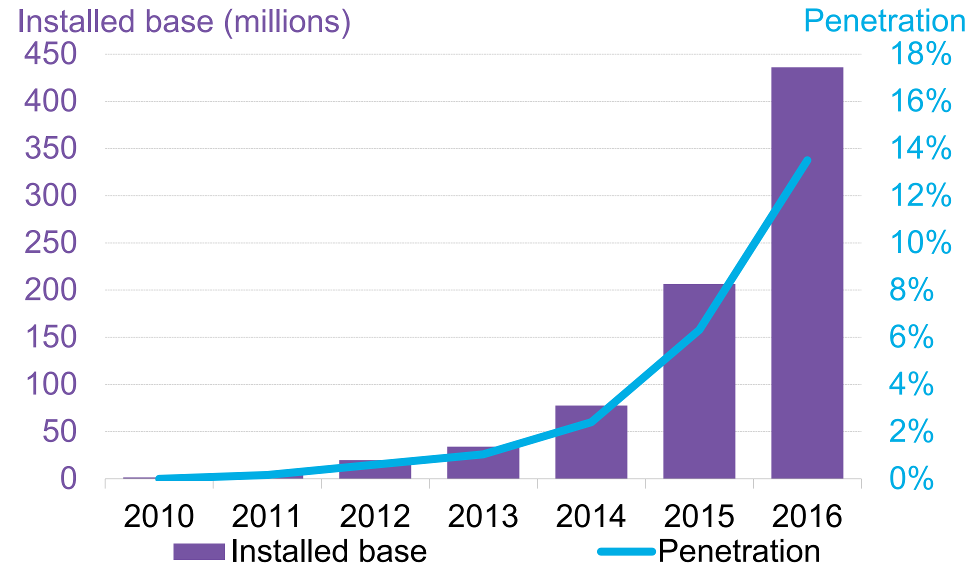
Source: Energy Star, BloombergNEF Note: Non-exhaustive selection of appliances; share of certified appliances sold is based on sales data compiled by Energy Star.

Deployment: Light-emitting diodes (LED)

LED price, A-type lamps



LED installed base and penetration, A-type lamps

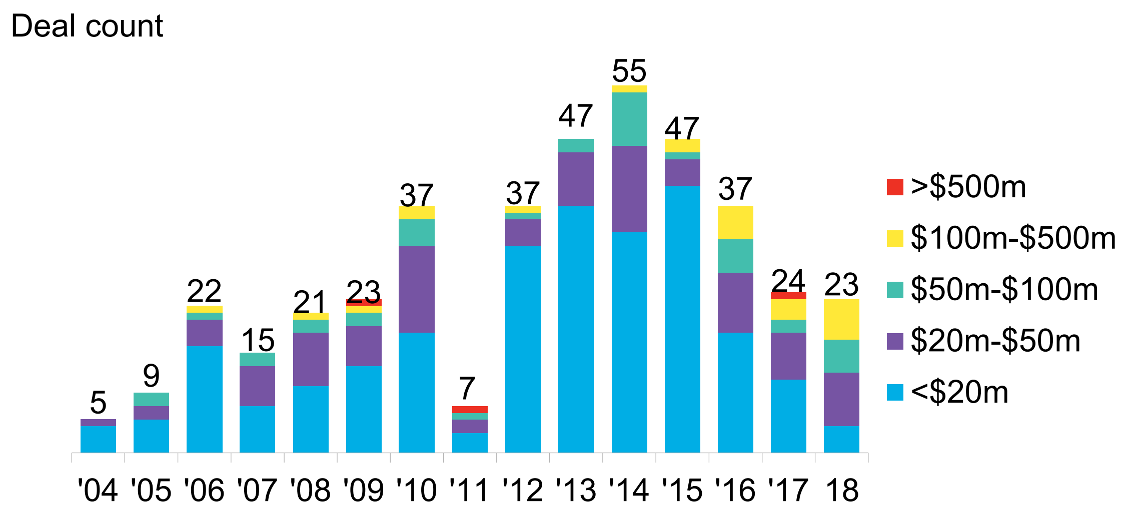


- The light-emitting diode (LED) is a technology that displaces traditional incandescent bulbs, while providing longer lifetimes and significant energy savings for consumers. The A-type lamp is the classic light bulb used in most household applications.
- The installed base of LEDs has accelerated rapidly in recent years, climbing to 436 million A-type units at the end of 2016, the latest year for which data are available. With an estimated 3.3 billion A-type bulbs installed in the U.S., this represents a 13.5% penetration. Annual savings of 99 trillion Btu are a fraction of the estimated 469 trillion Btu saved by all LEDs across the U.S.
- As deployment has picked up, costs have fallen dramatically. Costs per kilo-lumen (klm) have fallen 75% since 2012, to only $9/klm in 2016.
- Federal efficiency policies and utility energy efficiency programs (many, in turn, promoted by state policy) have helped spark LED uptake.
- LEDs also offer efficiency enhancement for connected and networked devices and “smart” buildings.

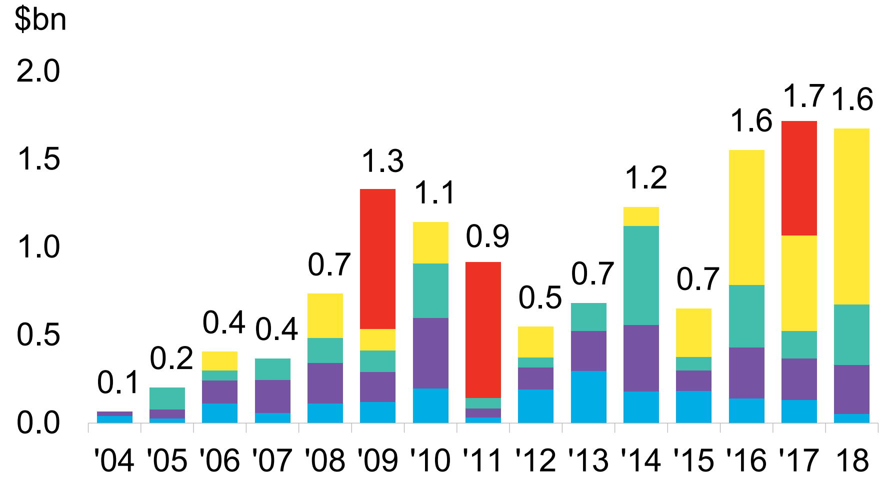
Source: Department of Energy. Note: Luminous flux differs from power (radiant flux) in that radiant flux includes all electromagnetic waves emitted, while luminous flux is weighted according to a model (a "luminosity function") of the human eye's sensitivity to various wavelengths.

Policy: U.S. federal energy efficiency contracts

Number of deals, sorted by deal size



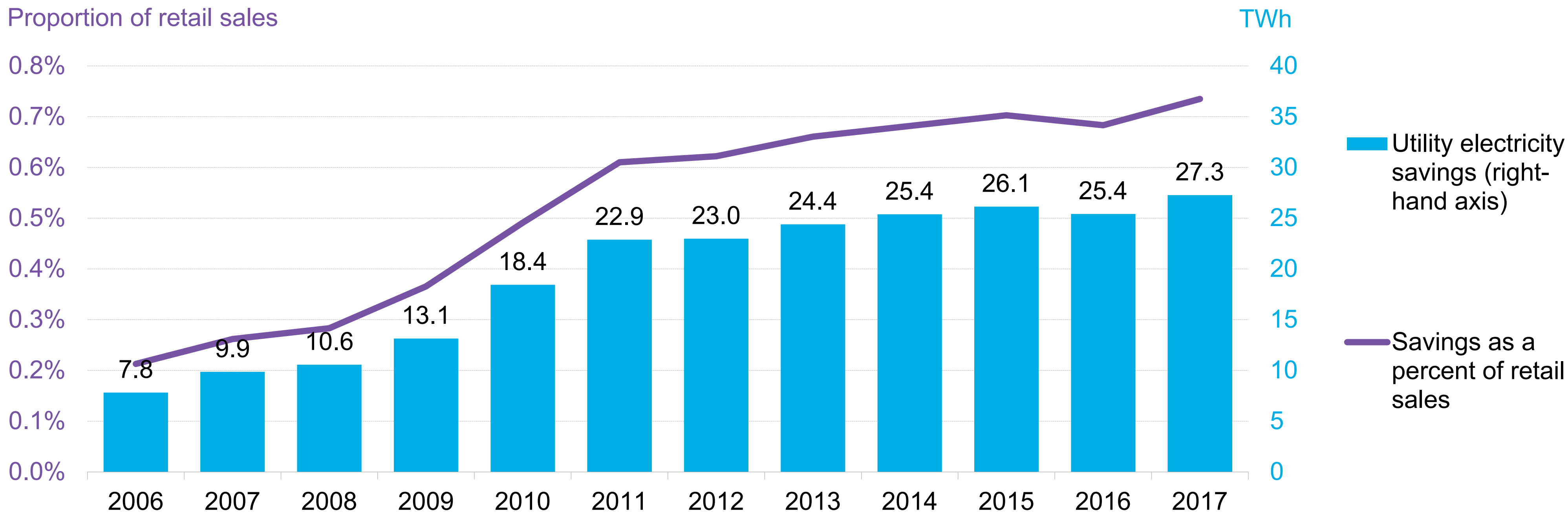
Total contract values, sorted by deal size



- The data represents a combination of federal energy efficiency service performance contracts (ESPCs) and utility energy service contracts for military facilities (UESCs). Federal entities signed $1.6 billion of ESPCs and $1 million of UESCs in 2017.
- Federal ESPCs and UESCs have average lifetimes of 16 and 15 years, respectively. These long time horizons (as compared to the commercial sector) are typical for government agencies and enable more comprehensive energy efficiency retrofits.
- 2016 was a busy year for both ESPCs and UESCs, in part due to then-President Obama's target (announced in 2014) of completing $2 billion of retrofits by the end of the year. This target was met through a shift towards larger projects, particular for ESPCs.
- 2018 followed 2017 and 2016 in contract values. However, the total number of deals inked in 2018 was down from 2016 and 2017.

Source: Federal Energy Management Program (FEMP), U.S. Department of Energy (DOE), 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.

