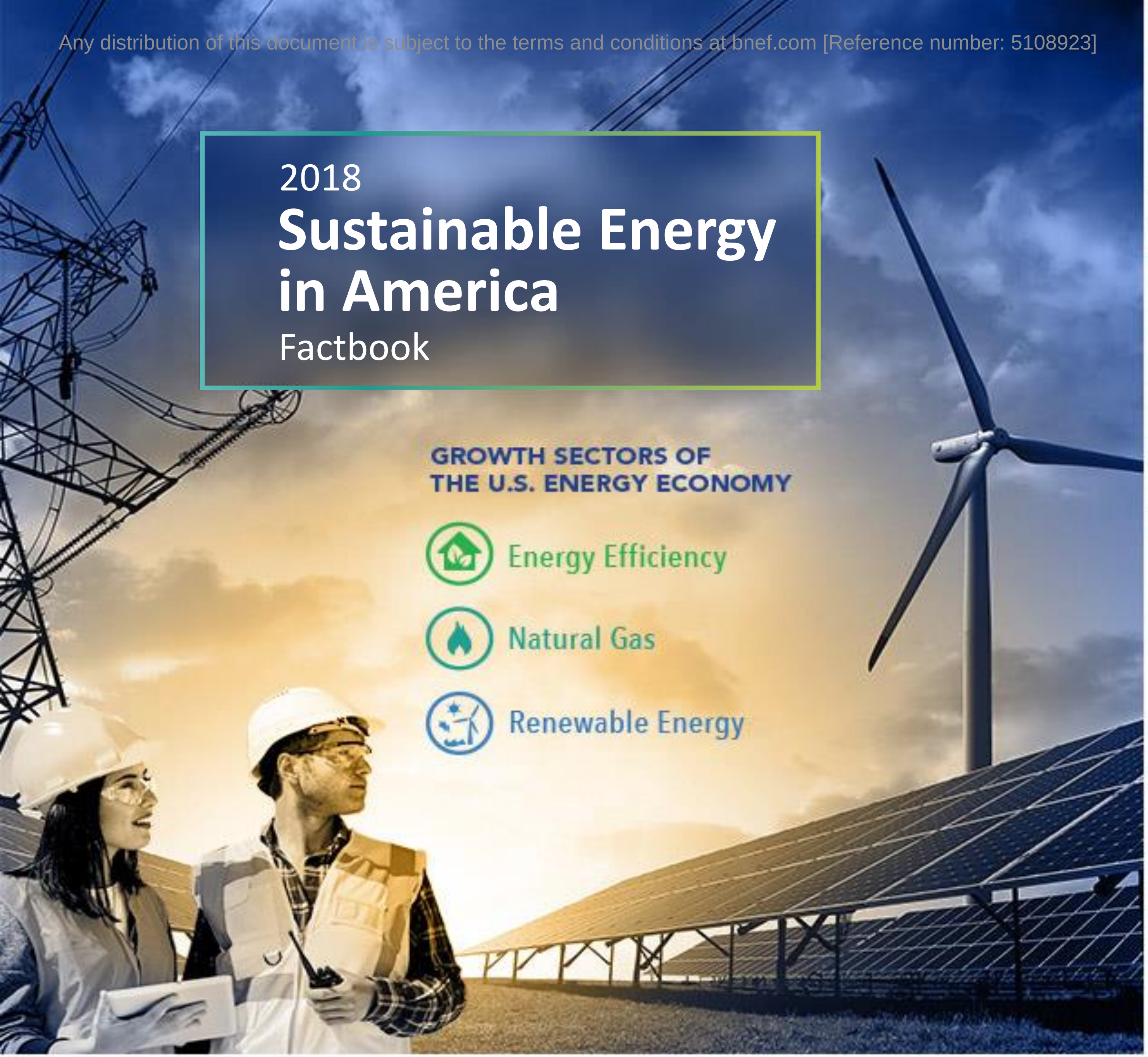

2018

Sustainable Energy in America

Factbook

GROWTH SECTORS OF THE U.S. ENERGY ECONOMY

- Energy Efficiency
- Natural Gas
- Renewable Energy

Bloomberg New Energy Finance

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Overview

The 2018 Sustainable Energy in America Factbook is the sixth in a series documenting the revolution in energy production, delivery, and consumption in the U.S. This most recent installment surveys the landmark developments that took place in 2017 – a year in which the transformation of the U.S. energy sector rapidly intensified, even in the face of domestic policy uncertainty.

Renewable energy output in the power sector soared to a record high on the back of a boom year for new renewables capacity additions, as well as the first full year of service for renewable facilities commissioned in 2016. Emissions from electricity production shrank as a result, achieving their lowest levels in at least two decades. At the same time, consumers are devoting less of their household spending towards electricity than at any other time on record. Power prices for industrial users also remained low, giving the U.S. a global competitive advantage in attracting energy-intensive industries.

The deployment of sustainable energy technologies has further supported a more productive U.S. economy. Economic growth picked up to an estimated 2.3%, even as energy consumption waned, reflecting the U.S.'s rising energy productivity. The renewables, energy efficiency, and natural gas sectors also supported the U.S. economy by providing jobs for roughly three million Americans.

Looking outward, the U.S. solidified its role as a global exporter of liquefied natural gas, for the first time spending every month of the year as a net exporter – rather than importer – of natural gas. And despite the federal government's announcement to withdraw from the Paris Agreement on climate change, U.S. corporations, states, and cities came together to pursue a sustainable future under the We Are Still In initiative.

The Sustainable Energy in America Factbook provides a detailed look at the state of U.S. energy and the role that new technologies, such as batteries and smart thermostats, are playing in reshaping the industry. The Factbook is researched and produced by Bloomberg New Energy Finance 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.

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

What is it?

- Aims to **augment** existing, reputable sources of information on U.S. energy
- Focuses on **renewables, efficiency, and natural gas**
- **Fills important data gaps** in certain areas (e.g., clean energy investment flows, contribution of distributed energy)
- Contains data through the end of 2017 wherever possible
- Employs **Bloomberg New Energy Finance 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 **sixth edition** (first published in January 2013)

What's new?

- **New coverage:** This report contains data shown for the first time in the Factbook series, including jobs produced by the sustainable energy sector, utility smart thermostat programs, and net metering developments.
- **Updated analysis:** Most charts have been extended by one year to capture the latest data.
- **2017 developments:** The text in the slides highlights major changes that occurred over the past year.
- **Format:** This year's edition of the Factbook (this document) consists of Powerpoint slides showing updated charts. For those looking for more context on any sector, the 2014 edition(1) can continue to serve as a reference. The emphasis of this 2018 edition is to capture new developments that occurred in the past year.

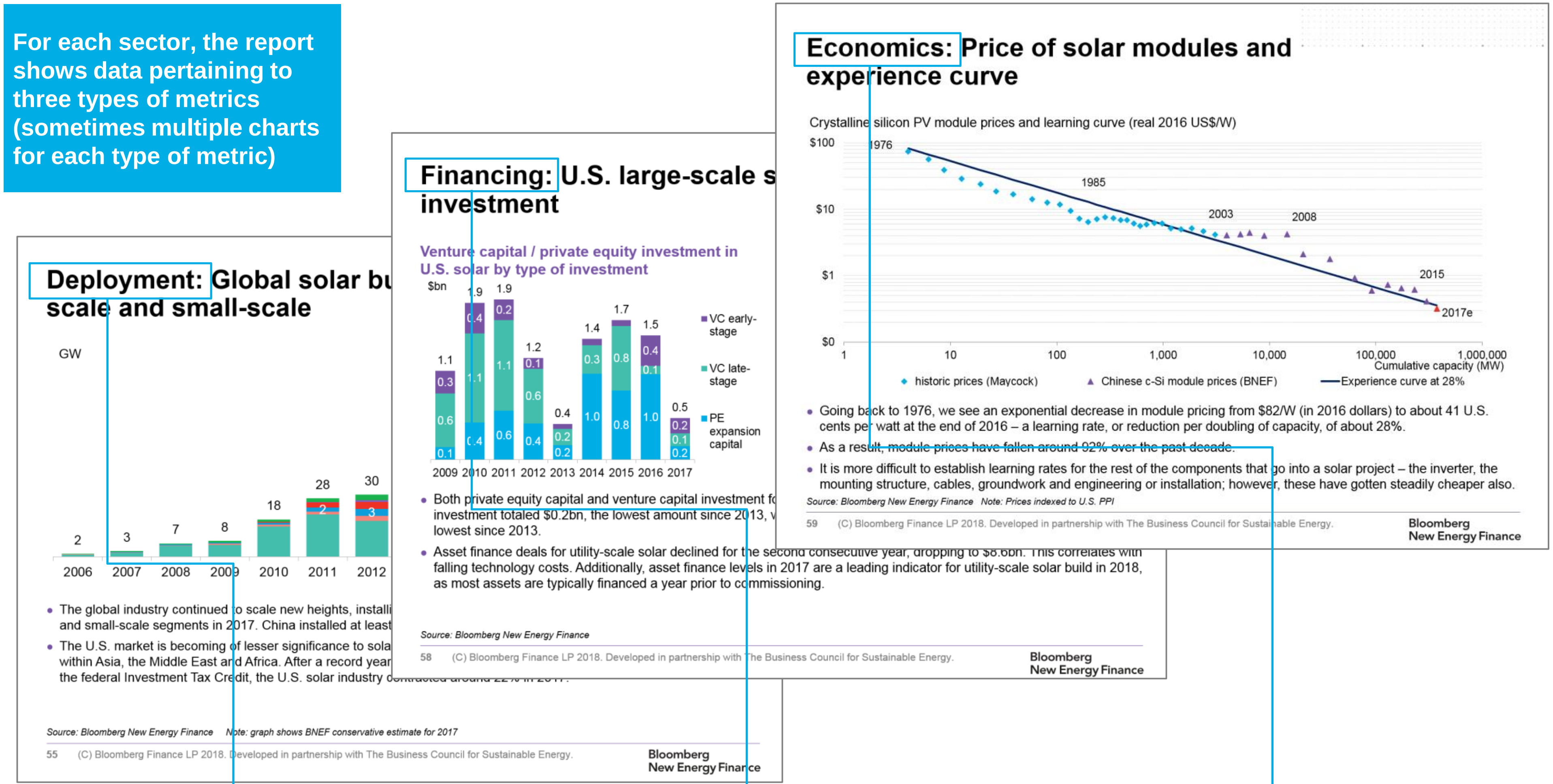
Notes: (1) The 2014 Factbook can be found at http://www.bcse.org/factbook/pdfs/2014%20Sustainable%20Energy%20in%20America%20Factbook.pdf

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
OTHER CLEAN ENERGY (not covered in this report)	• Nuclear	• Wave / tidal	• Lighting • 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

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. The Council membership also includes independent electric power producers, investor-owned utilities, public power, commercial end-users and project developers and service providers for energy and environmental markets. Since 1992, the Council has been a leading industry voice advocating for policies at the state, national and international levels that increase the use of commercially-available clean energy technologies, products and services.

Executive summary (1 of 9)

The massive and historic transformation of the U.S. energy sector clicked into a higher gear in 2017, despite some new headwinds including policy uncertainties. Renewable deployment grew at a near-record pace. Energy productivity and GDP growth both accelerated, demonstrating that the U.S. economy can grow at a reasonable rate even as total energy consumption actually declines. Liquefied natural gas export capacity expanded, allowing the U.S. to become a serious player in global exports for the first time. Power and gas infrastructure build continued to support grid performance and natural gas delivery. All of this combined to bring U.S. greenhouse gas emissions to a 25-year low while creating jobs and keeping costs in check for consumers. We draw out the key highlights below.

New U.S. wind and solar build, combined with an easing drought in the West, drove renewable generation up from 15% to 18% of the total electricity mix in one year, while contributions from natural gas and coal tapered modestly.

- Renewable generation (including hydropower) soared 14% to an estimated 717TWh in 2017, from 628TWh in 2016. The expansion brought renewables to 18% of total U.S. generation – double their contribution a decade ago. Renewables achieved new heights partly due to a rebound in hydro (up 13%, or 36TWh) as reservoir levels on the West Coast recovered after a severe, prolonged drought. At the same time, a chart-busting number of wind and solar projects built in 2016 (nearly 23GW worth) had their first full year of operation in 2017, bolstering non-hydro renewable generation by 15% to 413TWh. The surge further establishes renewables' critical role in the U.S. power mix – renewable technologies now contribute nearly as much electricity as the nuclear fleet.
- With 18.4GW of new additions, 2017 marked another boom year for renewables build, second only to 2016's record of 22.7GW. Overall, renewables have contributed 55% of total build in the past 10 years. Non-hydro renewables continued to represent the largest share of all U.S. new installations, hitting roughly 62% in 2017.
- Build in other renewable sectors (biomass, biogas, waste-to-energy, geothermal, and hydro) continued to stall without long-term policy support. Geothermal added only 24MW through one new project. Large-scale biomass, biogas and waste-to-energy combined added 176MW, while hydro commissioned 208MW.
- Renewables' rise came as natural gas-fired generation decreased by an estimated 8.1% (113TWh). This brought gas' share of total U.S. generation down from 34% in 2016 to 32% in 2017. Recovering gas prices, as well as a 1.7% year-on-year fall in total generation (including estimates for distributed solar), may have also contributed to the drop in natural gas-fired generation.
- Nonetheless, natural gas retained its position as the number one producer of U.S. power, as electricity production from coal slipped as well (although to a smaller extent – 37TWh, equivalent to a 3% decline). Continued changes to the structural make-up of the U.S. fleet will likely cement its role here for some years: natural gas build boasted its best year since 2005, as new installations reached 10.7GW in 2017. Further, by end-2017, owners of coal plants – which directly compete with gas in many areas of the country – had announced 12.5GW of planned retirements for 2018, foreshadowing the largest year for coal decommissioning since the 15GW of retirements in 2015.

Executive summary (2 of 9)

Consumers devoted a smaller share of their spending towards electricity than at any time ever recorded, while the total share of household expenses dedicated to energy costs also hovered near an all-time low. Power and natural gas prices remain subdued across the country, and contract prices for wind and solar continued to plunge.

- American consumer spending on electricity shrank slightly in 2017 to 1.3% of personal consumption expenditures, down from 1.4% in 2016. Greater energy efficiency and the continued availability of cheap fuels likely contributed to keeping electricity costs a modest part of total consumer expenditures. Spending on natural gas also remained muted, as consumers directed just under 0.4% of their outlays to this resource, similar to 2016 levels.
- A rebound in spending on other energy goods, especially gasoline and motor fuels, counterbalanced the drop in the share of expenditures devoted to electricity bills. Households put 2.1% of their total consumption towards gasoline and motor fuels, up from 1.9% in 2016. However, overall, Americans continue to direct just under 4% of their outlays to energy-related costs – only 2016 has seen a smaller share.
- Retail power prices remained subdued in the U.S. But unlike 2016, when prices fell across the country (on the back of waning wholesale power prices), average retail prices rose modestly in 2017 across most regions. They picked up by 0.5% in New England and the Northwest; around 1% in New York, MISO and the Southeast; 1.2% in SPP; 1.5% in the Southwest; 3.5% in California; 4.8% in Florida; and 6.4% in Alaska. However, average retail prices also dipped by roughly half a percent in PJM and ERCOT.
- In the wholesale power market, average prices rallied in 2017 across the U.S. on the back of natural gas prices, which rose 18% to average $2.96/MMBtu at Henry Hub.
- Electricity offtakers secured renewables at ever cheaper price points. The most competitive power purchase agreements (PPAs) came in at just over $20/MWh for solar, while wind PPAs executed in the U.S. wind belt averaged an estimated $17/MWh in 2017. Utility-scale PV capex costs in the U.S. have declined 49% since 2013 to $1.1m/MW from $2.2m/MW, with projects in regions such as the Southeast breaking through the symbolic “dollar-per-watt” threshold. Wind turbine prices have descended to an estimated $0.99m/MW, down 21% over the same time period. At the same time, taller turbines and improved capacity factors have boosted the productivity of new wind facilities, driving down prices in $/MWh terms at an even faster clip.
- Natural gas has become increasingly affordable for consumers. Retail prices for the commercial sector averaged just $8/mcf in 2017, down 42% over the past decade and near the recent trough observed in 2016. Gas prices for the industrial sector have followed a similar trajectory but continue to undercut commercial rates, averaging just over $4/mcf in 2017.

Executive summary (3 of 9)

The U.S. remains competitive globally for energy-intensive industries, thanks to low industrial power prices.

- Industrial power prices in the U.S. have historically been among the most affordable in the world (averaging 6.76¢/kWh in 2016, according to the EIA). The U.S. remained competitive even as exchange rate fluctuations—and market reforms, in the case of Japan—brought down the dollar cost of energy for industrial consumers in China, Japan, and Mexico. Canada, with its strong stock of cheap legacy hydro, hovered at or below U.S. prices. (Canada averaged 5.46¢/kWh in 2016.) These two countries offered the least expensive electricity for industrial users out of the G-7 countries.

The renewable, energy efficiency, and natural gas sectors employed approximately three million Americans in 2016. Energy efficiency was the top employer within the sustainable energy sectors, and solar was the fastest growing job-creator among all electricity generation technologies.

- Energy efficiency provided 2.2 million jobs in 2016, according to the January 2017 report from the Department of Energy. Efficiency was the top employer within the sustainable energy segments tracked in the report.
- Among sectors associated with electricity *generation*, solar employed the highest number of workers in 2016. The solar job count topped nearly 374,000, more than double those from fossil generation, which numbered 151,000 for coal, natural gas, and oil-fired sources combined (not counting employment associated with fuel supply). Solar is still a labor-intensive field and one where a boom in new installations is driving employment.
- Solar also added almost 74,000 jobs from 2015 to 2016, marking a 25% growth year-on-year and again taking top place out of all electricity generation sectors. Wind was second in terms of employment growth, adding 24,650 jobs.
- Fossil fuel-fired generation also creates upstream employment (i.e., jobs related to the extraction, production and transportation of fuels). For natural gas-fired generation, the vast majority of jobs are actually upstream; accounting for these positions brings employment tied to natural gas to an estimated 362,000, up from around 52,000 for downstream jobs at natural gas power plants.
- The electricity storage sector also supported nearly 91,000 jobs in 2016, with just over half affiliated with battery storage. Storage is a burgeoning sector: in 2017, the U.S. added an estimated 251MW in non-hydropower storage capacity, which drove up total commissioned capacity by 33%.

Executive summary (4 of 9)

American economic growth is picking up steam – without a parallel jump in energy consumption.

- The U.S. economy advanced 2.3% in 2017, up from 1.5% in 2016. At the same time, U.S. total energy consumption dipped 0.2% to 97.2 quadrillion BTU. Energy productivity, which is the amount of GDP produced by a unit of energy, climbed 2.5% in 2017 as economic growth continued its long-term trend of decoupling from energy use. Since 2008, energy usage has shrunk 1.7% even as GDP has accelerated by 15.3%.
- Annualized electricity consumption, excluding consumption of distributed energy resources, fell 2.6% in 2017 despite stronger economic growth. From 1950 to 1990, demand for electricity increased at an annual average rate of 5.9%. From 1990 to 2007, that dampened to 1.9% growth per year. Since 2007, electricity demand has actually *contracted* by an average of 0.2% per year.
- Energy efficiency has clearly contributed to this ongoing trend; however, the growth in utility spending on efficiency for electricity has slowed, advancing only 1.6% in 2016 (the latest year for which data is available) to $6.3 billion. This slowdown comes in part because fewer states are introducing new energy efficiency resource standards, while other states' existing mandates have matured.
- Investments to boost the efficiency of natural gas usage have also paid off. The number of residential customers using natural gas expanded 21% to 69 million in the 20 years from 1998 through 2017. But consumption stayed roughly the same during that period, likely due in part to efficiency gains.

Emissions from the electricity sector plummeted again, allowing transportation to retain its place as the largest-emitting sector for the second year in a row.

- U.S. GHG emissions fell to their lowest levels since 1991, shrinking to an estimated 6.4GtCO2e in 2017 after contracting another 1.4% year-on-year. The power sector continues to drive the economy's de-carbonization – emissions from this sector ebbed 4.2% in 2017, this time on the back of declining load and greater renewable generation (rather than coal-to-gas switching, a primary driver of 2016's 5.8% downturn).
- Power-sector emissions now sit 28% below their 2005 peak, which puts the U.S. only 4 percentage points away from achieving its former Clean Power Plan target of 32% below 2005 levels by 2030. The rapid emissions reduction in the power sector has also helped to bring the U.S. halfway to its abandoned Paris Agreement target of slashing economy-wide emissions to 26% below 2005 levels by 2025.
- In 2016, the transportation sector overtook power as the largest greenhouse gas emitter, thanks mostly to lower power-sector emissions and an absence of abatement opportunities within the transportation sector. It expanded the lead to 108MtCO2e in 2017, up from 21MtCO2e in 2016. Power and transportation account for approximately 60% of emissions, with agriculture, industry, and the commercial and residential sectors typically accounting for the other 40%.

Executive summary (5 of 9)

The U.S. is solidifying its role as a global liquefied natural gas (LNG) exporter, and for the first time was a net exporter of natural gas for every month of the year.

- Export activity stepped up at the Sabine Pass LNG terminal, which doubled its capacity in 2017 to 2.5Bcfd. LNG exports totaled 625Bcf from January through November 2017, a value of roughly $2.8 billion (out of a $90 billion/year global LNG market). The U.S. now exports LNG to 25 countries, with Mexico, South Korea, China, and Japan serving as lead offtakers. A second export terminal opening in Maryland (Cove Point) is scheduled to begin commercial operations in early 2018.
- Average pipeline exports to Mexico also rose, climbing 11% to 1,407Bcf as of end-November, compared to 1,265Bcf over the same period in 2016. Together, LNG and natural gas pipeline exports to Mexico have elevated average net *export* volumes to 2Bcfd as of end-November 2017, compared to an average 0.03Bcfd of net *imports* for the same period in 2016.
- The growth in foreign demand came as domestic gas demand dipped 2.8% year-on-year, in large part due to the 7.2% drop in natural gas used for gas-fired power generation. Strengthening exports helped to propel an estimated 1.5% uptick in total gas demand from 2016 to 2017.

Utilities and independent developers continue to invest in infrastructure to improve grid operations and support the growth of clean energy.

- Investor-owned utilities and independent transmission developers spent an estimated $22.9 billion on electric transmission in 2017, according to figures collected by the Edison Electric Institute (EEI). This represents a 10% rise above the $20.8 billion spent in 2016, and a 91% boost over 2011's levels. Investments have targeted replacing aging equipment, improving reliability, and bringing renewable generation to end-use consumers, among other purposes.
- The Midwest's system operator, MISO, is overseeing a large build-out of its wires infrastructure, seeking to replicate Texas' success in reducing wind curtailment rates. The construction of the Texas Competitive Renewable Energy Zone (CREZ) transmission lines brought wind produced in breezy west Texas to demand centers farther east, slashing curtailment rates from a peak of 17% in 2009 to under 2% for 2016. MISO, alongside New England, experiences curtailment rates of around 4%, some of the highest currently seen in the U.S. Five of the 17 transmission projects under development through MISO's Multi Value Project have already come online, alleviating bottlenecks and cutting curtailment rates by 21% between 2015 and 2016.
- Gas transmission infrastructure is also set to expand, after protracted delays on several major pipelines caused by the lack of a FERC quorum, project-specific setbacks, and regulatory hurdles. An estimated 14Bcfd of capacity was completed in 2017. Although this undershot the 33Bcfd developers originally planned to complete, it was a notable step up from the five preceding years, in which gas transmission build ranged from 5Bcfd to 9Bcfd a year. The pipeline expansions in 2017 included 4.1Bcfd in takeaway capacity from the Appalachian Basin; however, only 1% of this went towards relieving the natural gas constraints in New England.

Executive summary (6 of 9)

***Continued:* Utilities and independent developers continue to invest in infrastructure to improve grid operations and support the growth of clean energy.**

- Investment in midstream gas infrastructure (e.g., transmission, distribution and storage) climbed 19% from 2015 to 2016, with distribution accounting for nearly half of the escalation in spending. Total investment in distribution hit its highest level yet at $13.4bn, a 16% expansion from 2015 levels.
- On the consumer side, smart metering infrastructure has reached 51% of U.S. households, although regional penetration rates vary widely. As regulators and utilities begin to undertake more activity on grid modernization and dynamic retail tariffs, even players who have traditionally stayed away from smart meters are beginning to assess the technology's benefits. Utilities have also begun to offer rebates to incentivize the adoption of smart thermostats, which can be used to control peak demand. In 20 states, over half of households are eligible for rebates on smart thermostat purchases.

Global clean energy investment rebounded to the second-highest amount on record. U.S. investments tracked 2016 levels but saw a shift in capital deployment.

- Global new investment in clean energy advanced to $333 billion in 2017, second only to the $360 billion spent in 2015. A 24% escalation in Chinese investment more than offset the 26% contraction in European flows, while the U.S. contribution held its ground at $57 billion, or about 17% of the global total.
- The relatively stable headline figure for U.S. clean energy investment masked shifts in how capital was deployed. Solar investment slumped 20% as policy uncertainty delayed projects and leading residential solar vendors pulled back from the market. Meanwhile, energy smart technologies attracted 25% more funding in 2017 than in 2016 and wind investment expanded 19%.

New sales of battery, plug-in hybrid, and hybrid vehicles accelerated, driven especially by new, longer-range versions of existing models. Meanwhile, the price of lithium-ion battery packs, a key cost component for battery electric vehicles, plummeted 23% year-on-year.

- U.S. sales of electric vehicles (EVs), including battery electric vehicles (BEV) and plug-in hybrid electric vehicles (PHEV), jumped to over 194,000 units in 2017, up 23% from the year prior. PHEV sales leapt 24% year-on-year on the back of affordable, longer-range offerings like the Toyota Prius Prime. BEV sales surged 22%, also as a result of longer-range affordable models, including the Chevrolet Bolt, and offerings in new car segments such as the Tesla Model X. In all, EVs made up 1.1% of new vehicle sales in the U.S. in 2017, up from 0.9% in 2016. It is estimated that around 749,000 EVs are on the road in the U.S. as of end-2017.

Executive summary (7 of 9)

Continued: **New sales of battery, plug-in hybrid, and hybrid vehicles accelerated, driven especially by new, longer-range versions of existing models. Meanwhile, the price of lithium-ion battery packs, a key cost component for battery electric vehicles, plummeted 23% year-on-year.**

- On a subsidized, lifetime basis, BEVs can cost up to one-third less than equivalent vehicles with conventional internal combustion engines (ICE). PHEVs, on the other hand, tend to cost more than midsized ICE vehicles. This results from a combination of higher prices and fuel costs, as well as lower subsidies.
- The price of lithium-ion battery packs, a key driver of BEV pricing, crashed 23% in 2017. Pack prices tumbled 65% between 2013 and end-2017, bringing average prices down to $209/kWh. Cells, which contribute roughly 70% of the total cost of a pack, experienced a more rapid decrease (26%) last year than the other cost components, thanks to economies of scale, increasing energy density, and transitions to more efficient chemistries.
- Retail gasoline prices rallied 13% over the course of 2017, finishing at an average of $2.50/gallon compared to $2.21/gallon at end-2016. But prices remained historically low, and consumption ticked up by an estimated 0.7% relative to the previous year.
- Start-stop technology, which cuts vehicle fuel use and idling emissions by automatically shutting off the car engine when the car is stopped, continued to gain traction in the auto industry. The share of vehicles sold with this system in the U.S. leapt to 16.8% in 2017, up 75% from the penetration rate in 2016.

The federal government backtracked from national and international engagement on climate change issues, prompting greater climate commitments from sub-national and private sector players. Federal-level actions ranging from trade cases to tax reform also caused uncertainty in the market for clean technologies.

- On June 1, 2017, President Donald Trump announced his intention to withdraw the U.S. from the Paris Agreement, an international, non-binding climate change accord signed by 195 other countries and jurisdictions. In October 2017, the Environmental Protection Agency (EPA) also proposed to rescind and replace the Clean Power Plan. On the transportation front, President Trump ordered EPA to reconsider the upcoming tightening of corporate average fuel economy (CAFE) standards, covering model years 2021-2025.

Executive summary (8 of 9)

***Continued:* The federal government backtracked from national and international engagement on climate change issues, prompting greater climate commitments from sub-national and private sector players. Federal-level actions ranging from trade cases to tax reform also caused uncertainty in the market for clean technologies.**

- In response to the U.S. withdrawal from the Paris Agreement and fading federal-level climate action, sub-national actors have created alliances to support continued progress on the U.S. greenhouse gas reduction targets. The "We Are Still In" movement involves 2,642 mayors, governors, CEOs, college presidents, faith organizations, and tribal leaders (as of the time of this writing). Another group, the U.S. Climate Alliance, includes 16 governors representing over 40% of the U.S. population and $7.4 trillion in economic output. Separately, the U.S. Climate Mayors (founded at the signing of the Paris Agreement) saw its membership swell after the U.S. withdrew from Paris. It now encompasses 383 cities covering 23% of the U.S. population, half of which are in states that have not additionally joined the U.S. Climate Alliance. Together, these entities represent 2.7Gt in emissions (for comparison, total U.S. emissions stood at 6.4Gt for 2017). However, the level of ambition between different entities' emissions reduction commitments, plus the voluntary nature of such commitments, render it difficult currently to assess the expected impact from the movement. The America's Pledge initiative will aggregate the commitments made under these initiatives and attempt to measure their impact across the U.S.
- In October 2017, the U.S. Department of Energy (DOE) requested that the Federal Energy Regulatory Committee (FERC) create rules to subsidize "secure-fuel" power plants within competitive power markets that maintain 90 days' worth of fuel supplies on site. This would have mostly benefited coal and nuclear plants. FERC ultimately declined to implement the proposed rulemaking, citing insufficient evidence that price distortions or retirements were affecting resiliency or reliability in the targeted power markets. The DOE itself had previously reported that, while there might be challenges to come, wholesale power markets have ensured reliability to date, even as the electricity sector has transformed rapidly due to factors such as flattening demand, growing natural gas penetration, and policy interventions (including renewables support). FERC did ultimately call on system operators to study grid resiliency – that is, power systems' ability to recover from major service interruptions.
- In January 2018, President Trump instituted a 30% tariff on imported crystalline silicon solar modules and cells, which is scheduled to step down to 15% by 2021. The safeguard measure was imposed in response to a trade complaint submitted by two bankrupt domestic solar module manufacturers. The case, lodged by Suniva and SolarWorld, alleged unfair competition from Chinese manufacturers, but the resulting tariffs will apply to practically all countries of origin. These tariff will increase all-in project costs by an estimated 4-10%.

Executive summary (9 of 9)

Continued: **The federal government backtracked from national and international engagement on climate change issues, prompting greater climate commitments from sub-national and private sector players. Federal-level actions ranging from trade cases to tax reform also caused uncertainty in the market for clean technologies.**

- Tax reforms passed near the end of 2017 also promise change for clean energy. While the EV, wind, and solar tax credits remain unchanged from prior law, the corporate tax rate dropped down to 21% from 35%. This tax cut raises after-tax earnings for renewable projects, but also reduces the supply of tax equity available for supporting renewable build. Additionally, the tax cut may free up utility money for infrastructure investments or for lowering retail electricity rates. Further, under the new law, multinationals with overseas profits are now required to pay a minimum level of taxes on foreign transactions under the so-called “BEAT” provision. Although this can also limit tax equity supply, the negative impact is curbed by a provision that allows corporations to use 80% of the Investment Tax Credit (ITC) and Production Tax Credit (PTC) to offset BEAT. Finally, the introduction of immediate, 100% depreciation of most capital expenditures can benefit providers of long-lived assets such as energy saving building materials or technology.
- In February 2018, Congress passed the Bipartisan Budget Act, which impacted a range of energy incentives. Energy efficiency credits and non-wind PTC technologies (biogas, biomass, waste to energy, active geothermal, hydropower, marine and hydrokinetic) received one-year retroactive extensions. Several non-solar ITC-eligible technologies (fiber-optic solar, microturbines, fuel cells, combined heat and power, and small wind) received five-year extensions with phase-downs. The budget law also lifted the end-2020 in-service deadline for nuclear plants to qualify for the nuclear production tax credit. In addition, it expanded credits for qualified carbon capture and sequestration (CCS) facilities.
- States also explored reforms to some of their renewables support programs in 2017. Most customers in 40 states, plus DC, could access net metering at the full retail rate as of August 2017. But states across the country are looking at potential reforms to the scheme: over the past year, Arizona, Indiana, and Maine finalized plans to move away from net metering. The replacement options vary but generally offer lower compensation rates or set a deadline by which small-scale PV owners can still qualify for net metering.

Corporations are playing a stronger role in the energy transformation, increasingly demanding cleaner energy and seeking to capture gains from energy efficiency.

- Corporations continued to turn their attention to sustainability in 2017. The “EP100”, an initiative launched in 2016 through which companies promise to double their energy efficiency, has gained 13 pledgees. On the renewables front, 119 companies globally had pledged by end-2017 to source 100% of their energy from renewables under the “RE100” initiative. In the U.S., corporate clean energy deal volumes for off-site PPAs rose to 2.9GW in 2017, the second highest on record behind the 3.2GW of new contracts signed in 2015. Companies have also looked increasingly to source clean energy in the same service territory as their load, leading to new engagement with utilities via green tariff programs. These contributed 19% of corporate procurement in 2017.

The 2018 Factbook in the context of previous editions

The first edition of the Sustainable Energy in America Factbook, published in January 2013, captured five years' worth of changes that included a rapid de-carbonization of the U.S. energy sector. From 2007 to 2012, natural gas's contribution to electricity had grown from 22% to 31%, and total energy use had fallen by 6%, driven largely by advances in energy efficiency. Renewables including hydropower grew from 8% to 12% of total electricity output, with generation from non-hydro sources more than doubling during that time frame.

The second edition of the report, published February 2014, compared developments in 2013 to the longer-term trends described in the first edition. In some cases, the tendencies had continued: natural gas production, small-scale solar installations, policy-driven improvements in building efficiency, and electric vehicle usage had continued to gain ground, cementing five-year patterns. Other measures – total energy consumed, the amount of emissions associated with that energy consumption, and the amount of new investment into renewable energy – had bucked the longer-term trends.

The third edition of the report came out in February 2015 and provided updated data and analysis covering developments in 2014. Natural gas production continued its upswing, prompting the industry to build and reconfigure infrastructure. Renewables again grew their share of states' capacity mixes, reaching 206GW of installations across the country. But policy developments stagnated and the crude oil price collapse raised the possibility of impacts down the road on sustainable transport and second-order impacts on the power sector.

The fourth edition was released in February 2016 and reflected on a year in which the U.S. added hefty amounts of renewables while policy frameworks for supporting a clean energy future emerged at both the international and domestic levels. Natural gas generation hit a record-high at the expense of coal. Renewables capacity including hydropower grew by 16GW, and the last-minute extension of federal tax credits for renewables added further momentum to the industry. The signing of the Paris Agreement gave further policy support to sustainable energy.

The fifth edition of the Factbook, published in February 2017, highlighted 2016 developments that affirmed sustainable energy as the "new normal". The U.S. installed record amounts of renewable energy capacity, helping to drive down power-sector emissions to the lowest point in 25 years. The natural gas industry took on a new role as a leading global exporter even as domestic demand rose and prices set new lows, and more corporations embraced renewable energy and energy efficiency as their technologies of choice. As the transformation of the sector continued to play out, consumers devoted less of their household income to energy – under 4% in 2016, the smallest share on record.

This sixth edition of the Factbook covers 2017, a year in which economic growth accelerated while electricity and total primary energy demand fell, further lending credence to the trend of "decoupling" GDP and energy consumption. Renewable electricity generation soared to unprecedented levels, contributing 18% of total electricity produced in the U.S. (compared to 15% the preceding year). In addition, the U.S. cemented its position as a net natural gas exporter, utilities and developers ramped up spending on critical infrastructure, and sub-national entities stepped up the fight against climate change. The changes came as the U.S. maintained its position as a country with affordable energy for industrial users and household consumers.

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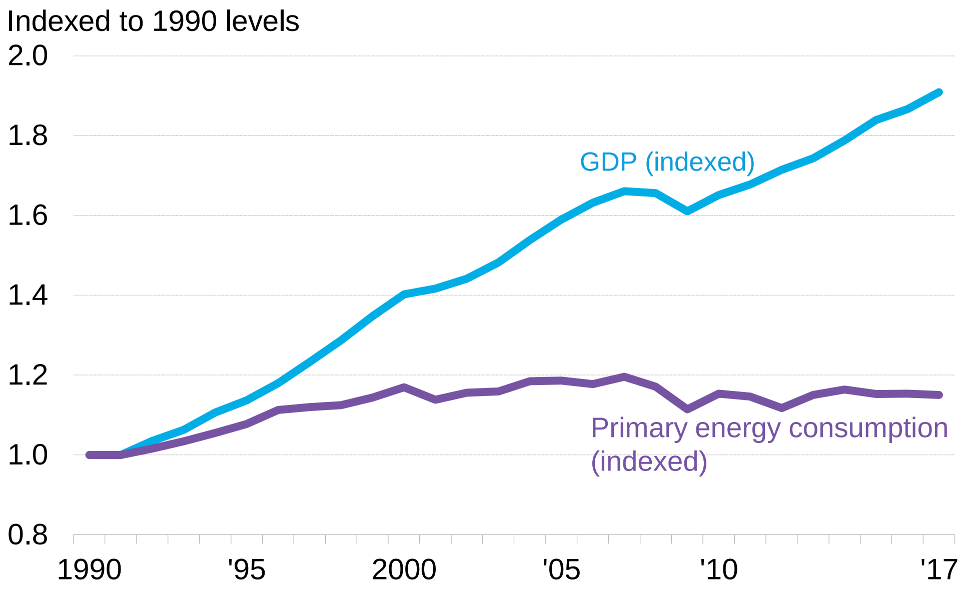
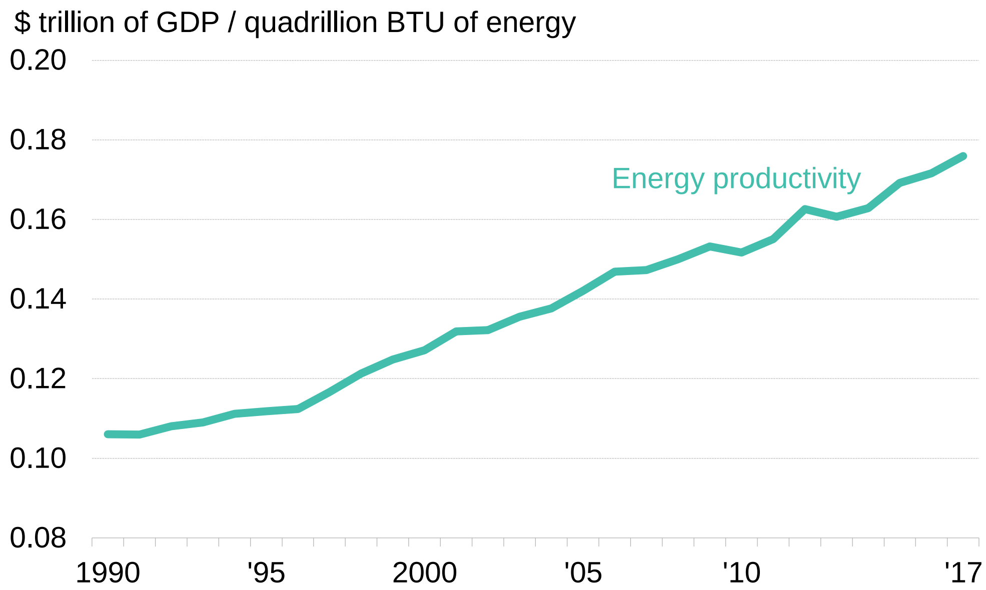
U.S. energy overview: Economy's energy productivity

U.S. GDP and primary energy consumption



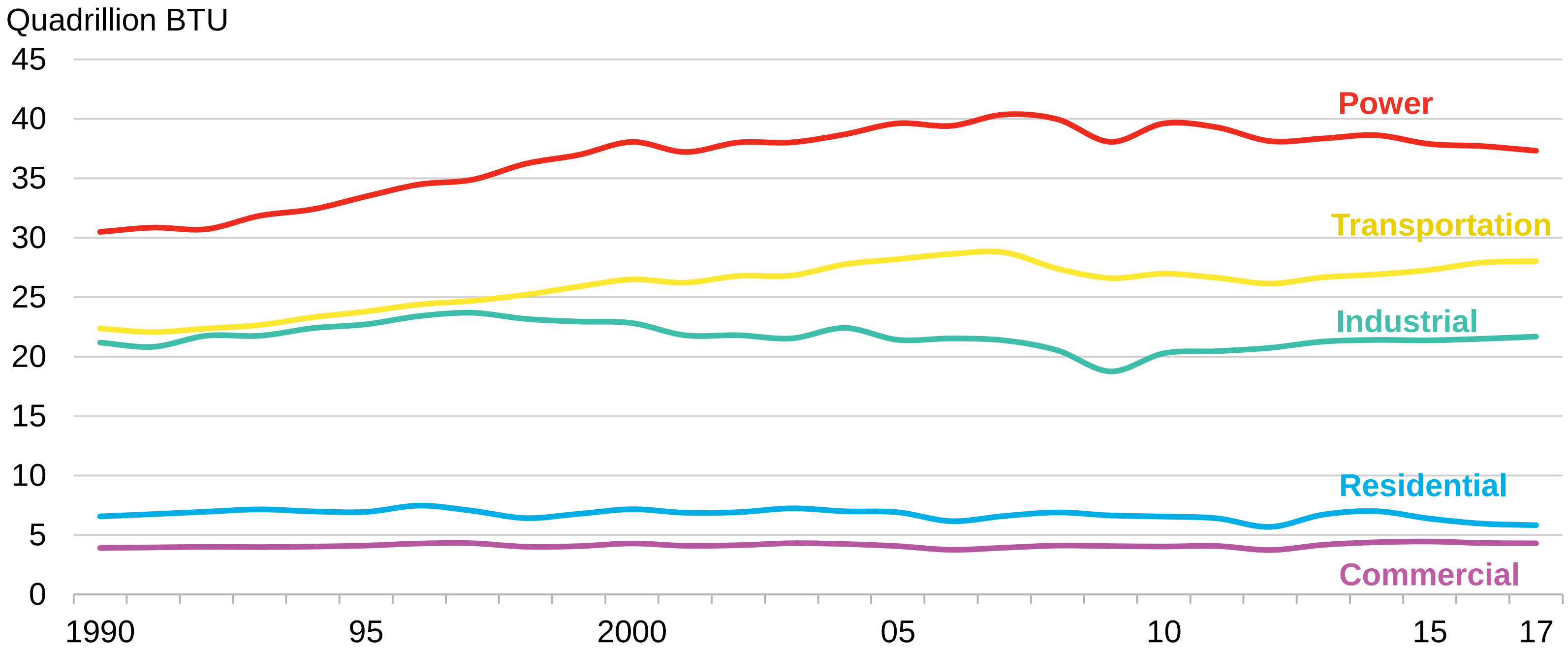
U.S. energy productivity



- GDP growth in the U.S. continued apace in 2017, even as primary energy consumption shrank. This decoupling between economic growth and energy use is reflected in improvements to energy productivity. Within the past decade, energy productivity ticked up 17%, as GDP jumped 15% while primary energy consumption shrank 2%.
- Energy productivity, which is the amount of GDP produced by a unit of energy, climbed 2.5% to approximately $176 billion per quadrillion BTU in 2017, up from $172 billion per quadrillion BTU in 2016. The economy is picking up steam, with annual GDP growth estimated at 2.3% for 2017 (compared to 1.5% in 2016) – without a corresponding uptick in the amount of energy used to drive the economy. Year-on-year, total primary energy consumption decreased by 0.2%.
- According to the Lawrence Berkeley National Laboratory, the average levelized cost of saving energy through efficiency declined to $28/MWh in 2013, from $44/MWh in 2009 – a 36% drop.

Source: Bureau of Economic Analysis, EIA, Lawrence Berkeley National Laboratory, BNEF Notes: Values for 2017 are projected, accounting for seasonality, based on latest monthly values from EIA (data available through October 2017). 2017 GDP estimate is a projection from economists compiled at ECFC <GO> on the Bloomberg Terminal.

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

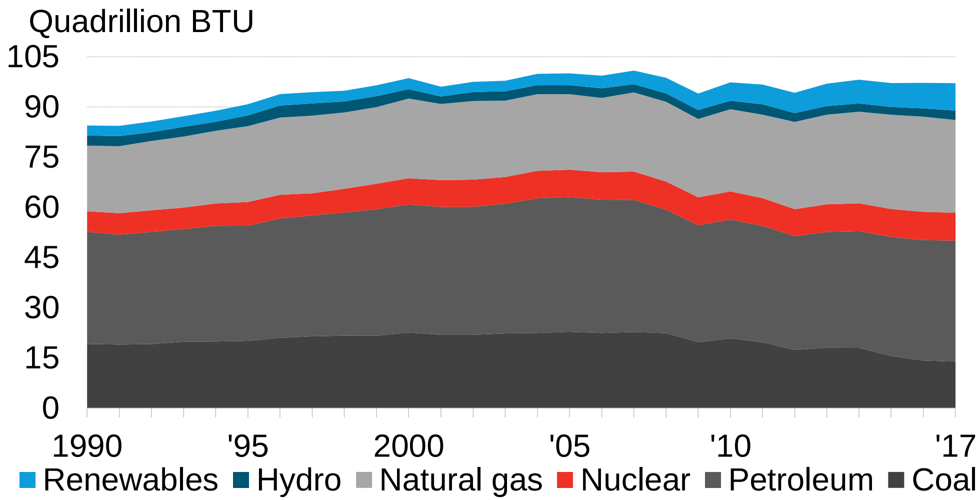


- While energy consumption as a whole dropped by 0.2% from 2016 to 2017, this was not the case for each individual sector.
- The power and residential sectors experienced larger declines: actual primary energy consumption in these sectors fell 1.0% and 2.2%, respectively, year-on-year. In the decade from 2008 to 2017, the residential sector cut its primary energy consumption by 16%, and the power sector by 7%.
- The transportation, industrial, and commercial sectors, on the other hand, consumed more energy at the end of that ten-year period. Primary energy consumption in the transportation sector, in particular, has risen steadily since 2013, on the back of more affordable gasoline prices.
- Not only has primary energy consumption for the electricity sector decreased, the sources of electricity have become cleaner as well. These factors, combined with the uptick in transportation energy usage, have allowed transportation to take over from power as the largest emitting sector in the U.S. (see emissions slide).