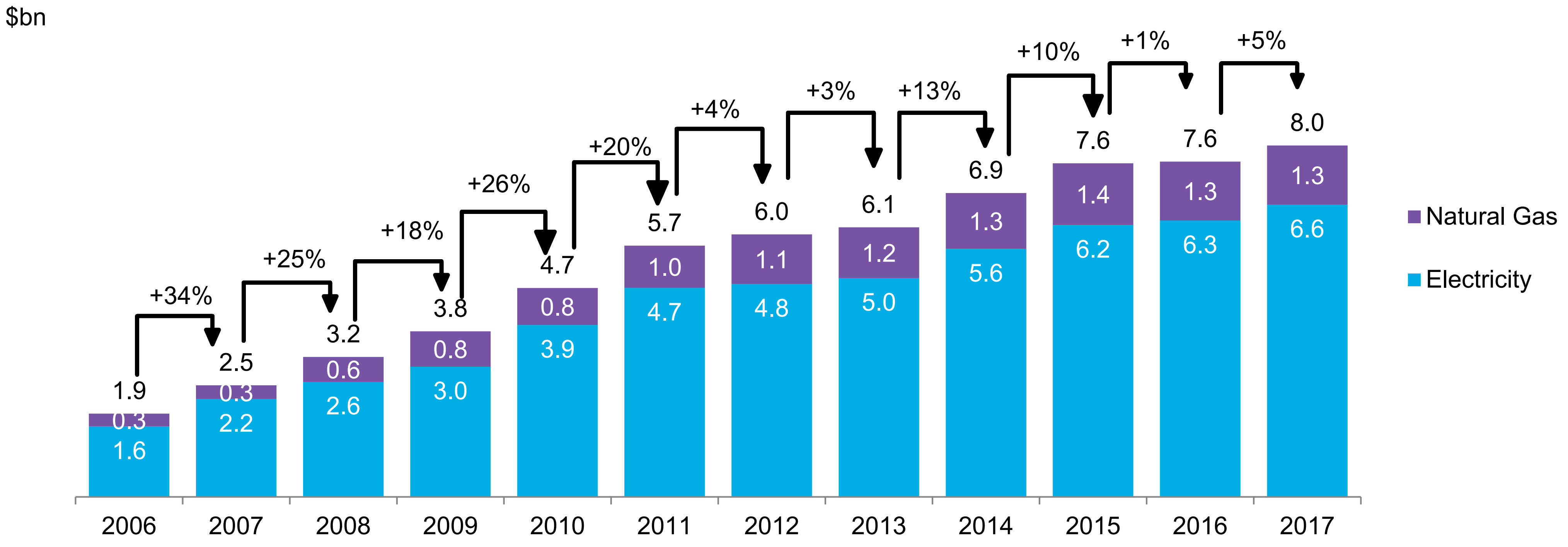
Deployment: Incremental annual energy efficiency achievements by electric utilities to date



- 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 leveled off, along with investment. 2018 utility energy efficiency savings increased by 7.4% from the previous year.
- As funding increased, so did utility electricity savings. Twenty-nine states increased their utility electricity savings from the previous year. Overall in the U.S., utility electricity savings increased by 8.8%. The ACEEE, which collects this data, attributes the difference to adjustments in its qualifying criteria for utility energy efficiency savings, rather than a decrease in energy efficiency activity.
- Between 2016 and 2017, California saw the largest savings increase of 1.15TWh.

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

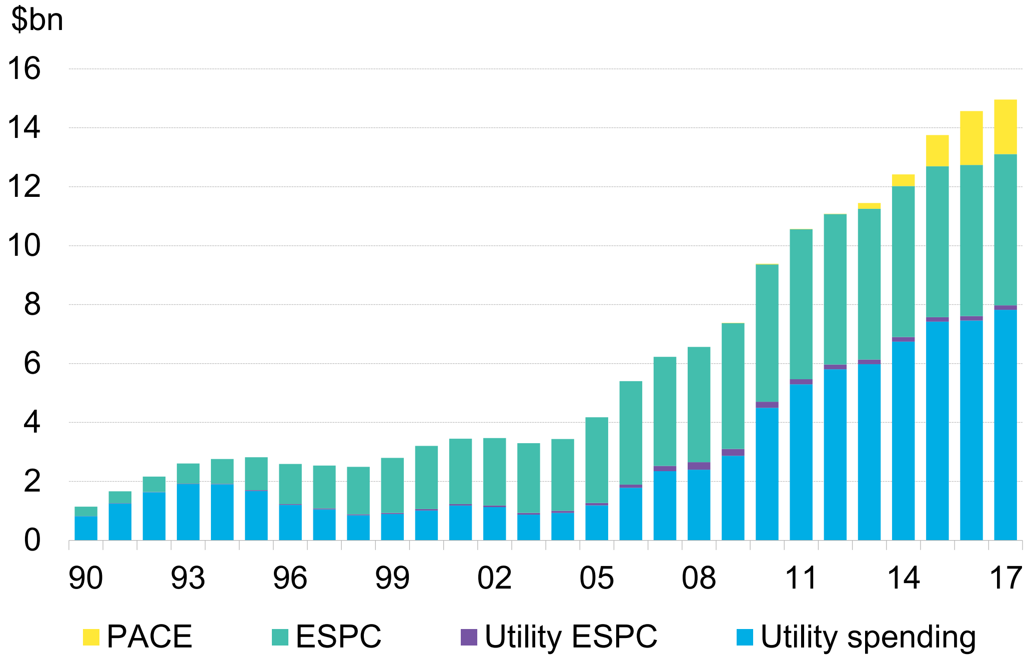


- In 2017, utility spending on energy efficiency rose to $8bn, 5% higher than the previous year. Most of the increase in spending is for electricity energy efficiency programs, as opposed to natural gas programs.
- While investment growth increased slightly nation wide, the picture was more dynamic at the state level. Utilities in Texas increased spending by $63.6m (+33%) and utilities in Illinois boosted spending by $86.3m (+33%). There were huge leaps in states with historically smaller utility budgets like Virginia (+$12.9m, 242%) and Delaware (+$0.4m, +264%).
- However, these gains were offset by falling investment in Pennsylvania(-$65.3m, -28%) and New Jersey (-$40.5m, -26%).

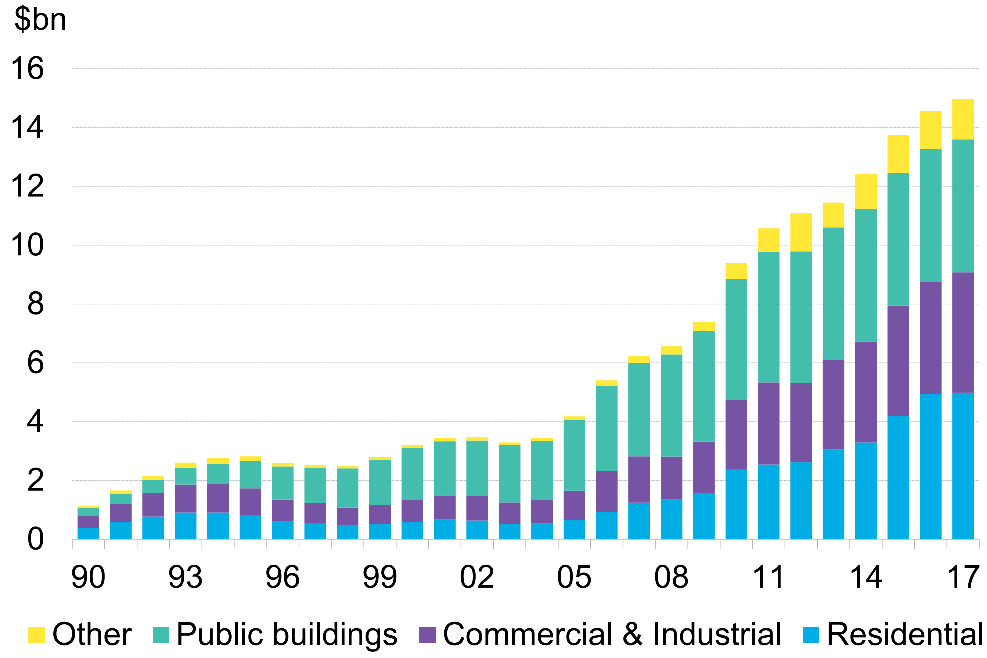
Source: CEE, ACEEE, BloombergNEF. Note that data for 2010-14 was sourced from CEE, and for 2006-2009 and 2015-18 from the ACEEE.

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

By framework



By sector



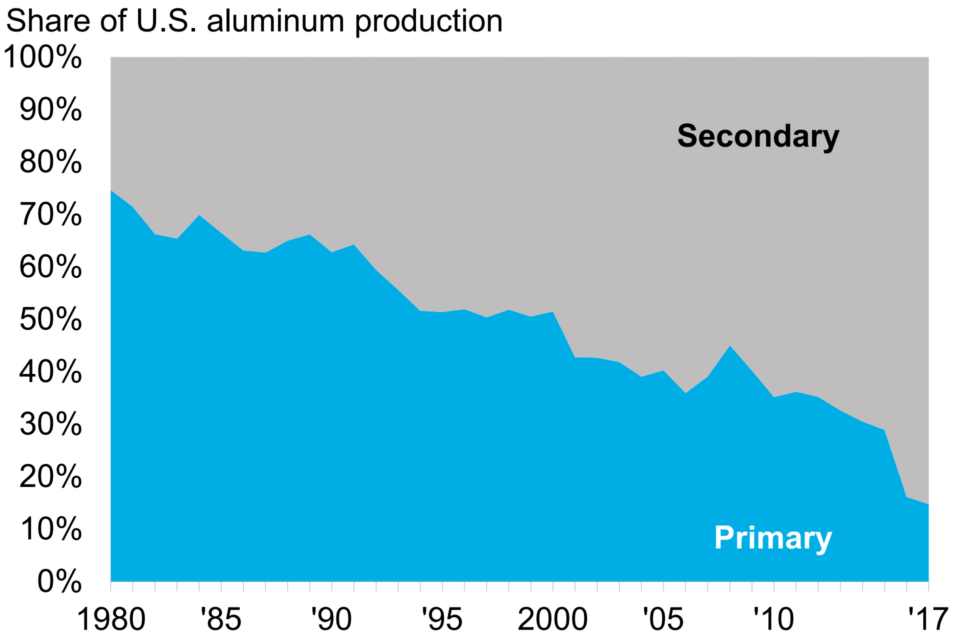
- Total U.S. spending on energy efficiency through formal frameworks climbed to an estimated record level of $15bn in 2017.
- Utility spending and ESPCs remain the most important frameworks. While the PACE financing framework was the fastest source of growth in 2016, particularly in the residential sector, 2017 was more muted. Instead, a boost in utility spending on energy efficiency accounts for over 90% of the estimated increase in energy efficiency investment. As discussed on the previous slide, most of this money was channeled through electricity energy efficiency programs.
- 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. The picture may change when new data becomes available.

Source: ACEEE, NAESCO, LBNL, CEE, IAEE, PACENation, BloombergNEF   Notes: The values for the 2015-17 ESPC market size shown here are estimates. The most recent data from LBNL reports revenues of $5.3bn in 2014. The 2015-17 estimates are based on a continuation of 2011-14 growth rates.

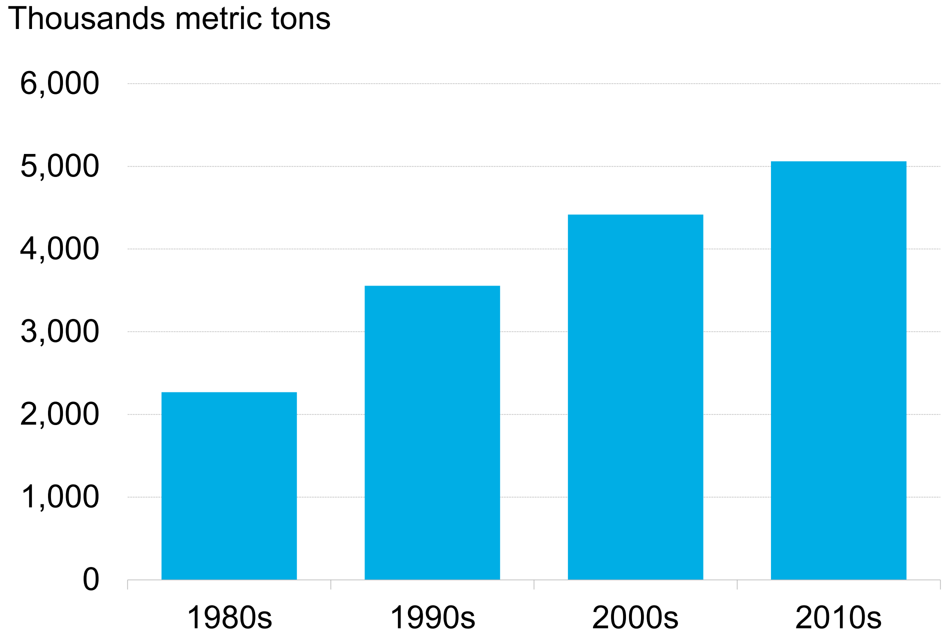
BloombergNEF

Deployment: U.S. aluminium recycling trends

U.S. production of primary v. secondary aluminum



Average annual aluminum scrap recovery, by decade



- Producing aluminum from secondary sources (i.e., recycled post-consumer and industrial scrap) consumes significantly less energy than making new aluminum. The aluminum industry therefore provides insights into industrial-sector adoption of energy efficiency.
- The share of U.S. aluminum derived from secondary sources climbed to 85% in 2017, a record high. The use of secondary sources of aluminum has risen dramatically from only 55% a decade prior, in 2008.
- Scrap recycling has risen to an annual average of 5 million metric tons this decade, up 15% from annual recovery in the 2000s. The advance is due in large part to factors such as the addition of imported cans into the U.S. recycling stream, increased scrap availability and increased demand for recycled aluminum in the U.S. market.

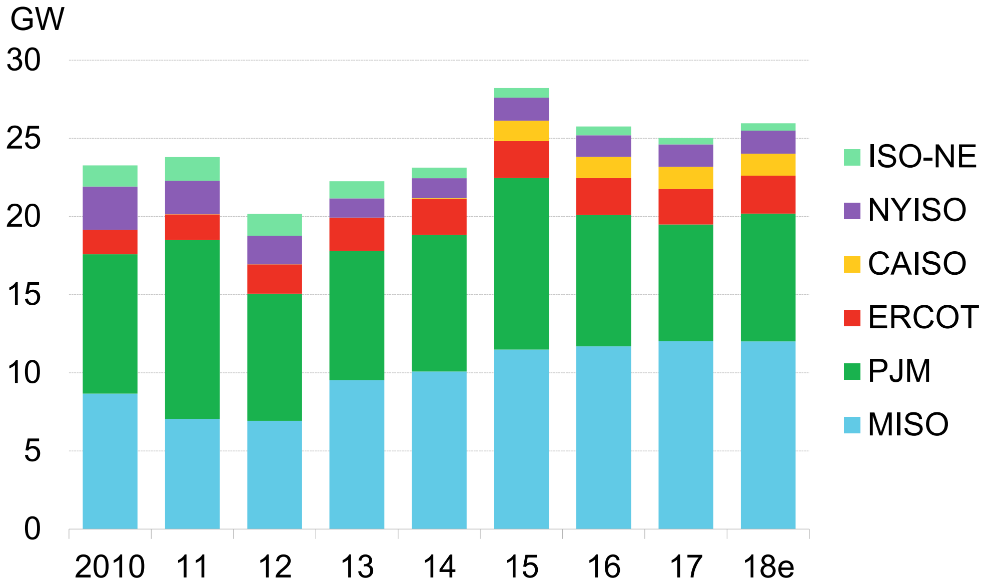
Source: The Aluminum Association, U.S. Geological Survey, U.S. Department of Interior, U.S. Department of Commerce, Can Manufacturers Institute, Institute of Scrap Recycling Industries
Notes: Not shown is the considerable share of aluminum imports consumed in the U.S., which have historically met around 45% of U.S. demand.

Table of Contents

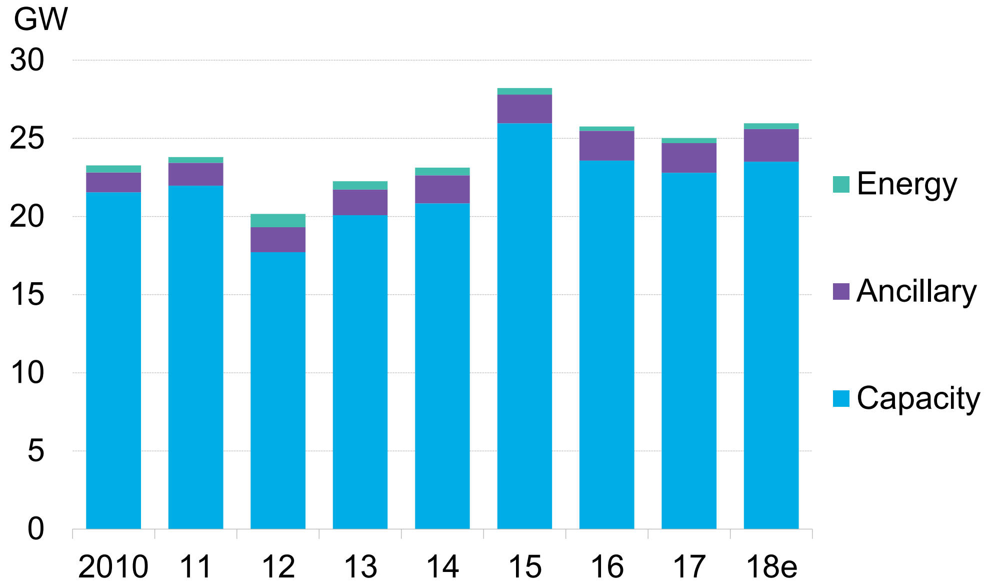
BloombergNEF

Deployment: U.S. wholesale demand-response capacity

By market



By application

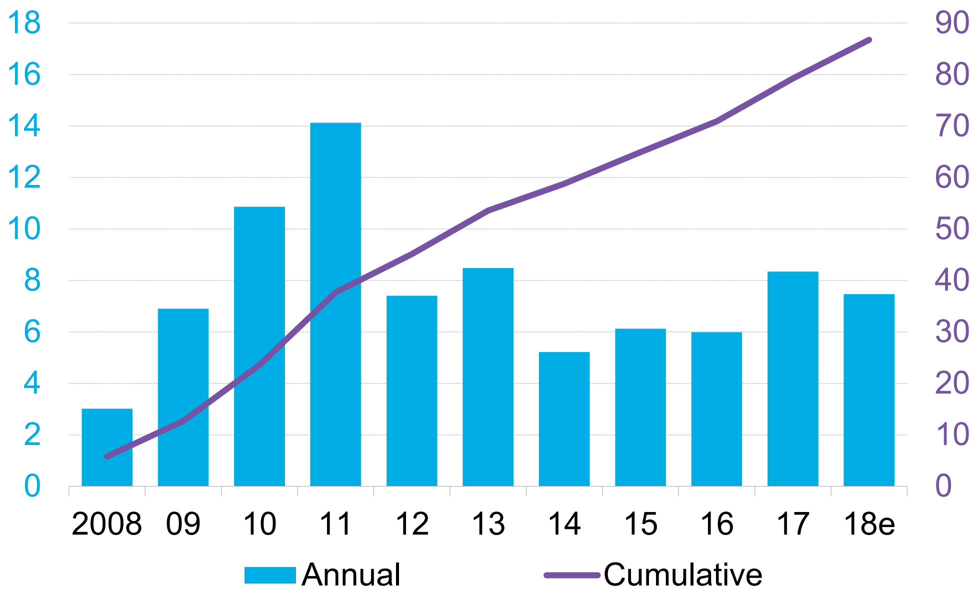


- U.S. wholesale demand response (DR) capacity returned to growth in 2018 for the first time in three years. Almost all regions saw flat or increasing capacity. Most notably, ISO-NE brought its seven-year decline in demand response to a close with a 14% jump to 464MW. PJM, the most significant market, also produced a recovery as demand response performed better in the restructured capacity market than had been expected.
- The vast majority of wholesale demand response is concentrated in capacity markets and reliability mechanisms. Even in ERCOT, which has no formal capacity market, 948MW of DR has been contracted through its capacity-style Emergency Response Service. Ancillary service participation, which grew 9% annually on average over 2010-2015 but then stalled, has picked up again. In ERCOT there is almost 1.5GW of DR providing reserves and frequency regulation. Despite the furor surrounding FERC 745, demand response activity within the energy markets remains negligible.

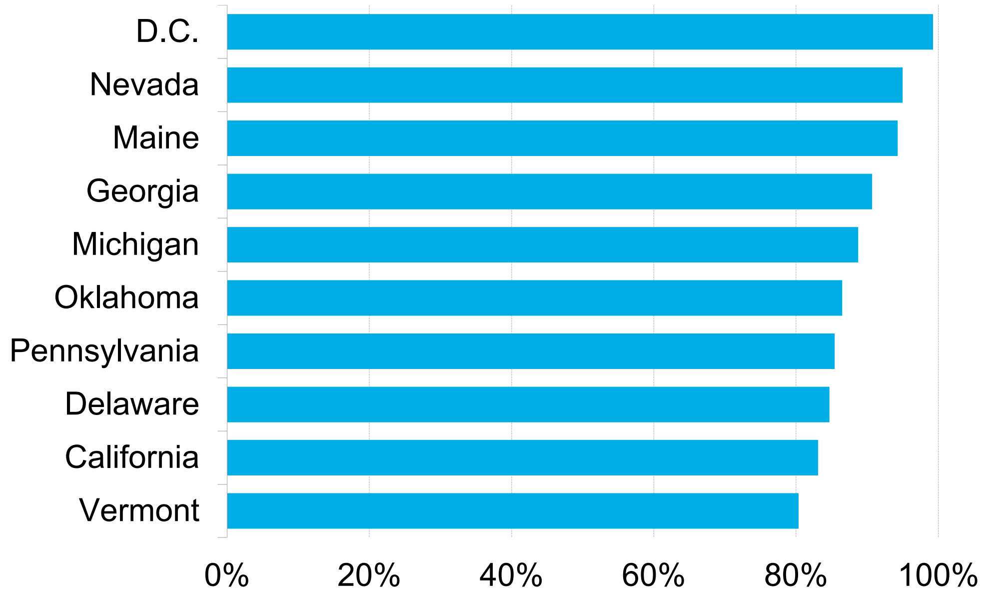
Source: BloombergNEF. Note: Demand-response was only formally integrated with the CAISO market in 2015.