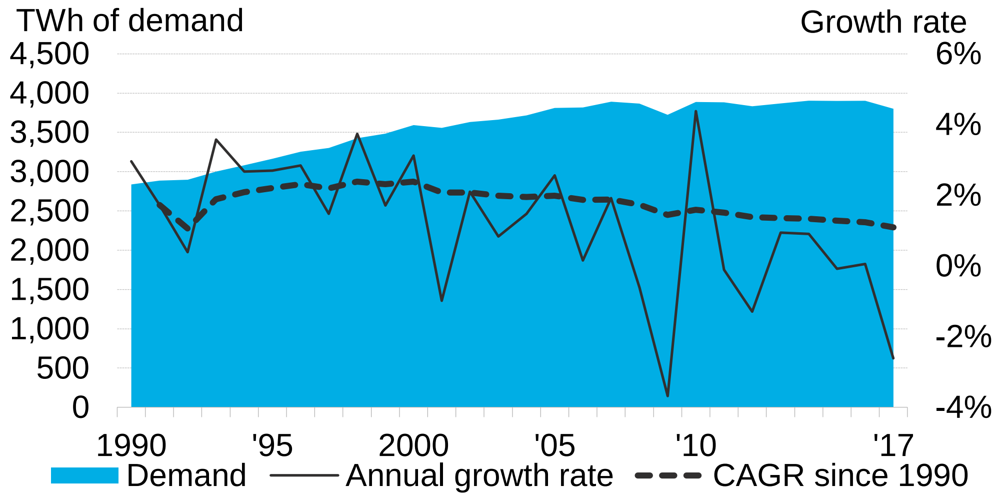
Source: EIA, BNEF Notes: values for 2017 are projected, accounting for seasonality, based on latest monthly values from EIA (data available through October 2017)

U.S. energy overview: Energy and electricity consumption

U.S. primary energy consumption by fuel type



U.S. electricity demand

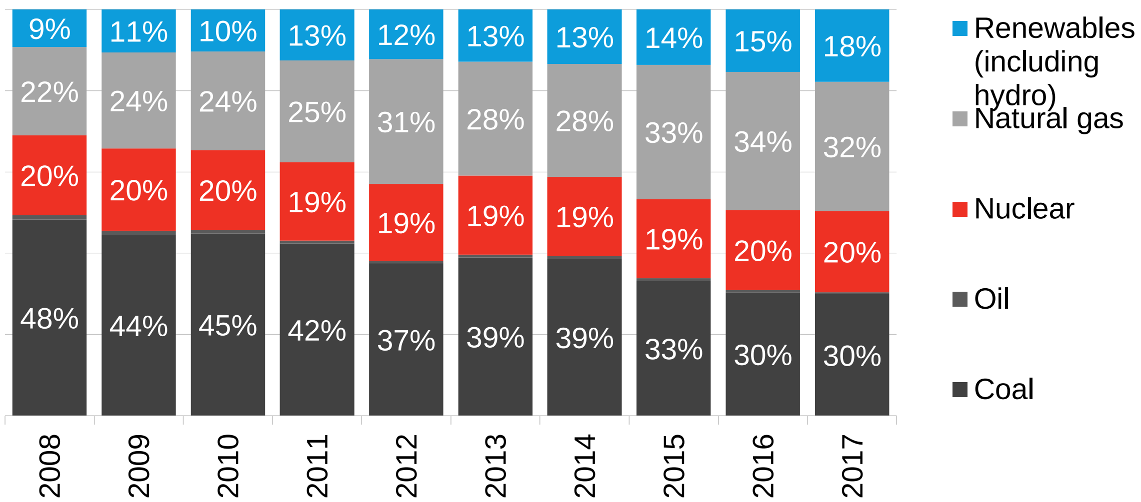


- U.S. total energy consumption decreased 0.2% to 97.2 quadrillion BTU in 2017, even as GDP growth accelerated to 2.3%. Consumption of coal, natural gas, and nuclear declined as petroleum, hydro, and renewable consumption expanded. Natural gas and coal saw some of the largest percentage reductions (-2.5% and -2.3%, respectively) in part because the power sector's shift away from these resources in 2017.
- Petroleum use advanced 0.3% as oil prices stayed relatively low, despite a price rebound in the second half of the year. The prior two years of low oil prices had encouraged greater purchases of light trucks, slowing gains in the fuel efficiency of the U.S. vehicle fleet.
- Hydro surged 13.6% year-on-year as West Coast reservoirs recovered after the drought. Other renewable resources jumped as well, rising 7.1% to 8.2 quadrillion BTU.
- Growth in retail electricity demand fell 2.6% 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 1.9% over 1990-2007, to -0.2% since 2007.

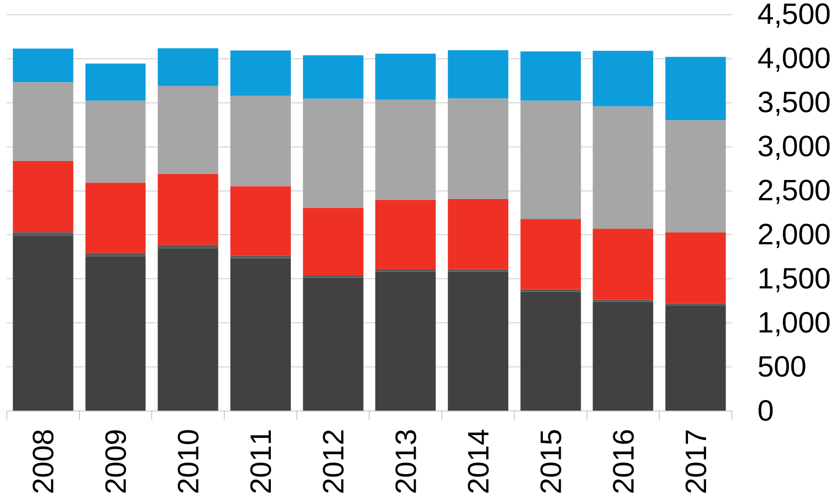
Source: EIA, BNEF Notes: "CAGR" on the right hand side graph is compound annual growth rate. Values for 2017 are projected, accounting for seasonality, based on the latest monthly values from EIA (data available through October 2017). BTU stands for British thermal units.

U.S. energy overview: Electricity generation mix

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



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

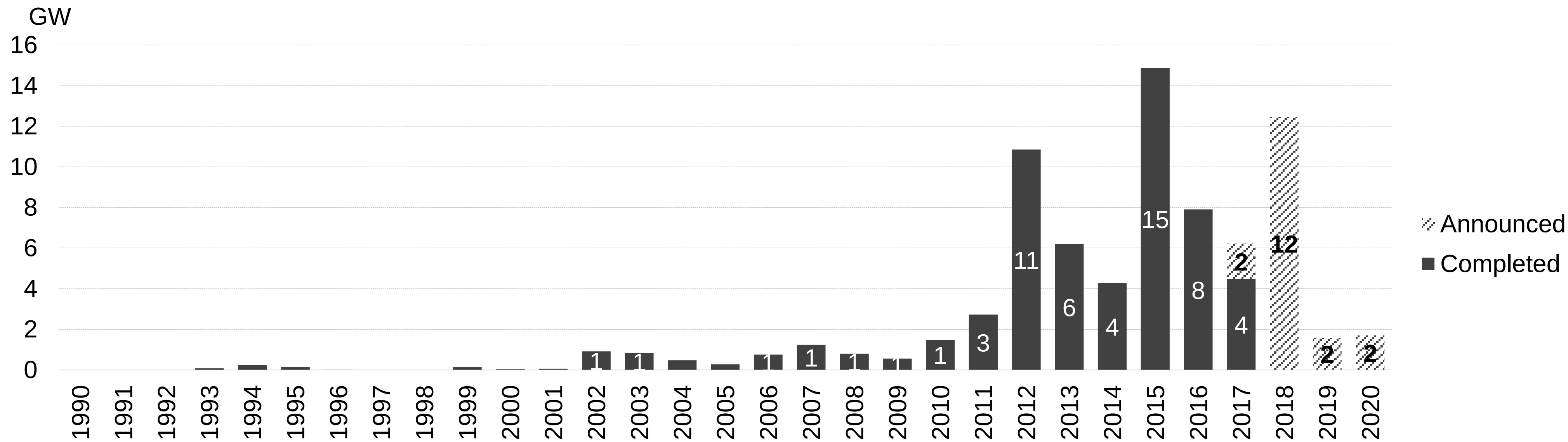


- Renewables generation (including hydropower) leapt an estimated 14.1% year-on-year in 2017, its largest ever one-year surge, as output increased nearly 90TWh. Total renewable generation hit 717TWh, thanks to a rebound in hydro (up 13%, or 36TWh) and new solar and wind build (which helped drive up generation by 53TWh, including estimates for small-scale solar).
- The growth in renewables came as natural gas's contribution to total generation dipped moderately to 32%, from 34% in 2016. In absolute terms, gas generation sank to 1,278TWh from a record-high 1,391TWh the previous year. Recovering gas prices and an estimated 1.7% slump in total generation (including estimates for distributed solar) also contributed to a squeeze on gas plants.
- Total coal generation declined 3% in 2017, but it held steady at roughly 30% of total electricity generation.

Source: EIA, BNEF Note: Values for 2017 are projected, accounting for seasonality, based on latest monthly values from EIA (data available through November 2017)

Bloomberg New Energy Finance

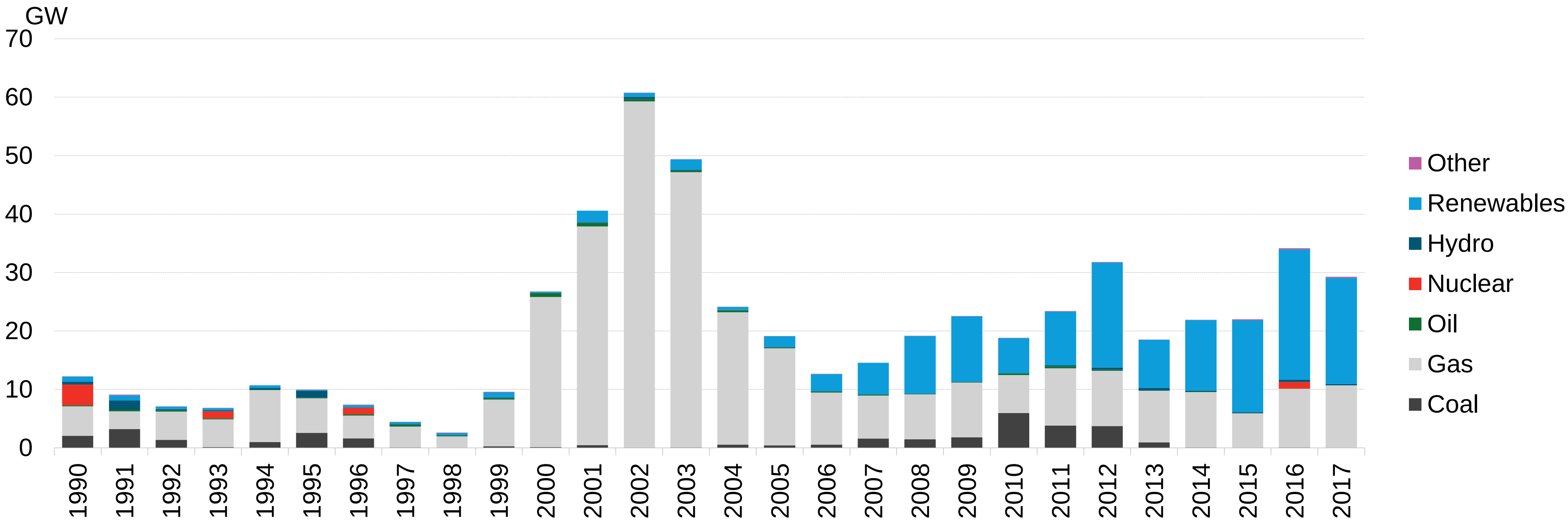
U.S. energy overview: Completed and announced coal-fired power plant retirements



- Although the pace of coal retirements slowed in 2017 to 6.2GW, companies have already announced enough upcoming coal retirements to make 2018 a near-record year. As of November 2017, companies had 12.5GW of coal plants slated to decommission in 2018, second only to 2015's high of 15GW.
- Since 2011, the coal fleet has shrunk 15% from its peak size of 306GW. Persistently low gas prices and flat load have contributed to less run-time and lower revenues for coal plants. Even as coal capacity dwindles, 22GW of new gas capacity is scheduled to commission in 2018.
- In addition, aging boilers and rising operating costs – partly due to U.S. Environmental Protection Agency (EPA) regulations covering sulfur, nitrogen, and mercury emissions from power plants – have forced many coal plants to retire earlier than originally planned.
- One such regulation, the Mercury and Air Toxics Standard (MATS) remains in place in the midst of a lawsuit. And though the Trump Administration has rescinded the Clean Power Plan, its companion law, the New Source Performance Standard (NSPS), is still in effect while litigation is stalled in the courts. NSPS sets emissions limits on new coal and gas plants.

Source: EIA, Bloomberg New Energy Finance Notes: "Retirements" does not include conversions from coal to natural gas or biomass; includes retirements or announced retirements reported to the EIA through November 2017. All capacity figures represent summer generating capacity.

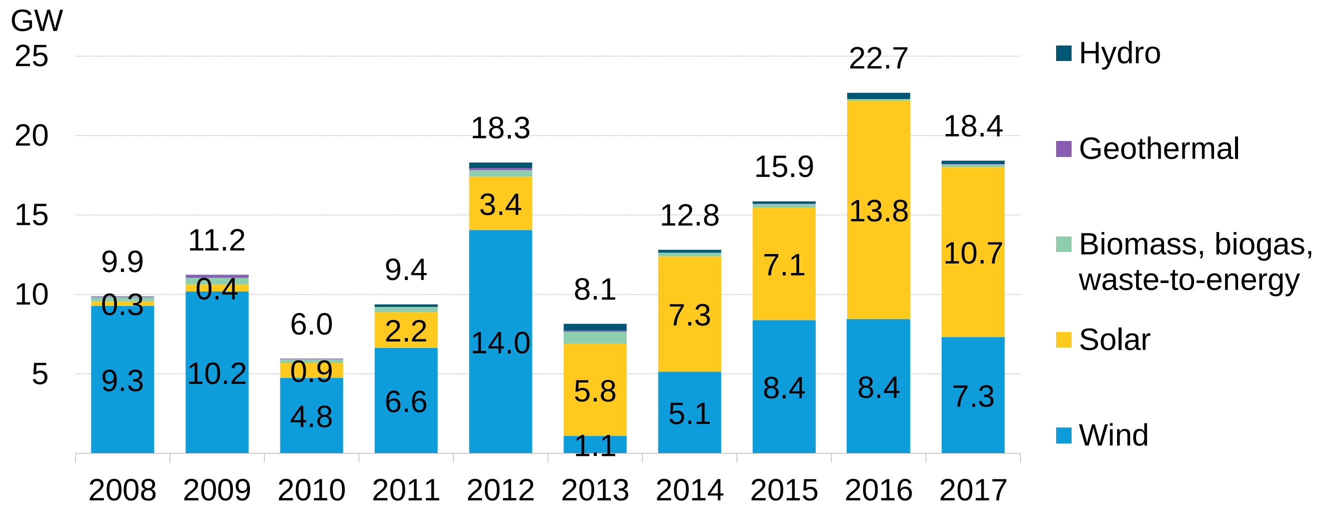
U.S. energy overview: Electric generating capacity build by fuel type



- In 2017, non-hydro renewables continued to represent the largest share of build, adding 18.2GW of capacity, or roughly 62% of total build.
- Renewable additions have dominated U.S. power sector build in recent years. In the ten-year period from 2008 through 2017, renewable energy projects, including hydro, made up 55% of all build. In the five-year period from 2013 through 2017, they contributed 62% of capacity additions. From 2014 through 2017, solar and wind together constituted the majority of U.S. build each year.
- Prior to the renewable build boom, gas made up the majority of new capacity additions from 1992 through 2007. In 2017, gas build hit 10.7GW, the highest level since 2005. Combined-cycle technology contributed the majority of new gas installations at 9GW.
- In total, renewables, hydro and natural gas have contributed over 93% of all generating capacity additions within the past 25 years.

Source: EIA, Bloomberg New Energy Finance 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.

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

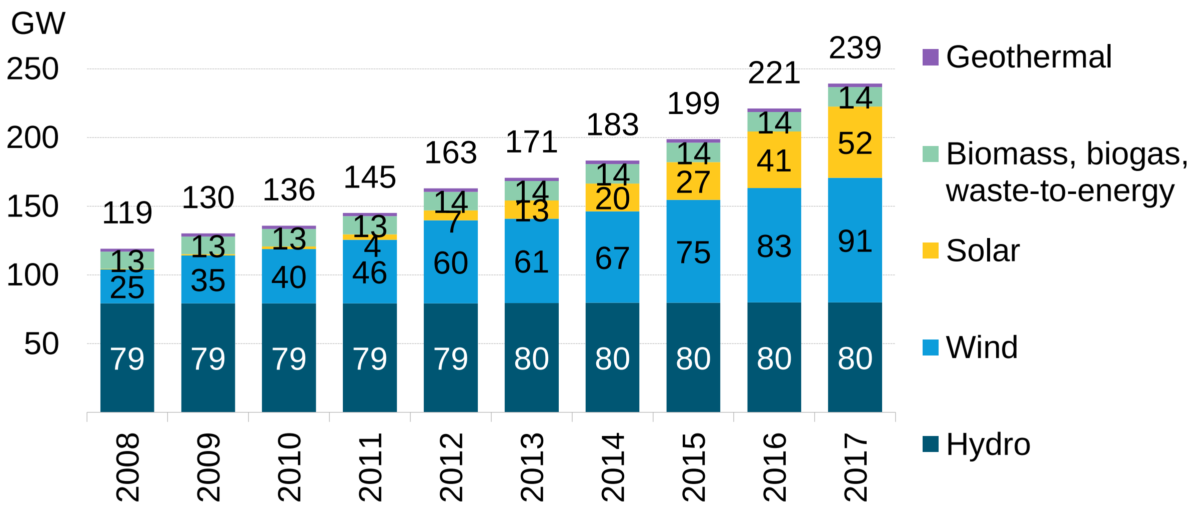


- Renewable build slowed in 2017 after record-level additions in 2016: it fell 19% to 18.4GW, from 22.7GW in 2016.
- Utility-scale solar developers are rebuilding their project pipeline after rushing to commission projects in 2016 (see Section 4.1, here). In 2017, the Southeast dominated utility-scale build with 2GW, twice as much as California. Small-scale solar was one area that showed some growth: build expanded 5% to 3.6GW, despite a 9% slowdown in residential PV as vendors scaled back their growth plans. The smaller commercial PV segment grew from 1.1GW in 2016 to 1.5GW in 2017. This growth did not come from a jump in deals, but due to larger system sizes.
- Wind build shrank to 7.3GW from 8.4GW in 2016. Wind developers are still aiming to bring projects online by the 2020 deadline to qualify for the full Production Tax Credit (PTC), but many are waiting to take advantage of falling equipment costs.
- 2017 was a year of policy turbulence for the renewable industry. Key events included tax reform, solar tariffs, and discussions about grid reliability and resilience (see the policy section for details).
- Other sectors (biomass, biogas, waste-to-energy, geothermal, hydro) are idling without similar levels of long-term policy support.

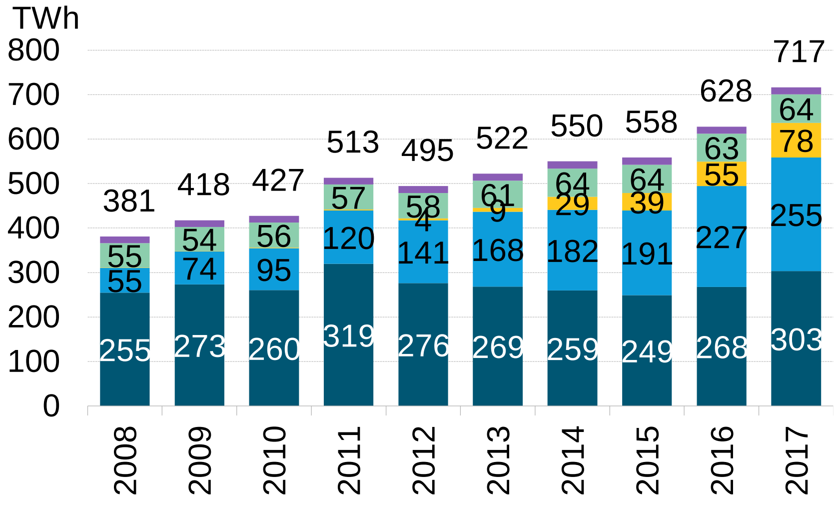
Source: Bloomberg New Energy Finance, EIA   Notes: All values are shown in AC except solar, which is included as DC capacity. Numbers include utility-scale (>1MW) projects of all types, rooftop solar, and small- and medium-sized wind.

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

U.S. cumulative renewable capacity



U.S. renewable generation by technology

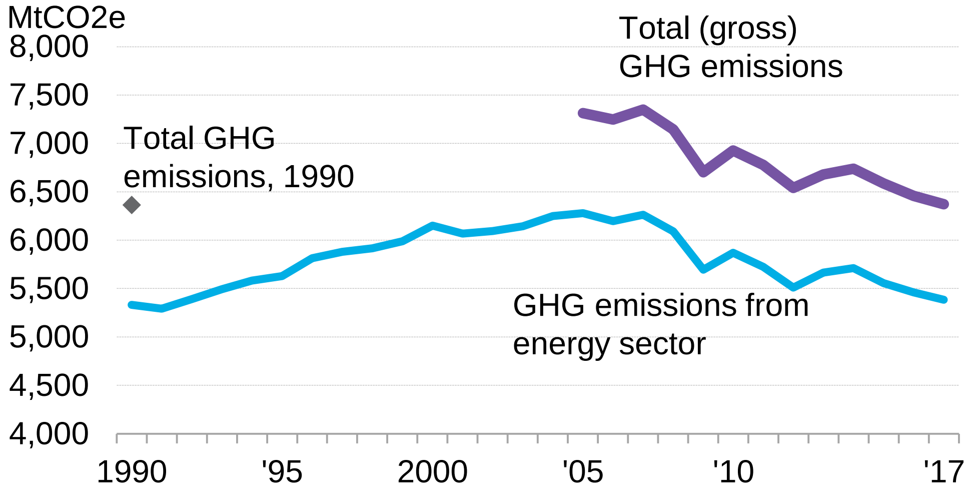


- Total renewable capacity has nearly doubled since 2008, reaching 239GW in 2017 (excluding pumped hydro). Nearly all the growth has come from wind and solar, which together jumped 471% during that period while other technologies held flat, in part due to weaker tax policy support. Wind and solar have also benefited from state-level renewable portfolio standards (RPS) and rapidly declining system costs.
- Wind capacity overtook hydropower for the first time in 2016, and extended its lead to 10.6GW in 2017 from 3.4GW the year prior.
- Hydro generation experienced a large rebound in 2017, leaping 13% year-on-year to 303TWh. This is up 22% from 2015, the last year before the West Coast's record-breaking drought began to ease.
- Wind generation also jumped 13%, to 255TWh in 2017. Solar generation soared 42% to 78TWh, thanks to the 10.7GW of capacity estimated to have come online in 2017 and the record-breaking 13.8GW added in 2016. Reflecting the massive buildout in these two technologies, they together added more incremental clean energy to the U.S. grid in 2017 than did the hydro rebound.

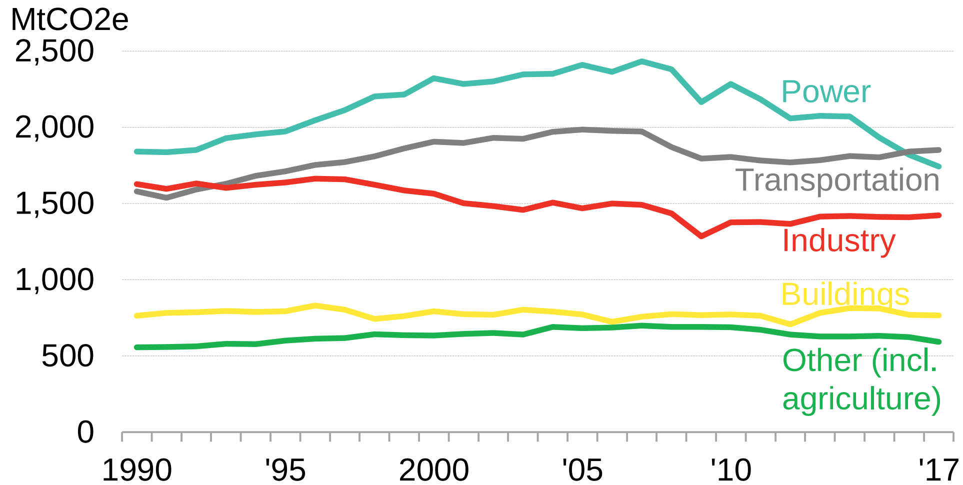
Source: Bloomberg New Energy Finance, EIA   Notes: All values are shown in AC except solar, which is included as DC capacity. Hydropower capacity and generation exclude pumped storage facilities (unlike in past Factbooks). Totals may not sum due to rounding. Values for 2017 are projected, accounting for seasonality, based on latest monthly values from EIA (data available through November 2017)

U.S. energy overview: Greenhouse gas emissions

Economy-wide and energy sector emissions



Emissions by sector

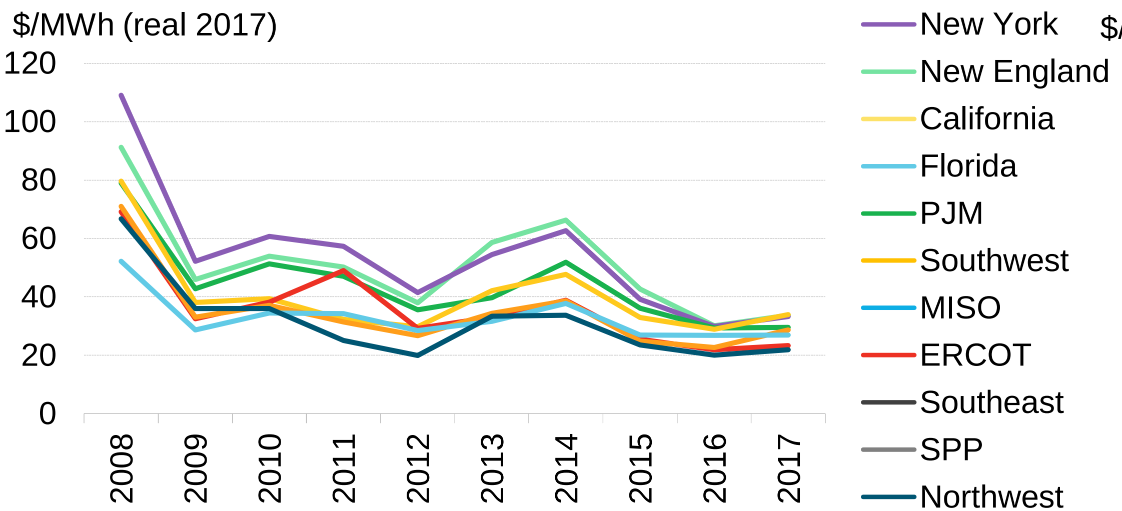


- U.S. GHG emissions are projected to be at their lowest levels since 1991, falling to an estimated 6.37GtCO2e in 2017. All told, total GHG emissions (excluding sinks) are approximately 13% below 2005 levels, or roughly halfway to the U.S.'s abandoned Paris Agreement target of 26% below 2005 levels by 2025.
- Total GHG emissions fell an estimated 1.4% year-on-year, following on the heels of a 1.9% decrease the year prior. The power sector has been a significant driver of the economy's decarbonization. In 2017, the power sector's footprint contracted further as renewable energy displaced coal and natural gas and electricity demand retreated modestly, pushing emissions down 4%. The sector's emissions now sit at roughly 28% below 2005 levels – only 4 percentage points away from the 2030 target of 32% below 2005 put forward in the Clean Power Plan.
- Transport emissions have continued to climb steadily, allowing the transportation sector to overtake power as the number one source of emissions for the first time in 2016. In 2017, transportation emitted an estimated 108MtCO2e more than the country's fleet of power plants.
- Federal progress on climate change has faltered: the Trump Administration announced its intention to withdraw from the Paris Agreement and rescinded the previous administration's regulation on power-sector greenhouse gas emissions, the Clean Power Plan.

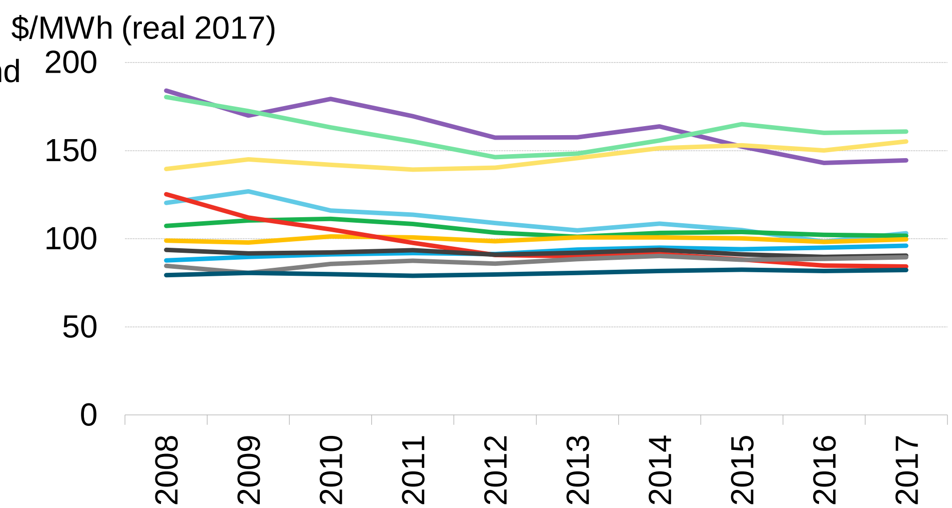
Source: Bloomberg New Energy Finance, EIA, EPA Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2015 Notes: "Sinks" refer to forests and green areas which absorb carbon dioxide. Values for 2017 are projected, accounting for seasonality, based on monthly values from EIA available through October 2017.

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

Wholesale power prices



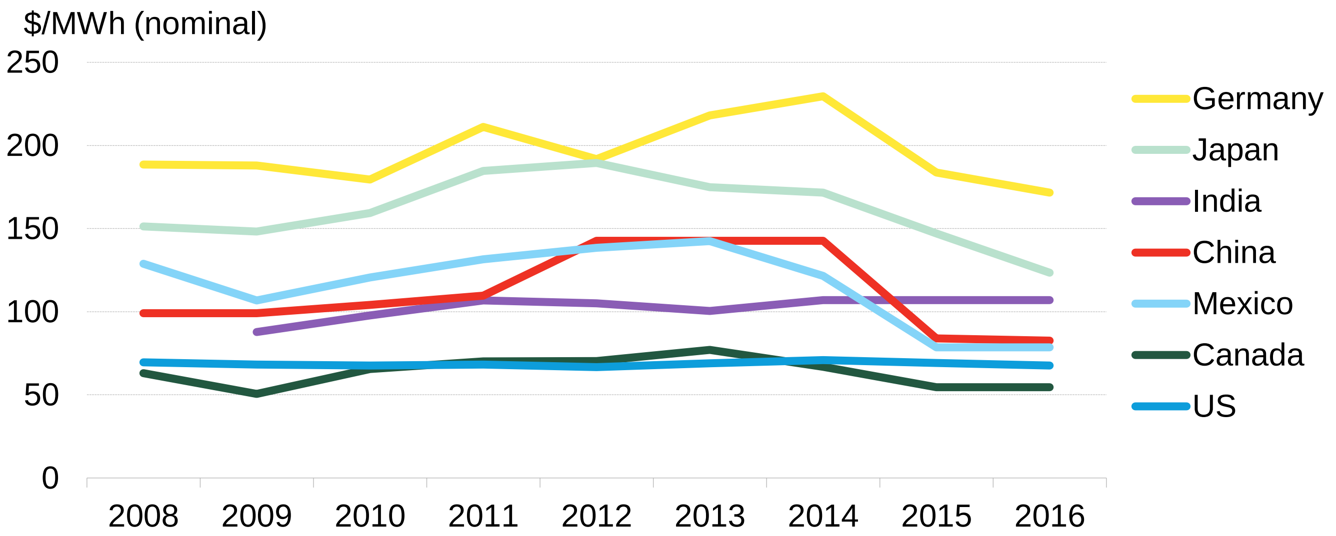
Average retail power prices



- Wholesale power prices remain historically low in real terms. However, they rebounded slightly in 2017 across most regions relative to 2016 levels, as the yearly average Henry Hub natural gas price picked up 18% to $2.96/MMBtu.
- Year-on-year, average wholesale prices rose as much as 27% in the Southwest and 17% in Northern California. ERCOT (Texas), PJM and MISO saw some of the smaller increases, at 6%, 0.9% and 0.6%, respectively.
- Retail price responses were more muted, as wholesale power prices do not directly translate to retail rates (for example, retail rates take into account wires costs, and in most regions they are set through a slow regulatory process). Prices rose by about half a percent in New England and the Northwest; around 1% in New York, MISO and the Southeast; 1.2% in SPP; 1.5% in the Southwest; 3.5% in California; 4.8% in Florida; and 6.4% in Alaska. PJM and ERCOT saw average prices ease down by 0.5% and 0.6%, respectively
- California has also switched end-users to time-of-use rates, which means rates will now vary throughout the day based on peak hours.
- Since their peak in 2008, average U.S. retail prices have come down 5.8% in real terms.

Source: Bloomberg New Energy Finance, EIA, Bloomberg Terminal Notes: Wholesale prices are taken from proxy power hubs in each ISO and are updated through end-2017. All prices are in real 2017 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 826. Retail prices are updated through end-October 2017. All prices are in real 2017 dollars.

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

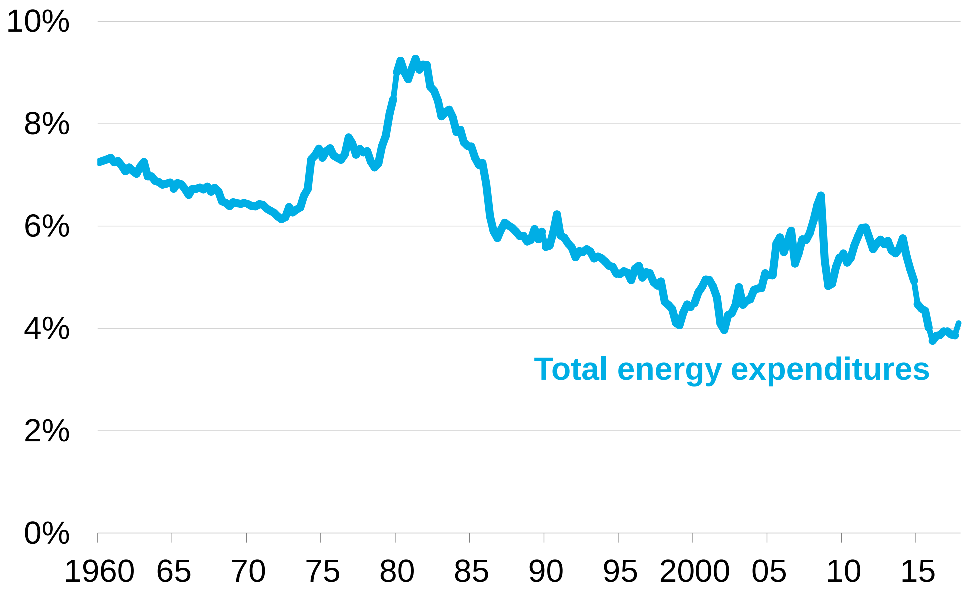


- The U.S. – and North America in general – has among the lowest electricity costs in the world for industrial customers. Among G-7 nations, the U.S, with an average price of 6.76¢/kWh in 2016, is second only to Canada.
- U.S. regions with the lowest costs of power include the Midwest, Southwest and Northwest.
- The steep power price declines in Mexico and China in 2015 are to a large extent due to the depreciation of their currencies against the U.S. dollar. Similarly, the weakening of the Indian rupee over the past year has limited the extent of India's power price increase when represented in USD (as the chart above does).
- Japanese power prices for commercial and industrial customers plunged in 2016, thanks to lower commodities prices and nuclear restarts. Additionally, the liberalization of residential electricity provision also had the spillover effect of driving up competition among C&I electricity providers, where competition had previously been more limited even though it was legally permitted.

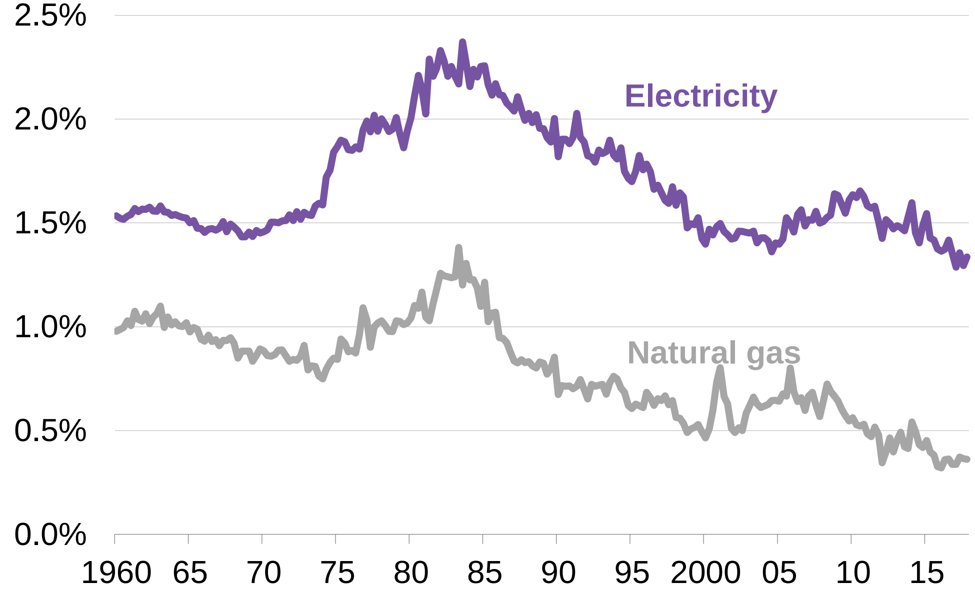
Source: Bloomberg New Energy Finance, government sources (EIA for the U.S.) Notes: Prices are averages (and in most cases, weighted averages) across all regions within the country. Japanese data is for the C&I segment and 2016 figures come from a different source than preceding years.

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

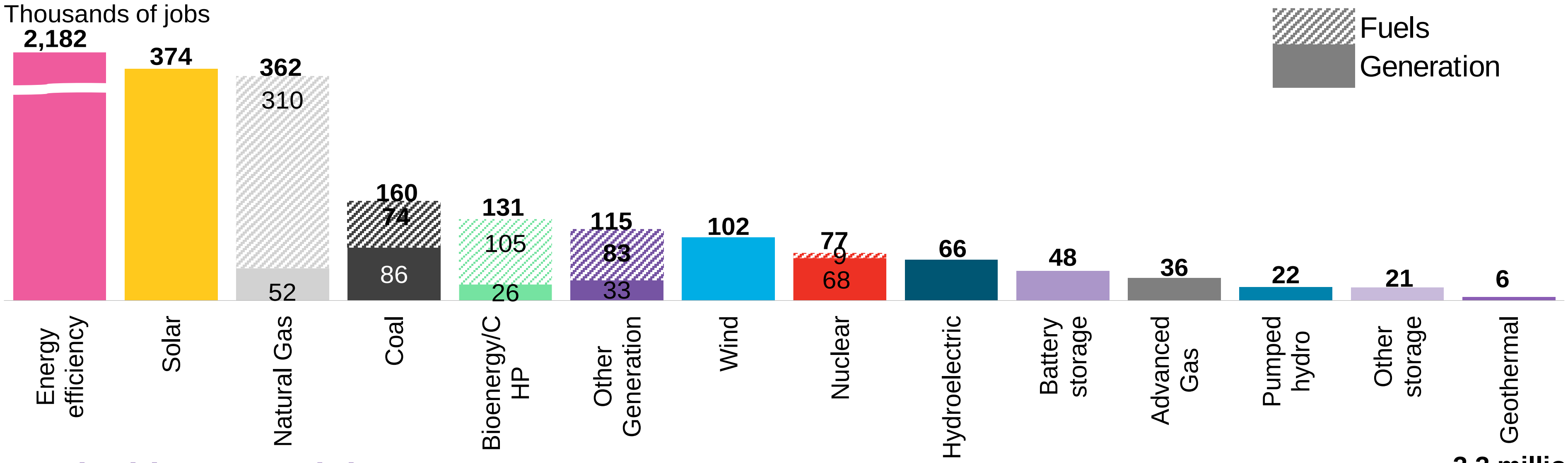


- Energy spending remains below 4% of total U.S. personal consumption expenditures.
- Year-on-year, the energy share of spending held roughly the same, near 3.9%, according to early estimates. A dip in the electricity share of spending was counterbalanced by a minor rebound in the portion of spending devoted to non-electricity, non-gas energy costs (e.g., gasoline and other motor fuels).
- The amount spent by consumers on electricity in the U.S. has fallen every year since 2014, even as total personal expenditures climbed. As a result, the *share* of personal consumption expenditures devoted to electricity has also shrunk. It dipped marginally again in 2017 to 1.3%, from 1.4% in 2016.
- Falling fuel costs and greater efficiency likely contributed to this trend.

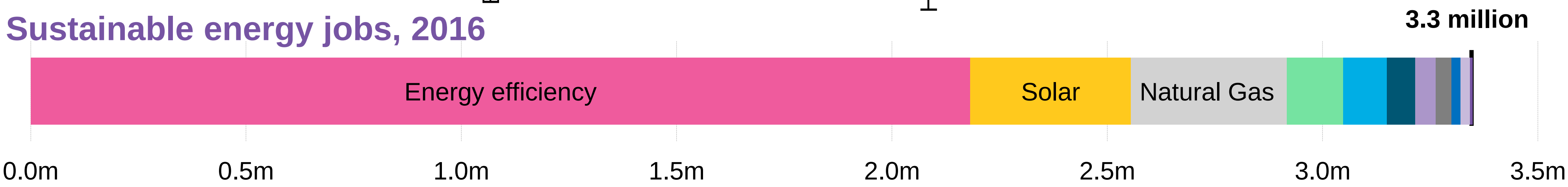
Source: Bureau of Economic Analysis, BNEF

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

Jobs in select energy segments, 2016



Sustainable energy jobs, 2016

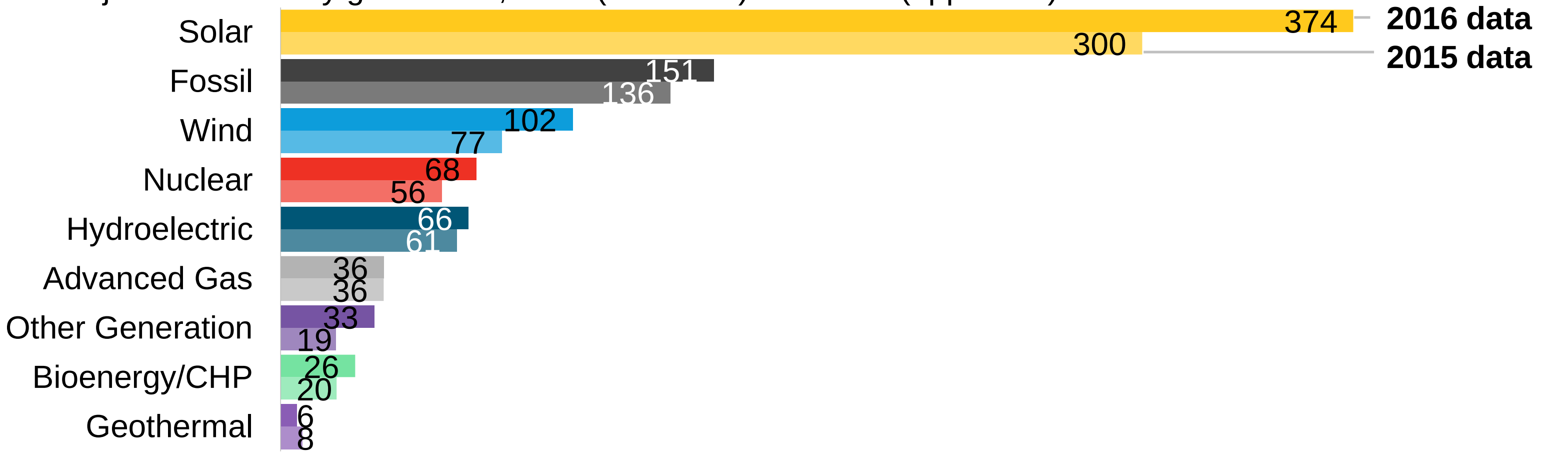


- The renewable, energy efficiency, and natural gas sectors employed an estimated 3.3 million Americans in 2016, according to the Department of Energy. Energy efficiency alone supported 2.2 million jobs, while solar supported roughly 374,000 and natural gas 362,000.
- While renewable sectors like solar, wind, hydropower and geothermal do not require upstream processing or extraction of a fuel, fossil-fired generation does. Adding in these fuel-related jobs notably boosts the total employment by fossil fuel-fired generation and bioenergy. In 2016, 86% of the 362,000 jobs associated with the natural gas sector came from fuel supply. Coal employed 160,000, with about half in coal production and supply.
- Energy efficiency jobs related to construction often hire people who also work on other types of construction tasks (26% of the 1.4 million employees in this category spend only the minority of their time on efficiency).