Deployment: U.S. smart electricity meter deployments

U.S. smart meter deployments



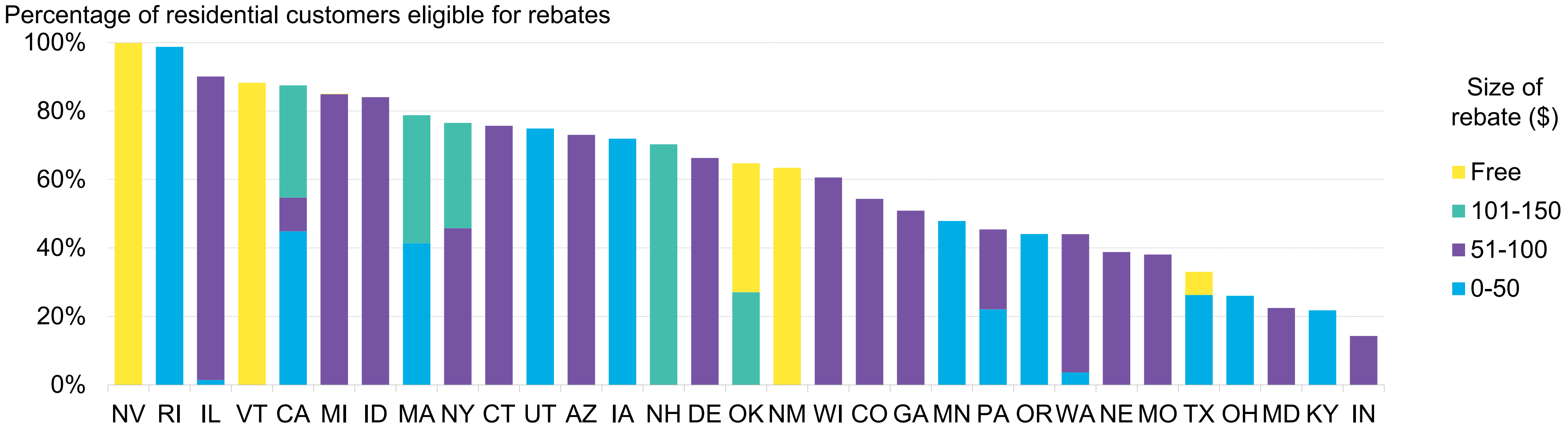
Top 10 states by penetration, 2017



- Smart meter installations hit a peak in 2010 and 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.
- Today 57% of U.S. electricity customers have a smart meter, but there is enormous regional variation. The top 10 states all have penetration greater than 80%. In contrast less than one in 10 customers has a smart meter in the bottom 10 states. Over 2016-17, Pennsylvania, Illinois, Texas and North Carolina were the most active smart metering markets, each deploying over a million meters according to estimates.
- The greatest cost saving for utilities from smart metering is replacing the need for manual meter reads. But a renewed focus on grid modernization and growing interest in dynamic retail tariffs is leading state regulators and utilities that have shied away from the technology to reassess the benefits of deployment. Hold-out states, such as New York and Rhode Island (where smart meters currently number in the hundreds), have both committed to extensive smart meter rollouts over the next five to 10 years.

Source: BloombergNEF, EIA. Note: there is a 10-month lag in official smart meter statistics, as a result 2018 figures include BloombergNEF estimates.

Deployment: U.S. smart thermostat rebate availability



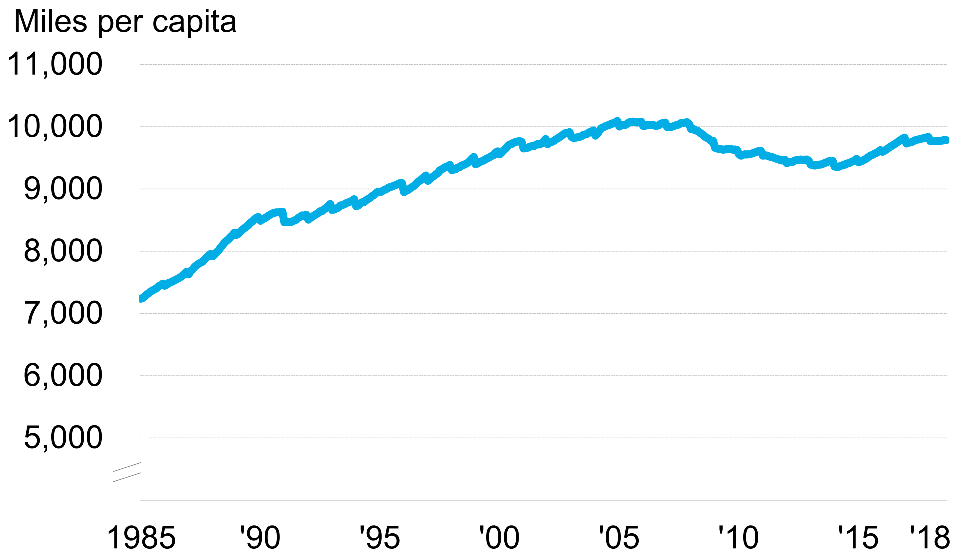
- Smart thermostats are becoming the weapon of choice in U.S. utility demand-response programs. Energy efficiency resources standards (EERS) and other state policies have enabled utilities to offer rebates to customers who reduce energy consumption and peak load. Smart thermostats are an appealing tool for utilities and customers alike to reduce peak load and, as a result, are widely marketed by utilities. For customers, they are a fun household appliance that offers convenience and integration with the connected home. For utilities, they are a new tool for directly controlling heating and cooling load, one of the greatest contributors to residential peak demand.
- In 20 states, over 50 percent of households are eligible for a smart thermostat rebate. In most cases the value of the rebate is under $100, but it can be much more. In Nevada, for example, 100 percent of residential customers can receive a smart thermostat for free.
- Smart thermostat costs continue to decline with all the leading brands now offering products for $170 or less, down from $250 only a year ago. Coupled with utility incentives that further reduce the sticker price, BNEF estimates that over 14 million households had a smart thermostat in 2017.

Source: BloombergNEF. Note: Colors indicate the size of the rebate. This analysis only includes utilities with more than one million customers or at least 20% of customers in their state. Eligibility is likely to be higher in states with several small utilities. States excluded from the graph do not have smart thermostat rebate programs among utilities that meet the threshold to be covered in this analysis.

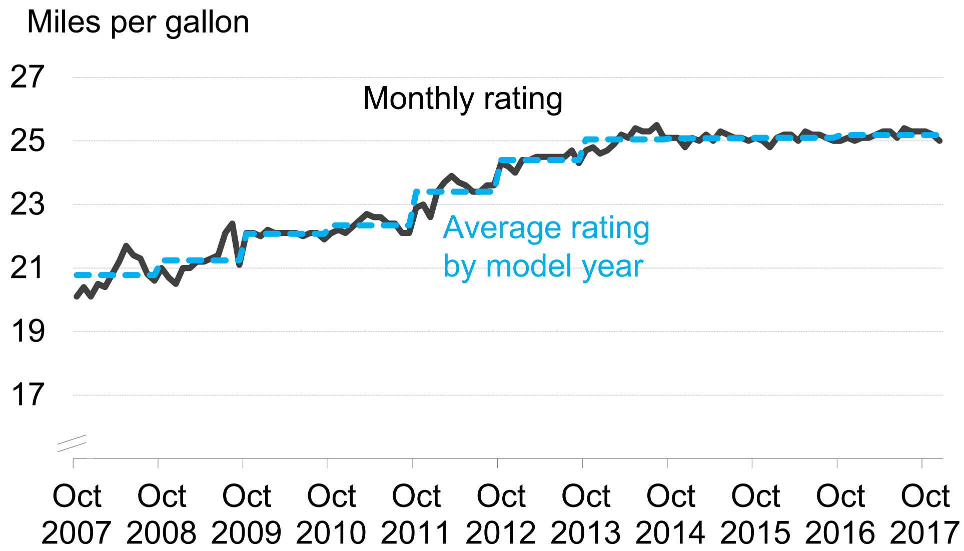
Table of Contents

Deployment: U.S. gasoline consumption and fuel economy

U.S. vehicle miles traveled, per capita



U.S. average fuel-economy rating (weighted by sales) of purchased new vehicles

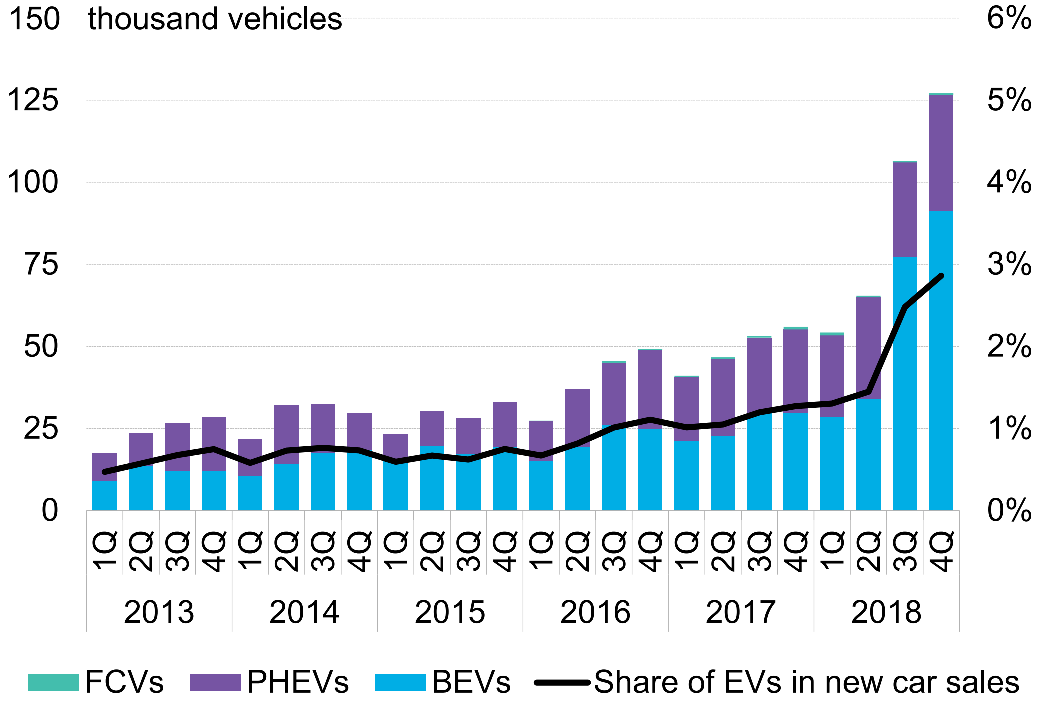


- Vehicle miles traveled per capita, a measure of how often individuals are using personal transportation, held fairly steady in 2018. Americans are driving 3% less than 2004's record, but total miles traveled have risen 4.7% from the recent trough hit in 2014. Lower fuel prices have helped spur the increase: gasoline prices in July 2018 sat 22% below their recent 2014 peak of $3.70/gallon, and 26% below the all-time high reached in 2008 of $3.91/gallon.
- Average U.S. vehicle fuel economy held flat at 25mpg in 2017, the last year for which such data is immediately available. Though federal corporate average fuel economy regulations have tightened, cheaper gasoline has led Americans to purchase less fuel-efficient vehicles. Light-duty truck sales, which include sport-utility vehicles, increased 9.8% from March 2017 to March 2018.