Source: Department of Energy (DOE) Notes: 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."

U.S. energy overview: Jobs in electricity generation

Thousands of jobs in electricity generation, 2015 (lower bar) and 2016 (upper bar)[1]



- The graph above describes employment within electricity *generation* (excluding upstream fuel extraction). The solar sector is the single largest employer in electricity generation for 2016, supporting an estimated 373,807 jobs according to the Department of Energy. Fossil fuels (coal, gas, and oil combined) was the next largest category at 151,000,[1] followed by wind with 101,738.
- Solar also added more electricity generation jobs from 2015 to 2016 than any other source. Over the year, solar employment grew by an estimated 73,615. Wind came in second place, adding 24,650 jobs. Both outstripped jobs growth in electricity generation from fossils, which climbed by about 15,102.[1]
- The strength of the solar jobs base comes partly from the labor-intensive nature of the sector, and also from the boom in solar build.
- Solar employees often work part-time in other sectors. Of the 300,192 solar industry employees counted by the Department of Energy in Q1 2016, around 30% spent the majority of their time employed in other, non-solar sectors.
- The growth in wind jobs for 2016 came on the back of strong build numbers, which hit 8.4GW that year. 2016 marked the largest year for wind capacity additions since 2012, when developers rushed to commission projects before the then-expected expiration of the Production Tax Credit (PTC).

Source: Department of Energy (DOE) Notes: 1-The graph does not separate fossil fuels into coal, gas, and oil, because this breakdown was provided for 2016 but not for 2015. To see how jobs for coal, gas, and oil stood individually for 2016, see previous slide. 2015 data is from 2Q 2015, and 2016 data is from Q1 2016. "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.

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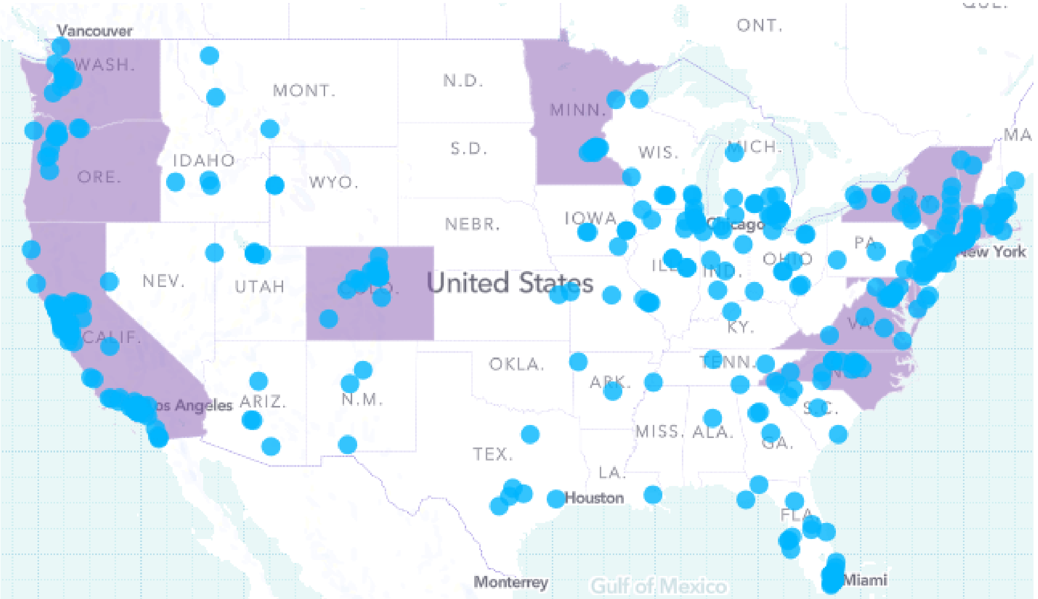
Policy (1 of 5) : COP 21 withdrawal, "We Are Still In" and other reactions

State members of the U.S. Climate Alliance and city members of Climate Mayors

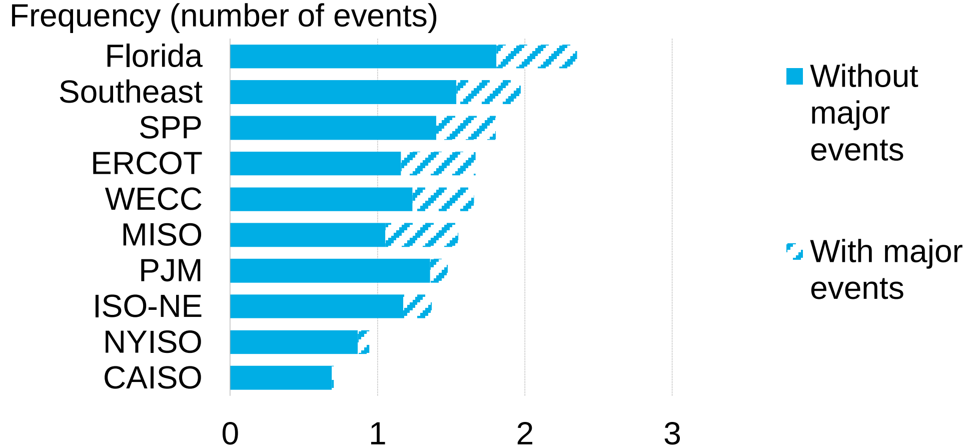


- President Trump, on June 1, 2017, announced his intention to withdraw the U.S. from the COP 21 Paris Climate Accord, calling it "an agreement that disadvantages the United States to the exclusive benefit of other countries."
- Many business and political leaders disagreed with the Administration's decision, arguing that it abdicated American leadership on climate and threatened the country's competitiveness in a low-carbon economy.
- Sixteen governors representing jurisdictions covering over 40% of the U.S. population joined the U.S. Climate Alliance (shown above, in purple). The existing U.S. Climate Mayors' group expanded to 383 cities (in blue) covering 23% of the U.S. population—half of which are in states not associated with the Climate Alliance.
- Additionally, more than 2,642 mayors, governors, CEOs, college presidents, faith organizations, and tribal leaders responded by forming "We are Still In," a movement that pledges ongoing commitment to the Paris Accord's goals. A related group, America's Pledge, is tracking these commitments and attempting to measure their impact. According to its initial accounting, these sub-national pledgees account for 2.7Gt in emissions. For comparison, U.S. emissions totaled an estimated 6.4Gt estimated in 2017.

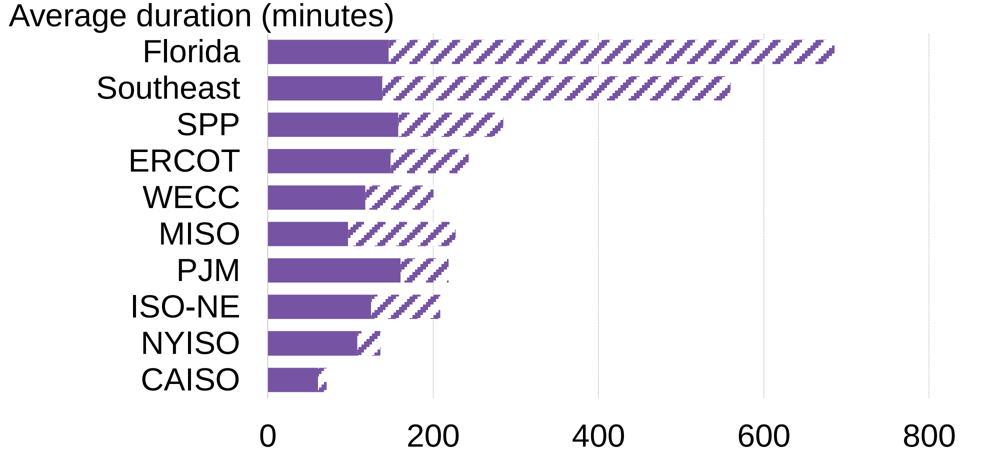
Source: Bloomberg Terminal, We Are Still In, America's Pledge, Climate Mayors, U.S. Climate Alliance, Simple Maps Note: Hawai'i and Puerto Rico have also pledged to the Climate Alliance but are not visible in the map above. Other state members not clearly visible include Massachusetts, Maryland, Rhode Island, Vermont and Delaware.

Policy (2 of 5): Department of Energy grid study on reliability and resilience

Average frequency of electric power service interruptions per customer (2016)



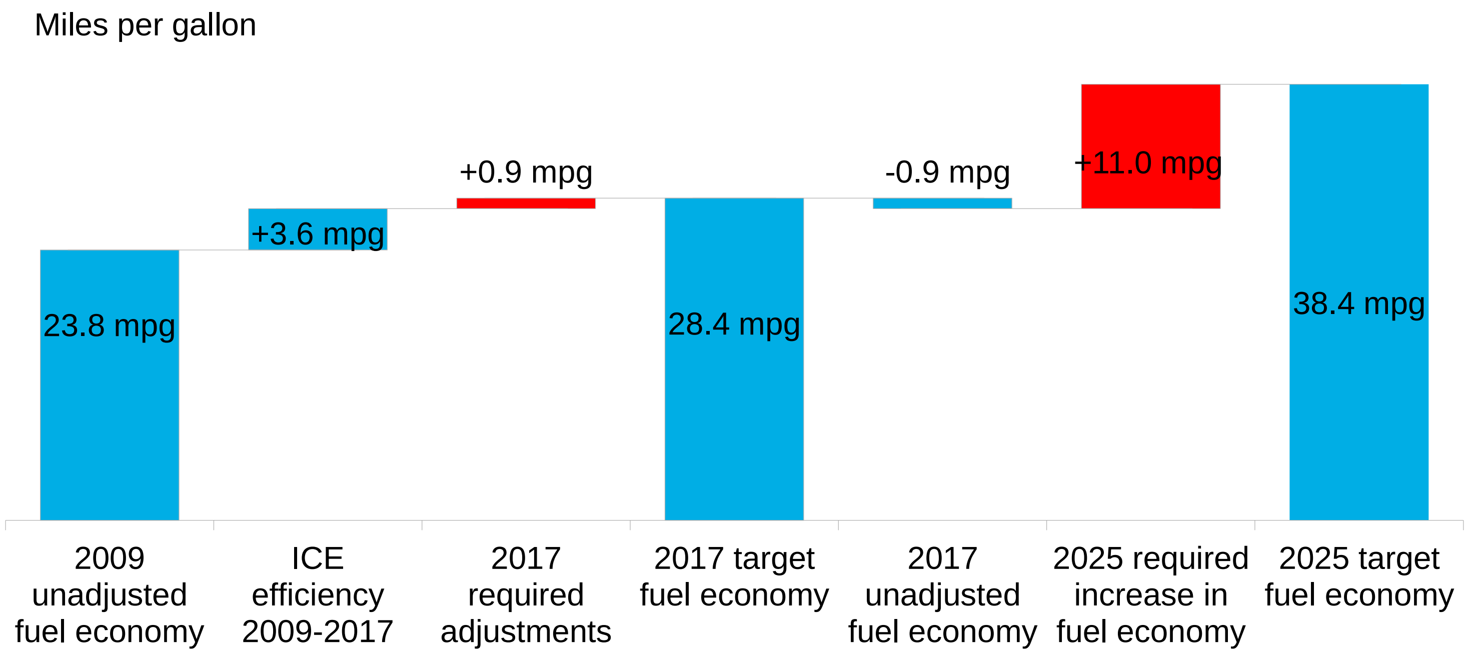
Average duration of electric power service interruption (2016)



- In August 2017, the Department of Energy issued a grid study concluding that generators capable of providing "essential reliability services," as well as resilience, to the grid should be compensated for these services. On the back of the report, Energy Secretary Rick Perry asked the Federal Energy Regulatory Commission (FERC) to launch an expedited rulemaking to provide cost recovery for "secure fuel" generators with 90-day fuel supplies on hand. Most coal and nuclear facilities meet that criterion; wind, solar and natural gas plants do not. The rule focused on plants in competitive wholesale power markets, as opposed to regulated power regions such as the Southeast.
- In January 2018, FERC refused to proceed with such a rulemaking, finding insufficient evidence that either on-hand fuel supplies or other criteria presented by Perry were satisfactory indicators of resilience. Instead, it asked regional grid operators to examine resilience within their systems.
- The Department of Energy grid study had noted that wholesale power markets have, to date, ensured reliability, despite pressures created by growing natural gas penetration, flat demand, and policy interventions (including renewables support); however, the study also questioned whether the grid would remain resilient in the face of future challenges.
- EIA power outage data suggest that two regulated power regions, Florida and the Southeast, topped 2016's list in terms of the frequency of outage events (a measure of grid reliability). This is the case both when accounting for and when excluding the impact of major disruptive events (e.g., weather-related events such as hurricanes or heatwaves, and man-made disruptions such as cyber attacks). SPP and ERCOT ranked third and fourth, respectively, when accounting for major events.
- Florida and the Southeast also topped the list in terms of the average duration of outages during major disruptive events. This is likely driven by the greater impact of hurricanes on these two regions compared to the rest of the U.S. Removing major events, PJM and SPP endured the longest average outages (around 160 minutes).
- A number of factors, including customer density, the length of power lines, the makeup of the fleet, tree density, and how utilities define "major events" can all affect these measures of how frequently each region experiences outages, and how long they last.

Source: EIA, IEEE, BNEF

Policy (3 of 5): U.S. vehicle fleet fuel economy standards



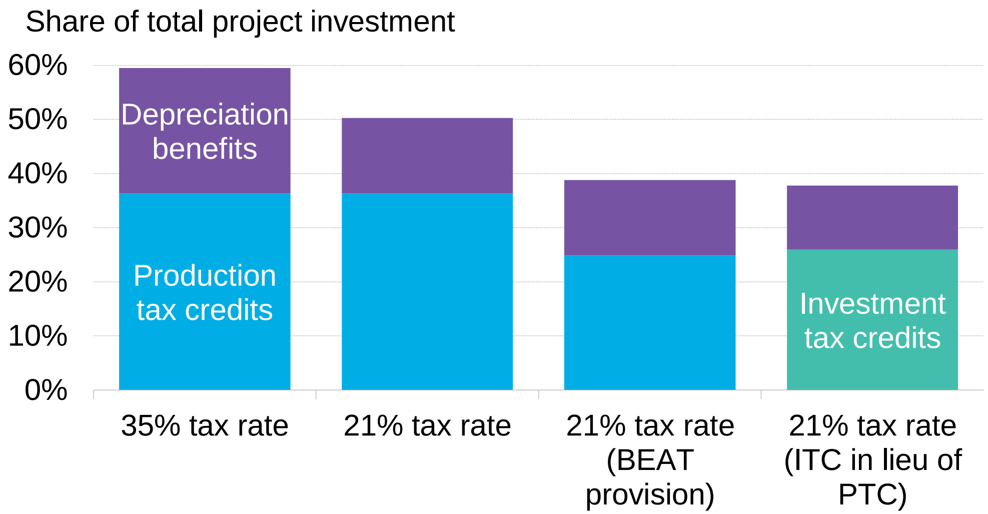
- Fuel efficiency for vehicles with internal combustion engines (ICE) has improved in order to meet increasingly strict federal and state emissions standards, the main federal example being the Corporate Average Fuel Economy (CAFE) rule. Historically, cars have kept pace with CAFE standards. But in recent years, record-setting sales of less fuel-efficient trucks and sport utility vehicles have closed the outperformance gap.
- For 2025, cars (as opposed to trucks) are expected to reach an average fuel efficiency of 38.4 miles per gallon. This can occur through a combination of ICE efficiency improvements and other adjustment mechanisms such as regulatory credits and selling more alternative fuel vehicles.
- President Trump has ordered EPA to reconsider the most stringent standards, covering model years 2021-2025.

Source: BNEF, National Highway Traffic Safety Administration. Note: “ICE” stands for internal combustion engine.

Policy (4 of 5): Tax reform

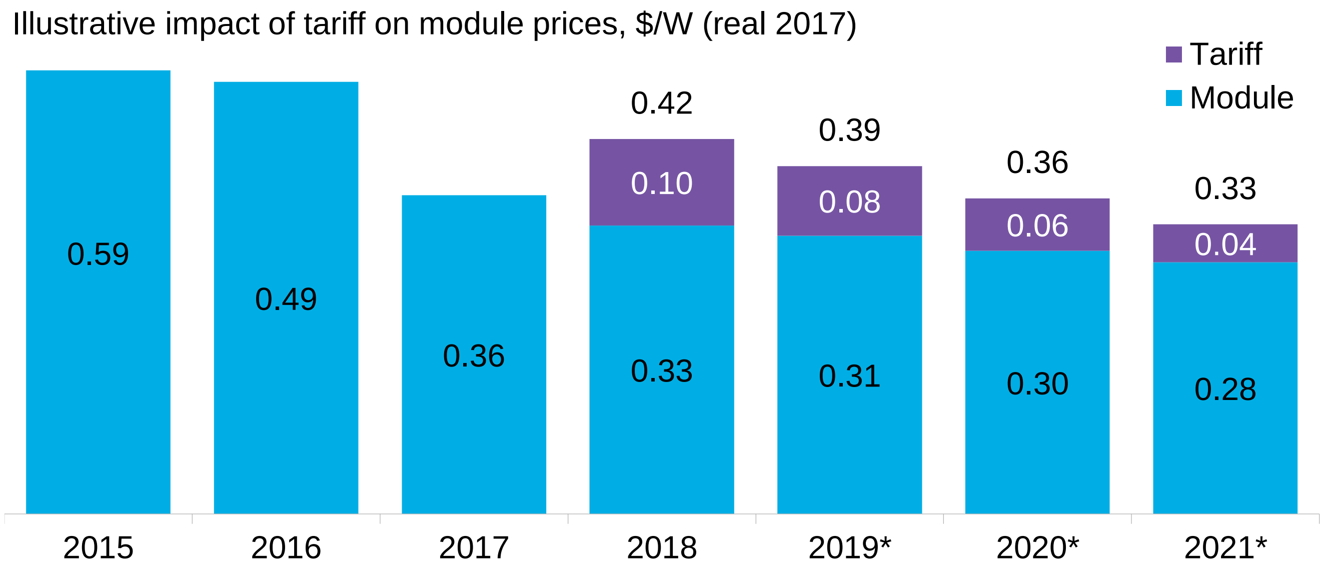
- In late 2017, President Donald Trump signed into law new tax legislation that preserved key tax subsidies for renewables and electric vehicles.
- The new tax law cuts corporate taxes from 35% to 21%. That raises after-tax earnings for renewable projects but also reduces the tax liability of major corporations that had used tax equity to offset that liability.
- Similarly, lower tax rates also reduce the value of depreciation, because each dollar of depreciation will produce a credit of no more than 21% as opposed to the previous 35%.
- Further, the reduced tax rate frees up utility dollars for infrastructure investments or to be passed back to consumers through lower retail electricity rates, since the lower tax rate cuts the amount utilities needed to set aside for future tax payments.
- The tax law also allows 100% expensing of most capital expenditures in the year they are made. That provision could be a boon for providers of long-lived products such as energy-saving building materials and technology.
- The new law allows filers that are subject to a minimum tax on foreign transactions, known by the acronym BEAT, to use 80% of the value of the clean energy Investment Tax Credit (ITC) and Production Tax Credit (PTC) to offset BEAT. This 80% offset mitigates BEAT's negative impact on tax-equity appetite.
- Some of the new law's provisions expire in 2025, an event that will impact wind projects in the pipeline today (due to the 10-year lifespan of the PTC) more than solar (the ITC is claimed in the project's first year).
- The BEAT provision leaves many tax equity providers uncertain of their tax exposure until the end of the tax year, which also means they are uncertain of the value they can gain by pursuing tax credits.
- In February 2018, Congress passed the Bipartisan Budget Act. The law gave a one-year, retroactive extension to incentives for non-wind PTC technologies (biogas, biomass, waste to energy, active geothermal, hydropower, and marine and hydrokinetic) as well as several energy efficiency measures. It also gave five-year extensions, with phase-outs, to several non-solar ITC technologies (fiber-optic solar, microturbines, fuel cells, combined heat and power, and small wind). Further, the law lifted the in-service deadline for nuclear plants to qualify for the nuclear production tax credit, and expanded credits for carbon capture and sequestration (CCS).

Estimated U.S. wind project tax equity investment share



Source: BNEF

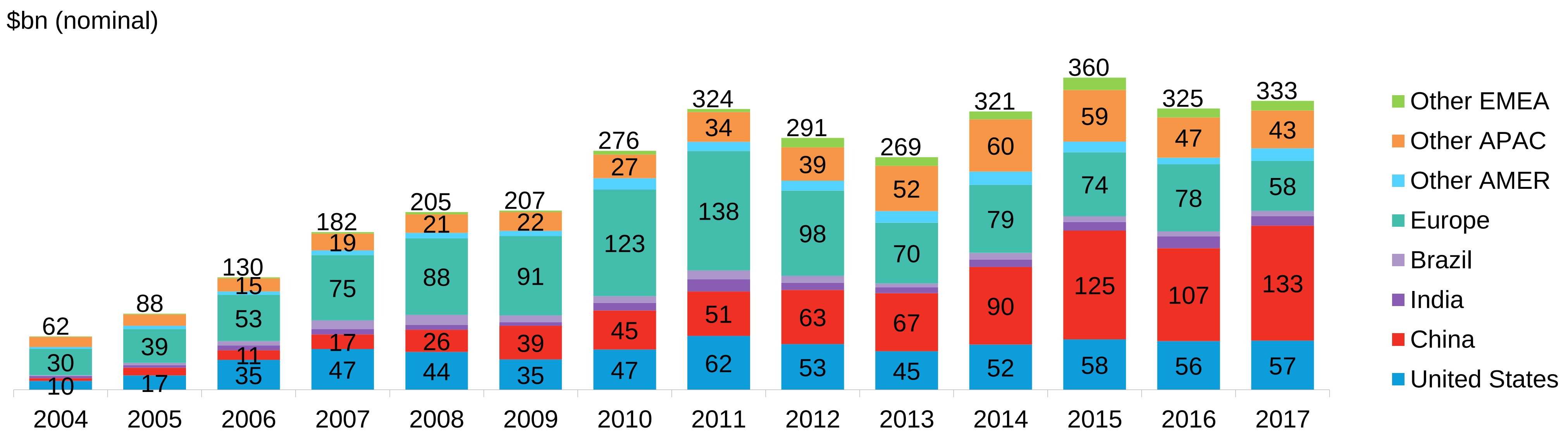
Policy (5 of 5): Trade policy



- President Trump in late 2017 began exploring in earnest how to make good on his campaign promise to renegotiate the North American Free Trade Agreement (NAFTA) with Canada and Mexico. The U.S. imports substantial hydroelectric power from Canada and is a major source of natural gas for Mexico.
- On January 23, 2018, Trump levied a 30% import duty on imported solar PV modules and cells, which will raise a module's 2018 landed price by about 10¢/W and raise all-in project costs by an estimated 4-10% in the first year. The tariffs phase down by 5% annually through 2021 (expiring thereafter), and also come with a 2.5GW annual exemption for cell imports.
- The president also has questioned the benefits to the U.S. of free trade with the European Union. Taken together, his words and actions raise the risk of retaliatory action by longtime U.S. trading partners.

Source: BNEF Note: 2019-21 prices are illustrative.

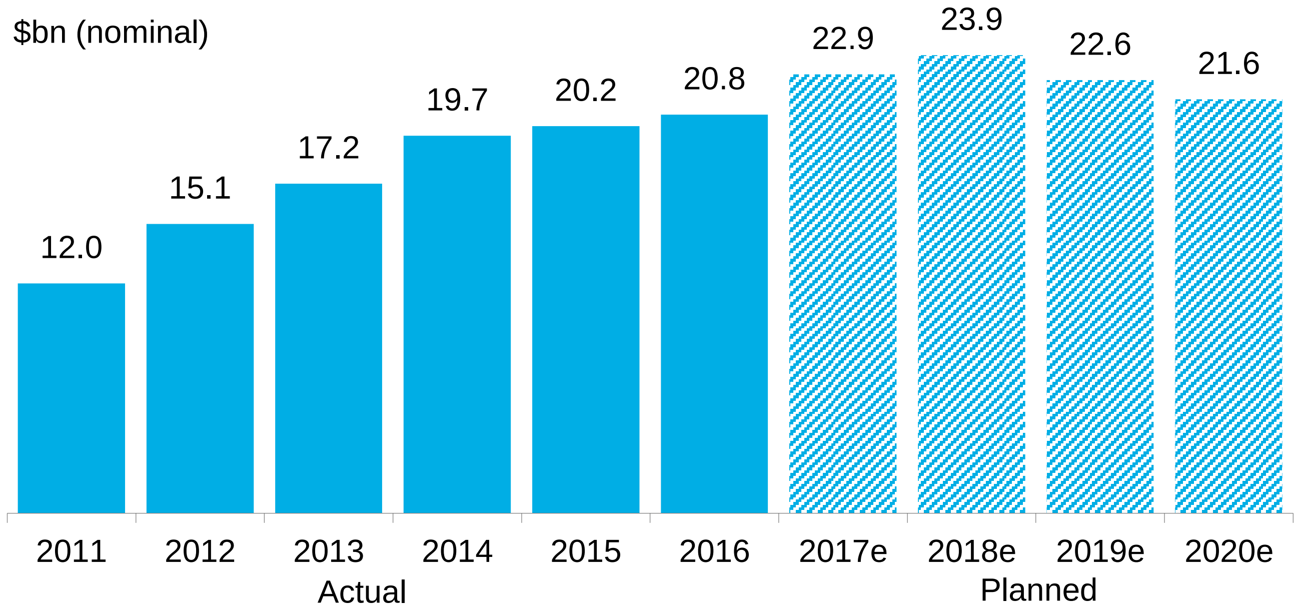
Finance: Total new investment in clean energy by country or region



- Global investment in clean energy hit $333.5 billion in 2017, the second highest after the $360 billion invested in 2015. This represented a 3% increase from 2016 investment levels.
- The jump came as Chinese investment leapt 24% year on year, following a 14% dip in 2016. Chinese clean energy investment made up 40% of the global total in 2017. European investment, on the other hand, dropped by 26%.
- Solar was the largest single recipient of investor dollars in 2017. Financing in this segment rose 18% year on year to $161 billion, even though the cost of the average utility-scale PV system actually shrank by around 25%.
- U.S. clean energy investment, which took second place after China's, held its ground at $57 billion despite a turn towards a less favorable domestic policy atmosphere.

Source: Bloomberg New Energy Finance 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. AMER is Americas; APAC is Asia-Pacific; EMEA is Europe, Middle East, and Africa.

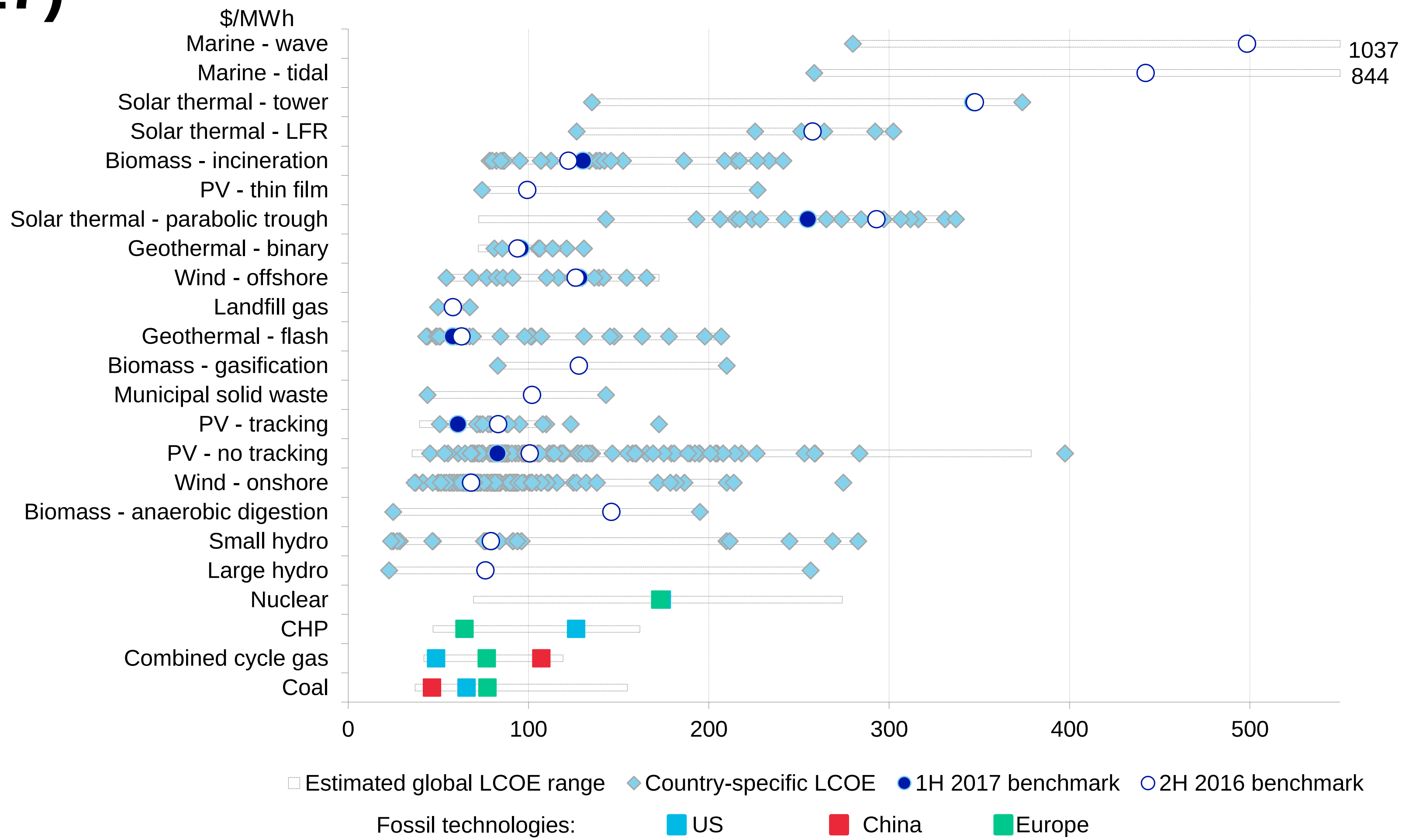
Finance: U.S. transmission investment by investor-owned utilities and independent transmission developers



- Investor-owned utilities and independent transmission developers spent an estimated $20.8 billion on electric transmission in 2016, a new high. This is up 3% from 2015.
- Based on company reports, investor presentations and a survey conducted by the Edison Electric Institute (EEI), transmission investment is likely to grow 10% in 2017 to $22.9 billion. Current capex plans suggest that investment will peak at $23.9bn in 2018; however, because 2018-2019 budgets are not yet finalized, these numbers may be revised upwards.
- The upswing in transmission investment is motivated 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.

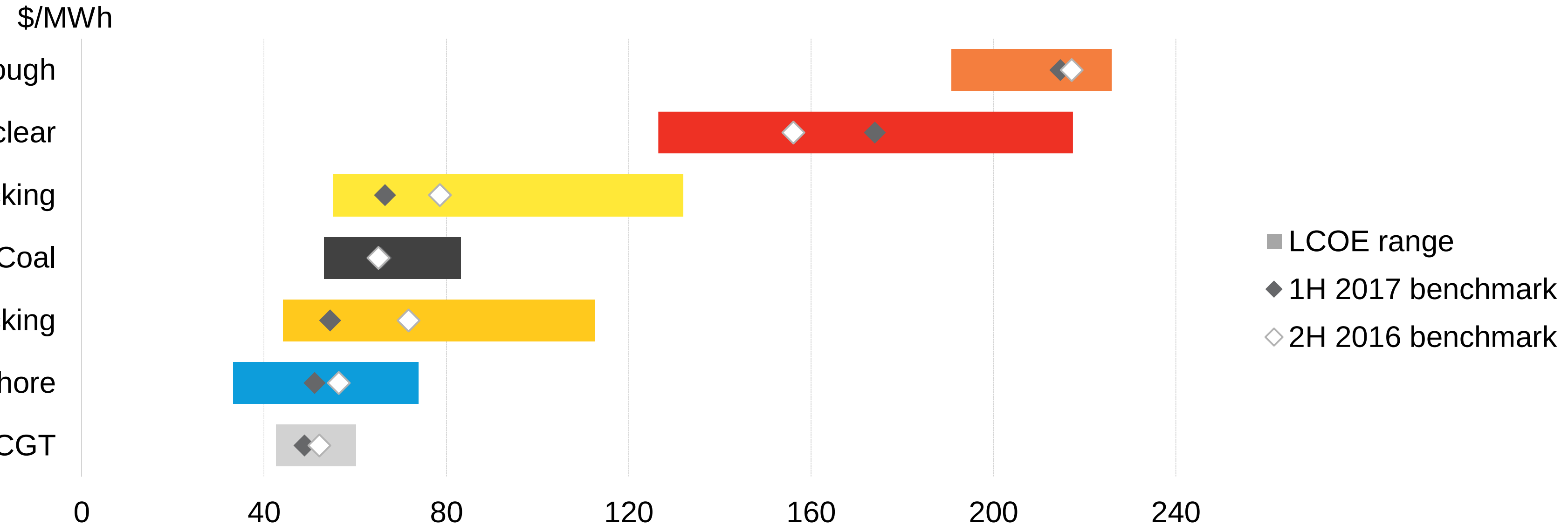
Source: Edison Electric Institute (updated September 2017)

Economics: Global levelized costs of electricity (unsubsidized for new build, 1H 2017)



Source: Bloomberg New Energy Finance Notes: LCOEs do not account for the impact of the 2017 tax reform in the U.S. LCOE is the per-MWh inflation-adjusted lifecycle cost of producing electricity from a technology assuming a certain hurdle rate (i.e., after-tax, equity internal rate of return, or IRR). The target IRR used for this analysis is 10% across all technologies. All figures are derived from Bloomberg New Energy Finance analysis, based on numbers derived from actual deals (for inputs pertaining to capital costs per MW) and from interviews with industry participants (for inputs such as debt/equity mix, cost of debt, operating costs, and typical project performance). Capital costs are based on evidence from actual deals, which may or may not have yielded a margin to the sellers of the equipment; the only 'margin' that is assumed for this analysis is 10% after-tax equity IRR for the project sponsor. The diamonds correspond to the costs of actual projects from regions all over the world; the hollow circles correspond to "global central scenarios" (these central scenarios are made up of a blend of inputs from competitive projects in mature markets). For nuclear, gas, and coal, the light blue squares correspond to U.S.-specific scenarios. "CHP"" stands for combined heat and power; "LFR" stands for linear Fresnel reflector. EIA is the source for capex ranges for nuclear and conventional plants.

Economics: U.S. levelized costs of electricity (unsubsidized for new build, 1H 2017)

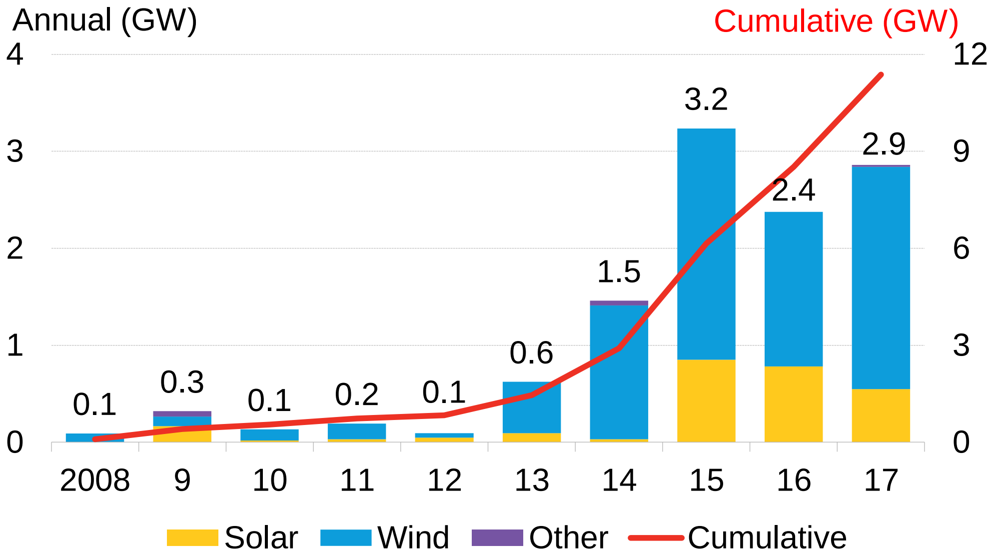


- New solar PV plants can now undercut new coal build on a levelized cost of energy (LCOE) basis in the U.S. The benchmark LCOE for a solar system with tracking was estimated at $54/MWh for 1H 2017, whereas coal came in at $66/MWh. Capex reductions drove a $17/MWh drop in the levelized cost estimate for solar with tracking since 2H 2016.
- Meanwhile, growing renewable energy penetration and coal-to-gas switching continue to limit the average capacity factor expected for new coal-fired power plants, helping to limit any levelized cost reductions.
- Combined-cycle gas remains one of the cheapest sources of new generation in the U.S., with benchmark projects achieving levelized costs of $49/MWh.
- New onshore wind projects constructed in areas with strong wind resources can achieve LCOEs as low as $33/MWh, beating out even cheap natural gas build.

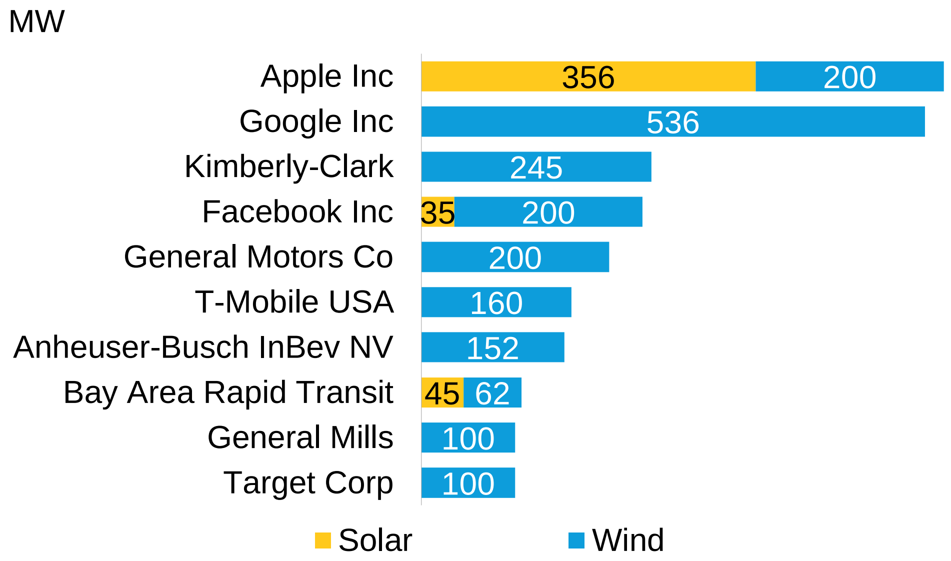
Source: Bloomberg New Energy Finance   Note: LCOEs do not account for the impact of the tax reform in the U.S. "CCGT" stands for combined cycle gas turbine. See previous slide for further notes regarding methodology.

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

Renewable capacity contracted by corporations, by technology



Largest corporate offtakers, 2017



- Corporate PPA volumes rose to 2.9GW in 2017, up from the 2.4GW signed in 2016. Sustainability continues to drive activity in the U.S., although many large corporations have met their medial targets domestically and are now looking to sign deals internationally.
- Power prices continue to remain low across the U.S., and are further depressed during hours of high wind in markets like ERCOT and SPP, and when solar generates in CAISO. This has left many PPAs underwater, and corporations are now targeting wholesale markets with lower existing renewable penetration, like MISO and PJM.
- Apple contracted 0.56GW of U.S. clean energy in 2017, more than any other corporation. It signed the largest PPA ever in the U.S. between a corporation and a utility – a 235MW PV plant with NV Energy under the utility's GreenEnergy Rider. Google signed PPAs for 0.54GW, en route to offsetting 100% of its global electricity demand. Kimberly-Clark, T-Mobile, General Mills and Cummins all signed their first PPAs in 2017.
- Green tariff programs made up 19% of corporate procurement activity in 2017, as companies are increasingly looking to source clean energy within the same service territory as their load. These programs are offered by utilities in 12 states, with one more state pending.

Source: Bloomberg New Energy Finance   Note: Charts show offsite PPAs only

Bloomberg New Energy Finance

Finance: Corporate procurement of clean energy and energy efficiency

Key players: corporate clean energy procurement

Retail	Groupe L'Occitane, Burberry
Financial & Insurance	Morgan Stanley, JPMorganChase, citigroup
Tech	Philips, ebay, Askul
Food & Beverage	Kellogg's, Carlsberg Group, ABInBev

Key players: corporate energy efficiency

Manu-facturing	covestro, Dalmia Bharat Group, Danfoss, Johnson Controls
Automotive	Mahindra, Detroit, Volvo
Retail	H&M, Woolworths
Financials	Landsec, Swiss Re

- Corporations are continuing to make commitments to purchase clean energy. Through 2017, 119 companies have pledged to source 100% of their energy consumption from renewables by signing onto the "RE100" initiative; 34% of these firms are domiciled in the U.S. Financial, consumer staples and technology companies are the most common signees. 35 companies from nine countries joined the RE100 in 2017.
- ISO 50001, an energy management systems standard for reducing costs and carbon emissions, has become increasingly popular with U.S. corporations. Companies and institutions that had buildings certified for ISO 50001 in 2017 include Dairygold, the Ogden Air Logistics Complex and Kingspan Group.
- The EP100, an initiative run by The Climate Group where companies pledge to double their energy productivity, continues to gain momentum. 13 companies have signed onto the EP100, including H&M, Landsec, Johnson Controls and Swiss Re.

Source: Bloomberg New Energy Finance, The Climate Group, company announcements, DOE. Note: The key corporate energy efficiency players displayed here are drawn from EP100 members and the list of ISO 50001 certified facilities. ISO 50001 certification means that a company has met established efficiency standards at one or more of its facilities. Corporate clean energy procurement key players are companies that signed onto the RE100 in 2017.

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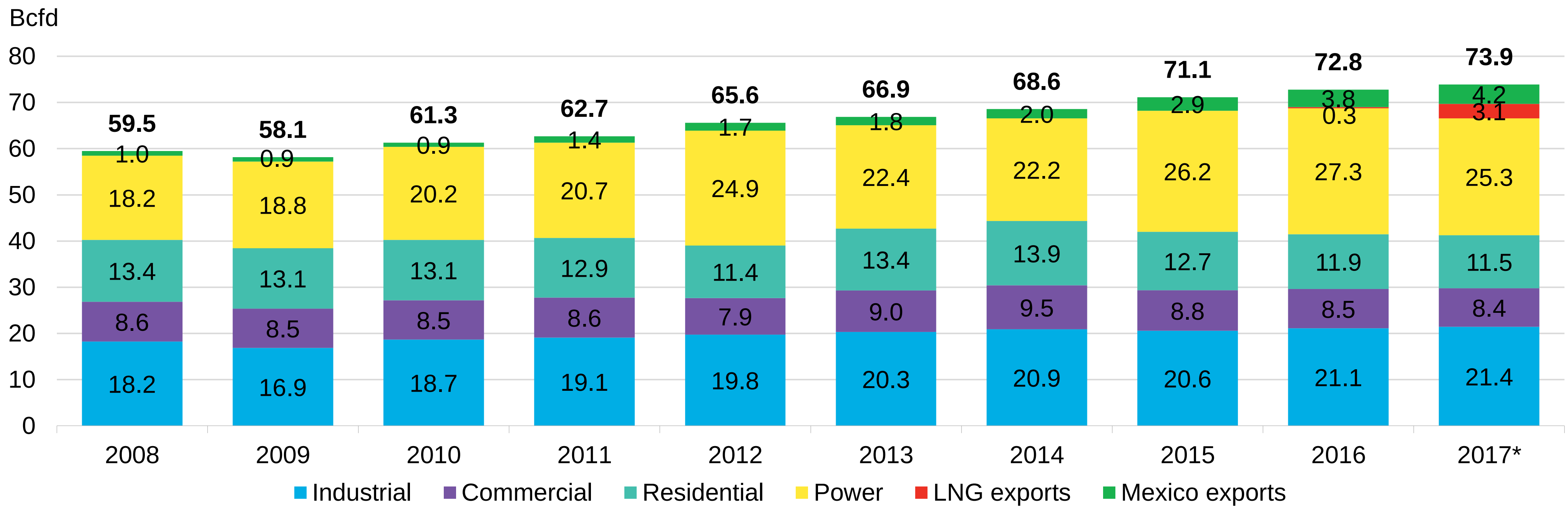
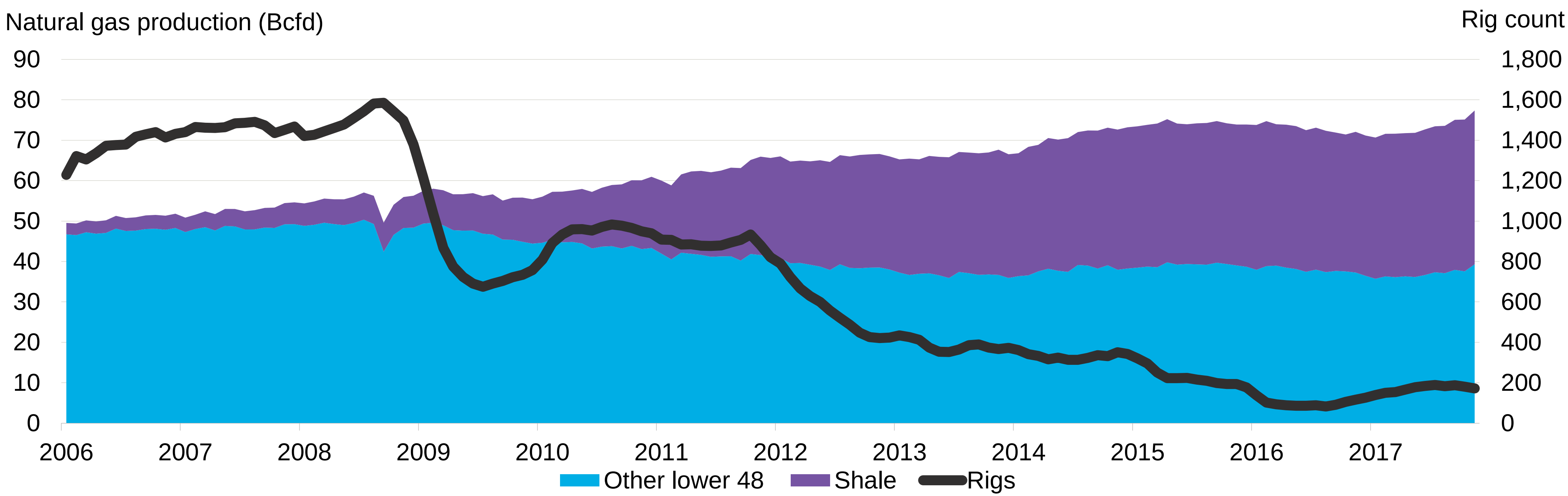
Deployment: U.S. natural gas demand by end use



- Total U.S. annual gas demand has grown 24% over the past decade, and is up 1.5% year-on-year in 2017.
- The growth occurred despite a decline in power sector demand, which dipped an estimated 7.2% compared to 2016 as renewable generation including hydropower climbed. Demand from the residential sector also shrank 3.5% over the same time period, as 2017 was warmer than 2016, resulting in less heating demand, particularly in the first ten months of the year. Overall, domestically, natural gas is estimated to have contributed 29% of the U.S.'s total primary energy consumption in 2017.
- While domestic demand fell year on year, foreign demand grew significantly. Pipeline exports to Mexico increased 11.5% and LNG exports rose ten-fold (2017 was the first *full* year of activity for the contiguous U.S.'s first LNG export terminal, Sabine Pass). In 2017, foreign demand accounted for 10% of total U.S. gas demand.

Source: Bloomberg New Energy Finance, EIA Note: Values for 2017 are projected, accounting for seasonality, based on latest monthly values from EIA (data available through October 2017).

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

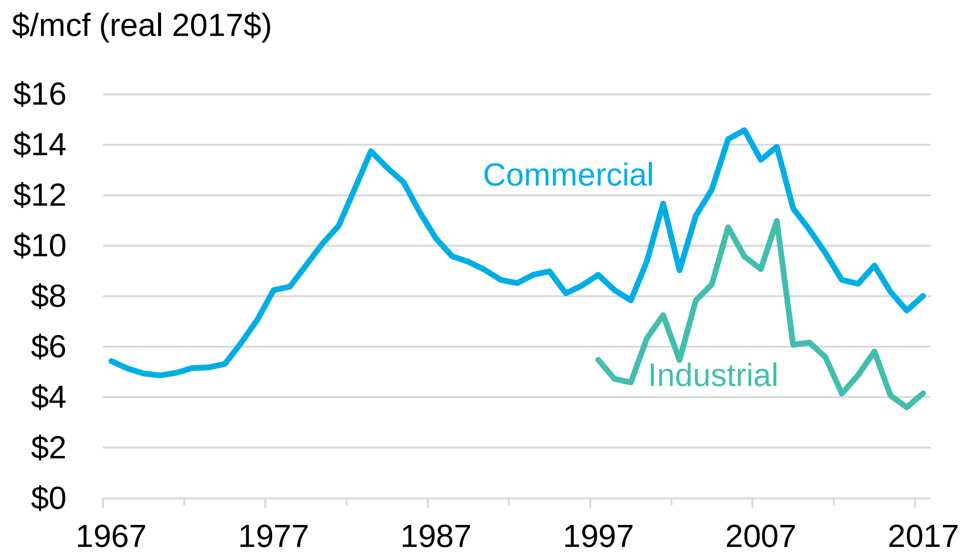


- Gas production has become more efficient since around 2009. Between September 2008 and November 2017, the U.S. gas-directed rig count collapsed nearly 90% from a monthly average of 1,585 to 172. But at the same time, total production rose 56%, driven by the explosive growth in shale gas production.
- In 2017, the gas-directed rig count rebounded as gas prices picked up, and infrastructure build-out promised to allow more gas to exit the Marcellus region and reach demand centers. Recent gas production has also been buoyed by the growing amount of associated gas generated as a byproduct of oil production.

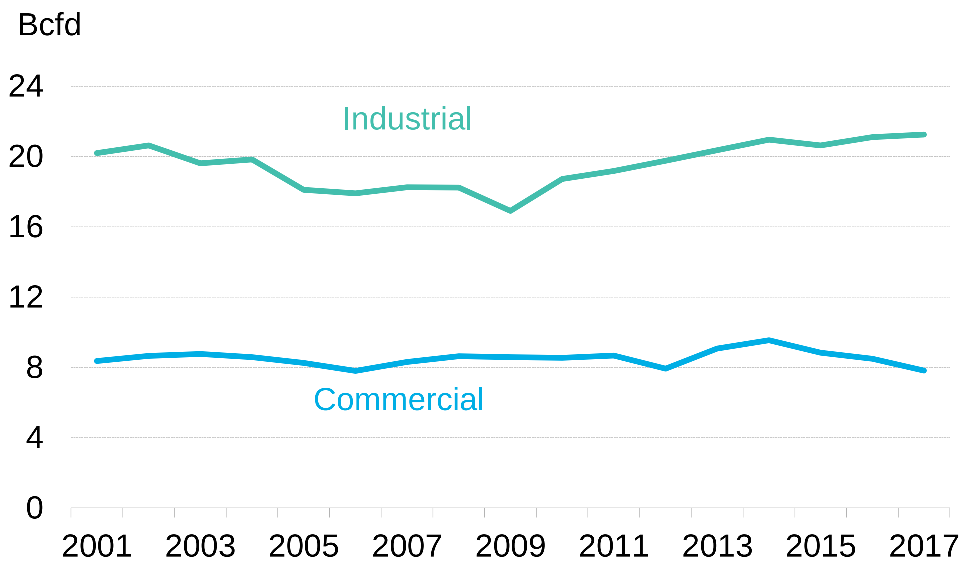
Source: Bloomberg Terminal, EIA, Baker Hughes

Deployment: Natural gas supplies to commercial, industrial sectors

Natural gas prices to commercial customers



U.S. natural gas industrial consumption

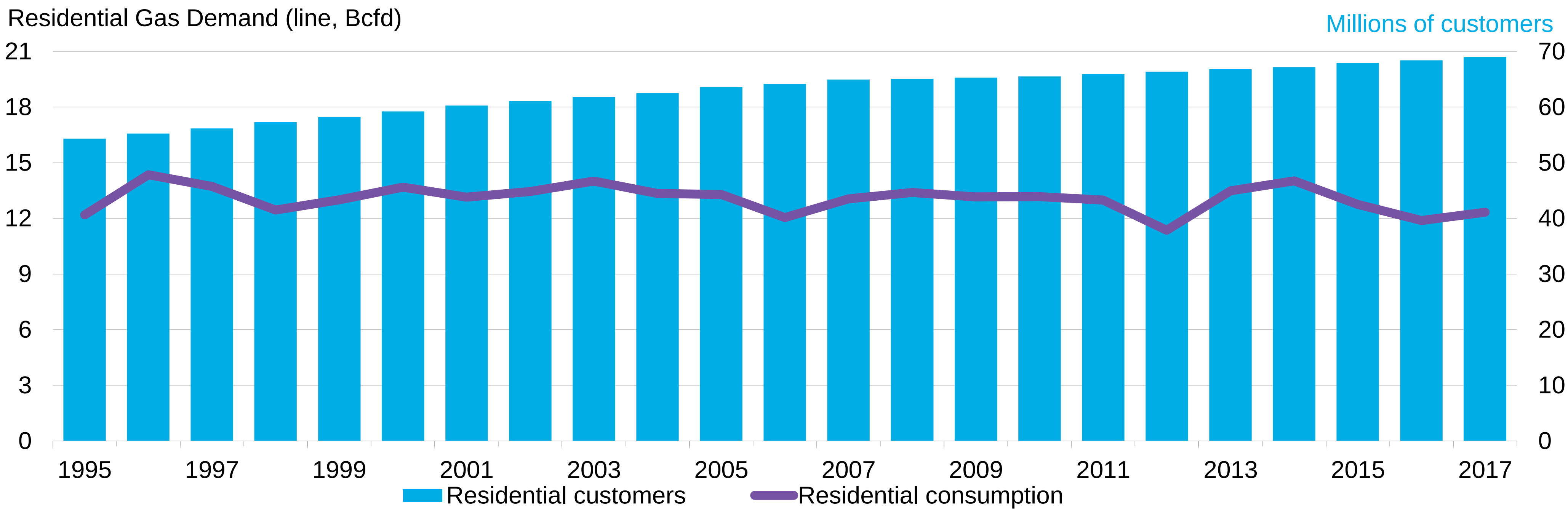


- Expanding U.S. gas production has pushed down the gas prices faced by industrial and commercial users by 62% and 42%, respectively, over the last 10 years. However, both these customer groups experienced a slight price uptick in 2017, with prices to the commercial sector up to $8.01/mcf from $7.43/mcf in 2016, and the industrial sector up to $4.15/mcf from $3.59/mcf (all in real 2017 dollars). Nevertheless, the last two years offered some of the lowest prices on record.
- The shale boom began pushing down gas prices around 2008, prompting growth in industrial demand. Industrial gas consumption swelled 17% from 2008 to 2017, with annual growth rates averaging 2% year-on-year since 2011.
- Commercial gas consumption, on the other hand, has remained flat despite falling prices, since commercial gas demand is largely driven by weather and the overall health of the economy.

Source: EIA, Bloomberg New Energy Finance. Notes: Values for 2017 are projected, accounting for seasonality, based on the latest monthly values from the EIA (data available through October 2017).

Bloomberg New Energy Finance

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

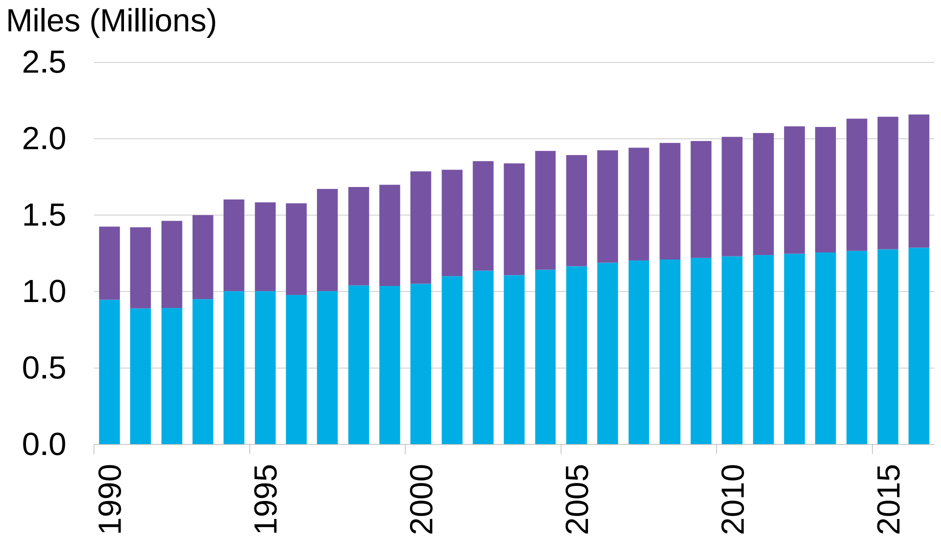


- Due to energy efficiency efforts, residential gas consumption has shrunk even as the number of customers has expanded. The customer base for residential gas expanded by 12 million customers, or 21%, over the past 20 years. Meanwhile, residential consumption has declined slightly over the same period.
- Residential gas consumption continues to be driven by weather patterns. Consumption dropped during the abnormally mild winter of 2011-12, then jumped during the polar vortices of 2013 and 2014. 2015's mild winter temperatures put residential consumption back to its longer term, lower rate. It then remained flat in 2017, with average consumption in the first ten months of the year roughly equal to that of 2016.

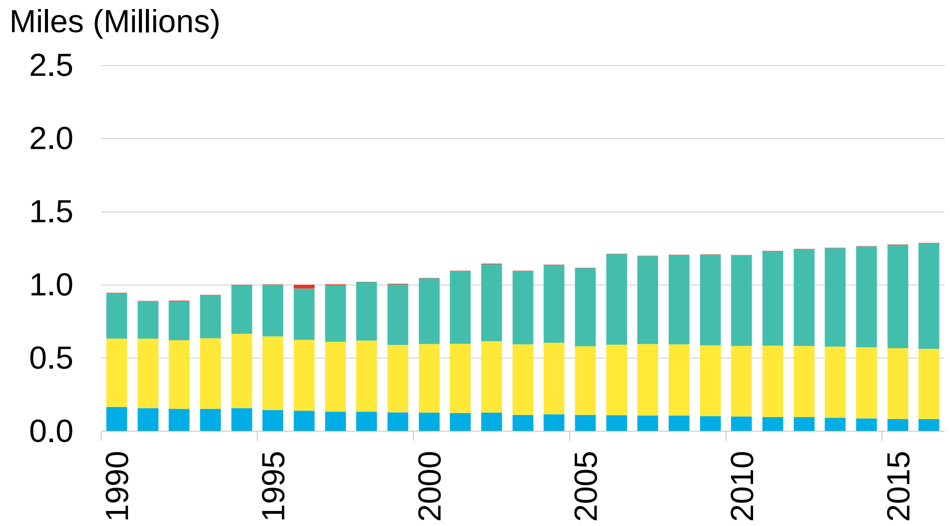
Source: Bloomberg New Energy Finance, EIA Notes: Values for 2017 are projected, accounting for seasonality, based on latest monthly values from EIA (data available through October 2017).

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

U.S. existing natural gas distribution pipelines



U.S. natural gas distribution mainline material

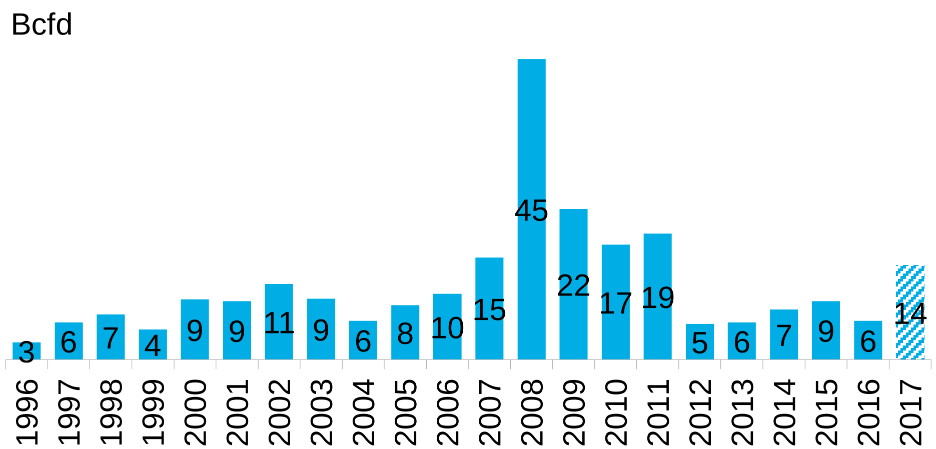


- Service and distribution pipelines that bring gas from transmission lines to end-users continue to develop incrementally, with growth averaging 1% per year over the past decade.
- Plastic is the material of choice for replacement and expansion efforts as U.S. pipelines are upgraded with more modern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

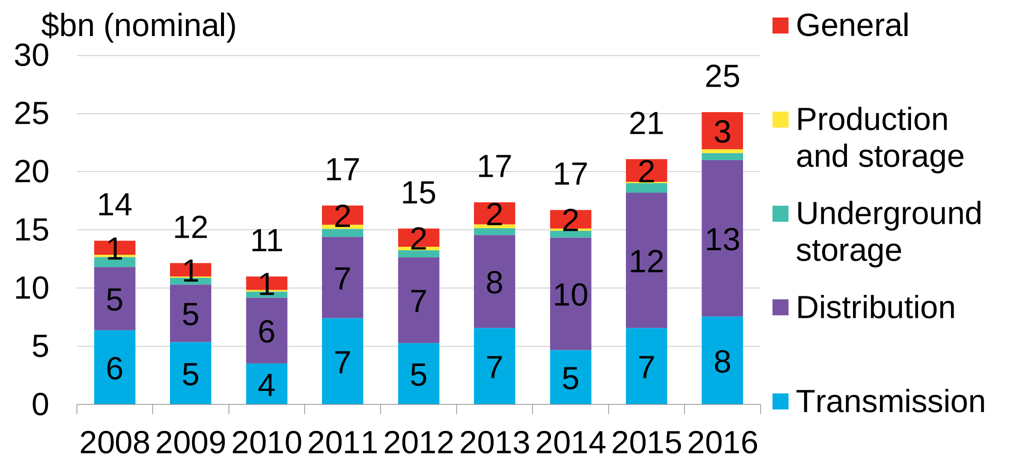
Source: American Gas Association, U.S. Department of Transportation

Deployment: U.S. midstream infrastructure capacity and investment

U.S. transmission pipeline capacity additions



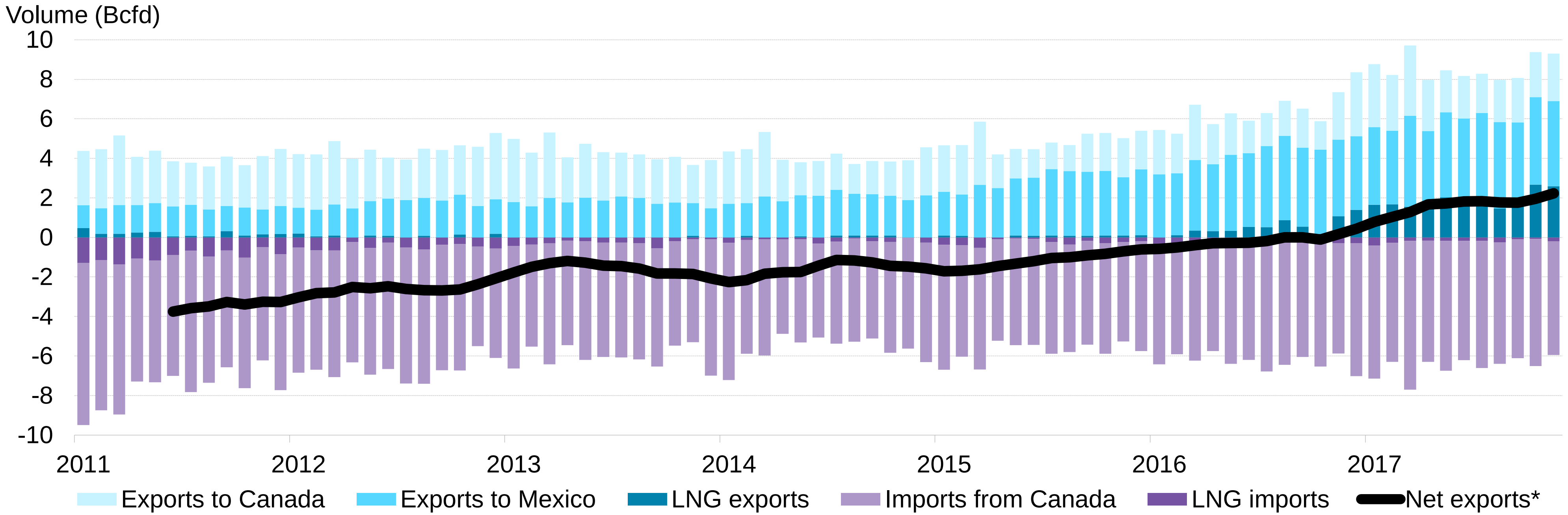
U.S. midstream gas construction expenditures



- Pipeline companies completed 6Bcfd of pipeline capacity in 2016, just slightly below the 7.6Bcfd planned. A number of delays pushed the online date of many substantial projects from 2015-2016 into 2017-2018.
- The next few years are scheduled to see major increases in pipeline capacity growth. 33Bcfd of capacity was scheduled to be completed in 2017, though just under half of this is estimated to have been complete by year's end.
- Takeaway capacity from the Appalachian Basin expanded by 4.1Bcfd in 2017, but only 0.04Bcfd (1%) of this brings gas into New England (through the Atlantic Bridge Expansion project on the Algonquin pipeline). As a result, natural gas delivery into New England remains constrained.
- Midstream expenditures increased 19% year-on-year in 2016. Distribution accounted for nearly half of the increased spending, rising to its highest level yet at $13.4bn, a 16% increase over 2015 levels. There was also a small but noticeable increase in production and storage expenditure, which more than doubled in 2016.

Source: Bloomberg New Energy Finance, American Gas Association, EIA Notes: EIA data used here include both first-mile takeaway capacity and other pipeline additions that do not impact takeaway capacity. 2017 transmission capacity addition is a BNEF estimate and not EIA historical data. Expenditure values reflect figures reported to the AGA by different types of 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.

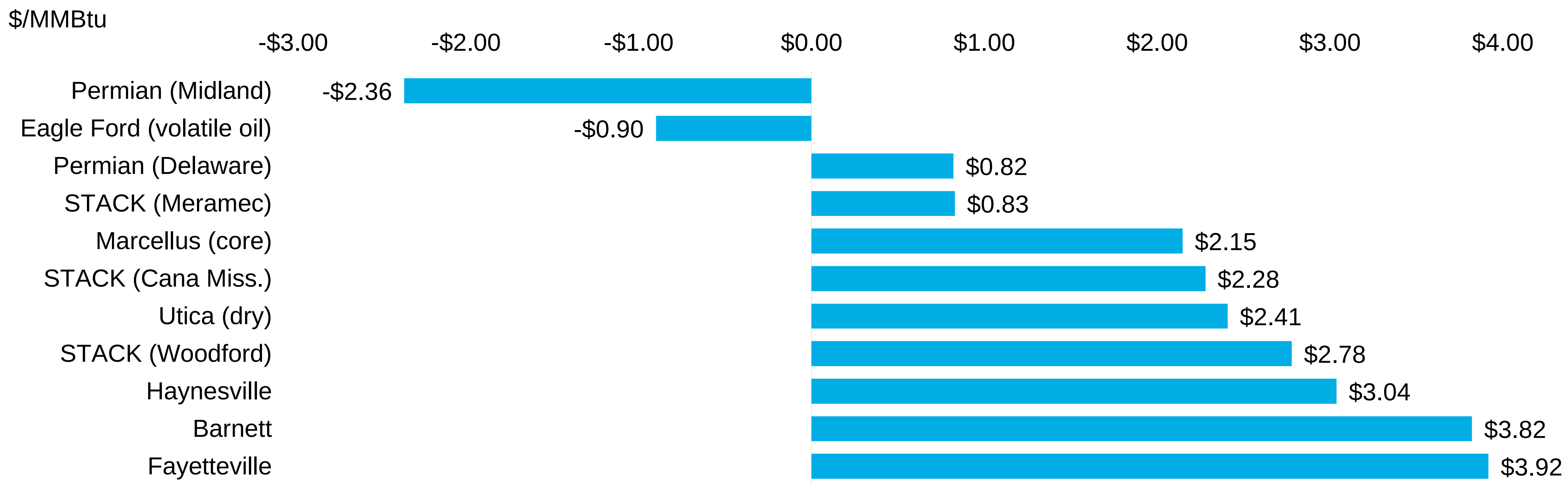
Deployment: U.S. natural gas exports and imports



- In 2017, the U.S. strengthened its position as a net exporter of gas. Net export volumes averaged 2Bcfd in the first eleven months of 2017, compared to net *imports* of 0.03Bcfd over that period in 2016.
- Exports were net positive every month in 2017, for the first time. The U.S. has exported 625Bcf of LNG, worth roughly $2.8 billion, through November 2017. For perspective, the global LNG market is $90bn/year, so there is room for growth.
- In 2017, the Sabine pass LNG export terminal (the U.S.'s first) doubled its capacity to 2.5Bcfd. The U.S. now exports LNG to 25 countries, with Mexico, South Korea, China and Japan serving as top offtakers. A second export terminal, Cove Point, is scheduled to open in Maryland in early 2018.
- The U.S. exported 1,407Bcf via pipelines to Mexico from January through November 2017, compared to 1,265Bcf over the same period in 2016.

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

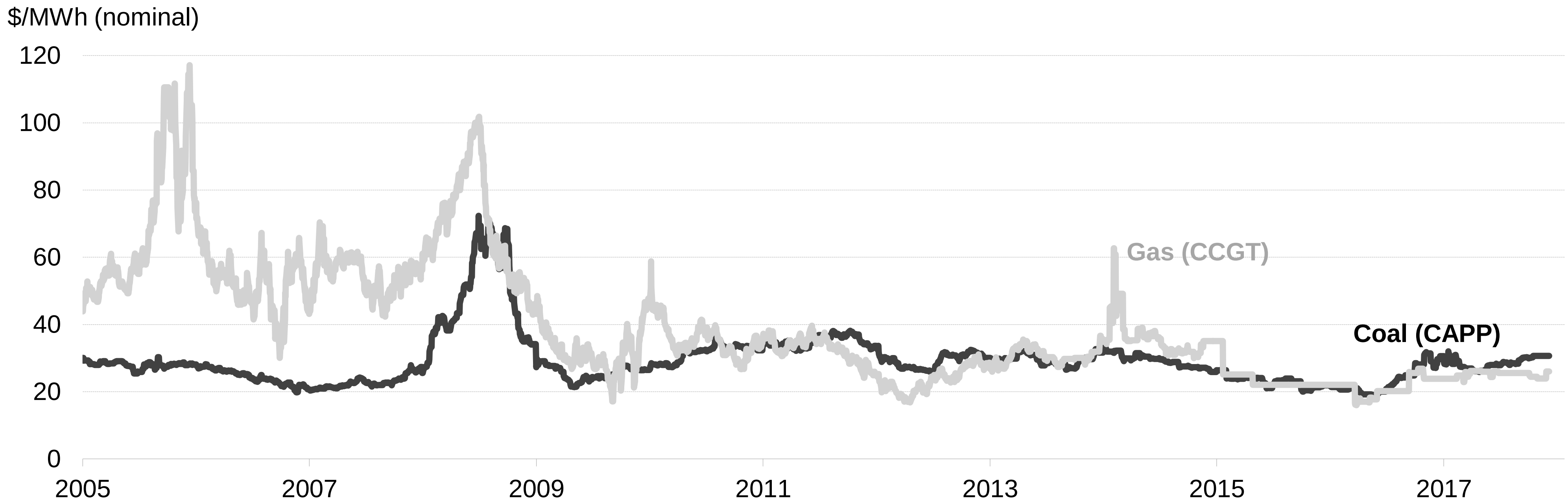
Economics: Gas wellhead breakevens by basin



- Producers have achieved strong efficiency gains and reductions in drilling and completion (D&C) costs over the past two years, resulting in “breakeven” prices of $2-4/MMBtu in most basins, assuming an internal rate of return of 20%.
- Oil-directed plays, such as the Eagle Ford and Permian, show even lower breakeven costs. This is because gas is produced as a byproduct of oil production, and the rebound in oil prices has buoyed both oil and associated gas production.
- Breakeven prices do not take into account the basis to Henry Hub. In areas such as the Marcellus and Utica, negative basis can eat into the attractiveness of the plays.

Source: Bloomberg New Energy Finance Note: The STACK play name is derived from “Sooner Trend Anadarko (basin) Canadian and Kingfisher (counties)”.

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



- Power has served as the swing demand source for natural gas: when the price of gas falls below that of coal, gas burn rises until the differential (in $/MWh) between the two fuels closes.
- As gas becomes consistently cheaper than coal, it creates a strong impetus for coal-to-gas switching. The U.S. observed this switching in 2012 and 2016. In 2017, gas again undercut coal in terms of marginal cost for power generation.
- Power burn in PJM has the greatest sensitivity to gas prices and also faces lower gas prices than Henry Hub (which is shown in the graph above). The coal-to-gas switch potential is, therefore, the strongest in this region.

Source: Bloomberg New Energy Finance 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.

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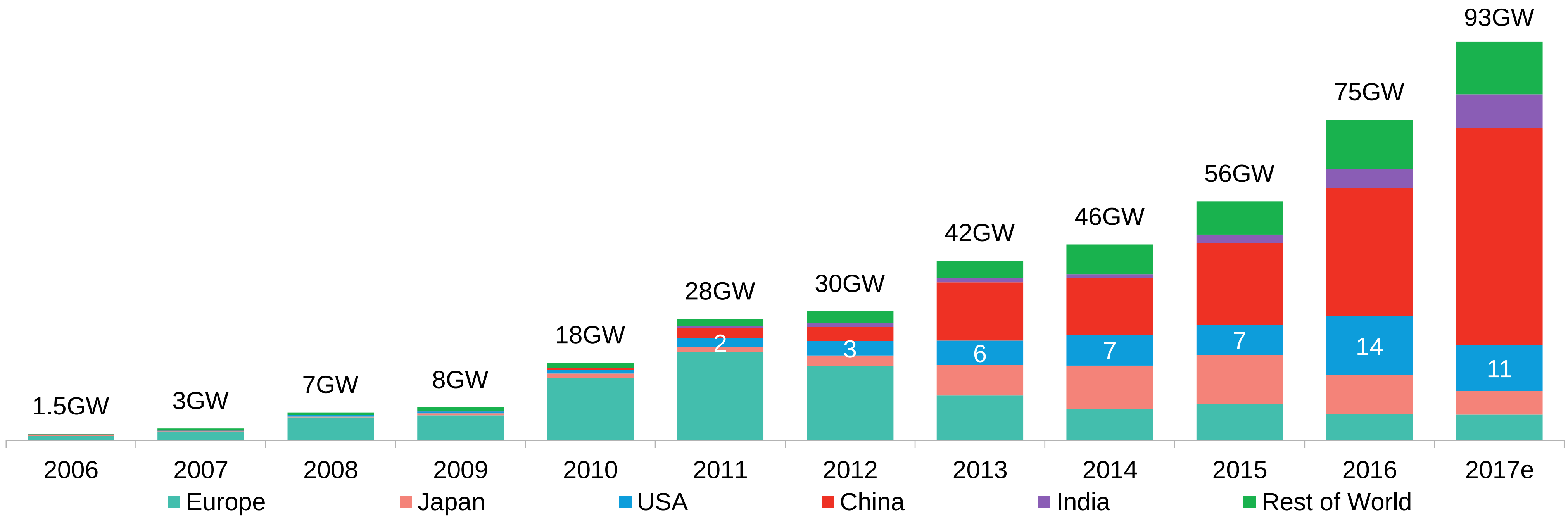
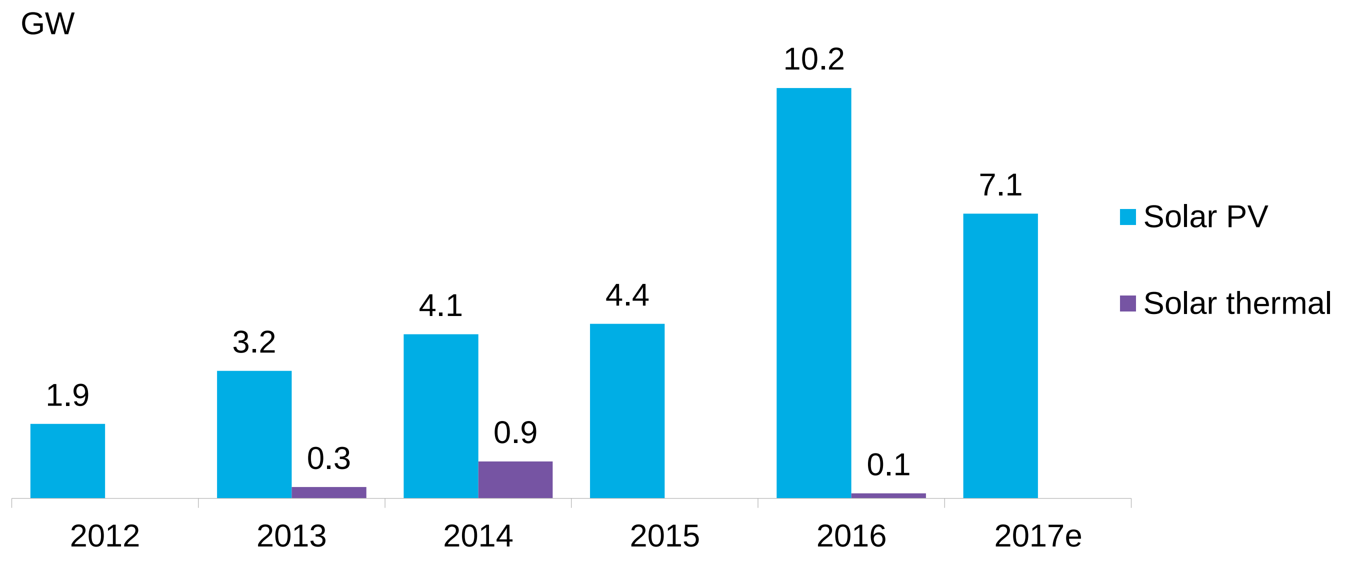
Deployment: Global solar build, large-scale and small-scale



- The global industry continued to scale new heights, installing an estimated 92-97GW of new capacity across utility-scale and small-scale segments in 2017. China installed at least 50GW in 2017, over half of global demand.
- The U.S. market is becoming of lesser significance to solar manufacturers who are instead focused on growth markets within Asia, the Middle East and Africa. After a record year of installations in 2016 driven by the anticipated expiration of the federal Investment Tax Credit, the U.S. solar industry contracted around 22% in 2017.

Source: Bloomberg New Energy Finance *Note: Graph shows BNEF conservative estimate for 2017.*

Deployment: U.S. large-scale solar build

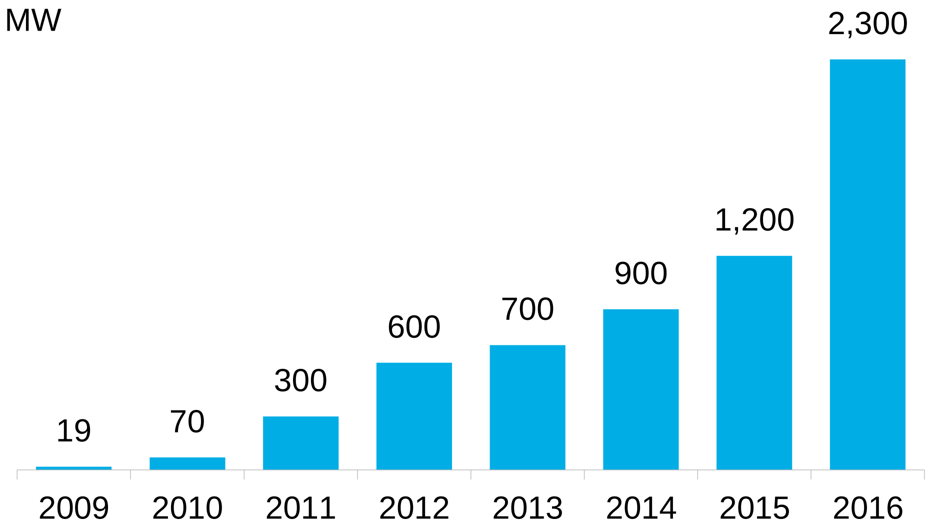


- After a boom year in 2016 due to the then-anticipated ITC expiration, utility-scale installations fell 31% year-on-year to 7.1GW in 2017.
- Developers are replenishing their depleted project pipelines and entering new state markets where the next generation of utility-scale solar projects will be developed in time to claim the full value of the Investment Tax Credit.
- No solar thermal facilities were commissioned in the U.S. in 2017, although there were a small number of project announcements. Developers and financiers continue to focus their attention on PV.
- In January 2018, President Trump's announced the introduction of a 30% duty on imported photovoltaic cells and modules. The tariffs ratchet down quickly and are complemented by a 2.5GW annual exemption for cell imports.
- While significant, the industry has developed buffers to absorb some of the tariff’s impact: modules have been stockpiled in anticipation, thin-film technology has been made exempt, and buyers still have access to tariff-exempt imports from a small number of countries home to miniscule PV manufacturing industries.

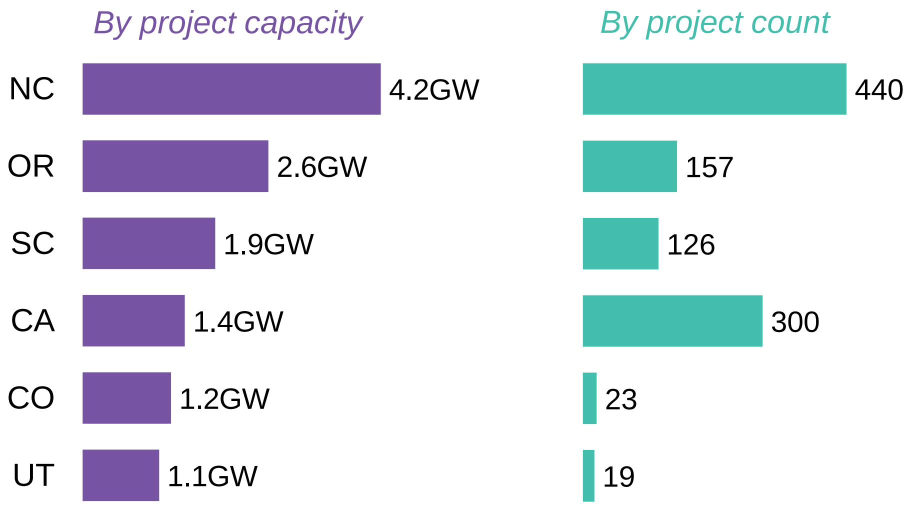
Source: Bloomberg New Energy Finance

Policy: PURPA

Annual PURPA qualifying PV build by year



New PURPA qualifying PV project applications by state, 2016-1H 2017

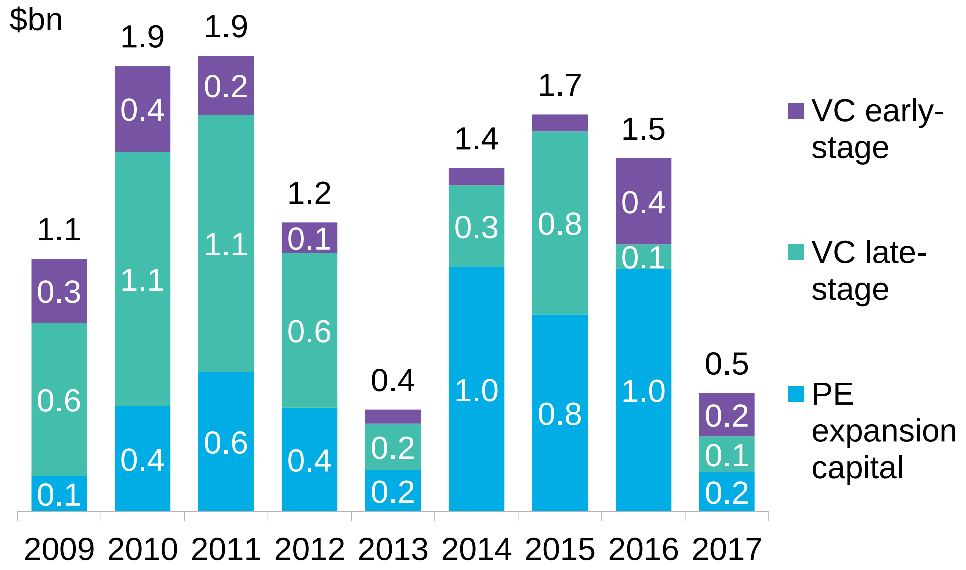


- The Public Utility Regulatory Policies Act (PURPA) has enabled over 6GW of PV build since 2009, mostly small (2-10MW) utility-scale projects in the Southeast and Northwest. From 2016 to 1H 2017, developers filed over 2,000 applications for more than 18GW of potential projects nationwide, including 4.2GW in North Carolina alone.
- The surge of solar projects flooding interconnection queues has caused concern among utilities who have historically been required under the law to sign long-term contracts with PURPA-qualified facilities. Utilities have sought to amend state-level implementation of PURPA, asking regulators to reduce the length and rates offered in standard PURPA contracts – with mixed success.
- In 2017, North Carolina passed legislation likely to shift the state's solar market toward larger (non-PURPA) projects. In Michigan, the Public Service Commission approved 20-year PPAs for small utility-scale PV projects up to 2MW in size.
- In the beginning of 2018, the U.S. House began hearings on the PURPA Modernization Act of 2017, which examines critical components of the law such as eligibility requirements and must-purchase provisions.

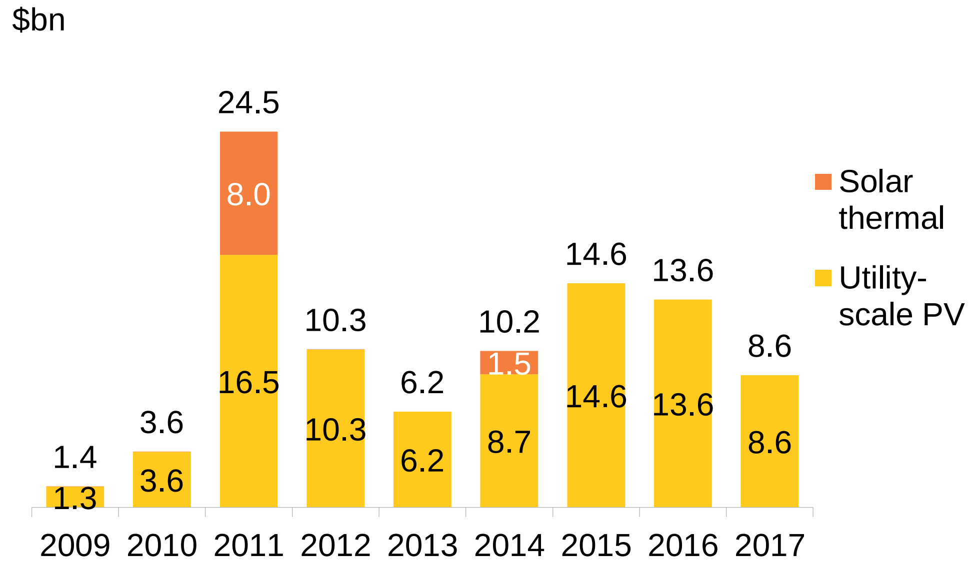
Source: Bloomberg New Energy Finance   Note: Although PURPA applies to other renewable technologies, in recent years it has primarily driven solar build.

Financing: U.S. large-scale 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

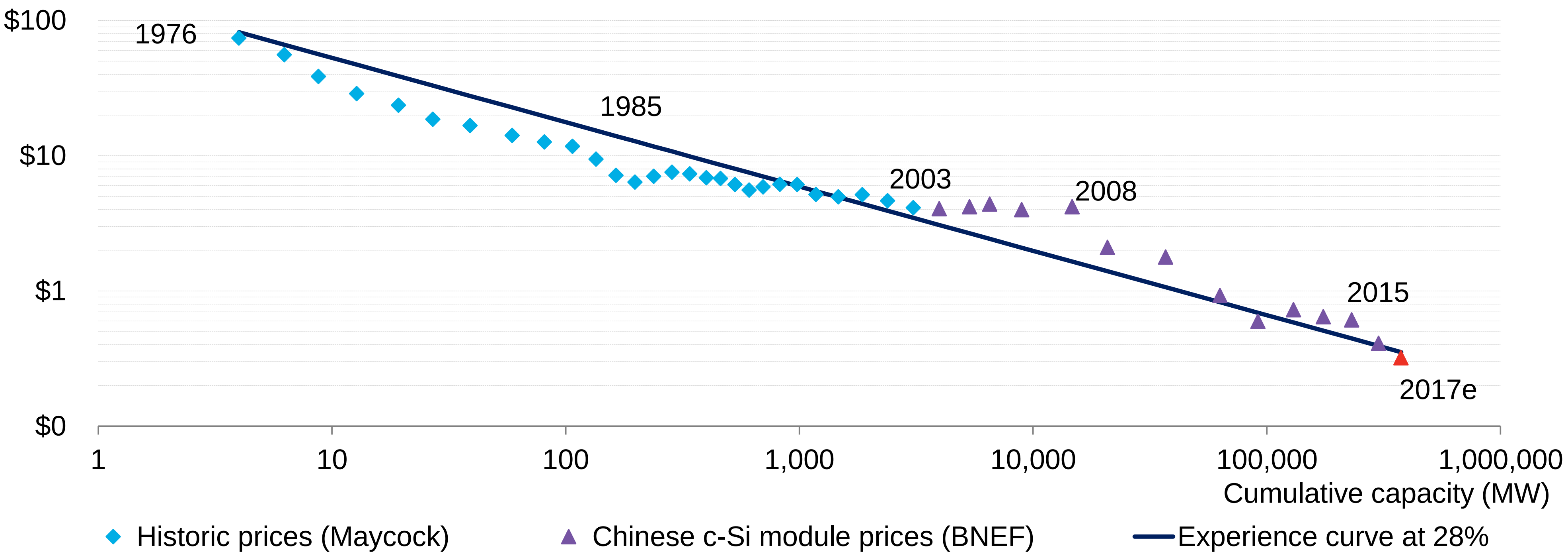


- Both private equity capital and venture capital investment for U.S. solar dropped significantly in 2017. Private equity investment totaled $0.2bn, the lowest amount since 2009, while venture capital investment dropped to $0.3bn, the lowest since 2013.
- Asset finance deals for utility-scale solar declined for the second consecutive year, dropping to $8.6bn. This correlates with falling technology costs. Asset finance levels in 2017 are a leading indicator for utility-scale solar build in 2018, as most assets are typically financed a year prior to commissioning.