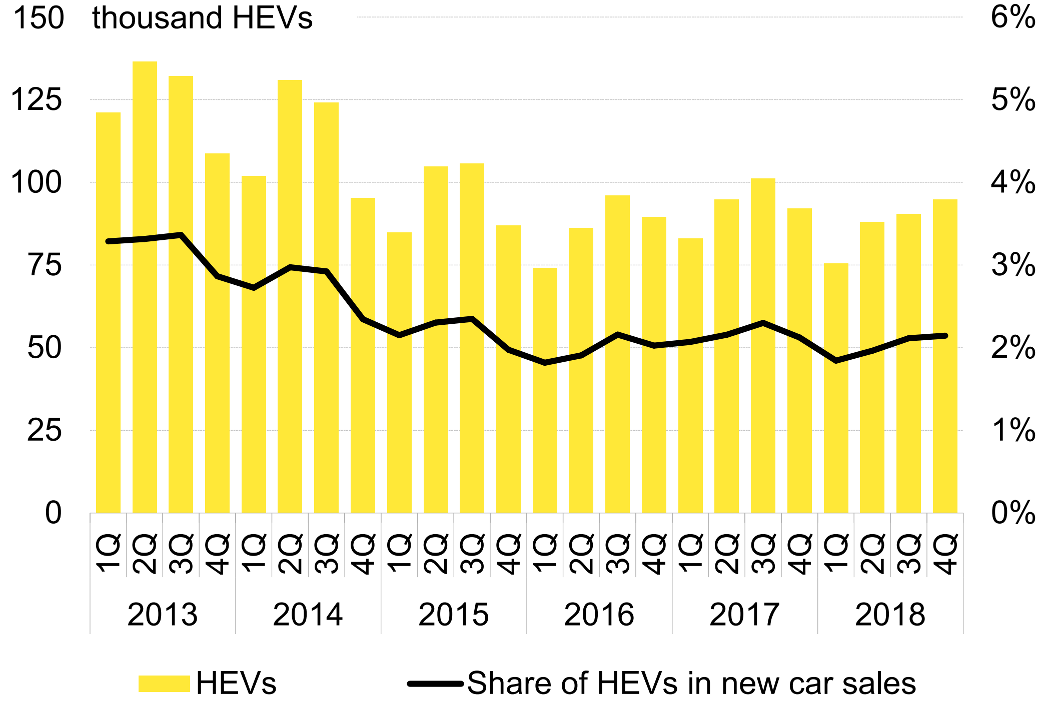
Source: Federal Highway Administration, Census.gov, UMTRI, Motor Intelligence, EIA, BloombergNEF   Note: Average fuel-economy rating relies on combined city/highway EPA fuel economy ratings.

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

U.S. EV and FCV sales



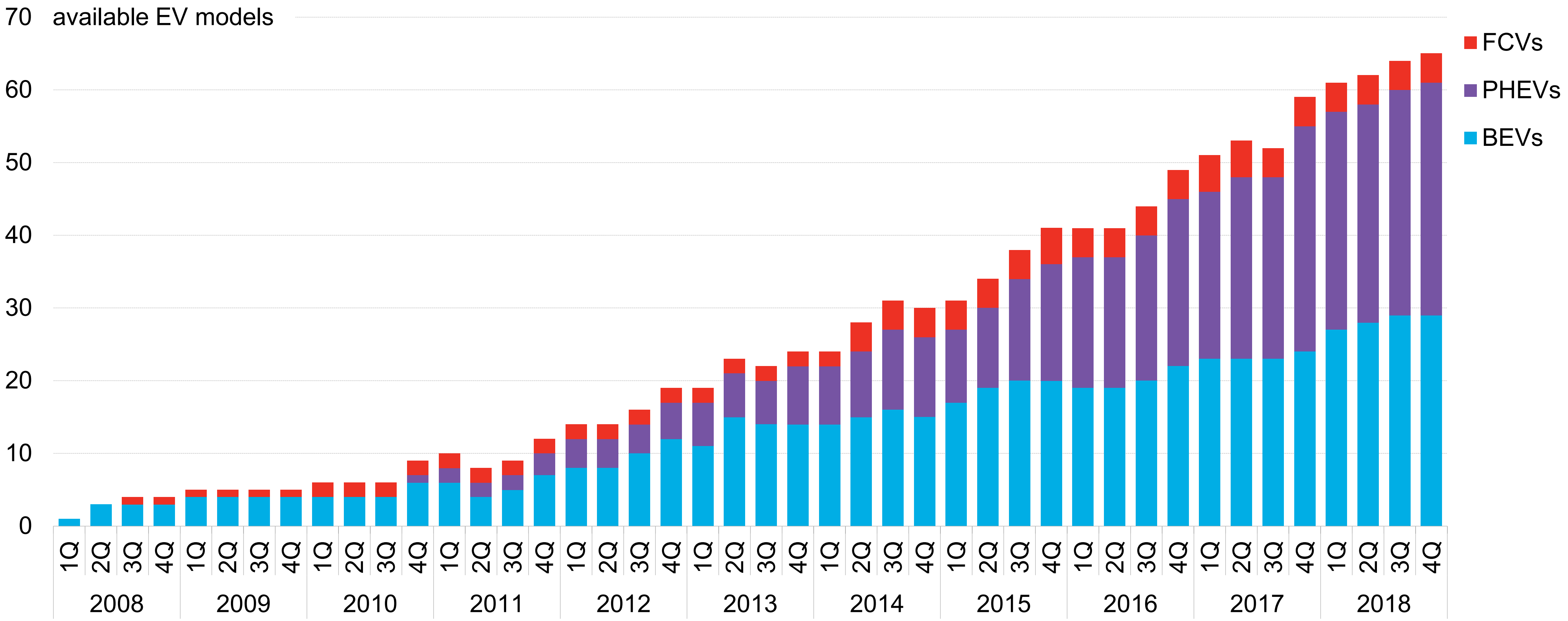
U.S. HEV sales



- Sales of electric vehicles (EVs) – a category that includes battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs) – increased about 80% last year, jumping from about 194,000 units in 2017 to over 355,000 units in 2018.
- The Tesla Model 3 – which sold around 140,000 units – was the model most responsible for increasing EV sales, and Tesla – which sold nearly 185,00 BEVs in total – accounted for over 50% of total U.S. EV sales in 2018.
- BEV sales jumped 128% year-over-year – eclipsing 235,000 units – and PHEV sales rose 32% year-over-year – approaching 120,000 units.
- Sales of hybrid electric vehicles (HEVs) totaled about 349,000 units in 2018 – a 6% decrease compared to 2017. Sales of fuel cell vehicles (FCVs) increased by only 20 units (rising to 2,368), representing a nearly 60% increase in the total number of FCVs on the road in California.

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. EVs includes BEVs and PHEVs. FCV sales data not available prior to 2016. FCV sales numbers too low to be visible.

Deployment: EV model availability in North America

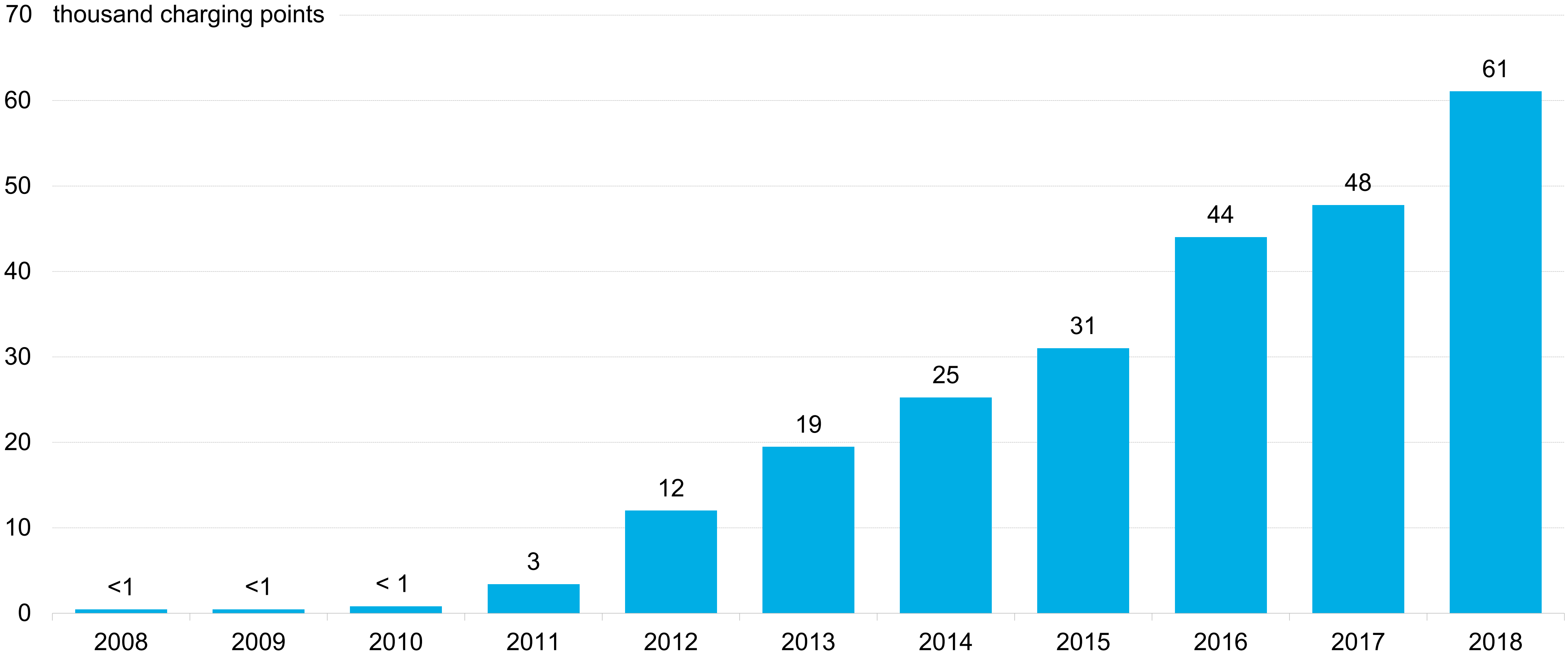


- By 4Q 2018, four FCV models, 32 PHEVs and 29 BEVs were available to consumers for purchase in North America.
- The availability of PHEVs has grown over the past three years, from 44% of all EVs on offer in 1Q 2016 to 49% in 4Q 2018, taking share from BEVs. The availability of BEVs, however, has increased significantly in absolute terms, growing from 19 in 1Q 2016 to 29 in 4Q 2018.
- New EV models launched in 2018 ranged in size and luxury from the Kia Niro to the Jaguar I-PACE.

Source: BloombergNEF, MarkLines. Note: Models available in North America (Canada and U.S.) are available in the U.S. CAFE stands for Corporate Average Fuel Economy. FCVs stands for fuel cell electric vehicles, PHEVs stands for plug-in hybrid electric vehicles and BEVs stands for battery electric vehicles.

BloombergNEF

Deployment: Public electric vehicle charging points in the U.S.