Source: Bloomberg New Energy Finance

Economics: Global price of solar modules and experience curve

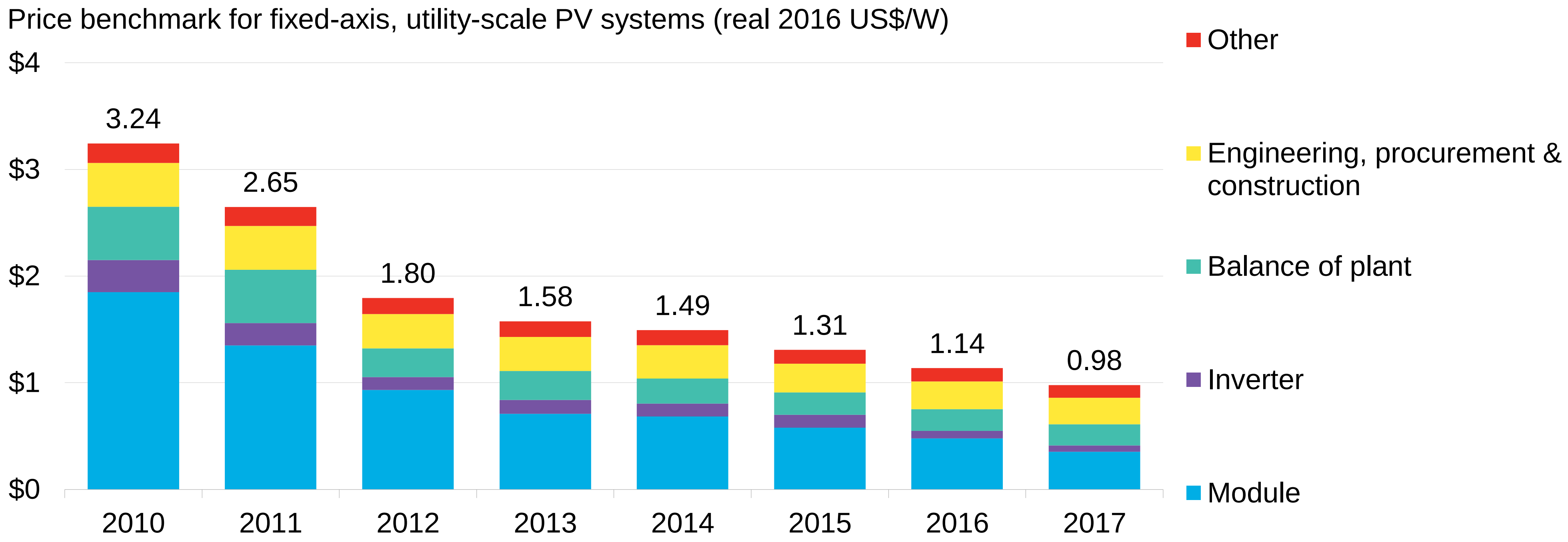
Crystalline silicon PV module prices and learning curve (real 2016 US$/W)



- Module prices have decreased exponentially to an estimated 32 U.S. cents per watt in 2017, down dramatically from $74 per watt (in 2016 dollars) in 1976 – a learning rate, or reduction per doubling of capacity, of about 28%.
- 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: Bloomberg New Energy Finance   Note: Prices indexed to U.S. PPI

Economics: Global benchmark capex for utility-scale solar PV



- 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.
- Utility-scale PV capex costs are estimated to have broken through the symbolic “dollar-per-watt” threshold in parts of U.S. such as the Carolinas; however, costs remain above this level on average.

Source: Bloomberg New Energy Finance Note: ‘Other’ refers to developer fees, land acquisition fees, finance arrangement, contingency and other miscellaneous costs.

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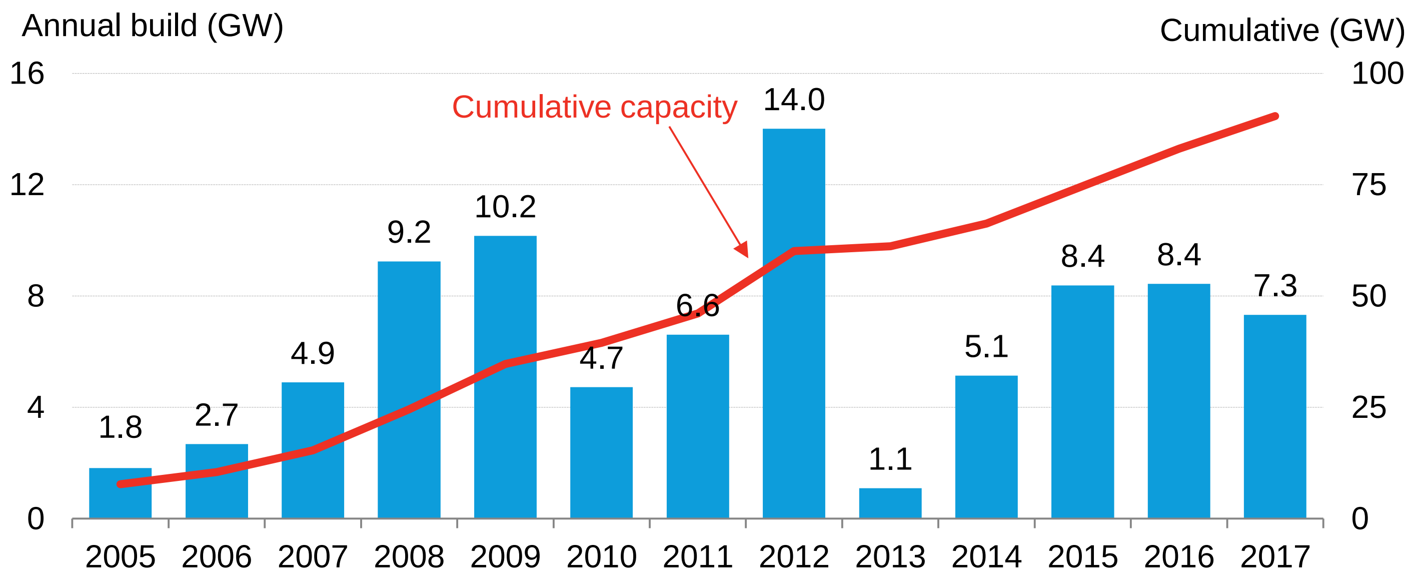
Deployment: U.S. large-scale wind build

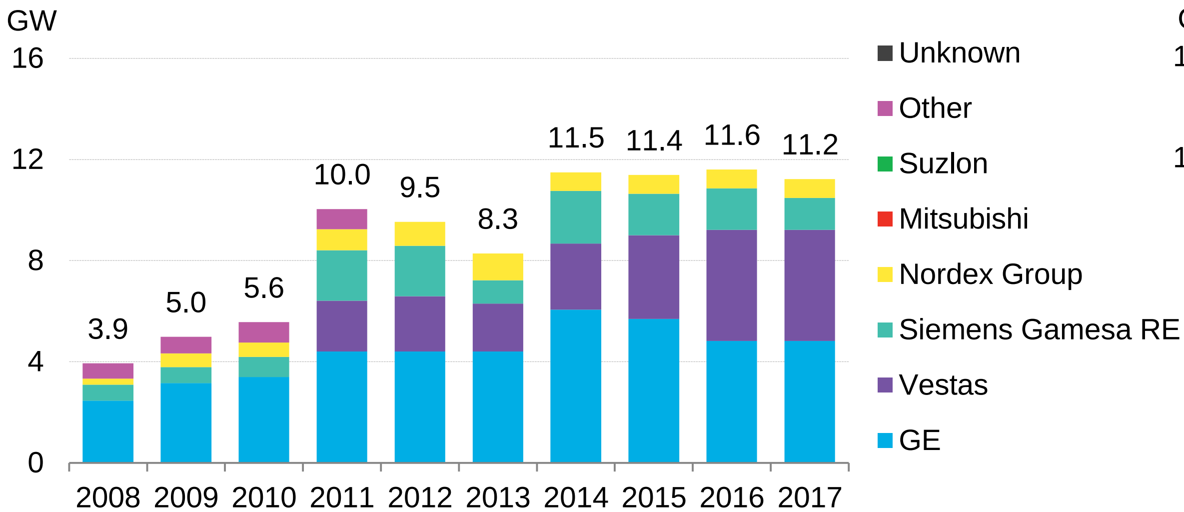


- The U.S. utility-scale wind market added 7.3GW of new capacity in 2017, a 13% slow-down from the 8.4GW installed in each of the two prior years. The year started off with an abnormally strong 1Q, because of the Production Tax Credit (PTC) extension that allowed projects initially intended to commission by year-end 2016 to spill over into 2017 and still qualify for the subsidy. However, total annual build was down largely due to a lack of policy pressure to commission projects, and anticipation that costs may decline even further over the next couple years. Still, the U.S. made up 13% of the 56GW in global onshore and offshore wind build seen in 2017.
- Peaks and valleys in U.S. wind build have historically tracked the expirations and extensions of the PTC. Each threat of expiration brings forth a rush to commission wind: both the PTC and the 1603 Treasury Program (which allowed developers to receive 30% of a project's cost back in cash) were set to expire at year-end 2012, spurring 2012 build. The PTC was extended for one year in January 2013, and the qualification standard was changed from "completion" to "start construction." This translated into a boom in 2015 build. Another PTC renewal in 2014 produced a 2016 boom. The final PTC extension in December 2015 applies to projects commencing construction through 2019, with a phase-down for projects beginning after 2016. There is a four-year build window to qualify, meaning that projects that broke ground in 2016 have until 2020 to complete construction and still qualify for the full value of the credit.
- A majority of the 2017 additions was again 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.
- Small- and medium-scale wind continue to struggle—the U.S. added only 2.7MW total across both categories in 2016 (data unavailable for 2017).

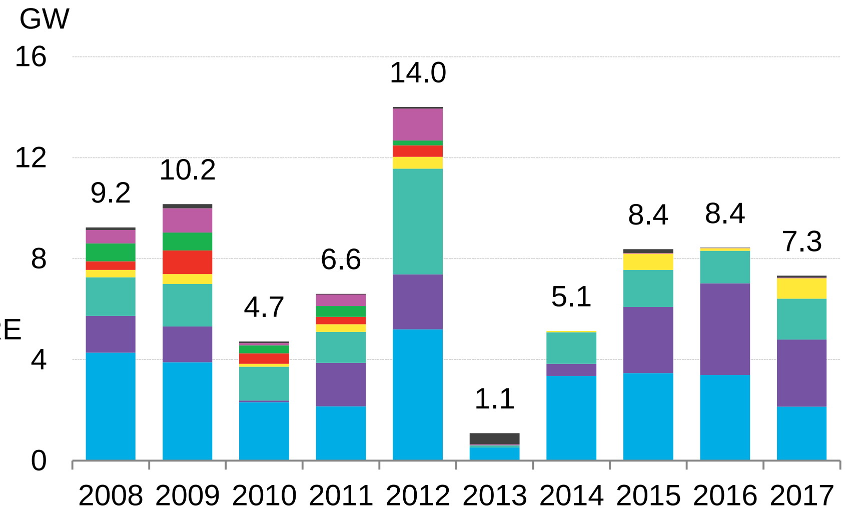
Source: Bloomberg New Energy Finance. Notes: Includes all utility-scale wind development, excluding partially commissioned projects and including distributed turbines that are above 1MW (Bloomberg New Energy Finance threshold for utility-scale).

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

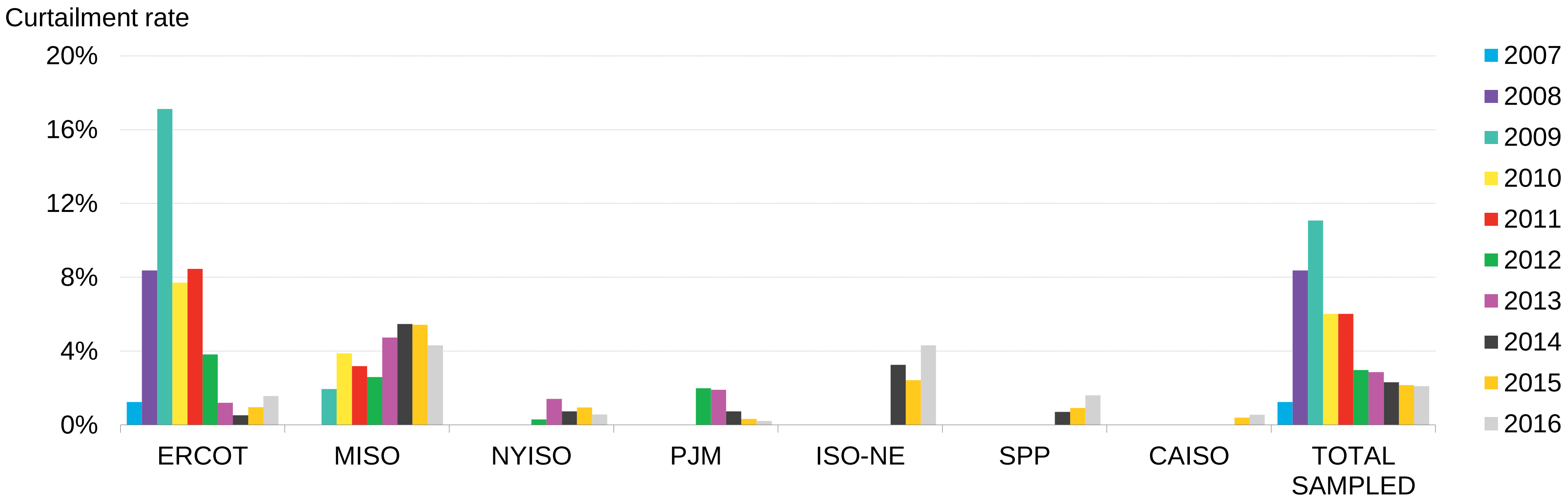


- The recent mergers of Nordex and Acciona Wind Power into Nordex Group (2016), and Siemens and Gamesa into Siemens Gamesa Renewable Energy (2017), accentuated a global trend toward market consolidation. This trend was also quite noticeable in 2016, when global wind build hit the second-highest level on record, and the top-10 manufacturers broke away from the remaining smaller players to dominate 75% of new capacity additions. Further, a “big four” of dominant wind turbine manufacturing emerged: Vestas in the lead, followed by GE, Goldwind, and Siemens Gamesa RE.
- 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: Bloomberg New Energy Finance. Notes: Production capacity measured by nacelle assembly on U.S. soil.

Bloomberg New Energy Finance

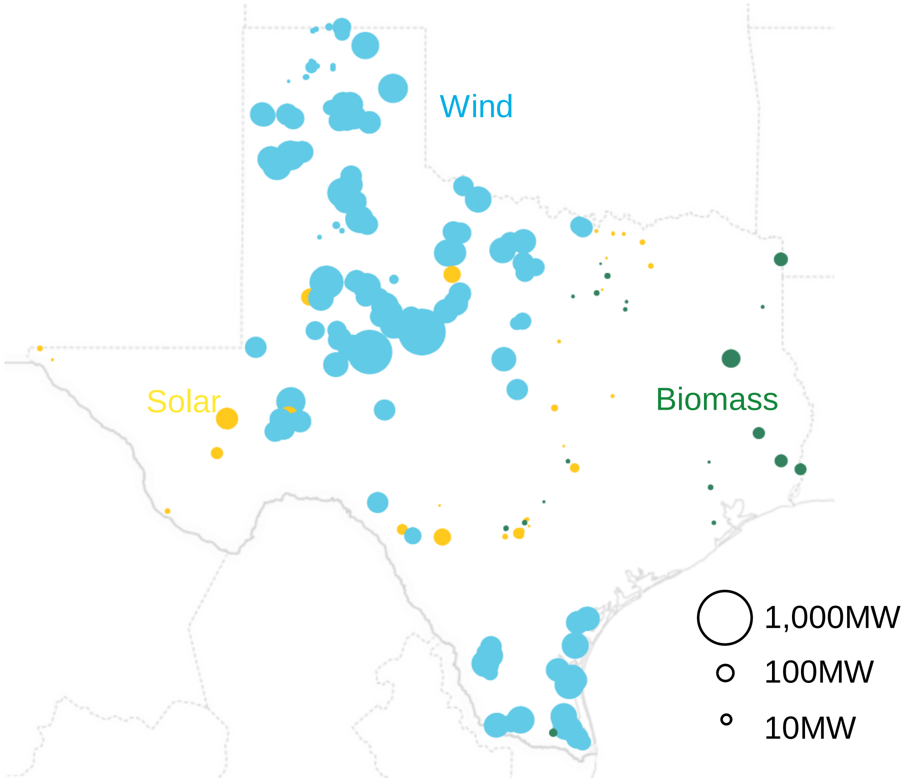
Deployment: U.S. wind curtailment

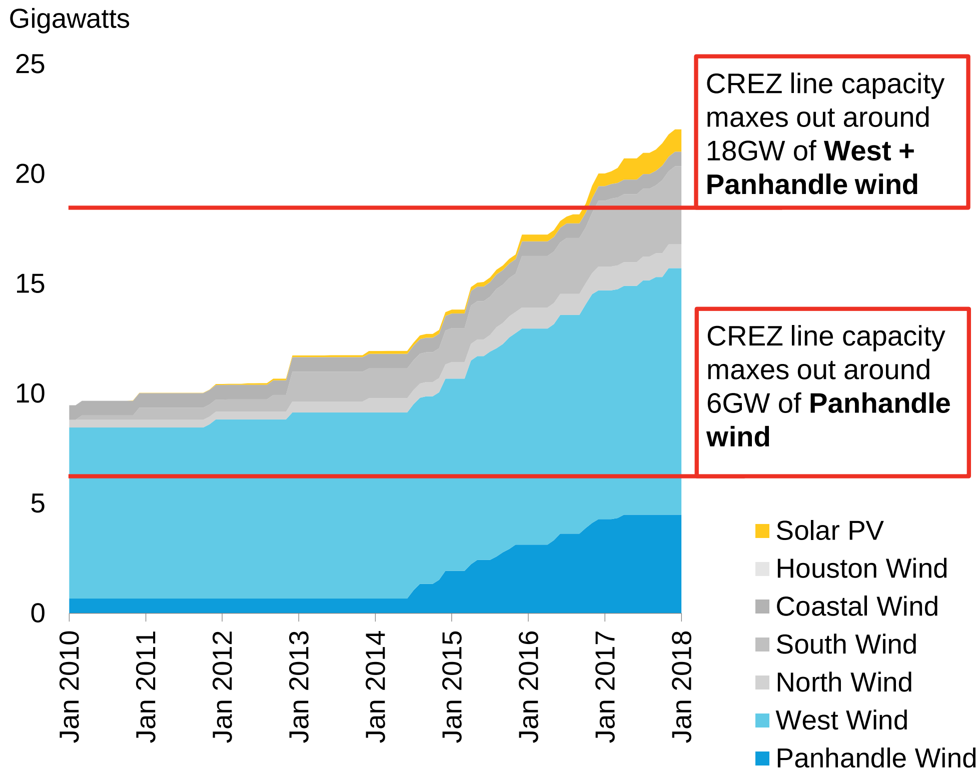


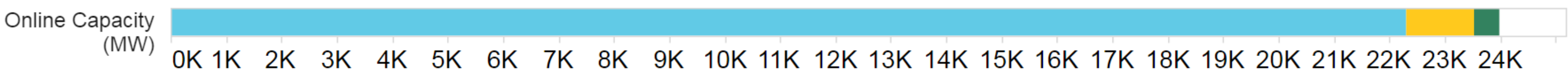
- Curtailment can occur due to transmission constraints, inflexibilities in the grid and environmental or generation restrictions.
- This was a significant problem in ERCOT (Texas) from 2008-2013, but the build-out and upgrade of the Competitive Renewable Energy Zone (CREZ) transmission lines and increased efficiency in ERCOT's wholesale electricity market lessened this concern. Curtailment in this region fell to only 0.5% in 2014, down from a peak of 17% in 2009. It stayed just under 1% for 2015, but ticked back up to 2% for 2016.
- In both 2015 and 2016, PJM experienced the lowest curtailment of any region, at 0.2%. MISO and New England continued to experience curtailment rates of over 4%, the highest out of all the regions sampled. However, MISO's wind curtailment dropped 21% from 2015 to 2016, as transmission build began to alleviate congestion; most of MISO's MVP transmission projects should be online by 2019. New England's curtailment levels in 2016 jumped 78% from 2015, an issue that needs to be addressed for Massachusetts to reach its 50% Renewable Portfolio Standard. CAISO, NYISO, and SPP fall in the middle, experiencing 0.5%, 0.6% and 1.61% of curtailment, respectively.
- 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: Bloomberg New Energy Finance, 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: ERCOT's Competitive Renewable Energy Zone (CREZ)





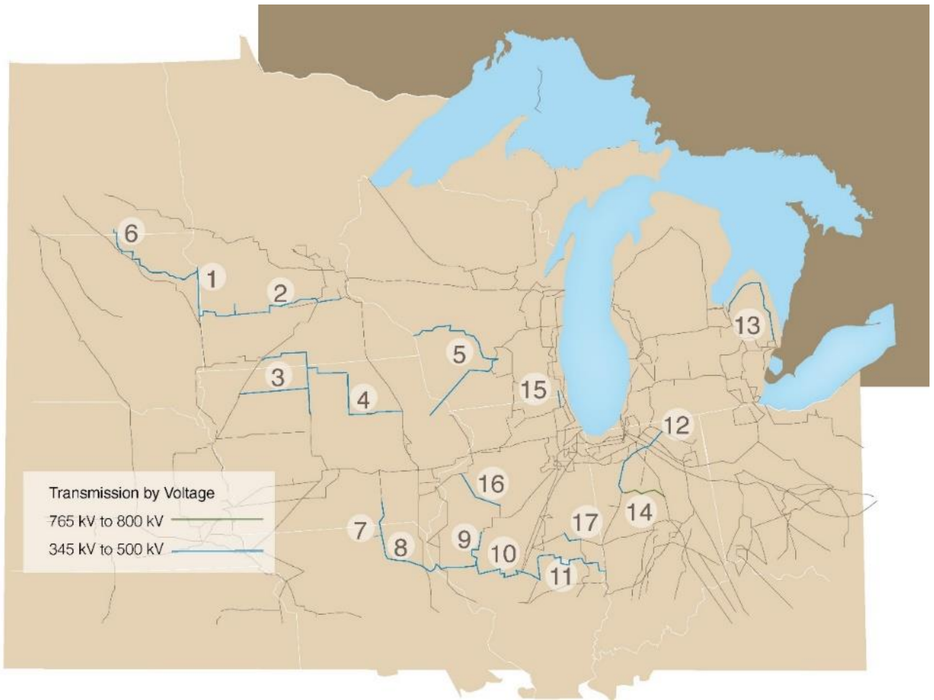


- Texas is home to one-quarter of America's installed wind capacity, hosting over 22GW out of 90GW installed nation-wide as of December 2017.
- The majority was enabled by a $7bn investment in the Competitive Renewable Energy Zone (CREZ) transmission lines, which connect West Zone and Panhandle wind to load centers in the East. The CREZ lines can accommodate roughly 12.7GW of West Zone and 5.8GW of Panhandle wind before significant curtailment (and congestion pricing) comes back into play. Most of this is already filled up, with only 2-3GW of space left on CREZ's lines and a plethora of wind projects proposed in the region.

Source: Bloomberg New Energy Finance, ERCOT, EIA. Note: The Texas map displays all commissioned wind in Texas, including those outside of ERCOT.

Deployment: Transmission build-out in MISO and Mountain West

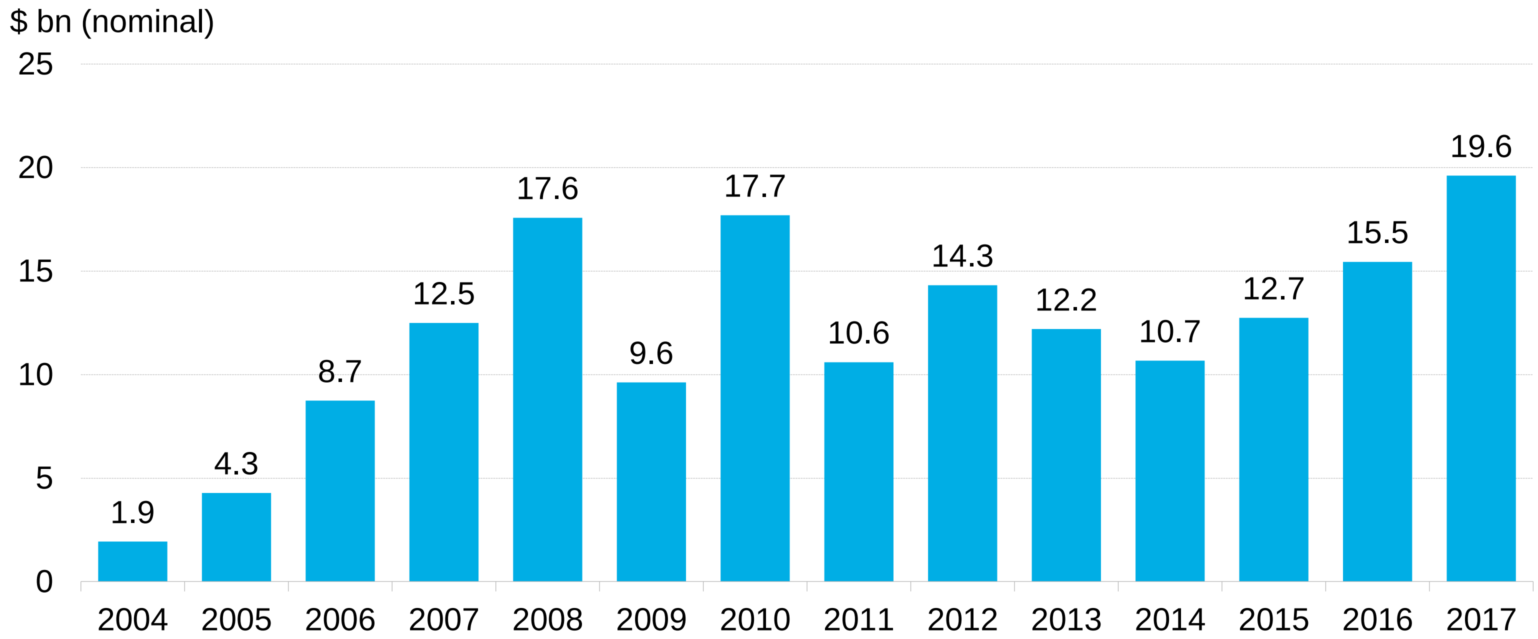
MISO Multi Value Project transmission portfolio



Source: Midwest ISO; MISO MTER14 MVP Triennial Review, September 2014. Notes: Projects are as follows: (1) Big Stone–Brookings, (2) Brookings, SD–SE Twin Cities, (3) Lakefield Jct.–Winnebago–Winco–Burt Area & Sheldon–Burt Area–Webster, (4) Winco–Lime Creek–Emery–Black Hawk– Hazleton, (5) LaCrosse–N. Madison–Cardinal & Dubuque Co– Spring Green–Cardinal, (6) Ellendale–Big Stone, (7) Adair–Ottumwa, (8) Adair–Palmyra Tap, (9) Palmyra Tap–Quincy–Meredosia–Ipava & Meredosia–Pawnee, (10) Pawnee–Pana, (11) Pana–Mt. Zion–Kansas–Sugar Creek, (12) Reynolds–Burr Oak–Hiple, (13) Michigan Thumb Loop Expansion, (14) Reynolds–Greentown, (15) Pleasant Prairie–Zion Energy Center, (16) Fargo-Galesburg–Oak Grove, (17) Sidney–Rising.

- The American Wind Energy Association (AWEA) estimates that transmission proposals across the U.S. could potentially enable 52GW of wind capacity between 2017 and 2024. This does not include transmission associated with AEP's Wind Catcher Energy Connection.
- AWEA's estimate includes the 14GW-enabling[1] Multi Value Project (MVP) transmission portfolio currently underway by the Midwest Independent System Operator (MISO). There are 17 projects within MVP: Five of these are already complete, 11 are expected to come online by 2019, and one by 2023. This expanded MISO transmission capacity is expected to fill up quickly—thirty gigawatts of wind and 15GW of solar are already in the MISO interconnection queue as of December 2017.
- Finally, five high-voltage DC transmission projects by Clean Line Energy Partners represent 16GW of potential wind capacity.
  - These projects have seen a myriad of challenges, including the Missouri Public Service Commission's denial of the Grain Belt Express application.
  - NextEra Energy Resources acquired Clean Line's Plains & Eastern project assets in Oklahoma, after the project struggled to sign on the Tennessee Valley Authority as an offtaker.
- Many of the proposed transmission projects have yet to begin construction and much of this will not be built. Generally, transmission build *within* a specific state or region receives full approval faster than those that cross multiple jurisdictions. Furthermore, utility-owned transmission projects have typically seen more success than private lines. The Transwest Express line, which expects to commission by 2021, has been under development since 2005 – meaning if the asset comes online, it will have taken 16 years to develop.

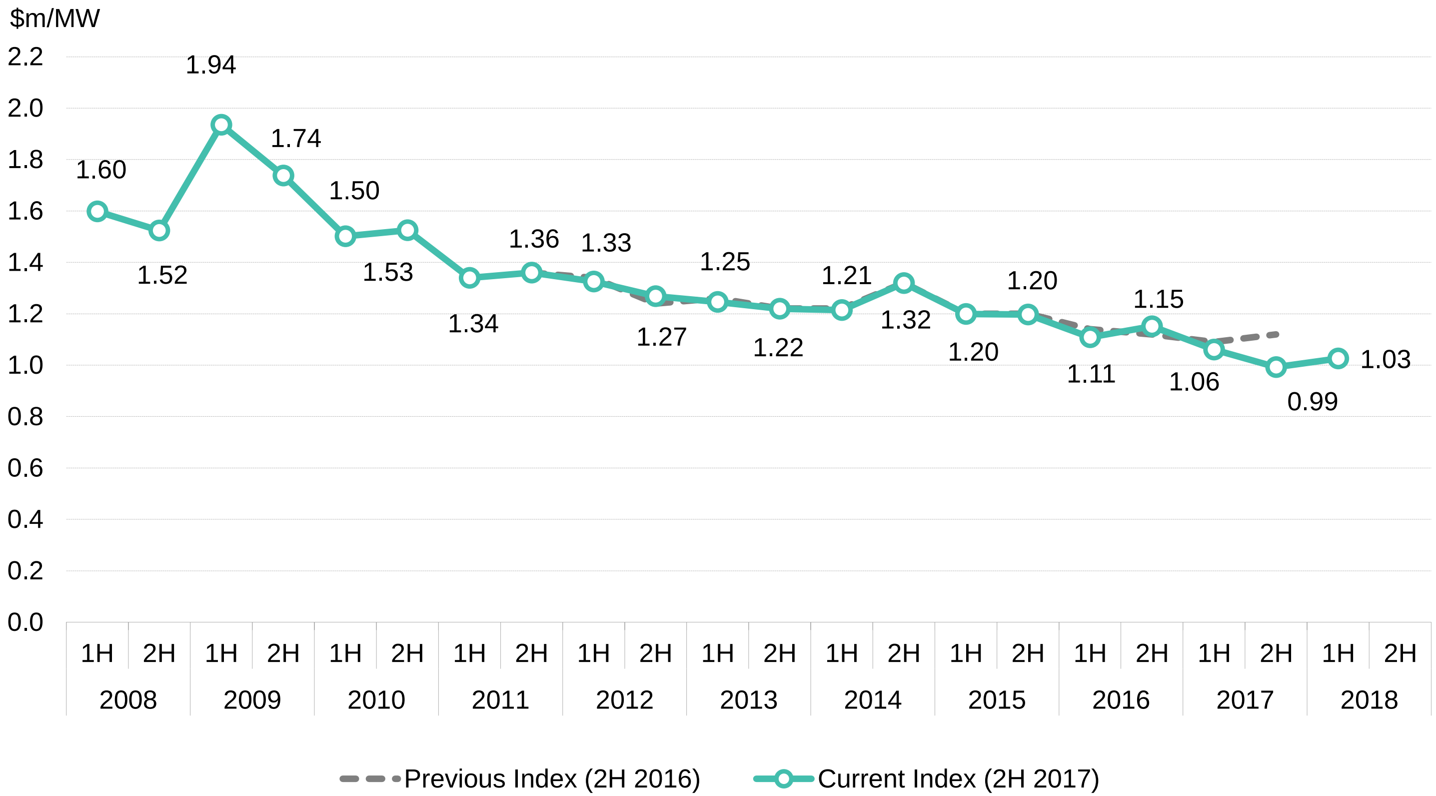
Financing: Asset finance for U.S. large-scale wind projects



- The 2017-20 wind pipeline is very healthy: a large portion of the $15.5 billion in financing secured in 2016 and the record $19.6 billion secured in 2017 is for wind projects to be commissioned in 2018-2020.
- 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: Bloomberg New Energy Finance   Notes: Values include estimates for undisclosed deals. 2015 figure includes $323m directed towards an offshore wind project, the Deepwater Block Island Offshore Wind Farm.

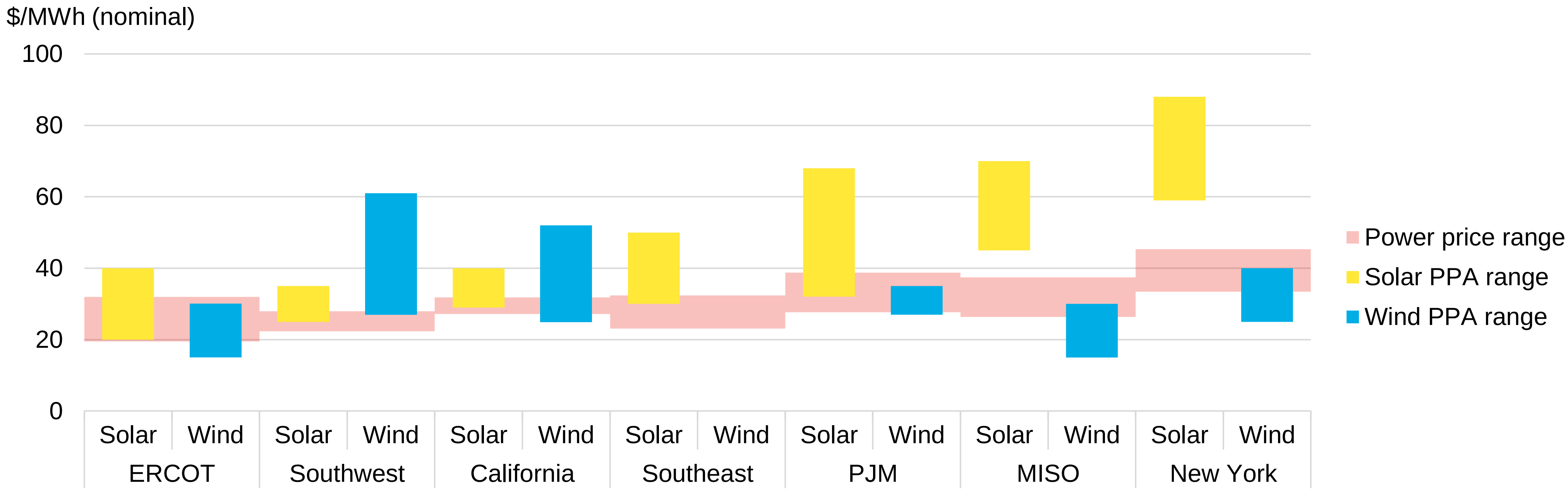
Economics: Global wind turbine price index by delivery date



- Turbine prices have fallen nearly 50% to $0.99 million/MW for turbines delivered in 2H 2017, down from $1.94 million/MW in 1H 2009. Global oversupply continues to suppress prices.
- The price for U.S. wind turbines delivered in 2H 2017 dropped well below the global average price of $0.99 million per megawatt. Fierce price competition between turbine manufacturers to maximize their share of the swell in 2016 orders drove the rapid U.S. pricing plunge. The 11GW surge in 2016 turbine and equipment orders was 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.

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

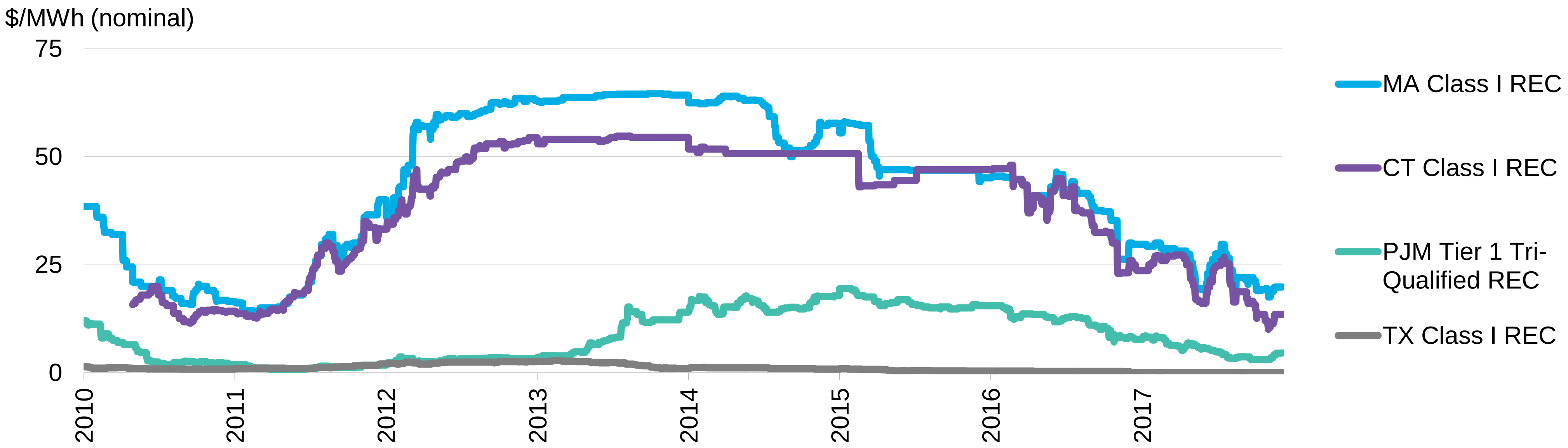
Economics: U.S. wind PPA prices compared to wholesale power prices in selected markets



- 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 2017. 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 2015 – representing 2.4GW of capacity – secured corporate PPAs. The popularity of corporate PPAs continued in more recent years, with an additional 1.6GW contracted in 2016 and 2.3GW in 2017.

Source: Bloomberg New Energy Finance, 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 selected U.S. state markets



- In areas with Renewable Portfolio Standards, Renewable Energy Credits (RECs) are given to eligible renewable generators for each MWh of electricity they supply to the grid. Eligible plants 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. REC prices are driven by supply-demand considerations, among others.
- Renewable build in most major REC markets has surpassed RPS demand, thereby depressing REC prices.
- Massachusetts and Connecticut Class I RECs lost over a third of their value in 2017. New England’s Clean Energy Request for Proposals, which seeks to procure additional Class I eligible renewables through long-term contracts, threatens to prolong the glut in regional REC markets.
- PJM Tier I Tri-Qualified REC prices fell over 70% in 2017. The drop reflects worsening market sentiment with respect to the extent of the oversupply. Cheap wind build in western PJM has proliferated rapidly and has exerted downward pressure on REC prices.
- Texas’ massive wind fleet has greatly exceeded state renewable energy goals. Texas RECs trade at their transactional value ($.50/MWh), reflecting the low likelihood of future REC shortages.

Source: Bloomberg New Energy Finance, 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. In contrast, solar REC (SREC) markets are not Class I, as these can only be met through solar. The “Class I” component is usually the bulk of most states’ renewable portfolio standards. 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.

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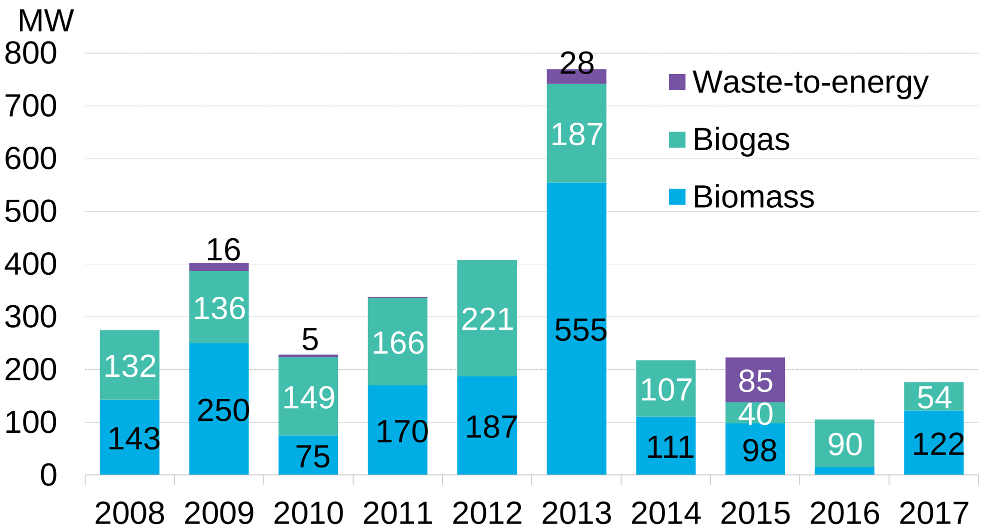
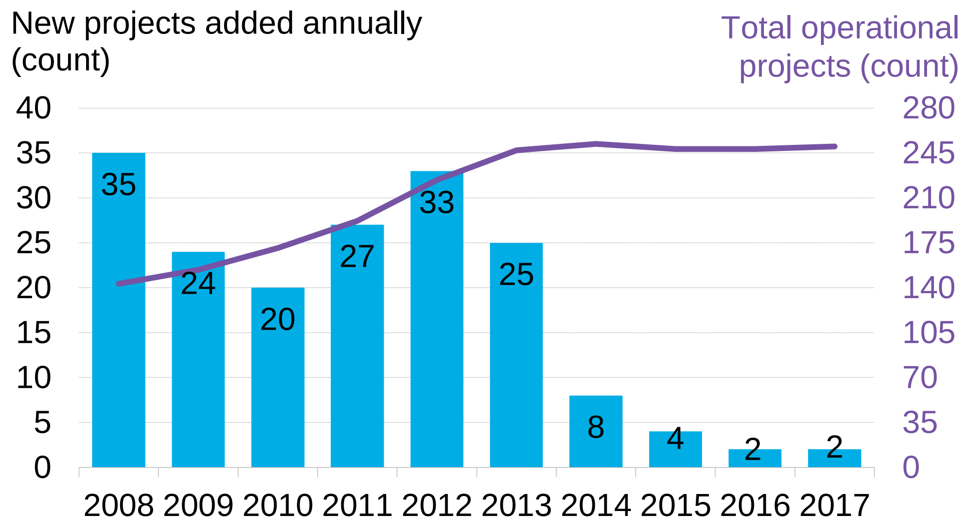
Deployment: U.S. bioenergy and anaerobic digester build

Annual build: large-scale bioenergy



Annual build: U.S. farm-based anaerobic digesters

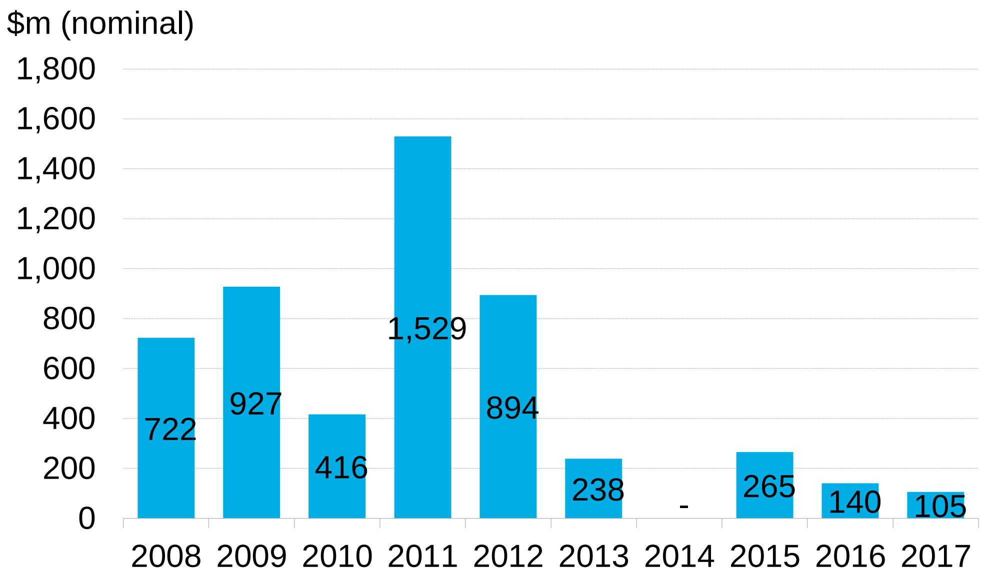


- In 2017, the U.S. installed 122MW of biomass, 54MW of biogas, and no new waste-to-energy plants. Bioenergy build has tapered since 2013, when the Production and Investment Tax Credits, as well as the 1603 Treasury program, encouraged nearly 800MW of new installations.
- Waste-to-energy technology has seen more growth in countries such as China, where the processing capacity rose 207% to 219,090t/day in 2015, from only 71,253t/day 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 five new facilities totaling 180MW of electrical generation capacity in 2015.
- The number of new farm-based anaerobic digesters coming online (shown in the graph to the right) has also slowed. 2017 saw the addition of two projects, identical to 2016 levels. The total count of operational projects (i.e., total count accounting for retirements) has held fairly flat since 2014 because a number of farm-based digesters have ceased operations.

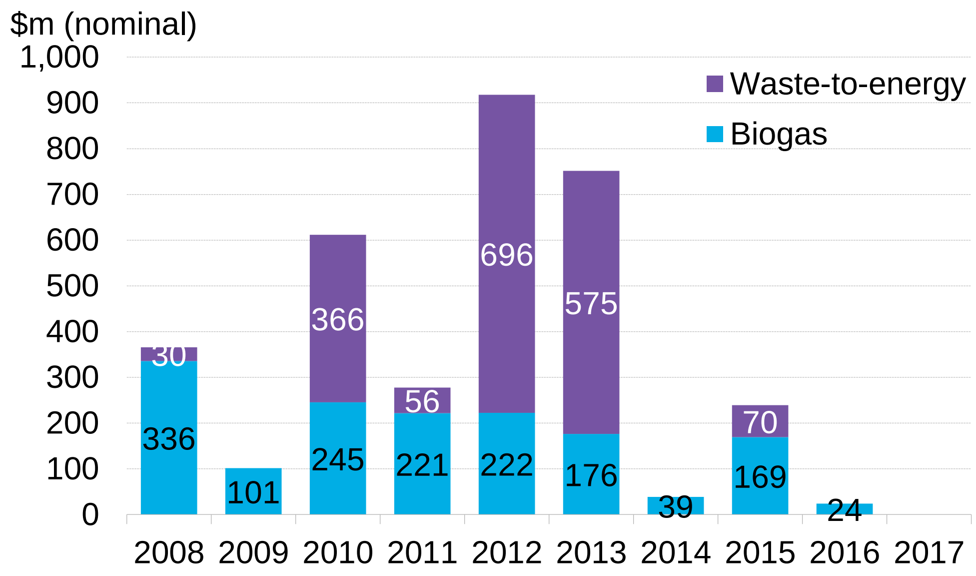
Source: Bloomberg New Energy Finance, EIA, company announcements, EPA AgSTAR database Notes: Biomass includes black liquor. Biogas includes anaerobic digestion (projects 1MW and above except wastewater treatment facilities). The graph on the right reflects anaerobic digesters on livestock farms in the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

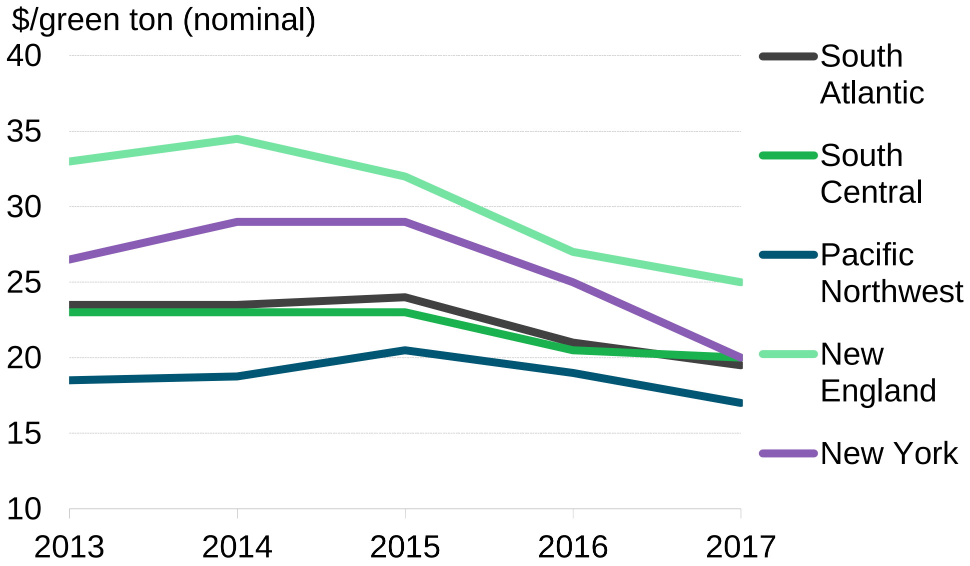


- Asset finance for new biomass and biogas build continues to dwindle. Biomass asset finance fell 25% to $105 million in 2017, while biogas financing fell from $24 million in 2016 to zero.
- Virtually no new financing has been secured for waste-to-energy since the $70m directed towards the 25MW Constellation Hyperion plant in 2015.
- Low investment in the past four 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.

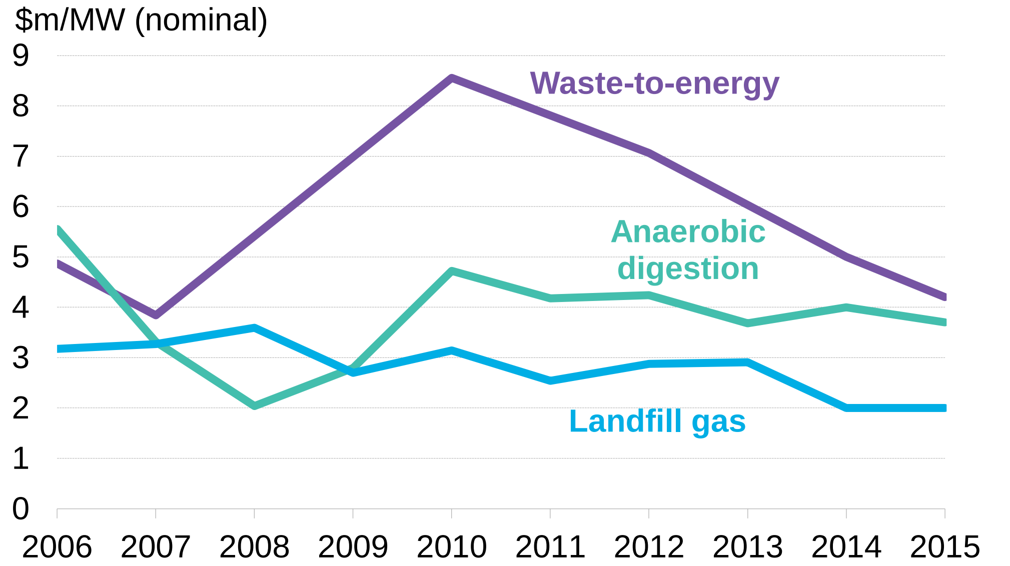
Source: Bloomberg New Energy Finance, EIA, company announcements   Notes: Values are nominal and include estimates for deals with undisclosed values. Biogas includes anaerobic digestion (1MW and above, except for wastewater treatment facilities) and landfill gas.

Economics: Bioenergy feedstock prices and capex

Biomass feedstock prices in selected U.S. markets, 2013-2017



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



- Biomass feedstock prices dipped in most regions of the U.S. in 2017. New York prices plummeted $5/green ton, or 20%, to $20/green ton. Prices in the Pacific Northwest also shrank 11% to $17/green ton.
- 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.
- For an overview of the levelized cost of energy (LCOEs) for these technologies, which accounts for capacity factors in addition to capex and feedstock prices, please see the slide on global LCOEs.

Source: Bloomberg New Energy Finance, RISI, U.S. Department of Agriculture, EIA   Notes: Capex values are for projects 1MW and above.

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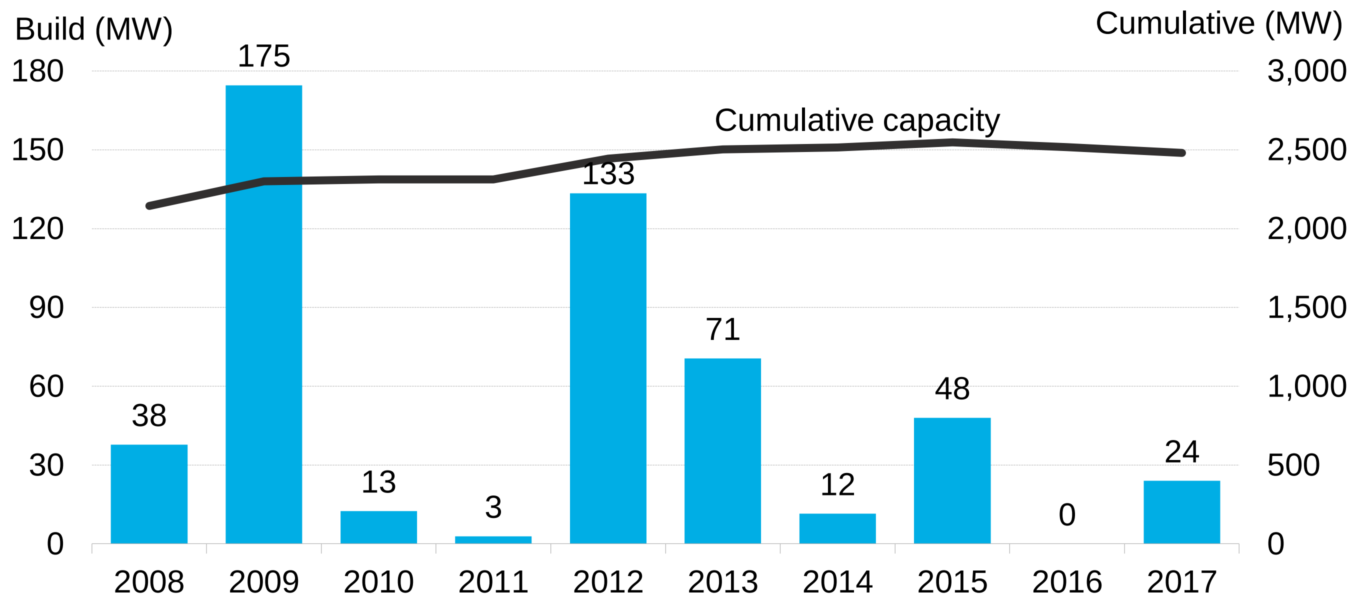
Deployment: U.S. geothermal build



- After building no new geothermal plants in 2016, the U.S. added the 24MW Tungsten Mountain plant in 2017. 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 face high development costs. These factors contribute to the low build volumes.
- Another key area of activity within U.S. geothermal is hybridization – the combination of geothermal with another technology to enhance output. Two such facilities by Enel Green Power began operation in 2016. The first was at its Stillwater plant in Nevada, where photovoltaic and solar thermal have been integrated into the geothermal plant. The second project added a hydroelectric generator into an injection well at Enel’s existing Cove Fort geothermal power plant in Utah.

Source: Bloomberg New Energy Finance, EIA

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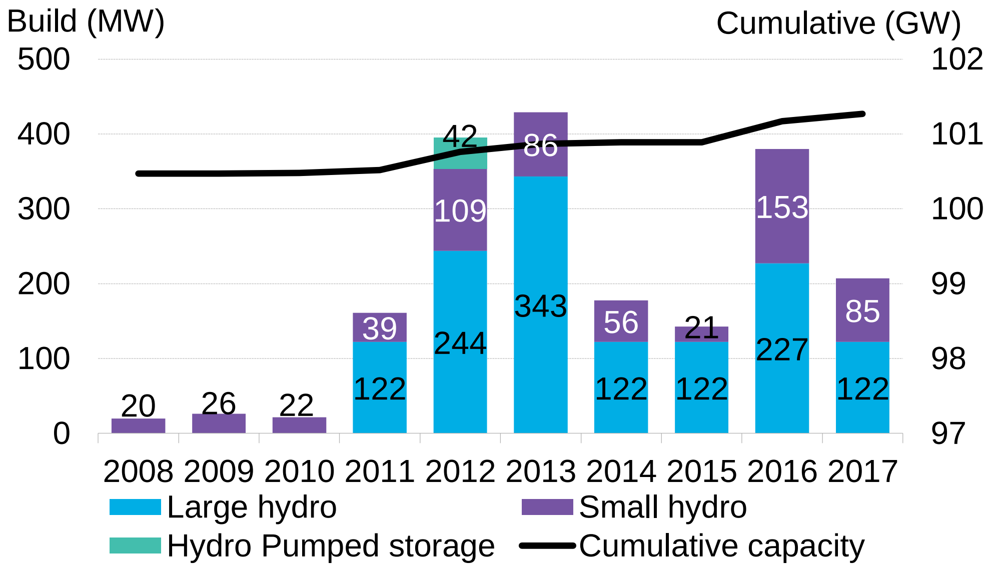
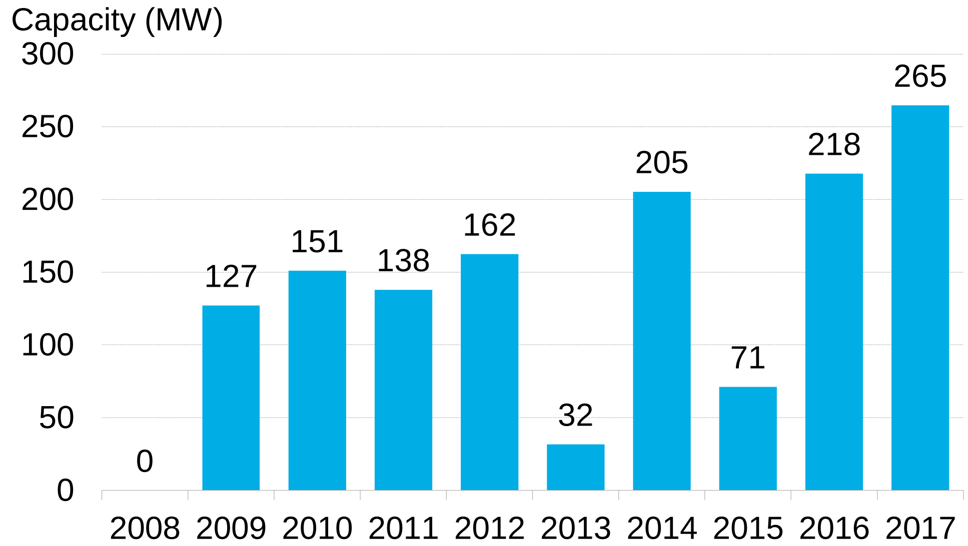
Deployment: U.S. hydropower build and licensed capacity

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 2017 than in the previous year. Out of the 208MW of new build, 122MW came from the repair effort at the Wanapum dam in Washington. The remaining 85MW came from small hydro projects, the most sizable of which was the 76MW Smithland Hydroelectric project southwest of Louisville, Kentucky. No new pumped hydro storage capacity has been added in the U.S. since 2012.
- FERC issued licenses or exemptions for 265MW of hydropower in 2017, the highest amount in at least a decade.
- Hydro projects that began construction before the end of 2016 were able to claim eligibility for the Production Tax Credit (PTC), which was worth $12/MWh for this technology in 2016 and is indexed to inflation. This is roughly half the value of the wind PTC. The Bipartisan Budget Act passed in February 2018 extended the PTC qualification deadline for hydropower by one year retroactively, through December 31, 2017.

Source: Bloomberg New Energy Finance, EIA, FERC Notes: 2017 data are as of end-November 2017. The licensing figures exclude pumped storage licenses.

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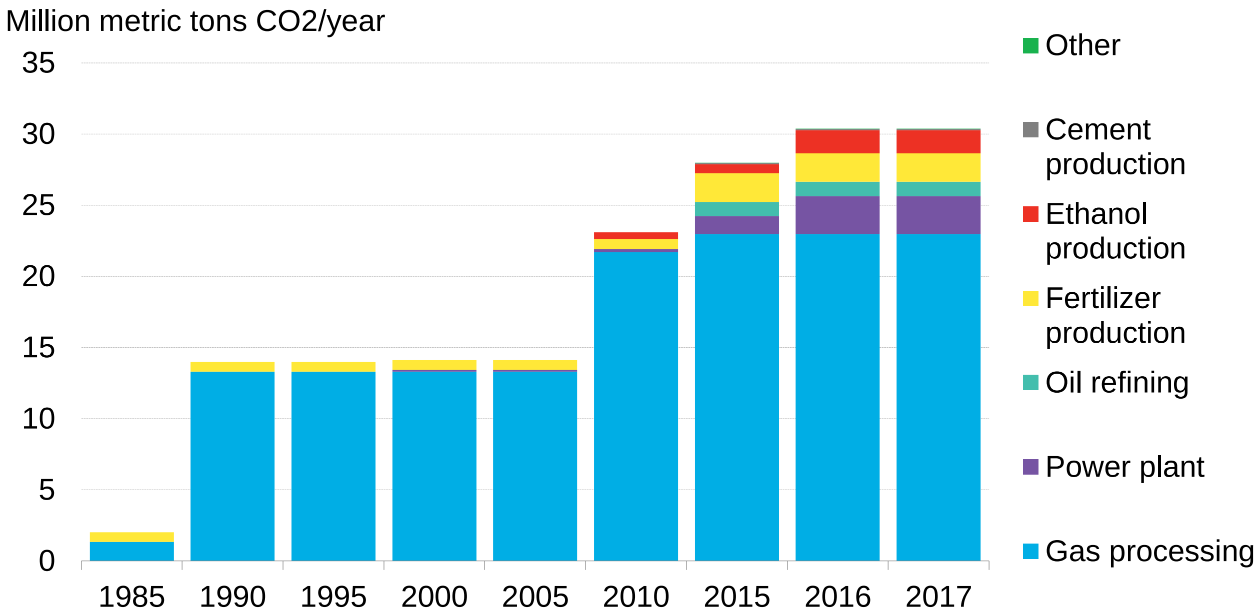
Deployment: Cumulative installed CCS capture rate in the U.S.



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

Source: Bloomberg New Energy Finance

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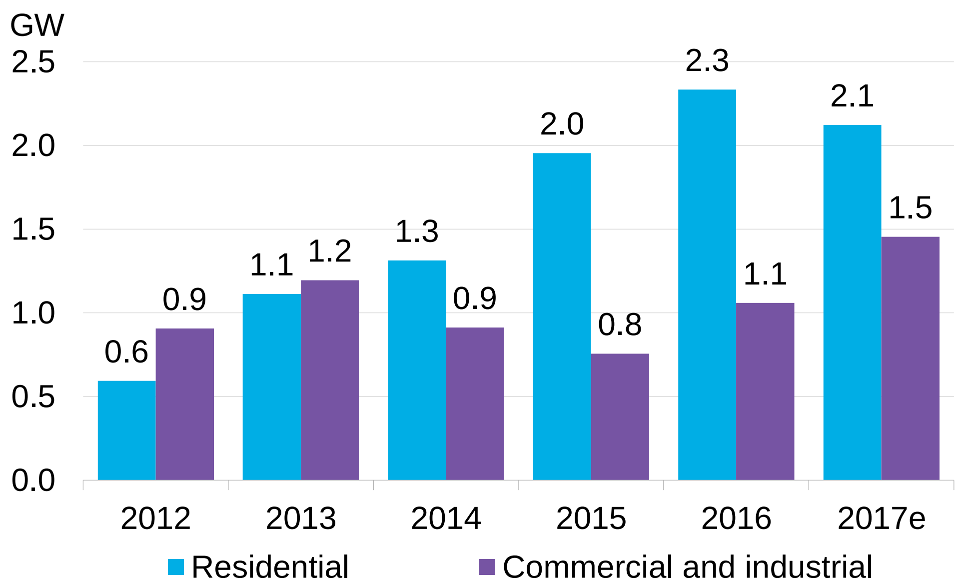
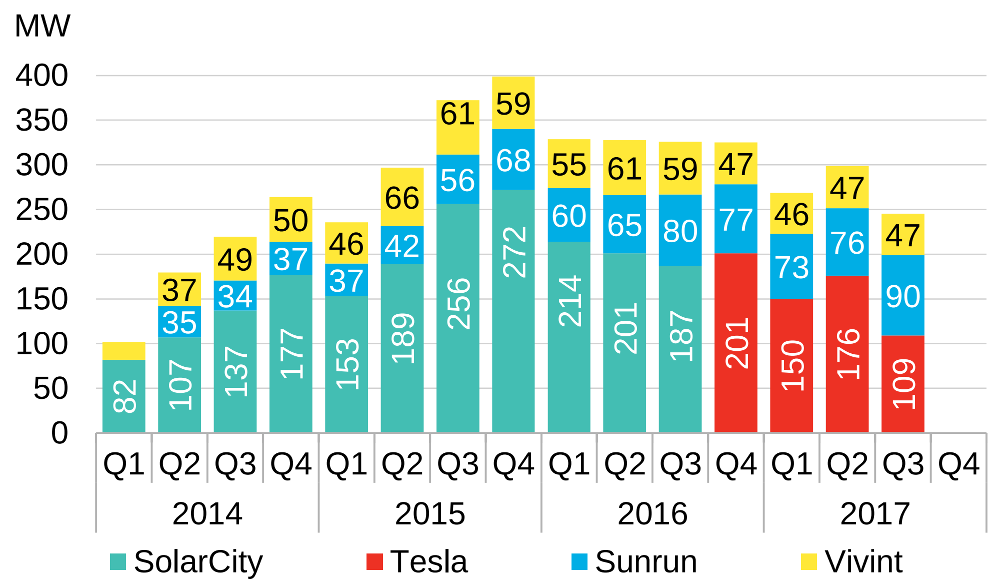
Deployment: U.S. small-scale solar build by type

Annual U.S. small-scale PV build



Installations of top three residential PV vendors

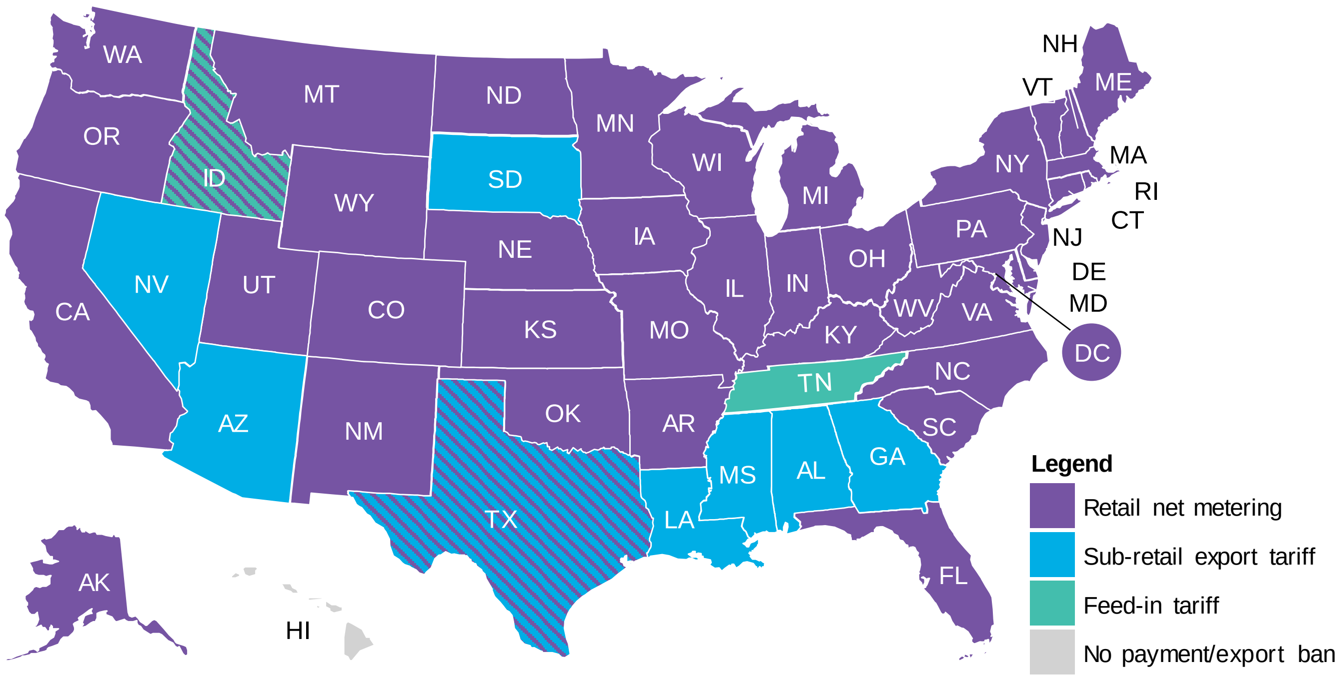


- In 2017, the U.S. residential solar market contracted for the first time in more than a decade as the industry undergoes a prolonged period of restructuring. The three leading vendors have moderated their growth ambitions in search of near-term profitability. In combination, they installed 25% less capacity in 3Q 2017 than the same period in 2016. Most notably, Tesla's 3Q deployments fell to 109MW, 42% below the run-rate achieved by SolarCity immediately before it was acquired, and its lowest levels in over three years. While Sunrun and the large number of local installers are winning some of the share left by Tesla's decline, their growth was insufficient to maintain national-level growth in 2017.
- The residential downturn has been led by California, and the SREC states of Massachusetts and Maryland. In addition, many of the states that enacted net-metering reforms in 2016 have seen their residential solar markets contract as a result.
- Onsite commercial and institutional solar was the only U.S. solar segment to grow in 2017. The uptick was driven largely by California, which lifted the 1MW system threshold in 2016. New York, Texas, Oregon and South Carolina were also stand-out performers in 2017, with each market tripling in size.

Source: Bloomberg New Energy Finance, company filings   Note: Q4 2017 data for individual vendors was not available at time of production.

Bloomberg New Energy Finance

Policy: Net metering regulation as of August 2017 by state

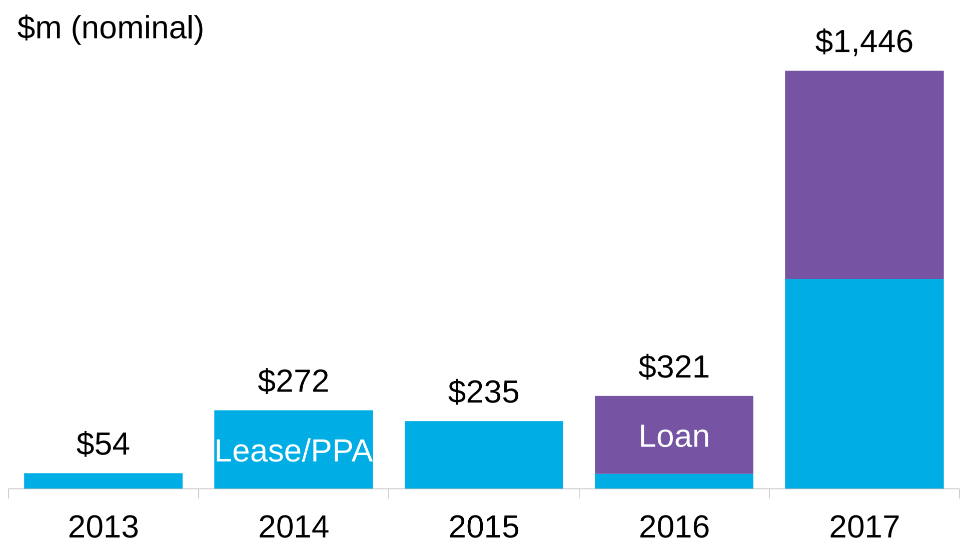


- As of August 2017, net metering at the full retail rate was available to most customers within 40 states and D.C. Net metering has been discontinued in three states over the past year and reform proposals are being considered in a number of other states.
- Arizona, Indiana and Maine formalized plans to transition away from retail-rate net energy metering in the past year, joining Hawaii, Louisiana and Nevada. The replacement schemes vary: Arizona will compensate small-scale PV systems at the five-year-average utility-scale PPA price, and only for 10 years; Indiana will only offer net metering to systems connected before 2022; and Maine will phase down the value of a net metering credit by 10% each year starting in 2018.

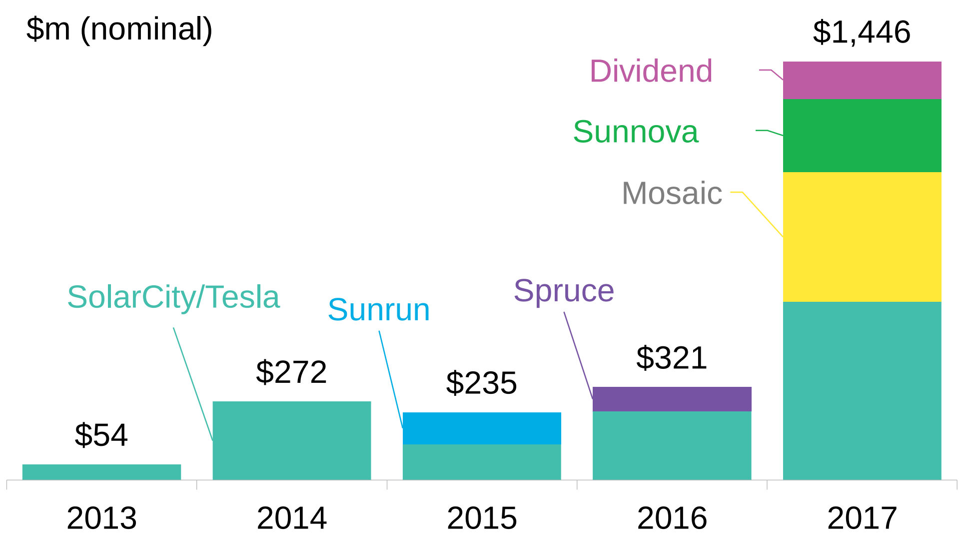
Source: Bloomberg New Energy Finance, DSIRE

Financing: Issuance of solar asset-backed securities

Annual U.S. solar ABS issuance by type



Annual U.S. solar ABS issuance by vendor



- 2017 saw record issuance of U.S. solar asset-backed securities: $1.45bn through the end of November.
- The growing number of solar loan-backed securitizations – as opposed to lease/PPA-backed deals – is consistent with the trend toward host ownership of PV systems among U.S. households, and the rising market share of "long tail" installers (i.e., the fragmentation of the U.S. solar market).
- Bespoke finance products for regional and local installers (provided by Mosaic and Dividend, for example) promise to keep the pressure on newer national third-party installers like Sunnova even as sales from "the big three" (SolarCity/Tesla, Sunrun and Vivint) fall.

Source: Bloomberg New Energy Finance Note: 'Lease/PPA' and 'loan' refer to the type of payments securitized.

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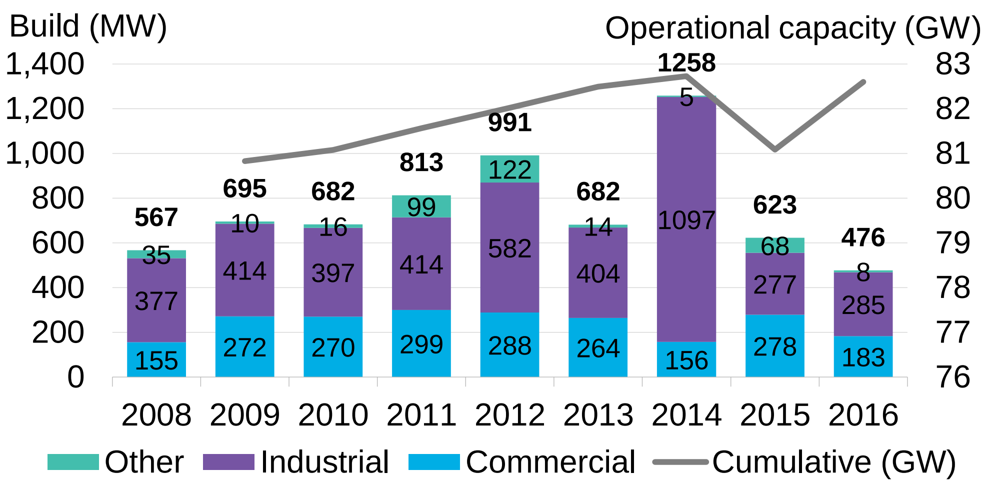
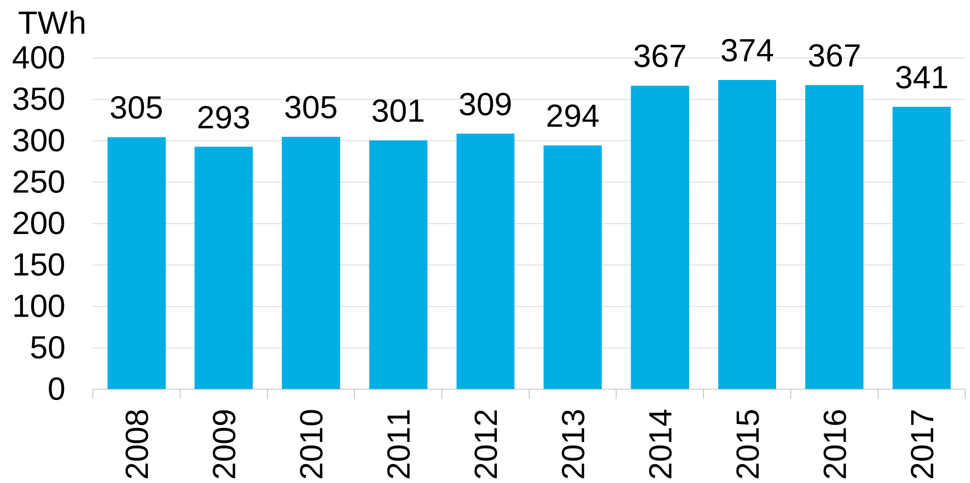
Deployment: U.S. CHP build and generation

U.S. CHP build and cumulative capacity



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

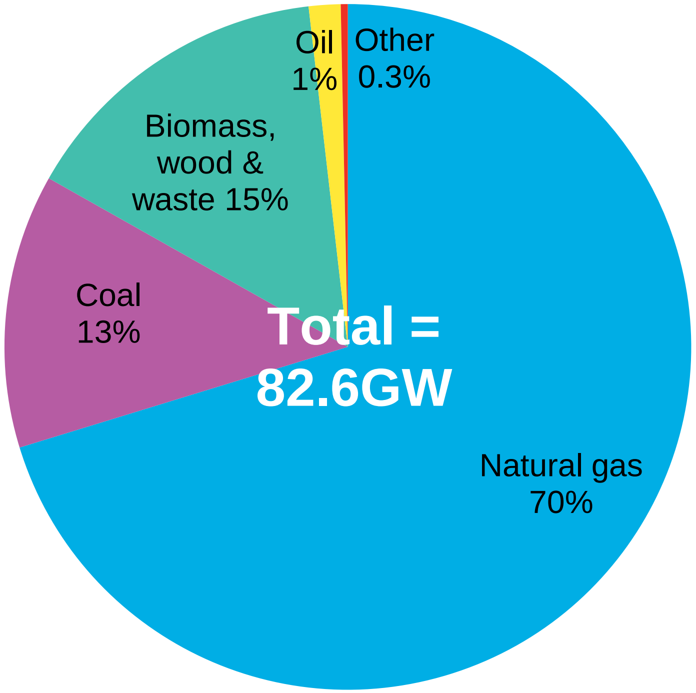


- New CHP installations dropped in 2016 to 476MW, from 623MW in 2015. Since spiking in 2014 to 1.3GW, build has fallen each year as industrial installments contracted.
- The total operational CHP capacity in the U.S. has remained relatively stable in recent years. In 2016, the operational capacity ticked back up to 82.6GW, rebounding from the slight dip in 2015 to 81.1GW due to site retirements and industrial plant closures.
- The sharp jump in installations in 2014 also provided a lasting uptick in CHP generation. Further, in 2015 and 2016, low gas prices continued to encourage greater CHP generation. According to EIA net generation data, CHP units produced an estimated 341TWh in 2017, or 8.5% of total U.S. generation. EIA data may underestimate total CHP production as they do not capture some newer installations, which tend to be smaller and excluded from EIA estimates (see notes below).
- In 2016, the U.S. added 76 large-scale CHP projects (500kW or greater) and 97 small- to medium-sized projects (1-500kW). This represents a growth in installations over 2015 levels, when the U.S. added 73 large-scale facilities and 91 small- to medium-size projects .

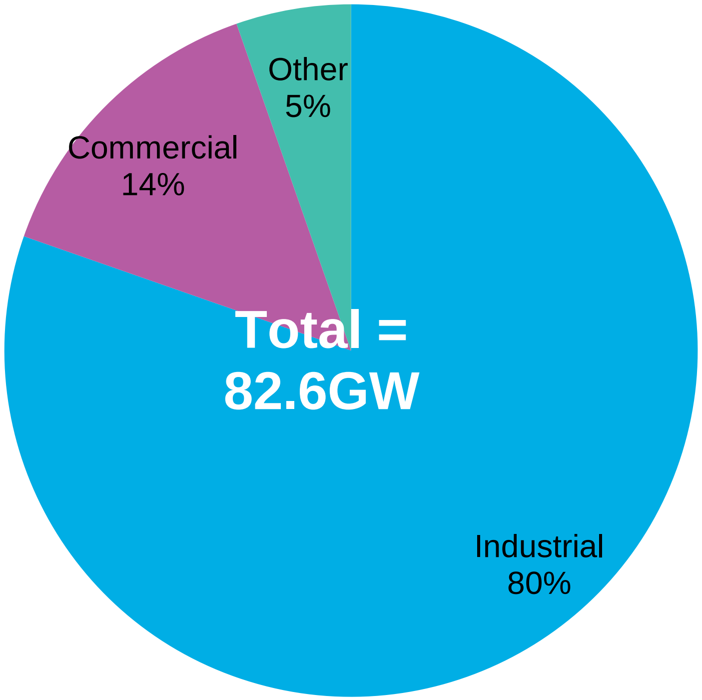
Source: Bloomberg New Energy Finance, DOE CHP Installation Database (maintained by ICF)   Notes: EIA is the best available source for generation data, but is not comprehensive for CHP. The generation figures here are thus underestimated. Specifically, EIA does not collect data for sites <1MW; EIA may not be aware of certain installations and thus may not send these sites a survey for reporting; and EIA categorizes some CHP systems as “electric power” rather than “industrial CHP,” if these systems sell power to the grid while providing steam to an adjacent facility. Values for 2017 are projected, accounting for seasonality, based on latest monthly values from EIA (data available through November 2017).

Deployment: U.S. CHP deployment by fuel and by sector, 2016

U.S. CHP deployment by fuel source



U.S. CHP deployment by sector

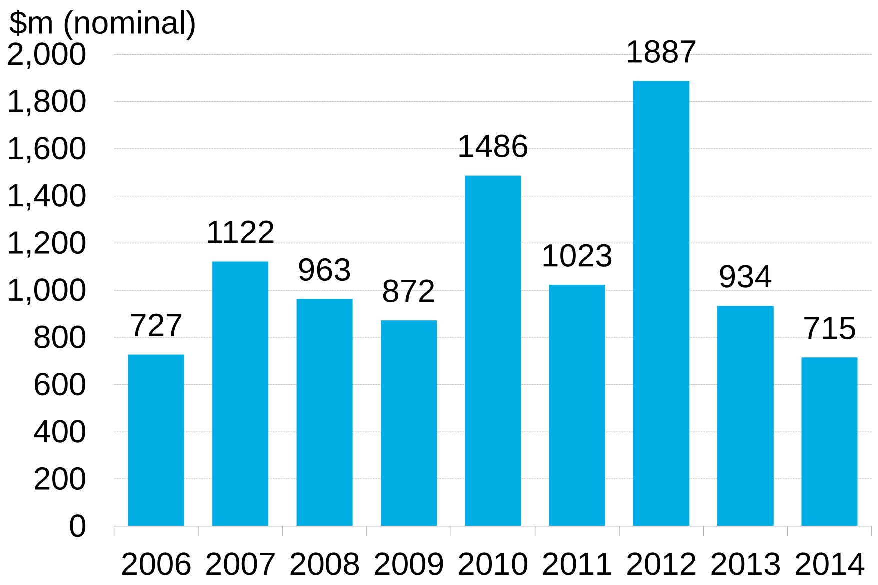


- Natural gas remained the dominant fuel source for CHP, providing 70% of CHP capacity. Units running on biomass, wood, or waste contributed 15% of total operational capacity, while units running on coal made up 13%.
- The industrial sector dominates CHP deployment at 66GW, or 80% of all operational capacity. Commercial users form the second largest share, at 14%.

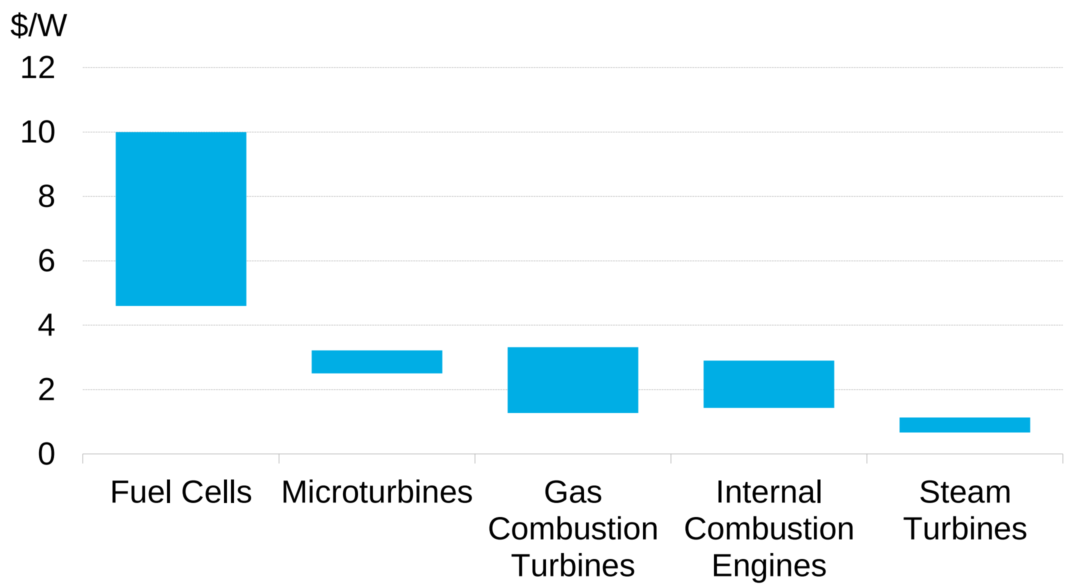
Source: Bloomberg New Energy Finance, DOE CHP Installation Database (maintained by ICF) *Note: totals may not add to 100% due to rounding.*

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: Bloomberg New Energy Finance, DOE CHP Installation Database (maintained by ICF) Notes: 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 only available through 2014 since deployment figures are only available through 2016.

Source: Bloomberg New Energy Finance; 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.

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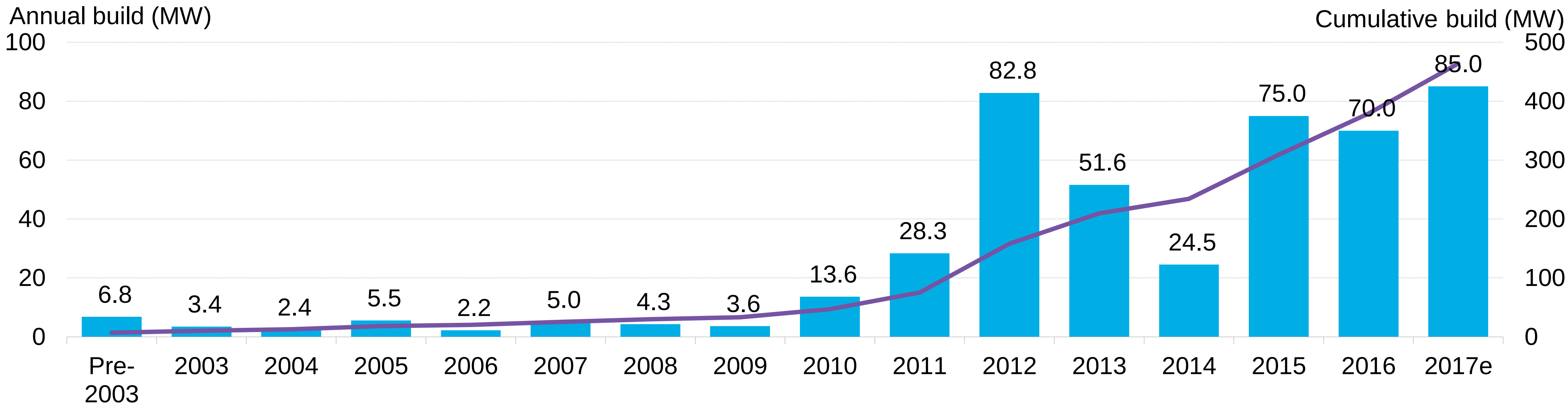
Deployment: U.S. stationary fuel cell build



- Stationary fuel cell build hit its highest point on record, reaching an estimated 85MW of new installations in 2017. Build has rebounded since reaching a low in 2014, surpassing 70MW every subsequent year. Key developments in 2017 included:
  - Bloom Energy's strategic alliance with PowerSecure generated 37MW of installations using its solid oxide fuel cell (SOFC) technology at twelve Equinix data centers in California and New York state. These began installation in 2017 and will be completed in 2018.
  - FuelCell Energy reduced its annual output from 50MW to 25MW to support cost control measures. Despite this, its carbonate fuel cell technology has been sought for a sizeable 39.8MW project with Long Island Power Authority's FIT IV Program at three sites. It also secured a 7.4MW PPA with Connecticut Municipal Electric Energy Cooperative which will provide resiliency to the local U.S. Navy submarine base.
  - Doosan Fuel Cell America signed a strategic alliance with Wells Fargo to finance new PPAs that Doosan Energy Solutions secure may with new commercial, industrial and municipal customers.
- U.S. fuel cell activity is concentrated in six states: California, Connecticut, Delaware, New York, New Jersey and North Carolina. In 2017, subsidies were cut in California and New Jersey. Fuel cell companies have moved towards PPA models that shield end-customers from the high upfront cost of these systems, finding some success in 2017.