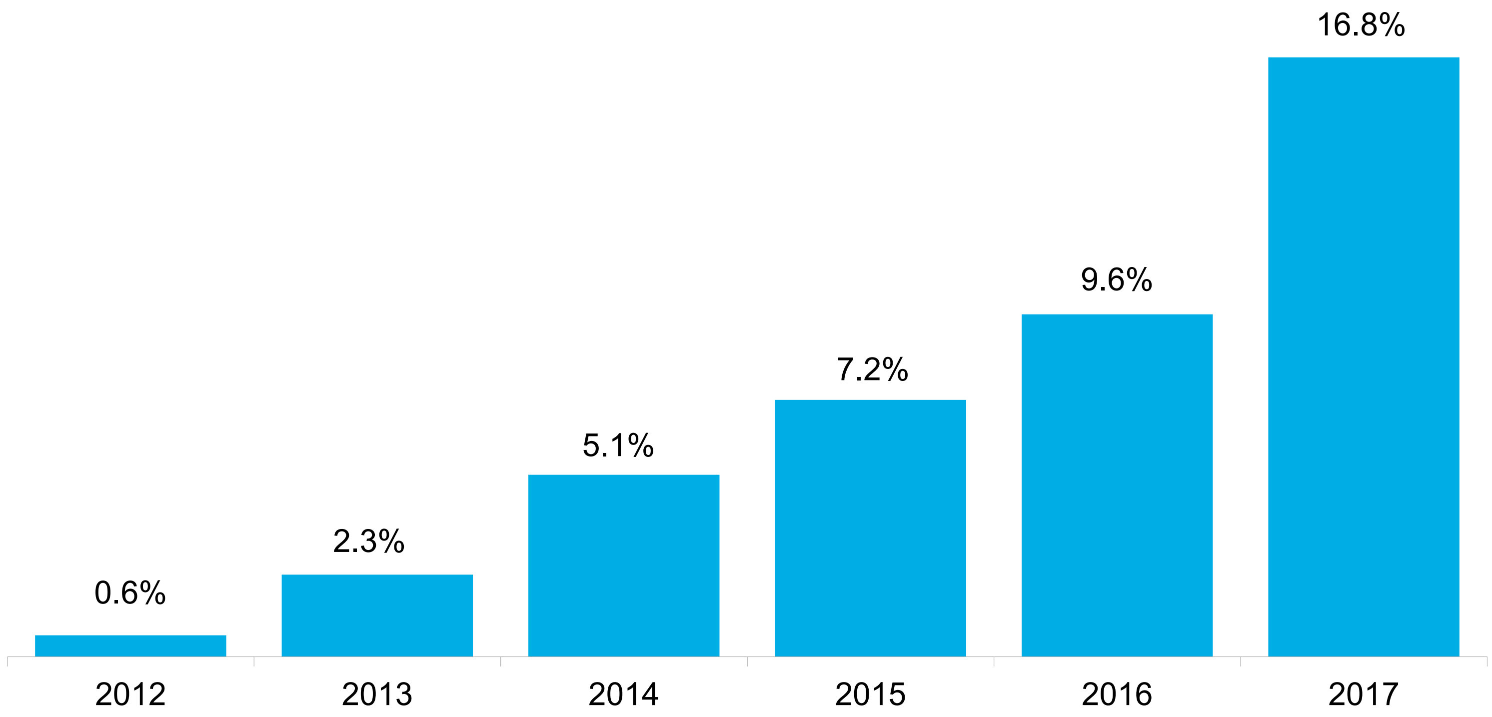


- At the end of 2018 there were about 61,000 public and workplace EV charging points in the U.S., an increase of nearly 28% over 2017.
- About 81% of these EV charging outlets are Level 2. Another 16% are DC Fast and around 3% are Level 1.
- Despite the build-out of public EV charging infrastructure, the majority of EV charging in the U.S. continues to take place at home, usually with Level 1 or Level 2 outlets.

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

Deployment: Share of vehicles with start/stop technologies in the U.S.

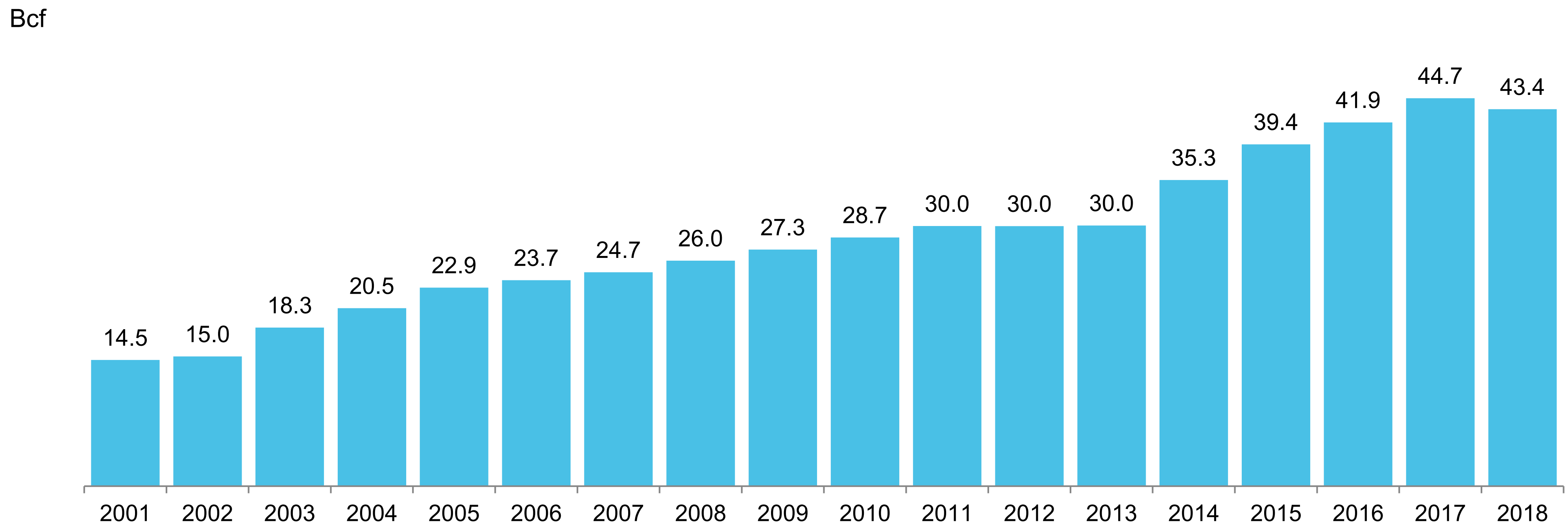
Share of new vehicles sold with stop/start systems in the U.S.



- Start-stop systems automatically shut off the engine when the vehicle is stopped, to cut fuel use and reduce idle emissions. A battery continues to power lights and accessories while the engine is off. The engine automatically restarts when the driver lifts their foot off the brake pedal. Start-stop systems deliver up to 5% fuel savings to conventional internal combustion engine vehicles, depending upon driving conditions.
- The share of new vehicles sold with this system in the U.S. jumped 16.8% from 2016 to 2017, the last year for which data is available.

Source: EPA, BloombergNEF.

Deployment: U.S. natural gas demand from natural gas vehicles

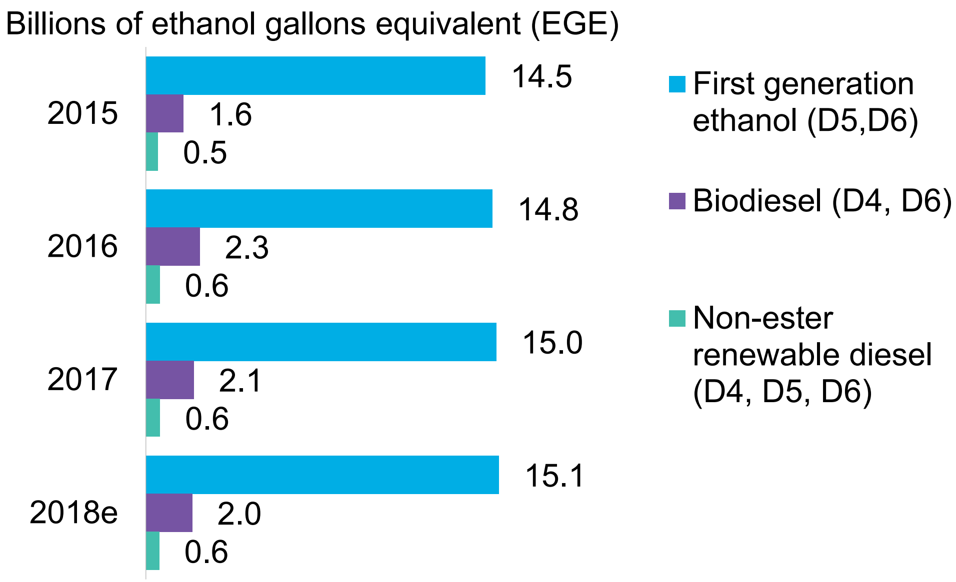


- Natural gas use in vehicles had grown steadily since 2013, but leveled off in 2018, sliding 2% year-on-year to 43.4Bcf. This represents a 5.3% compounded annual growth rate over the last decade (since 2008). The consumption uptick in 2014 coincided with the start of a period of low natural gas prices 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 September 2018, there were 1,659 CNG stations across the U.S., compared to 137 LNG stations (including public and private stations).
- The number of CNG stations shrank modestly from 2017, when the CNG station count had hit 1,693, while the number of LNG stations rose from 131.

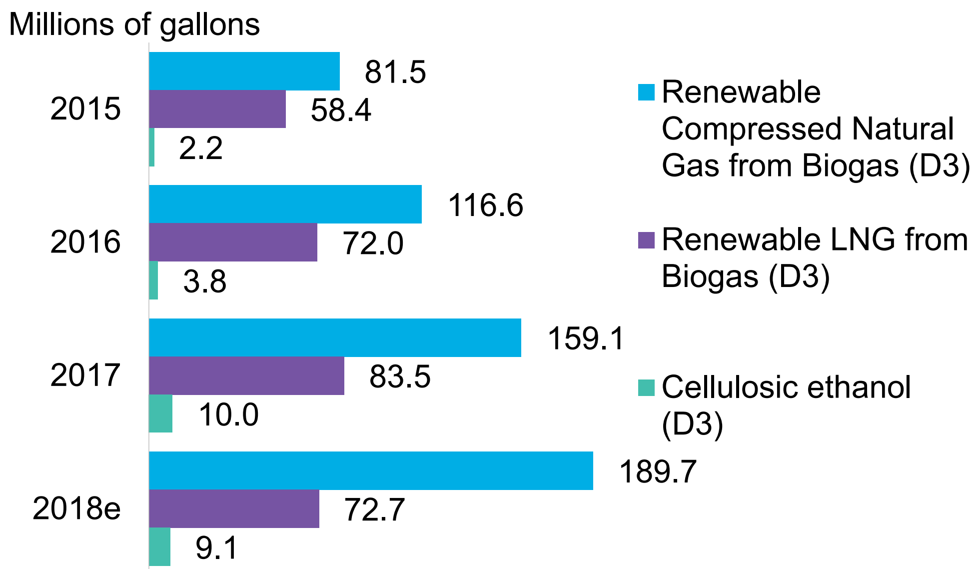
Source: EIA, natural gas monthly Notes: Values for natural gas demand in 2018 are projected, accounting for seasonality, based on latest monthly values from EIA (data available through October 2018). Data excludes gas consumed in the operation of pipelines.