*Source: E4Tech Fuel Cell Industry Review 2017, Fuel Cell and Hydrogen Energy Association, SGIP, Bloomberg New Energy Finance Notes: Fuel cells installed before 2003 are excluded due to the expected 10-year lifetime of these installations. *2017 data are preliminary.*

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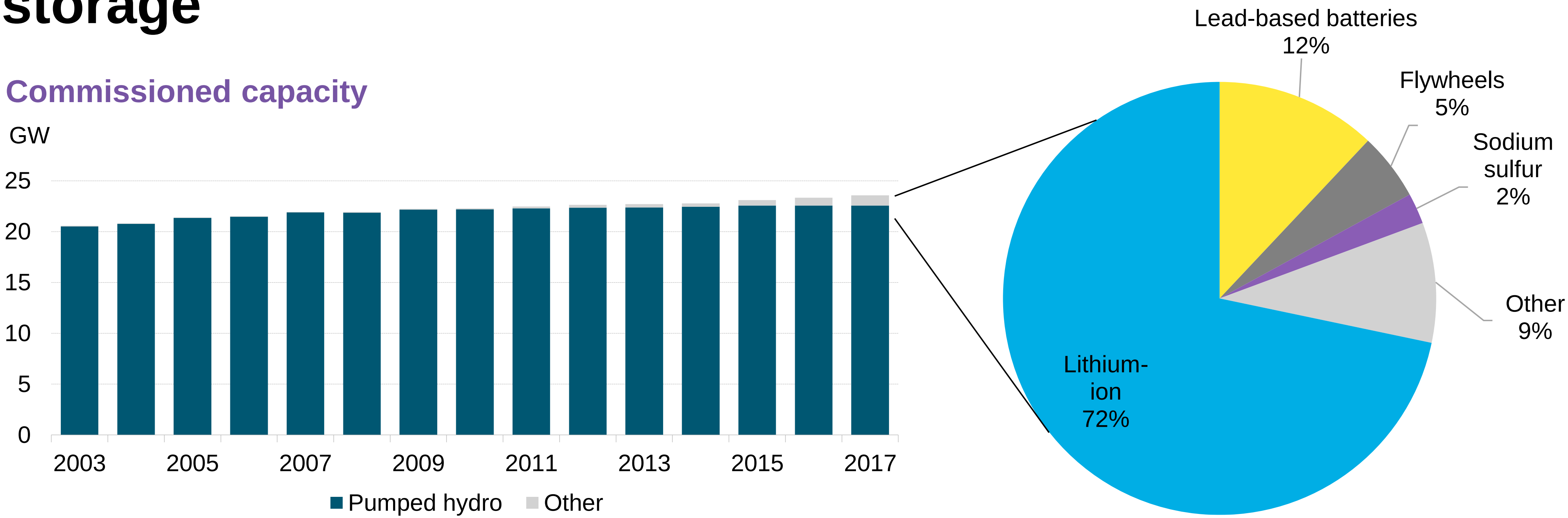
Deployment: U.S. cumulative energy storage

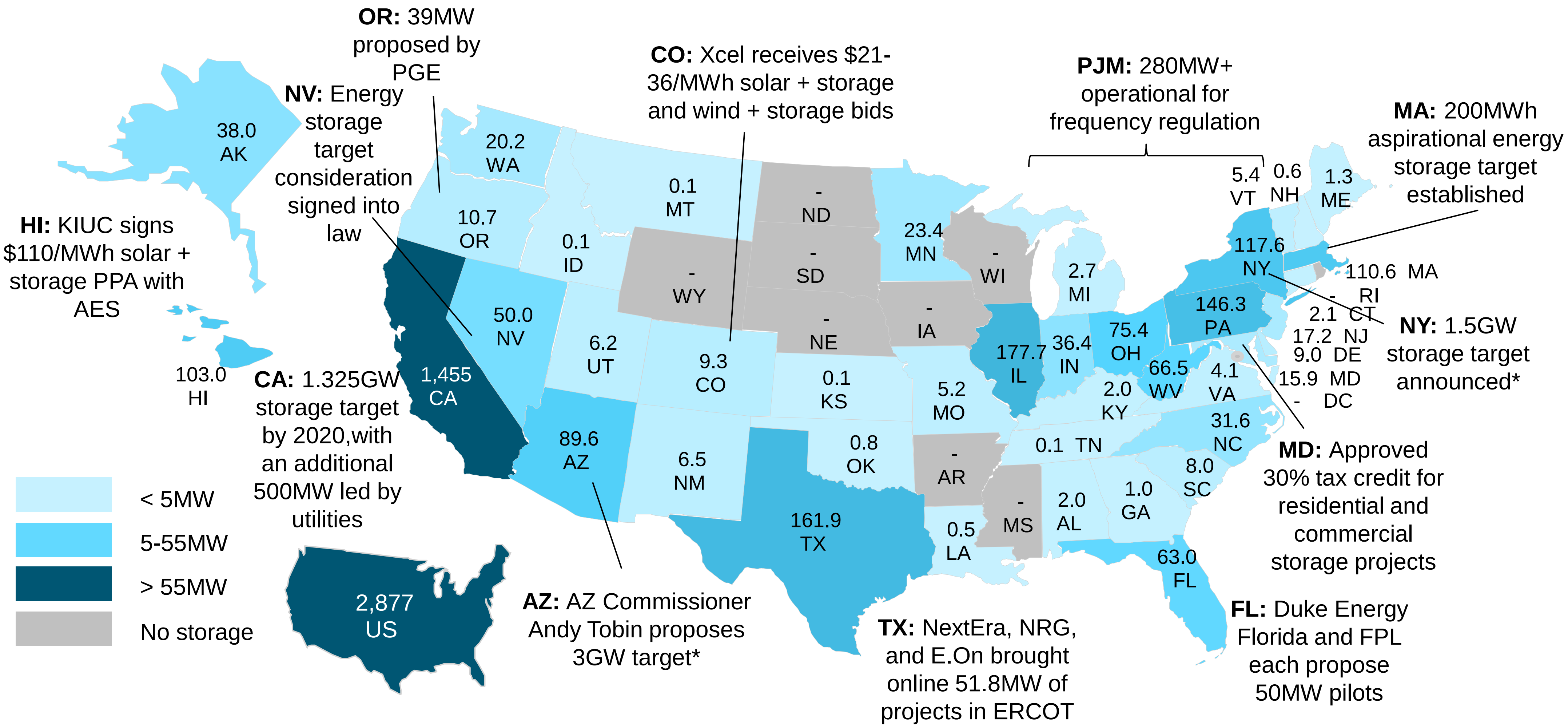
Commissioned capacity



- Pumped hydropower storage projects account for around 96% 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 2017, FERC counted 19 pending licenses for further pumped storage projects, totaling 2,271MW in new capacity. The largest projects are all closed-loop facilities: the 1,000MW Parker Knoll in Utah, 500MW Lake Elsinore in California, 393MW Swan Lake in Oregon and 240MW Mineville in New York.
- In 2017, FERC did not advance on a November 2016 proposal concerning the role of energy storage and distributed energy resource (DER) aggregation in U.S. wholesale markets. The proposal aimed to remove barriers for these new energy resources and bring a measure of consistency to how they participate across organized power markets. FERC was originally expected to advance this throughout 2017, as the industry awaited the issuance of a final regulation after FERC reviewed public feedback. However, FERC's focus on other priorities and its lack of quorum throughout most of the year caused delays. The timeline for final issuance is unclear as of December 2017, but if issued, this would be a major regulation in support of energy storage resources in U.S. wholesale markets.

Source: EIA, FERC, Bloomberg New Energy Finance

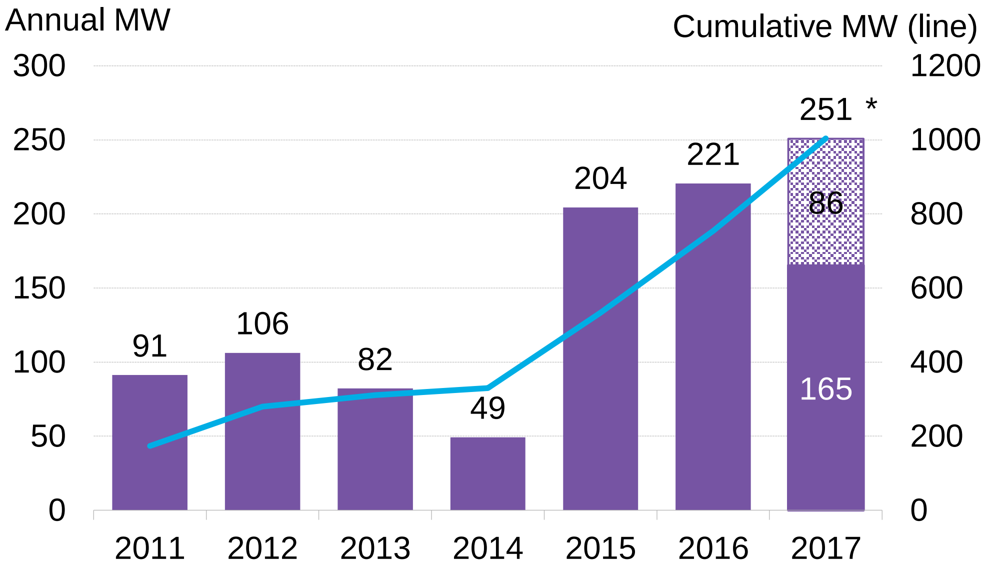
Deployment: U.S. announced and commissioned energy storage projects



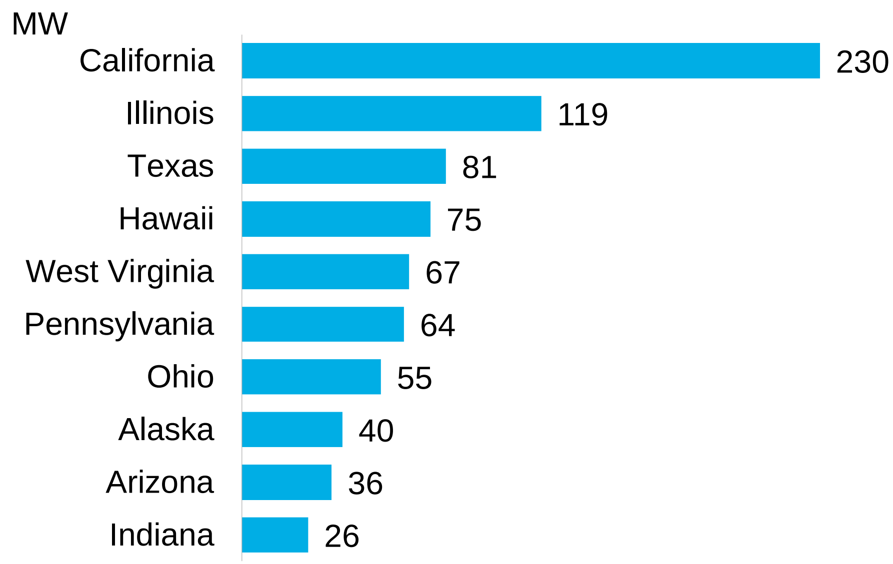
*Source: Bloomberg New Energy Finance Note: Includes projects that are larger than 500kW/500kWh, have announced a specific location, and has been confirmed by the relevant company through public data. *These targets were proposed in January 2018*

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

Commissioned capacity



Installations by state (top 10 states)

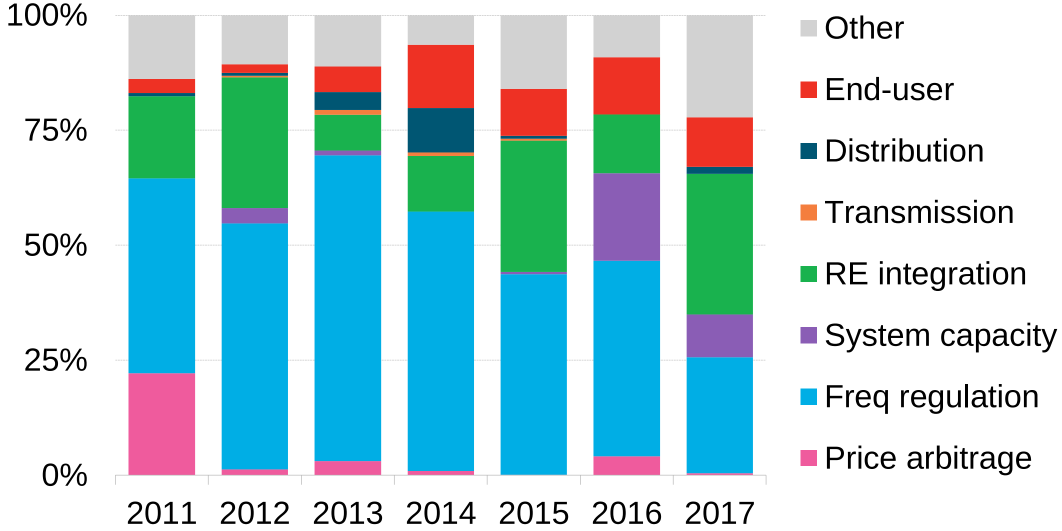


- Annual energy storage installations have increased since 2014, and is expected to do so again in 2017. Build ramped up in 2015 from projects seeking to participate in the PJM frequency regulation market – those represent most of the capacity in Illinois, West Virginia, Ohio and Pennsylvania.
- While 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. The majority of the commissioned capacity there was built between late 2016 and early 2017 as an emergency response to the gas supply shortages expected from the Aliso Canyon gas storage facility leak-mitigation efforts.
- Beyond California and PJM, many smaller projects have commissioned in other states such as Hawaii, Texas, Indiana and New York.
- Falling lithium-ion battery pack prices have helped to lower costs for new stationary storage applications (see here).

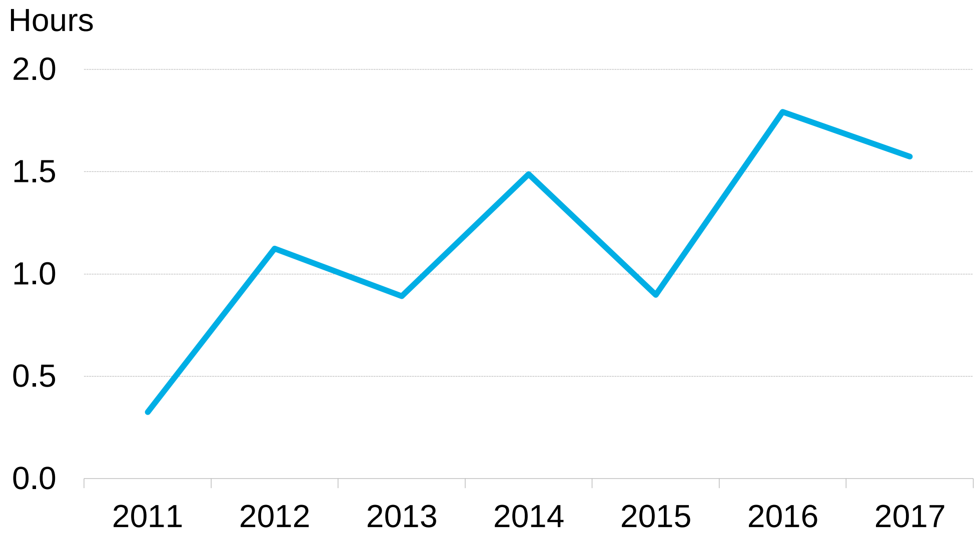
*Source: Bloomberg New Energy Finance Notes: *2017 includes expected but unconfirmed capacity as of January 31, 2018. Unconfirmed capacity is marked in white. Does not include pumped hydropower, underground compressed air energy storage, or flooded lead-acid batteries. Minimum project size for inclusion in this analysis is 500kW or 500kWh. Cumulative capacity subtracts capacity that was decommissioned. Installations by state includes only confirmed capacity.*

Deployment: Application mix for U.S. non-hydropower energy storage for commissioned projects

Applications (% by MW)



Average project duration

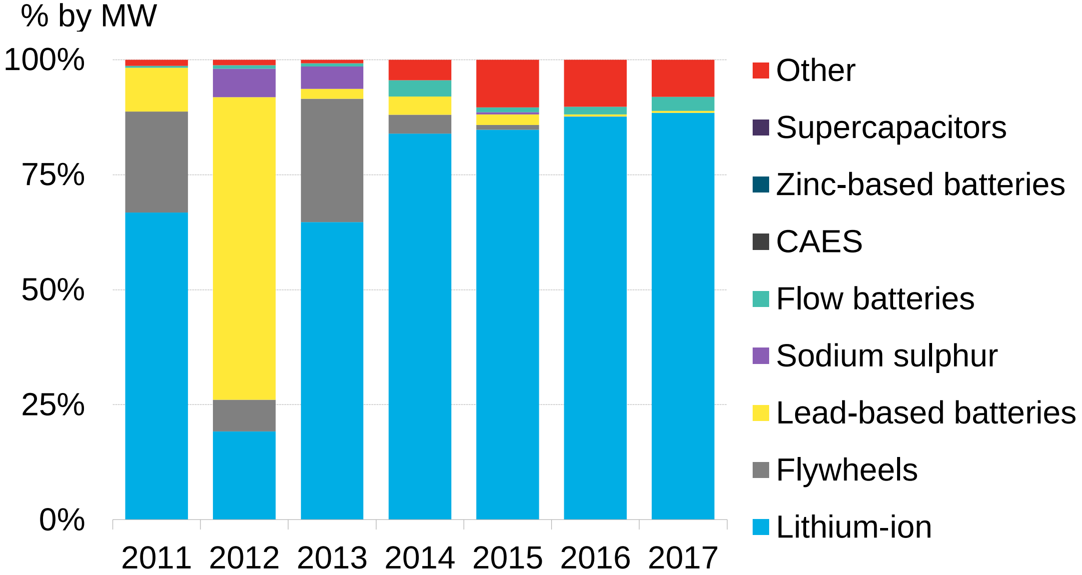


- Frequency regulation was the most common application for new storage systems installed between 2011 and 2016. Much of this was driven by deployments in PJM. However, the market for frequency regulation in PJM is now essentially saturated and opportunities for this service in other territories are less attractive.
- In 2016 and 2017, projects providing peaking capacity began to contribute a notable part of the application mix (this appears as "system capacity" in the applications mix graph above). This was mainly 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 1.6 hours in 2017.
- In 2017, many more longer duration projects were announced. Examples include Hawaiian utility KIUC's solar-plus-storage PPA, which has a 5-hour duration battery, and National Grid projects in Nantucket and Long Island featuring 8-hour duration batteries.

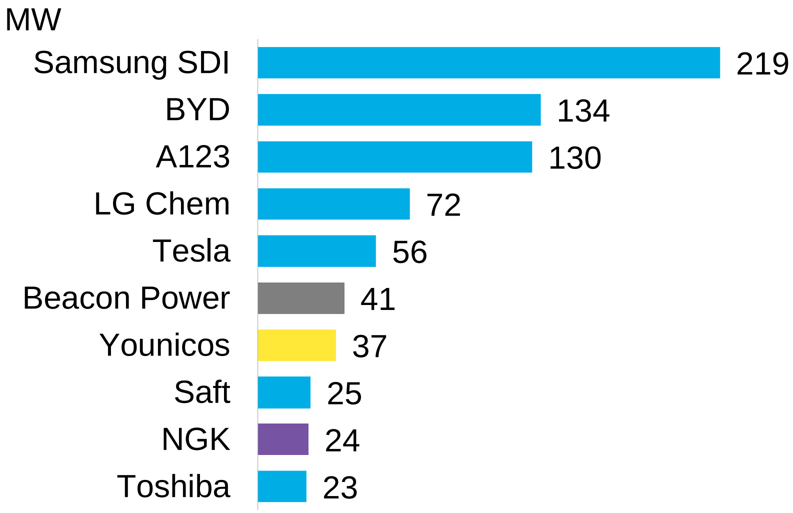
Source: Bloomberg New Energy Finance   Notes: Pumped hydropower storage is not included as it would dwarf all other technologies. "Other" refers to applications not represented in the legend; many of these are government-funded technology testing or proof-of-concept pilot projects.

Deployment: Technology mix for U.S. non-hydropower energy storage for commissioned projects

Technology mix



Top 10 storage technology providers



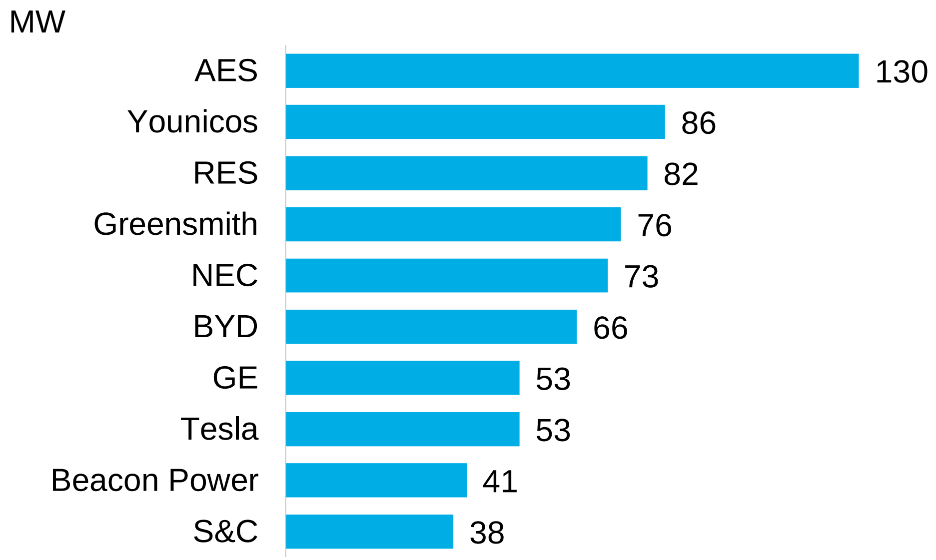
The lithium-ion battery has been the technology of choice for developers of projects of all sizes, because:

- It is widely available and mass produced all over the world;
- It can provide high power for short-duration applications (e.g. frequency regulation) and up to 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. In 2014, two prominent pure-play companies (Xtreme Power, A123 System) filed for Chapter 11; 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.

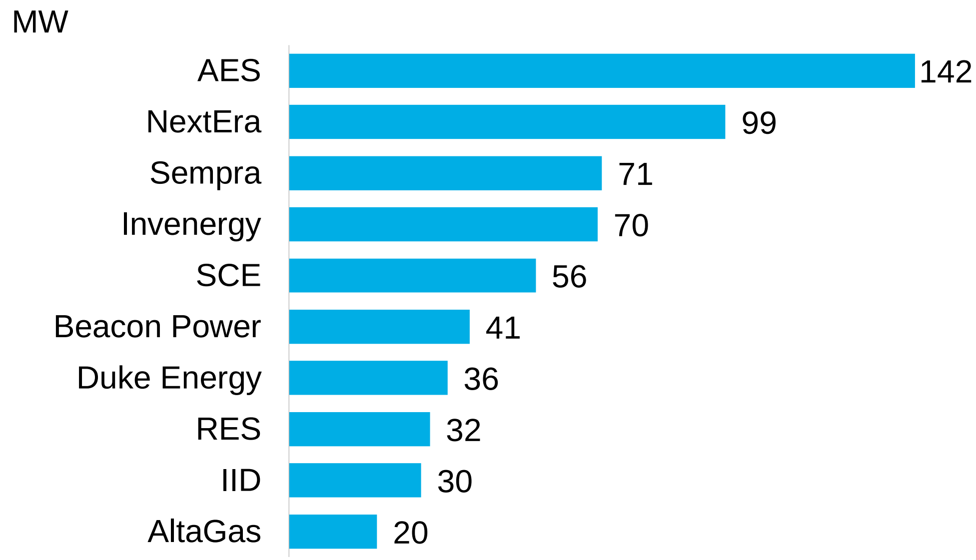
Source: Bloomberg New Energy Finance Notes: Pumped hydropower storage is not included as it would dwarf all other technologies. "Other" refers to applications not represented in the legend; many of these are government-funded technology testing or pilot projects to prove concepts. Top 10 based on commissioned capacity.

Deployment: U.S. energy storage commissioned projects, by integrator and owner

By system integrator



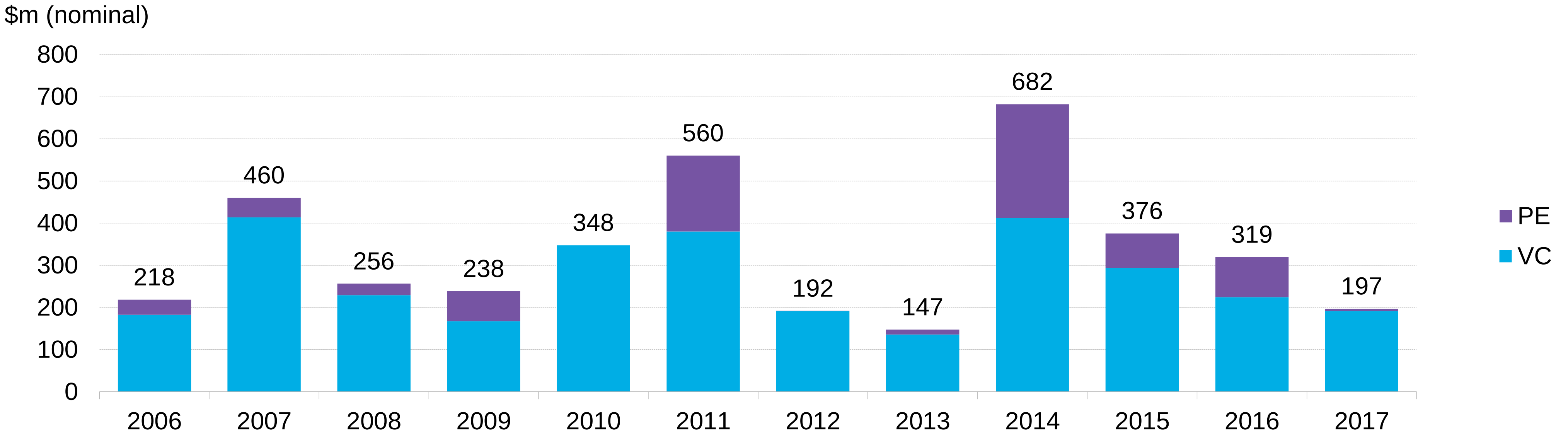
By owner



- 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.
- AES Energy Storage has been the leading system integrator as well as project owner in the U.S.
- 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 alone. Meanwhile, AES Corp. and Siemens AG announced on July 11, 2017 that they are forming Fluence, a new energy-storage technology and services company. 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: Bloomberg New Energy Finance

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



- There has been over $4 billion of venture capital and private equity investment in U.S. energy storage companies since 2006. Of this, $197 million came in 2017, according to latest available data. The top disclosed investments for stationary storage in 2017 were:
  - $34 million for Advanced Microgrid Solutions, a California-based distributed storage turnkey solution provider which received a investment that was led by Southern Company, Energy Impact Partners and DBL Partners;
  - $32 million for Primus Power, a zinc-based flow battery technology company with investors from a consortium of five companies led by Anglo American Platinum;
  - $6 million for Gridtential Energy, a lead-battery technology company which received investment from 24 participants, including lead battery companies East Penn Manufacturing and Crown Battery;
  - $2.65 million for FlexGen Power Systems, an energy storage system integrator and power conversion company with undisclosed investors.
  - Total VCPE investment in the sector has shrunk each year since 2014. 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.

Source: Bloomberg New Energy Finance Note: Values include estimates for undisclosed deals.

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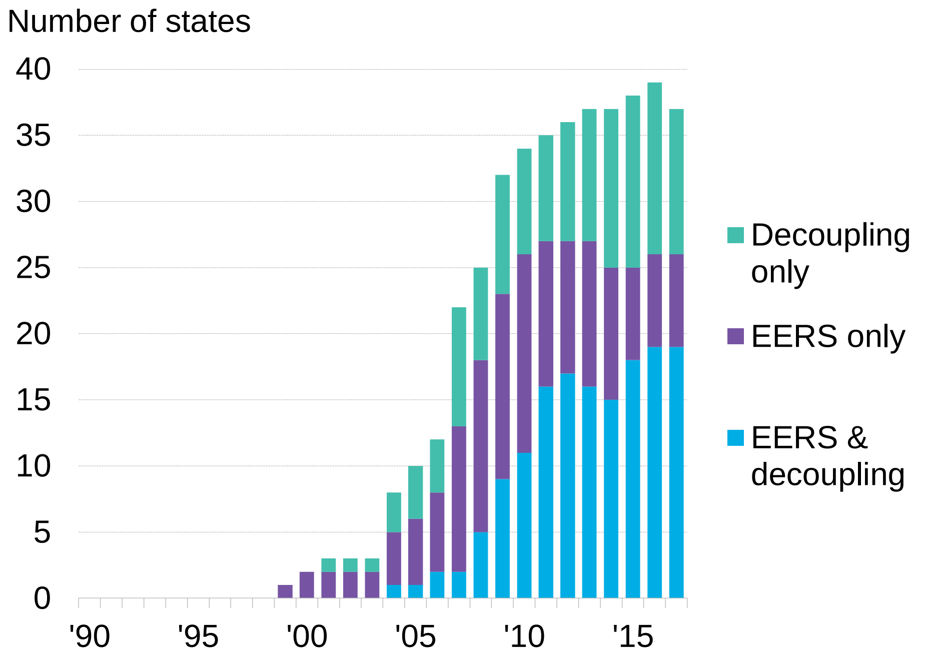
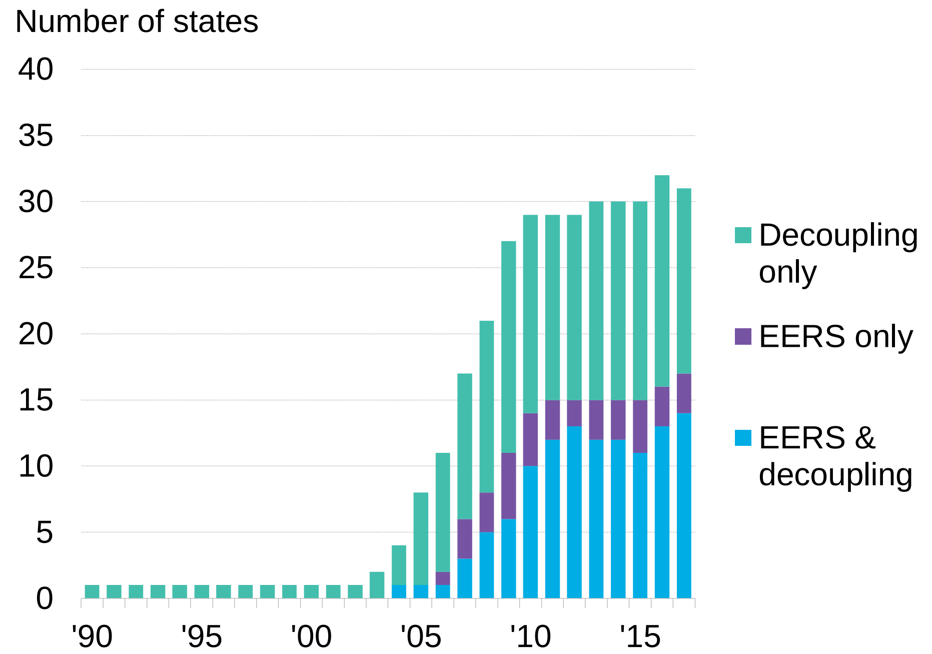
Policy: U.S. states with EERS and decoupling legislation for electricity and natural gas

Electricity



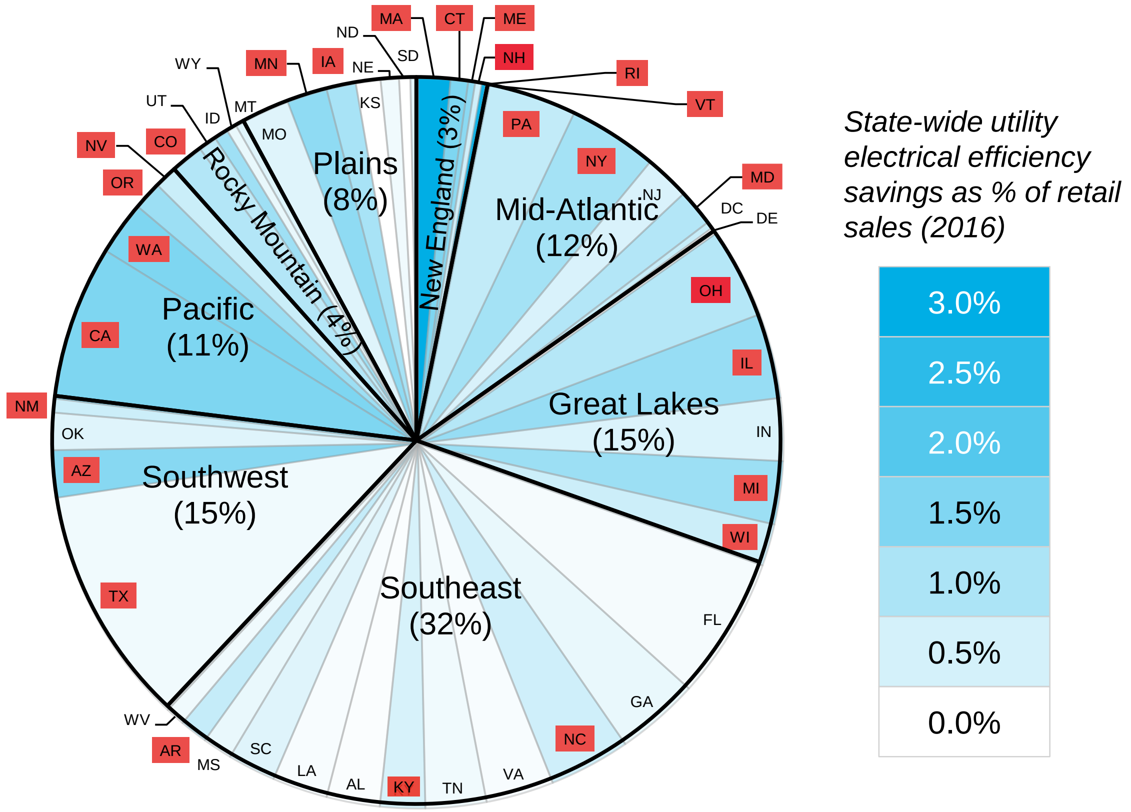
Natural gas



- 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 (see here). Although the number of states adopting legislation has slowed, spending has continued to rise as EERS targets have become more stringent. In 2016, utility spending on efficiency reached $7.6bn.

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

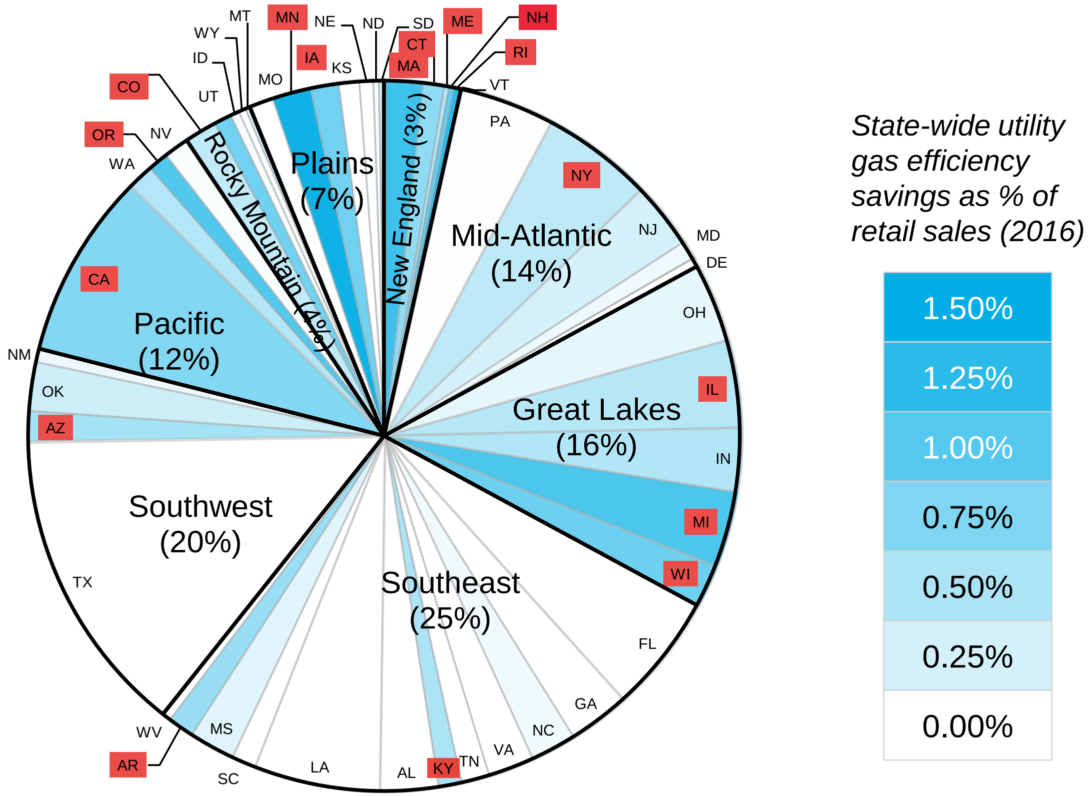
Policy: Share of total electricity consumption by U.S. state and region, and electrical efficiency savings by state, 2016



- The presence of EERS legislation (red highlights) and electricity savings (blue shading) are correlated and follow regional trends.
- The Southeast is notable for having both low EERS uptake and limited utility electricity savings.
- In the Rocky Mountain and Plains regions, uptake of EERS is mixed. In the rest of the U.S., uptake is near universal and electricity savings are accordingly higher.

Source: ACEEE, EIA, Bloomberg New Energy Finance   Notes: The shading for individual states indicates savings from utility electrical efficiency programs as a fraction of retail sales. State codes highlighted in red indicate EERS requirements for electric utilities. Hawaii and Alaska are not depicted.

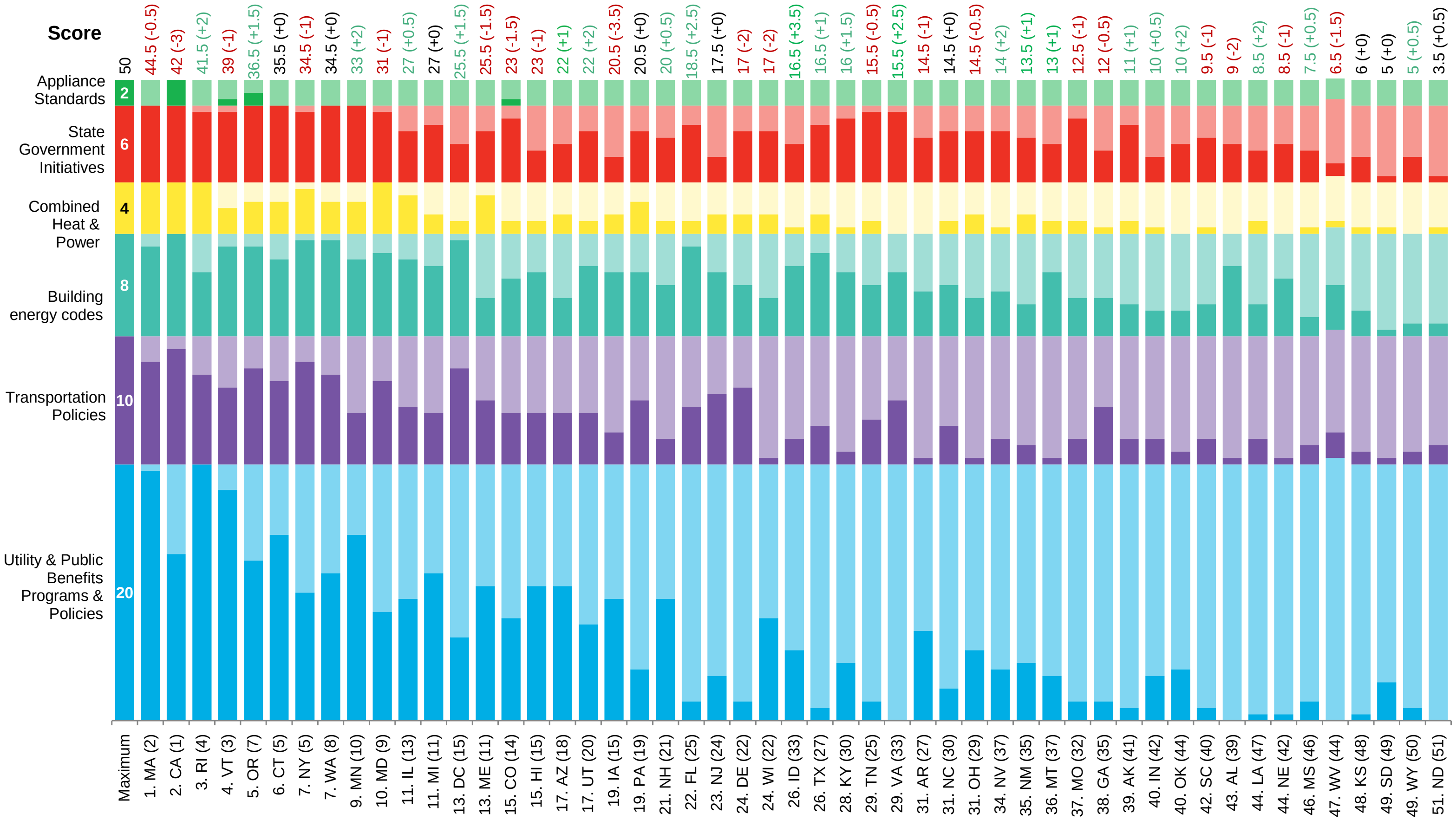
Policy: Share of total natural gas consumption by U.S. state and region, and natural gas efficiency savings by state, 2016



- As with electricity, states which have implemented natural gas EERS see higher utility natural gas savings, and both these factors follow regional trends. However, EERS policies appear more correlated with savings for natural gas than for electricity—states with natural gas EERS in a region with low savings (e.g. AZ, AR, KY) stand out more from their neighbors, as do states with no EERS in high-savings regions (e.g. PA, OH).
- Fewer states overall have adopted EERS for natural gas than for electricity.
- The Southeast and Southwest, which account for 45% of U.S. gas (end-use) consumption, have the lowest levels of overall savings.

Source: ACEEE, EIA, Bloomberg New Energy Finance Notes: The shading for individual states indicates savings from utility natural gas efficiency programs as a fraction of retail sales. State codes highlighted in red indicate EERS requirements for natural gas utilities. Hawaii and Alaska are not depicted.

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

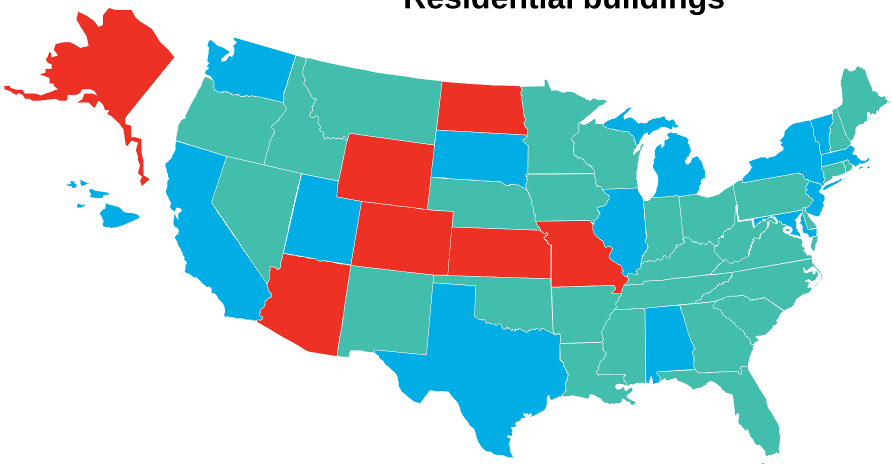


- Massachusetts was the highest-ranked state in 2017. Through utility programs, it achieved record-high electricity savings equal to 3% of sales.
- Second-placed California scored maximum points across a number of categories, including building energy codes, state government initiatives and appliance standards, reflecting a number of major policy initiatives.
- Idaho was a notable climber in the middle-rankings, moving from 33rd to 26th year-on-year due to increased utility spending on efficiency, updates to building codes and an uptick in electric vehicle registrations.
- Iowa fell the furthest, due to a temporary suspension of its loan and grant programs while the Iowa Energy Center moves from Iowa State University to the Iowa Economic Development Authority.