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

First generation biofuels



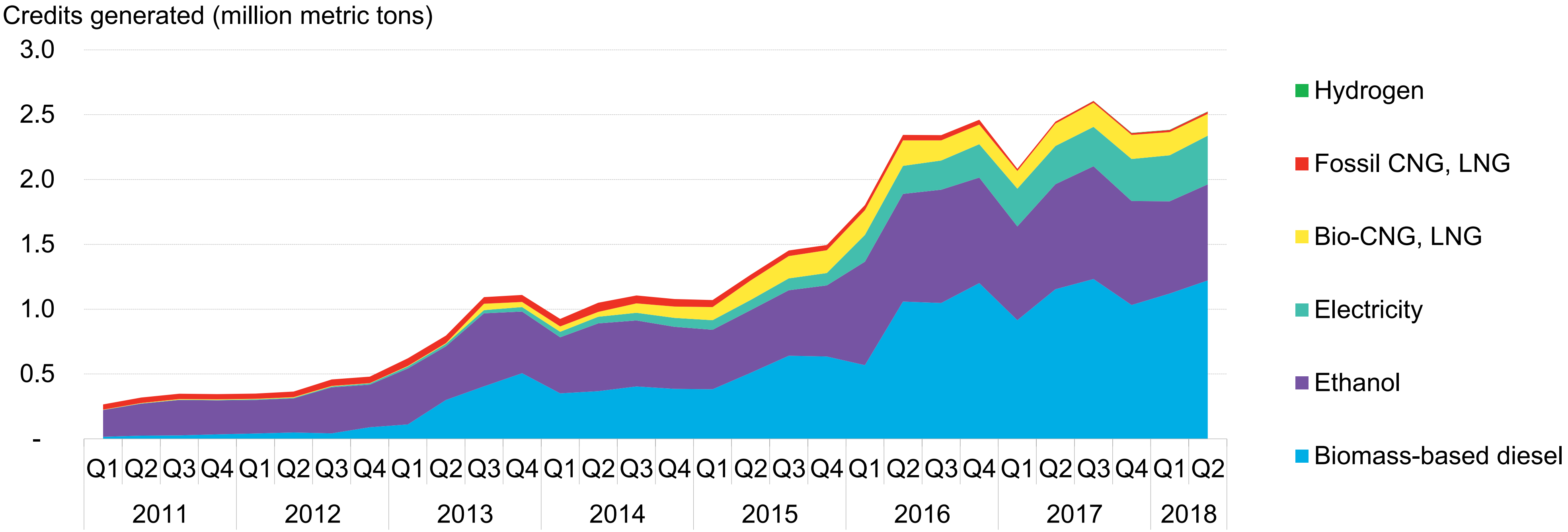
Next generation biofuels



- 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. Electricity, part of the statutory RFS program, has not yet been implemented but is a clean source of power for electric vehicles.
- Each biofuel gallon 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 2018, prices fell dramatically for biomass-based diesel and advanced biofuel RINs (D4 and D5), from as high as $0.99 to as low as $0.25, as well as for ethanol (D6), which traded down to $0.20.
- The highest value RINs are for cellulosic or "next generation" biofuels. These include cellulosic ethanol, diesel and biogas (including renewable natural gas) made from non-food feedstocks and possessing lower carbon footprints. Cellulosic RINs (D3) traded between $2-2.75 in 2018. The biofuel blending targets for 2018 were 19.3 billion physical gallons (of which 288 million was the cellulosic target). For 2019, the mandate is for 19.9 billion gallons, of which "next generation" biofuels must provide 418 million gallons.

Source: BloombergNEF, EPA Notes: 2018 values are estimated. Fuels under the RFS2 are categorized by D codes, to determine fuel type. D3 stands for Cellulosic Biofuels, D4 for Biomass-based Diesel, D5 for Advanced Biofuel, D6 for Renewable Fuel, D7 for Cellulosic Diesel. See the EPA's website for more information. EGE refers to ethanol gallons equivalent.

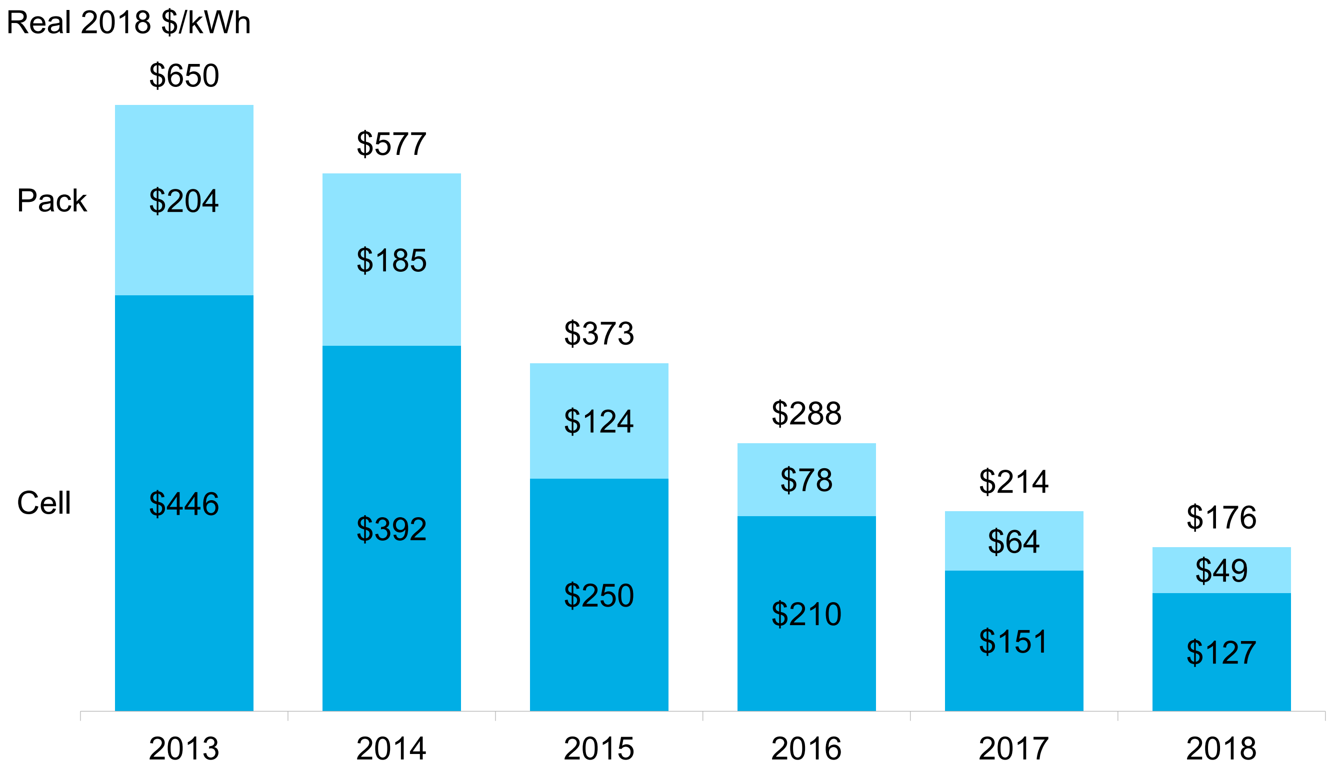
Policy: California Low-Carbon Fuel Standard



- The California Low-Carbon Fuel Standard incentivizes the use of fuels with lower carbon footprints. Its goal is to reduce the carbon intensity of transportation fuels in California by 10% by 2020 (relative to 2010 levels), as part of California's broader suite of climate change regulations.
- Through blending lower-carbon fuels into gasoline and diesel, or supplanting their use with other fuels or sources of energy (such as natural gas or electricity), blenders generate credits under the program. Since its launch, the sources of credit generation have shifted: in 2011, most credits were generated by traditional ethanol, which is blended with gasoline. Biomass-based diesel (including renewable diesel and biodiesel) became more common in 2013 and produced 48% of total credits in the first half of 2018, while ethanol generated 30%.
- Electricity, bio-CNG, and bio-LNG have also provided a growing share of credits. Electric vehicle charging made up 15% of the market in 1H 2018, while bio-CNG and bio-LNG made up 7%.
- Hydrogen still makes up only 0.1% of the LCFS credit market, due to low penetration of fuel cell electric vehicles.

Source: BloombergNEF, California Air Resources Board   Note: CNG stands for compressed natural gas; LNG stands for liquefied natural gas.

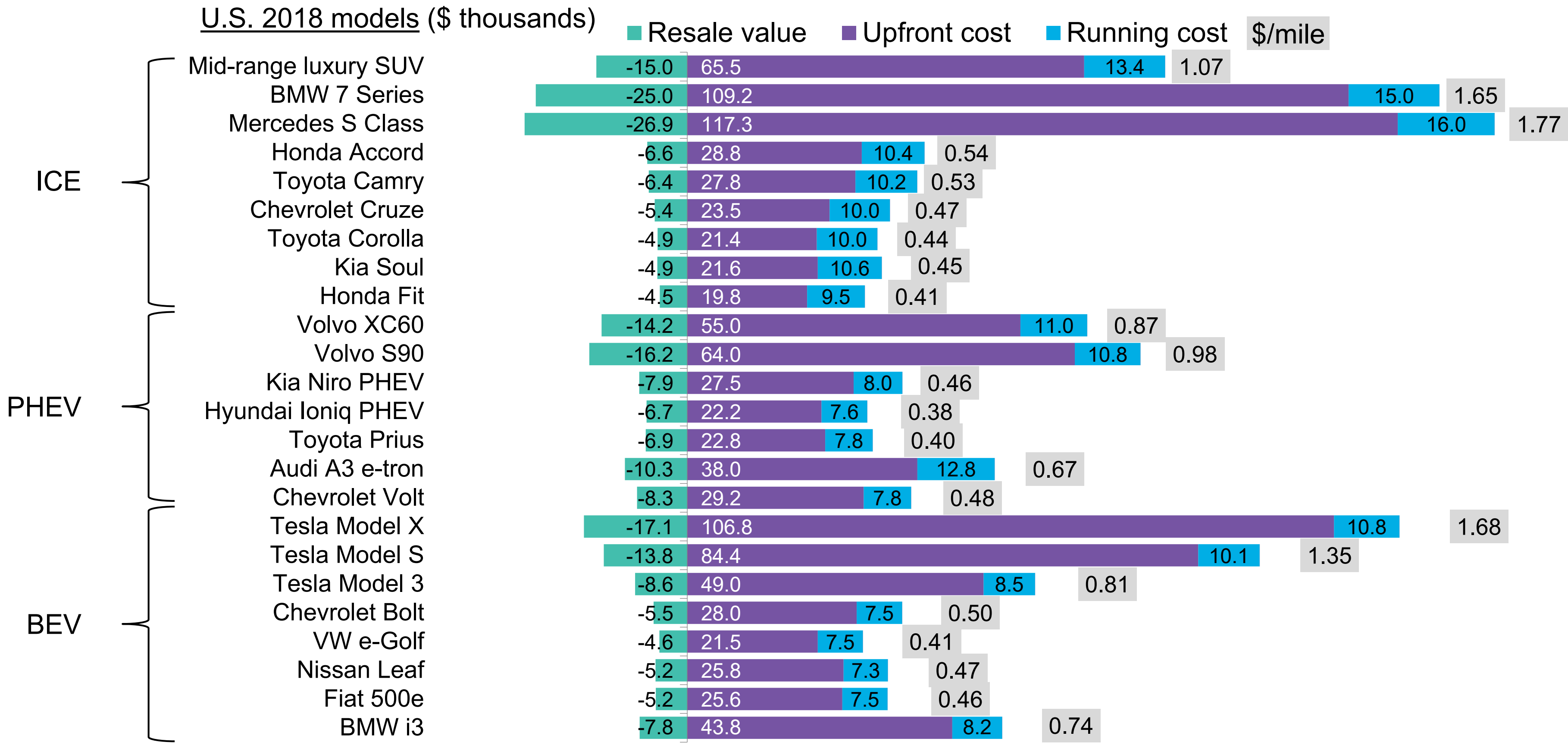
Economics: Lithium-ion battery prices (volume-weighted averages)



- Lithium-ion battery prices have fallen 85% since 2010 (in real terms), hitting $176/kWh in 2018. Industry-wide prices fell due to increasing EV demand, the adoption of new cell designs and the availability of higher energy density cathodes.
- Battery packs consist of cells and the equipment that make up the rest of the pack. For BEV batteries, the pack consists of the battery management system, wiring, pack housing and the thermal management system.
- From 2017 to 2018, both pack and cell prices declined – cell prices shrank $24/kWh and pack prices fell by $15/kWh. Cells now account for around 70% of the total battery price on average.
- Stationary storage systems use similar cells. However, because of smaller order volumes, the average 2018 price across all stationary storage batteries was $228/kWh.

Source: BloombergNEF. Notes: BNEF has tracked lithium-ion battery prices since 2010 through an annual market survey process. It collects, anonymizes and aggregates price data for battery cells and packs. The numbers presented in the chart include cell and pack prices for electric vehicles.

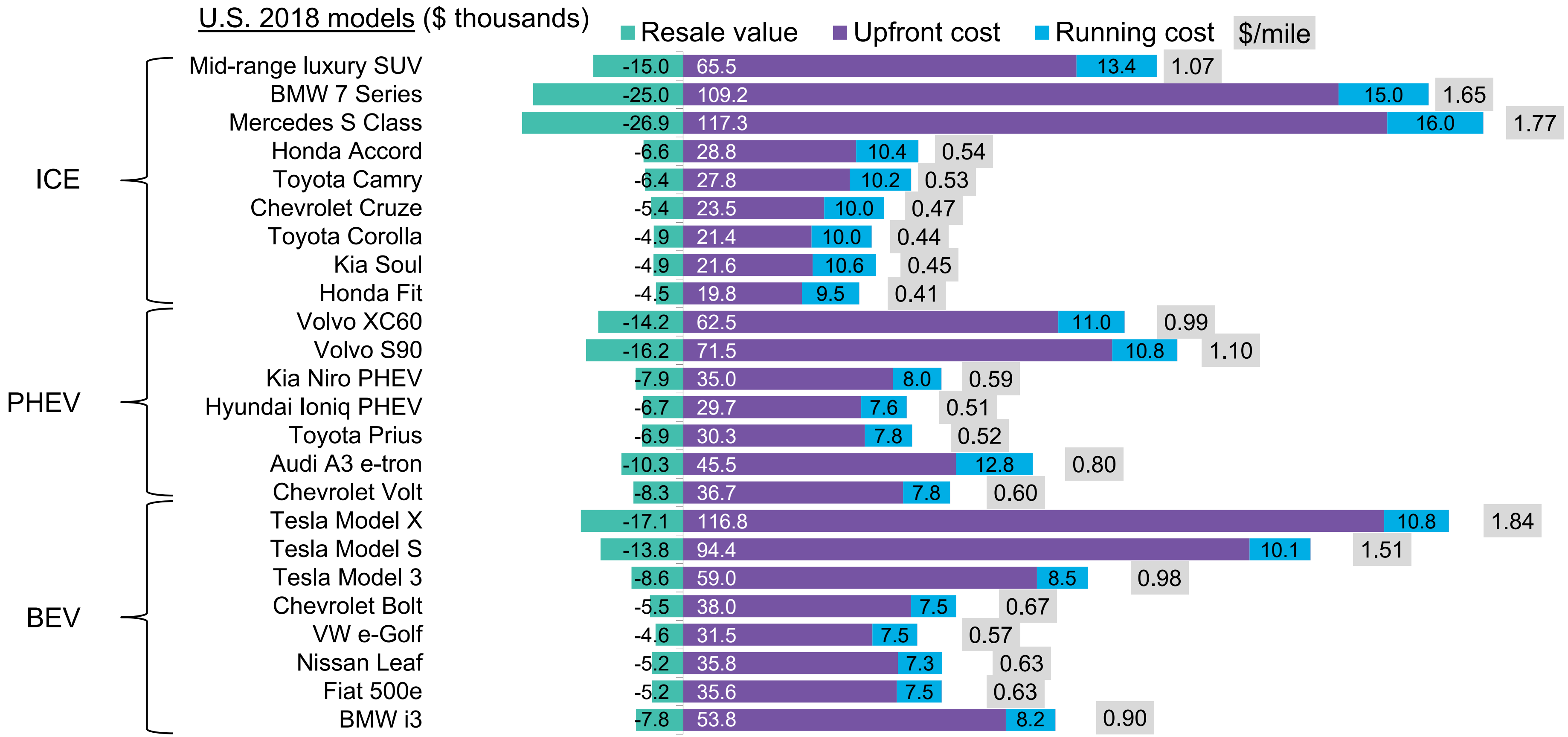
Economics: Total cost of ownership for BEVs, PHEVs, and ICE vehicles, including purchase incentives



- Small and midsize battery electric vehicles are as cheap to own and operate as equivalent gasoline cars. Large passenger BEVs can be more than a fifth cheaper. Capital costs benefit from up to $10,000 in federal and state incentives. Once an automaker reaches a cumulative 200,000 EVs sold, however, a phase-out period is triggered and the available tax credit is eliminated over the subsequent six quarters. Tesla hit this threshold in 3Q 2018 and General Motors hit it in 4Q 2018.
- Plug-in electric hybrids cost a similar amount to ICE vehicles. SUV PHEVs are even cheaper than equivalent gasoline cars, due to lower fuel costs.

Source: BloombergNEF. Notes: Upfront cost includes down payment, financing and sales tax and is net of incentives; running costs consist of road tax, insurance, maintenance and fuel. Calculations assume 12,000 miles driven per year, $2.6/gallon cost of gasoline and $0.105/kWh cost of electricity.

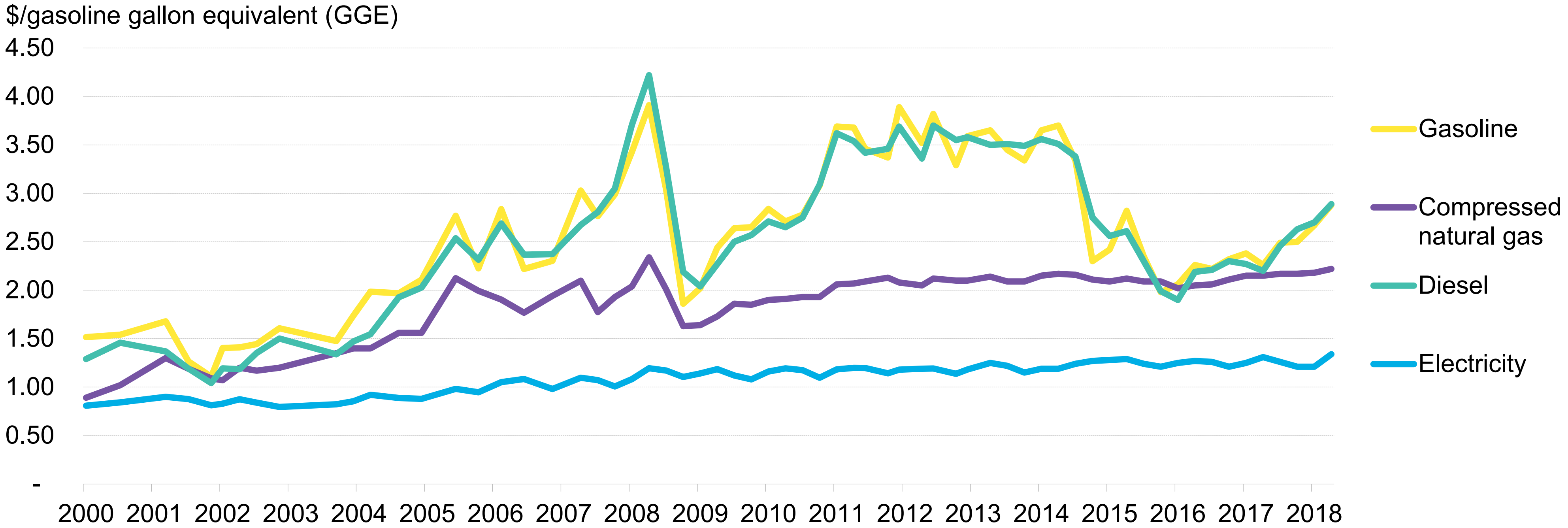
Economics: Total cost of ownership for BEVs, PHEVs, and ICE vehicles, excluding purchase incentives



- Without purchasing incentives, current BEV models can be more than 50% more expensive than small vehicles and SUVs, and medium BEVs cost about a third more to own and operate. Luxury BEVs, however, are cheaper than comparable gasoline vehicles, primarily due to their substantially lower fuel costs.
- Midsize plug-in electric hybrids, meanwhile, are a third more expensive than equivalent gasoline cars, but in the SUV segment PHEVs are more than a quarter cheaper.

Source: BloombergNEF. Notes: Upfront cost includes down payment, financing and sales tax and is net of incentives; running costs consist of road tax, insurance, maintenance and fuel. Calculations assume 12,000 miles driven per year, $2.6/gallon cost of gasoline and $0.105/kWh cost of electricity.

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



- Electricity has been the most competitive fuel for transportation in the U.S. for over a decade, remaining well below gasoline prices. In 2018, this discount widened to 53%. This can help overcome the larger upfront cost of a battery-electric vehicle.
- Compressed natural gas enjoyed a substantial discount to diesel and gasoline from 2010-14, but falling crude oil prices erased this gap 2015 and 2016. A summer 2018 rebound in oil markets widened the gap once again, to almost $0.60/GGE or 23%, as of July 2018. Natural gas engines function almost identically to gasoline/diesel engines, but require new fueling systems. A fuel price discount is therefore needed to incentivize consumers to convert. Oil prices declined sharply in the second half of 2018, however.
- Electricity and CNG prices are also less volatile.

Source: BloombergNEF, Department of Energy Alternative Fuels Data Center   *Note: Data is through July 2018*

Copyright and disclaimer

BloombergNEF

Copyright and disclaimer