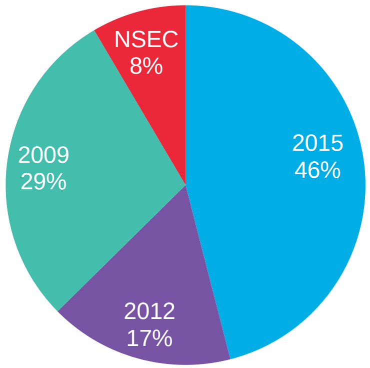
Source: ACEEE, EIA, Bloomberg New Energy Finance Note: Numbers in parentheses at the bottom of the chart indicate 2016 ranking. Numbers in parenthesis at the top denote the change in score from 2016 levels.

Policy: State adoption of International Energy Conservation Code in buildings

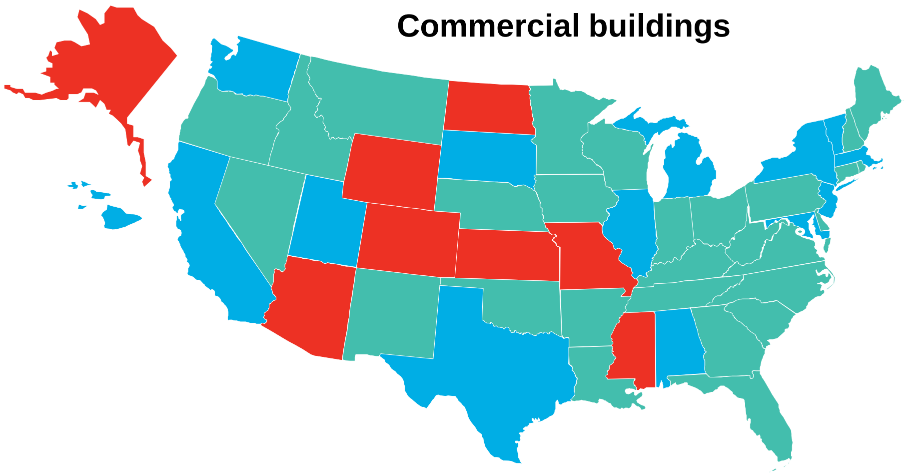
Residential buildings



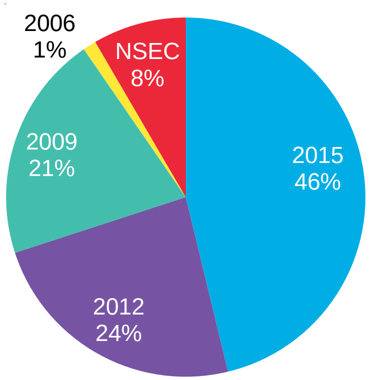
As a percentage of U.S. population



Commercial buildings



As a percentage of U.S. population

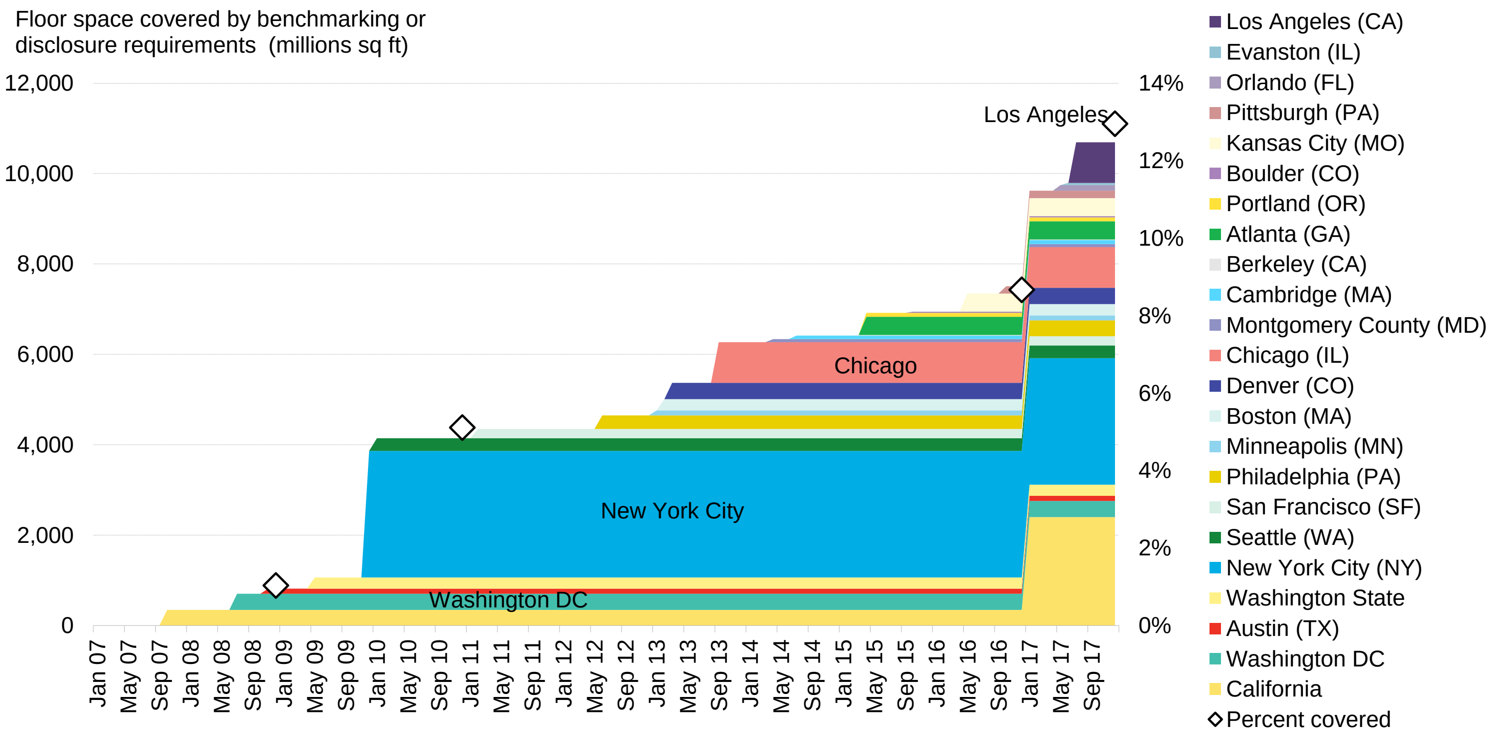


2015 IECC | Earlier IECC | No state energy code

Source: U.S. Department of Energy, U.S. Census Bureau, BNEF

- The majority of states have adopted some version of the International Energy Conservation Code (IECC) for both residential and commercial buildings.
- Over time, standards are amended and become more stringent. Thus states that have adopted the most recent (2015) standard have stronger incentives in place for building efficiency.
- As with other legislation, there are strong regional trends. States on the West Coast tend to have either 2015 or 2012 standards in place, whereas on the East Coast 2012 and 2009 are more common.
- The four most populous states (California, Texas, Florida and New York) all have 2015 standards in place for both residential and commercial buildings.
- Even for states that are labeled as having “no state energy code,” many of the larger jurisdictions within these states have adopted a recent version of the IECC.

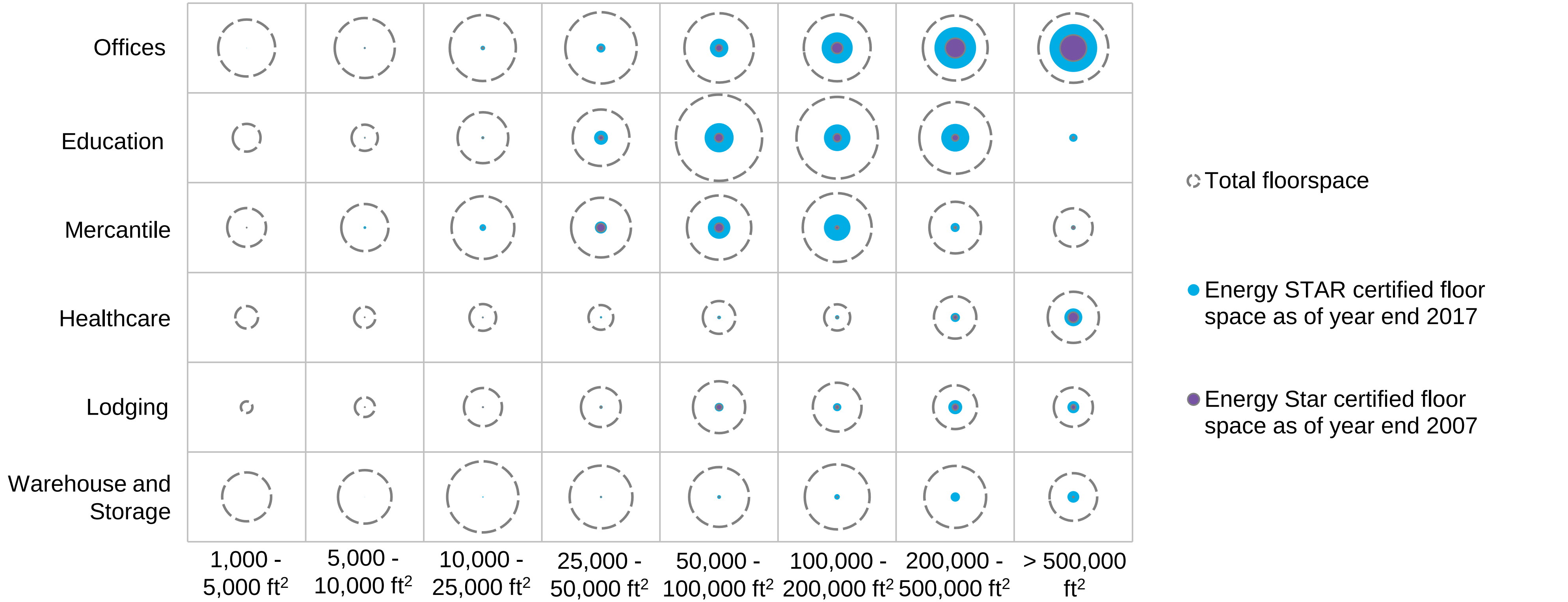
Policy: U.S. building floor space covered under state or local energy use benchmarking/disclosure policies



Source: Institute for Market Transformation (IMT), U.S. DOE's Buildings Energy Data Book, Bloomberg New Energy Finance Notes: Accounts for overlap between cities and states (e.g., no double-counting between Seattle and Washington State numbers). 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. Diamonds are spaced out in irregular intervals since data for the denominator (total commercial sector floor space in the U.S.) is available at irregular periods (2008, 2010, 2015e). The diamond for December 2014 assumes linear growth in the denominator over 2010-15. Previous editions of the Factbook omitted Cambridge, MA as the floor space was still being tallied. Portland, ME is not shown this year for the same reason.

- 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.

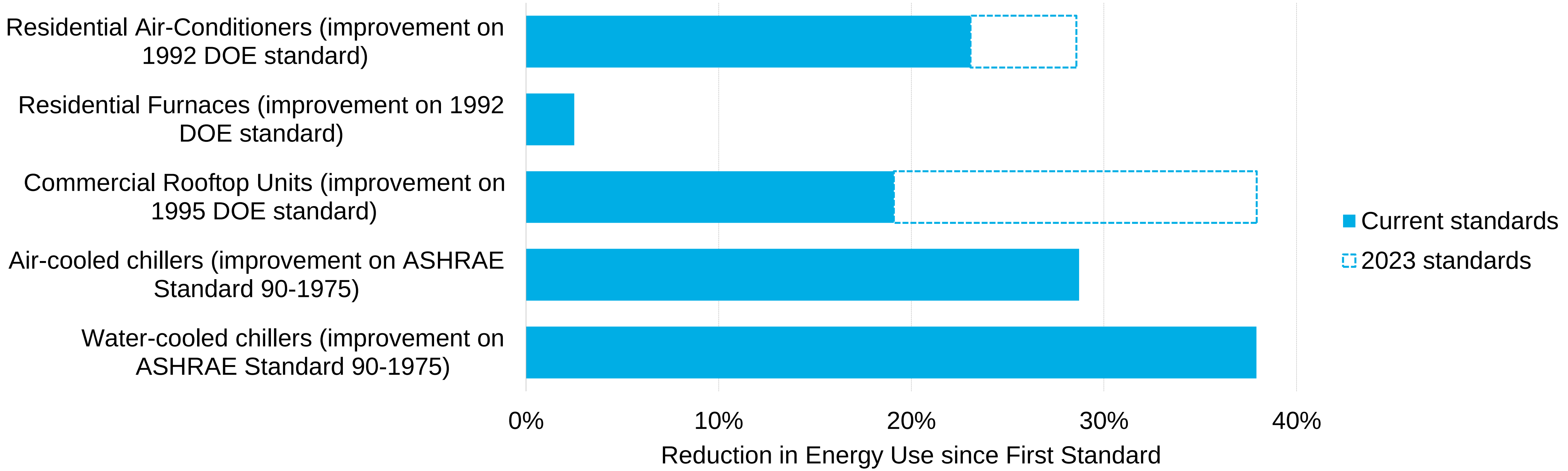
Deployment: Energy Star-certified floor space and total floor space for U.S. commercial buildings



- 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, Bloomberg New Energy Finance Notes: There is insufficient data for total U.S. floor space of educational buildings in excess of 500,000ft^2.

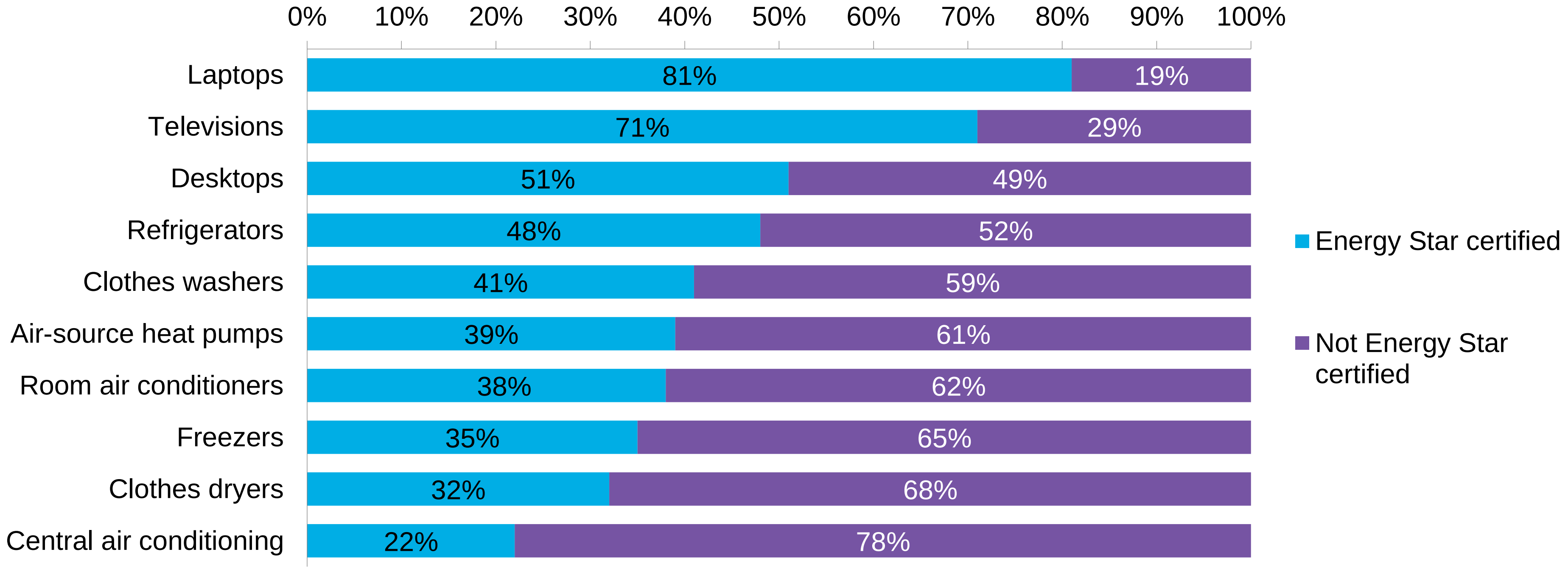
Policy: Reductions in energy use by HVAC equipment, as required by efficiency standards



- As technology advanced, efficiency standards have tightened in order to continue driving building energy use reductions through innovation and other improvements.
- 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: Percent of Energy Star-certified products sold by product type, 2016

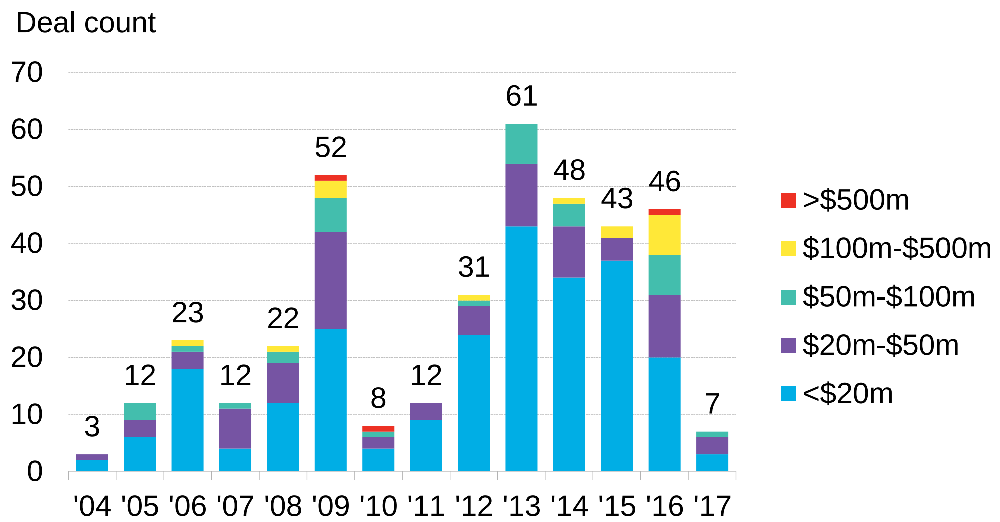


- Of the products considered, laptop computers have the highest rates of certification at 81%. This is in contrast to desktop computers, where the certification rate stands at only 51%. Because energy efficiency also impacts laptop battery life, there is an additional incentive for consumers to opt for an efficient option. This is a likely explanation for the difference.
- Central air conditioning and clothes dryers remain among the products with lower certification rates (below one third each).
- 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.

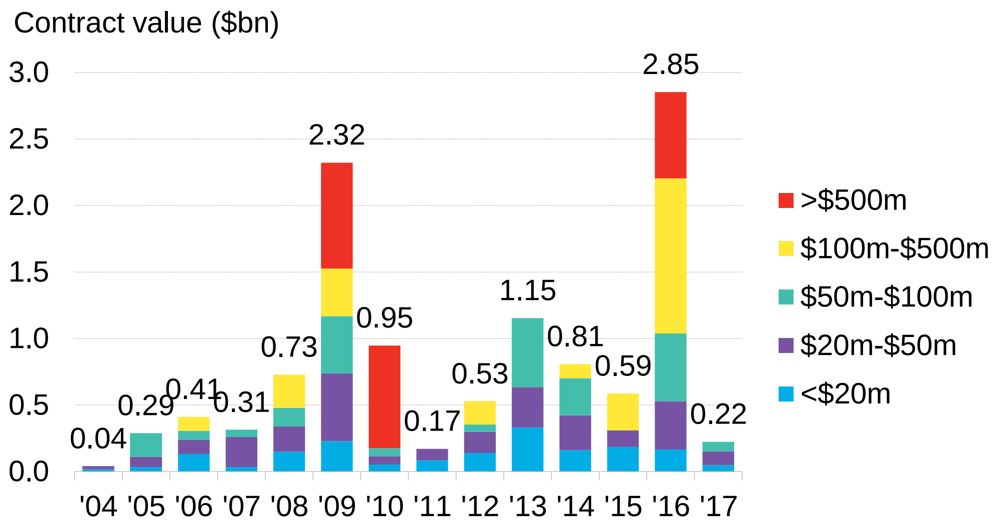
Source: Energy Star Note: Non-exhaustive selection of appliances; share of certified appliances sold is based on sales data compiled by Energy Star.

Policy: U.S. federal energy efficiency contracts

Number of deals, sorted by size



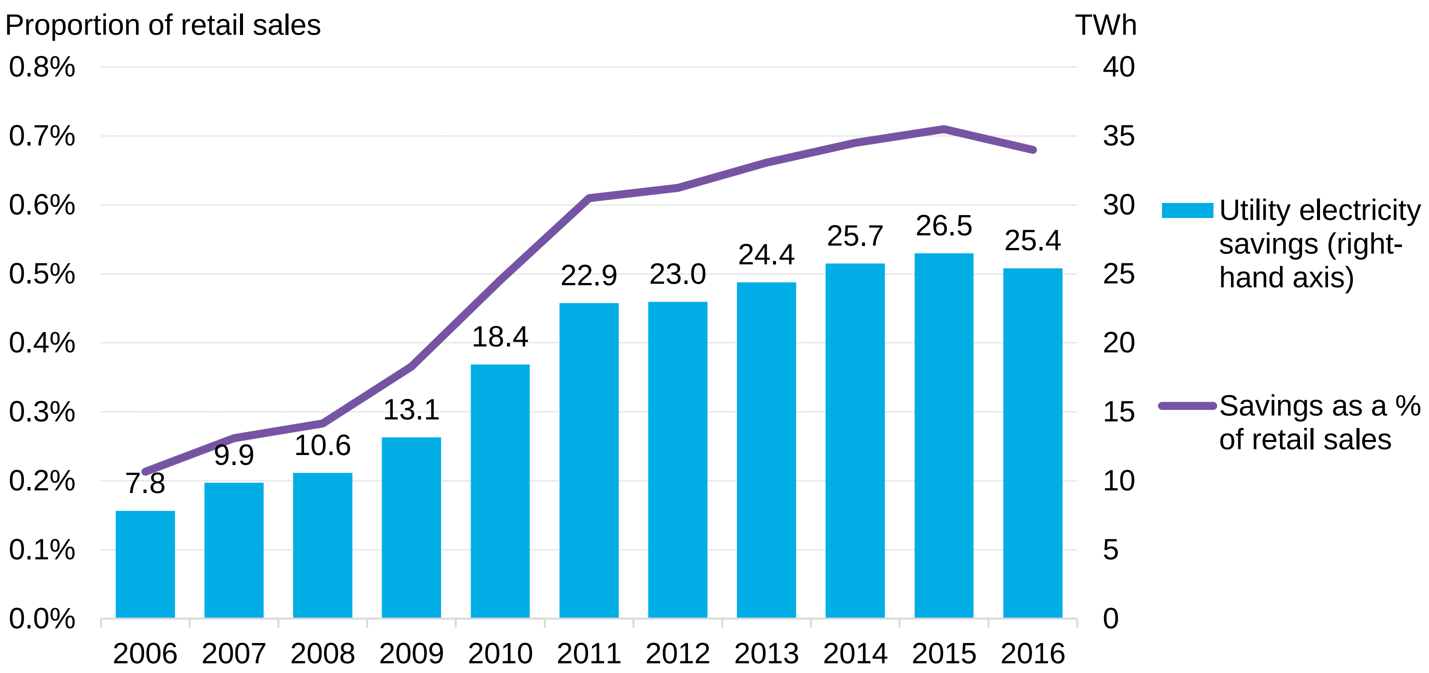
Total contract values, sorted by deal size



- The data represents a combination of federal energy efficiency service performance contracts (ESPCs) and utility energy service contracts for military facilities (UESCs). According to early estimates, federal entities signed $152m of ESPCs and $72m 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 President Obama's target (announced in 2014) of completing $2bn of retrofits by the end of the year. This target was met through a shift towards larger projects, particular for ESPCs.
- 2017 was a quiet year – this could be due to projects being brought forward to 2016, or less appetite for efficiency among federal agencies.

Source: Federal Energy Management Program (FEMP), U.S. Department of Energy (DOE), Bloomberg New Energy Finance 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, as has investment. In 2016 utility energy efficiency savings decreased for the first time, falling slightly from the previous year.
- Although 28 states saw an increase in energy savings in 2016, Californian utilities' savings decreased from 5.0TWh to 3.9TWh, bringing the overall total for the country down. 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 2015 and 2016, Arkansas, Illinois and Pennsylvania saw savings increase by 0.19TWh, 0.16TWh and 0.15TWh respectively.

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.

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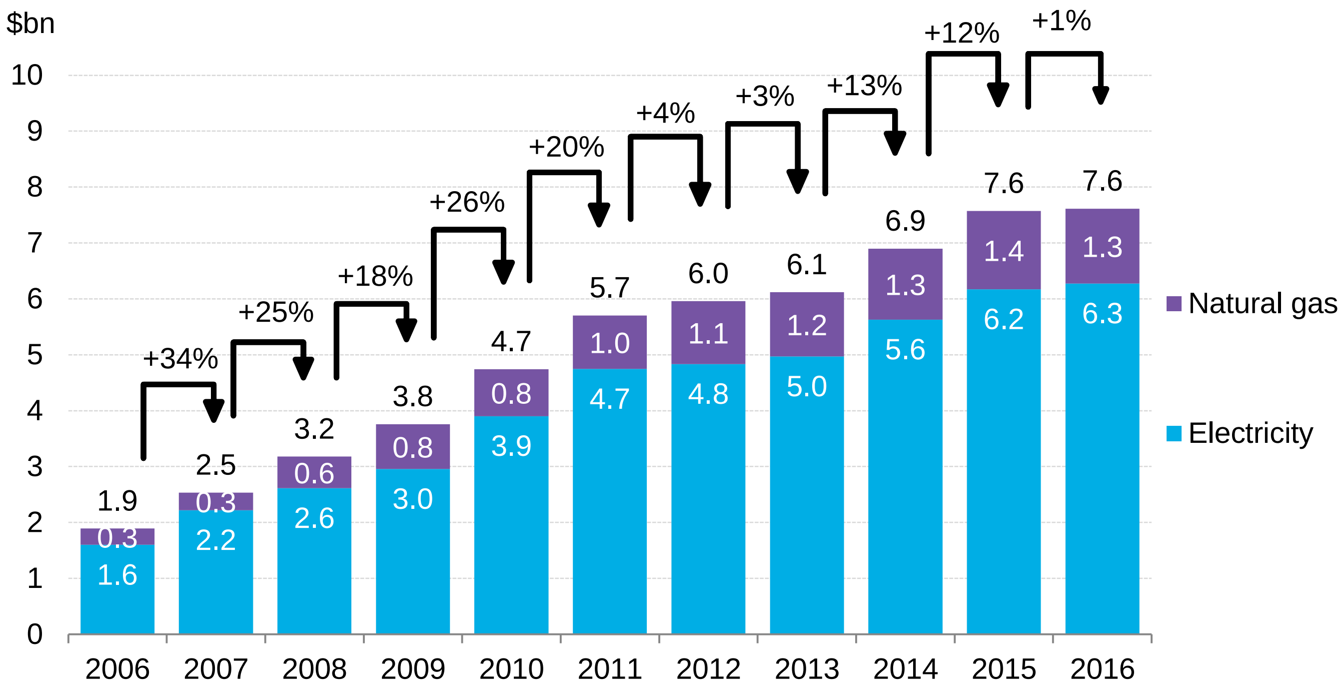
Financing: U.S. utility energy efficiency spending

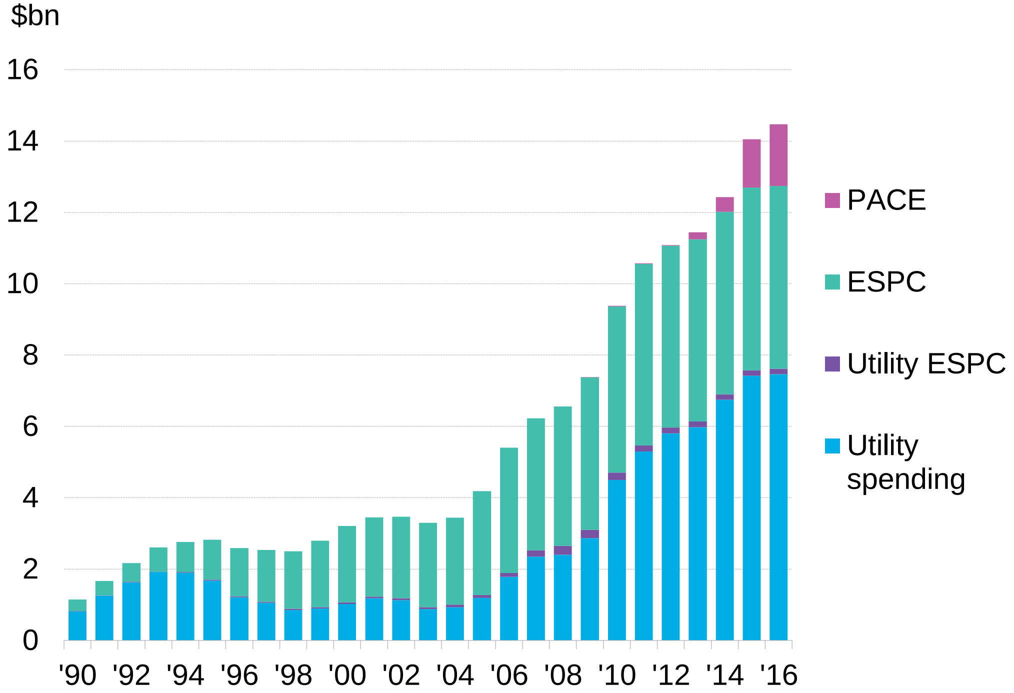


- In 2016, growth in utility spending on energy efficiency level off at $7.6bn, only 1% higher than the previous year. This reflects the slowdown in new states introducing EERS policies and the maturing of many states schemes.
- While investment growth eased at the national level, the picture was more dynamic at the state level. Utilities in Washington increased spending by $34m (+11%), and there were also notable increases in Indiana (+$34m, +33%), North Carolina (+$31m, +21%) and Kentucky (+$30m, +38%).
- However, these gains were offset by falling investment in California (-$57m, -3%) and Maryland (-$90m, -44%). The decrease in Maryland stems in part from a general decline in investment by the state's utilities. The drop-off in California is relatively minor when compared against the increase from $1.57bn to $1.71bn between 2014 and 2015.

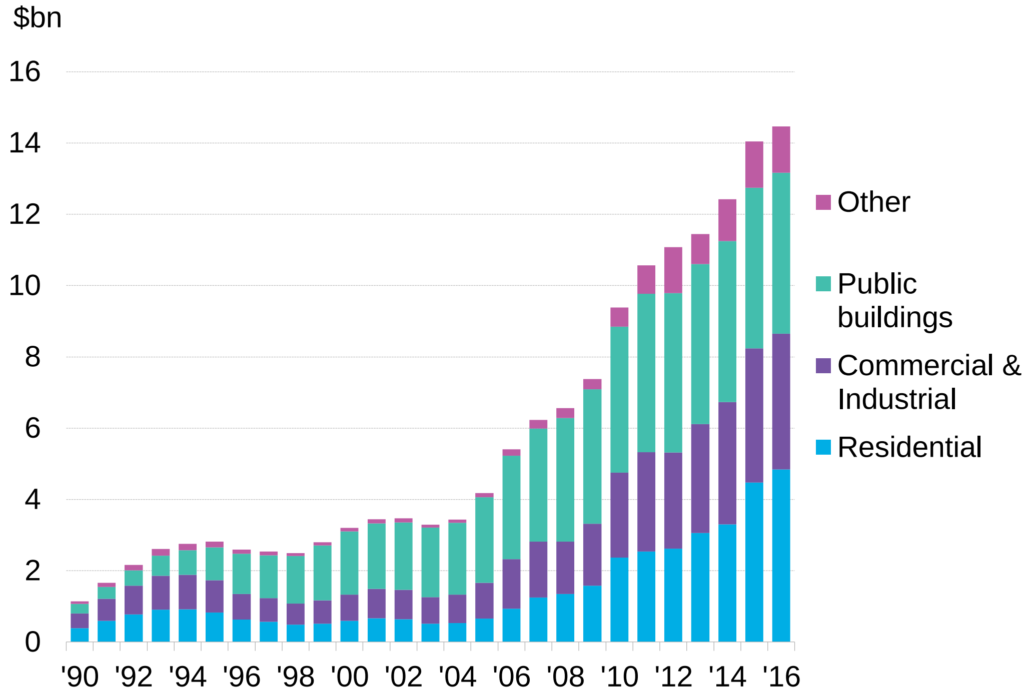
Source: CEE, ACEEE, Bloomberg New Energy Finance. Note that data for 2010-14 was sourced from CEE, and for 2006-2009 and 2015-16 from the ACEEE.

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

By framework



By sector

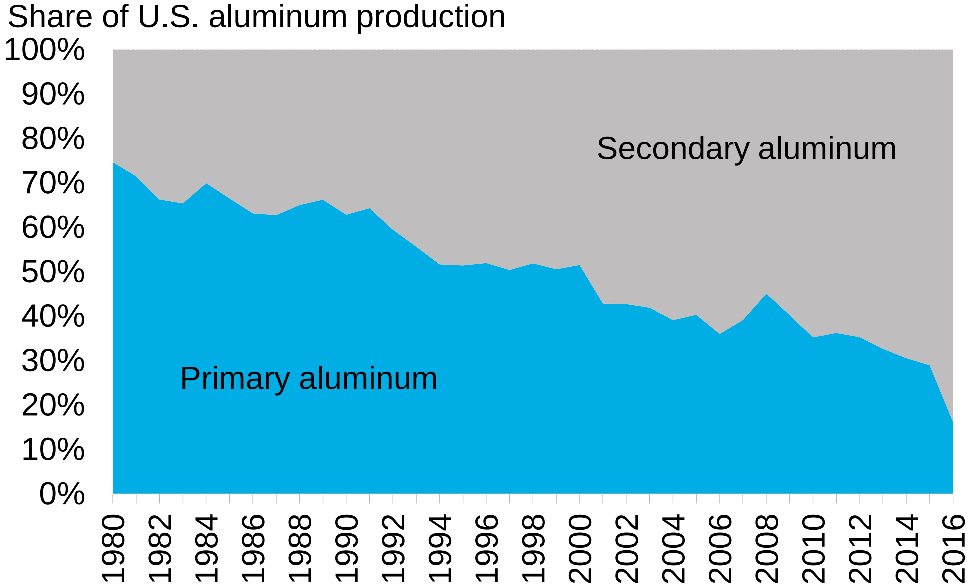


- Total U.S. spending on energy efficiency through formal frameworks climbed to an estimated record level of $14.5bn in 2016.
- While utility spending and ESPCs remain the most important frameworks, the majority of growth between 2015 and 2016 was due to the scaling of the PACE financing framework, particularly in the residential sector. According to PACENation estimates, residential investment in PACE hit $1.6bn in 2016. PACE investments climbed 28% from 2015 to 2016, contributing to the overall 133-fold increase from 2012 through 2016.
- 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.

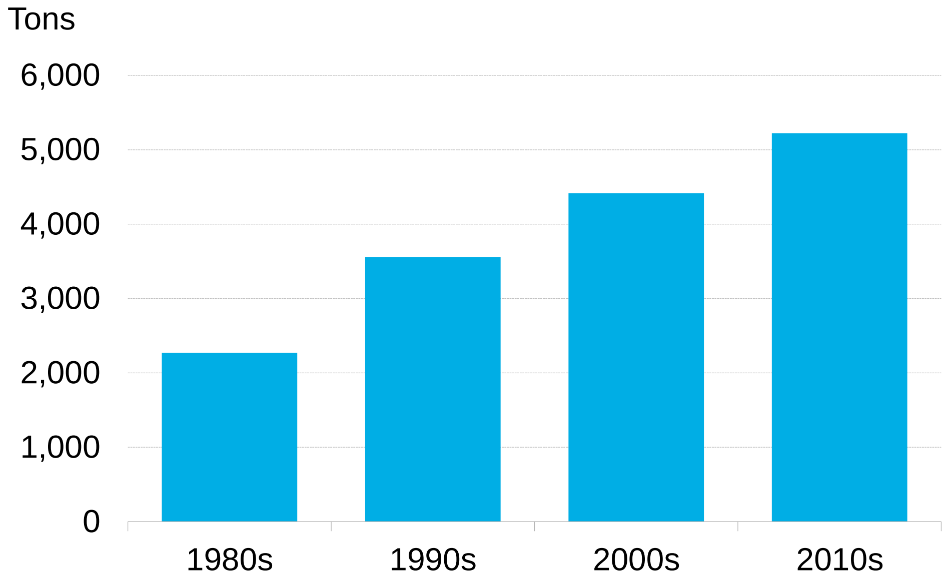
Source: ACEEE, NAESCO, LBNL, CEE, IAEE, PACENation, Bloomberg New Energy Finance Notes: The values for the 2015, 2016 ESPC market size shown here are estimates. The most recent data from LBNL reports revenues of $5.3bn in 2014. The 2015 and 2016 estimates are based on a continuation of 2011-14 growth rates.

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 aluminum derived from secondary sources leapt to 84% in 2016, up from 71% in 2015. More broadly, aluminum production from secondary sources has risen dramatically from 61% a decade prior in 2007, and from only 25% in 1980.
- Scrap recycling rose 18% from the previous to the current decade, 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.

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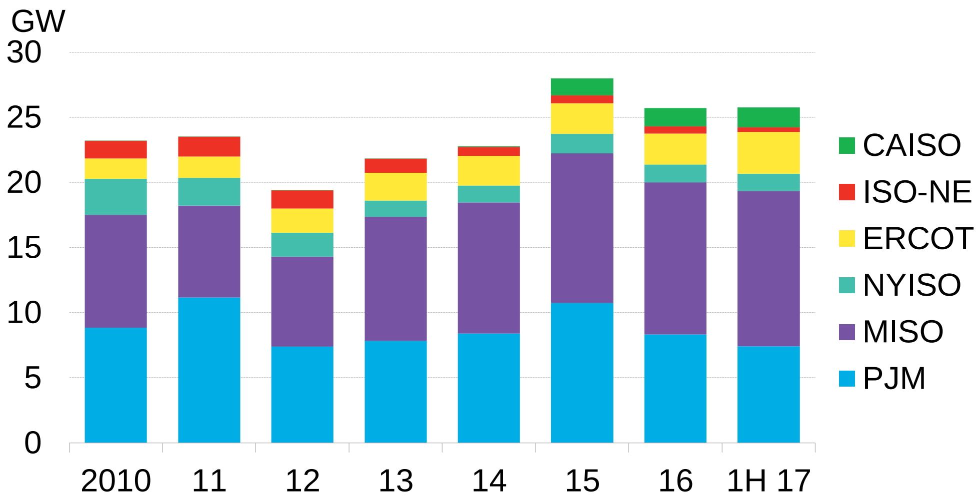
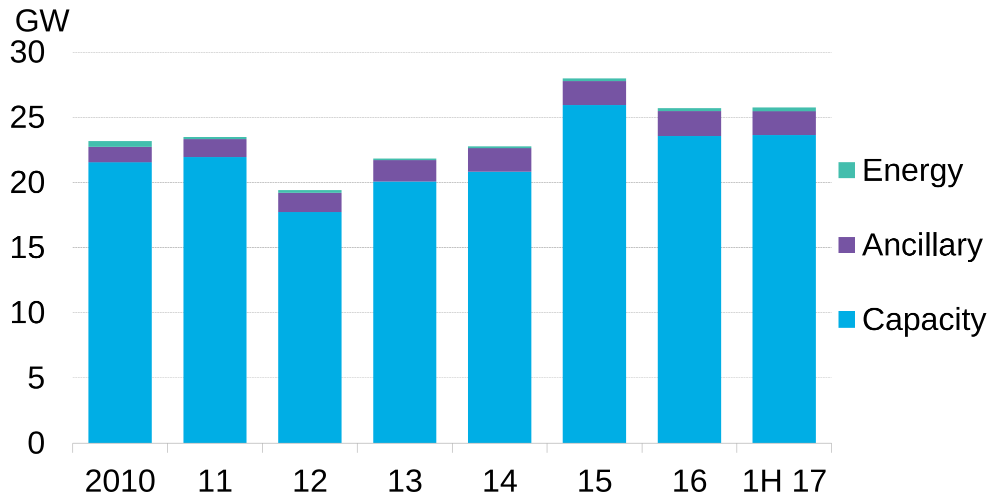
Deployment: U.S. wholesale demand-response capacity

By region



By application

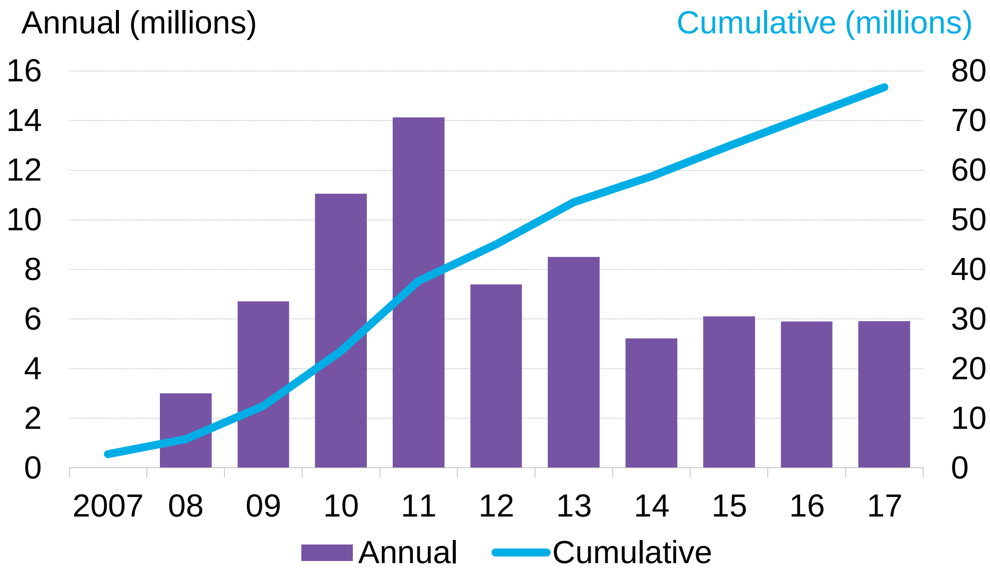


- U.S. wholesale demand-response (DR) capacity remained flat through the first half of 2017, growing a measly 61MW. Despite growth in some markets – notably ERCOT which jumped to 3.2GW from 2.4GW in 2016 – it only just offsets the continued erosion of DR capacity in the Northeast. PJM volumes declined for the second year in a row, while ISO-NE capacity dropped for the sixth straight year. A variety of changes to the capacity markets in both ISOs have challenged demand response and will put downward pressure on volumes and revenue in the years ahead.
- The vast majority of wholesale demand response is concentrated in capacity markets and reliability mechanisms. Even in ERCOT which has no formal capacity market, almost 1.9GW of DR has been contracted through its capacity-style *Emergency Response Service.* Ancillary service participation, which grew 9% annually on average over 2010-2015, has remained flat since, in the 1.8-1.9GW range. Despite the furor surrounding FERC 745, demand response activity within the energy markets remains negligible.
- Our methodology for tracking demand-response capacity has changed since last year. Previously we used data reported to FERC and the results of capacity auctions. This year's analysis is built bottom-up by assessing the amount of demand response active within each market in each ISO/RTO. The most notable change is in PJM, where for some years the GW value is as much as a third lower than previously.

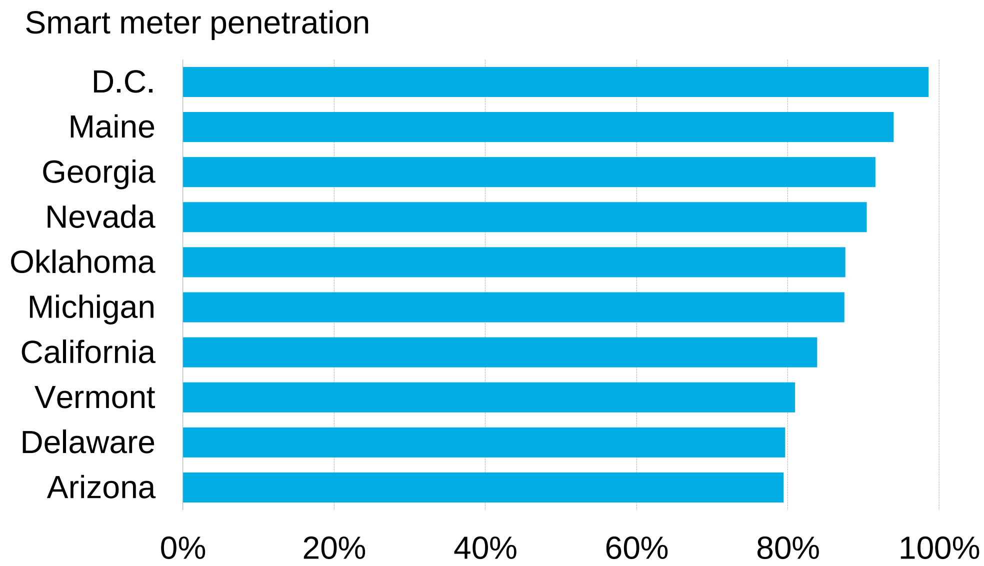
Source: Bloomberg New Energy Finance. Note: Demand-response was only formally integrated with the CAISO market in 2015.

Deployment: U.S. smart electricity meter deployments

U.S. smart meter deployments



Top 10 states by penetration



- 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 increased to a fairly constant six million meters per year.
- Today almost 51% of U.S. electricity customers have a smart meter, but there is enormous regional variation. The top 10 states all have penetration of greater than 79%. In contrast only one in five or fewer customers have smart meters in the bottom 10 states. Over 2016-17, Illinois and Michigan were the most active smart metering markets, deploying 2.4 and 1.1 million meters, respectively.
- 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 ten years.

Source: Bloomberg New Energy Finance, EIA. Note: there is a 10-month lag in official smart meter statistics, as a result 2017 figures include BNEF estimates.

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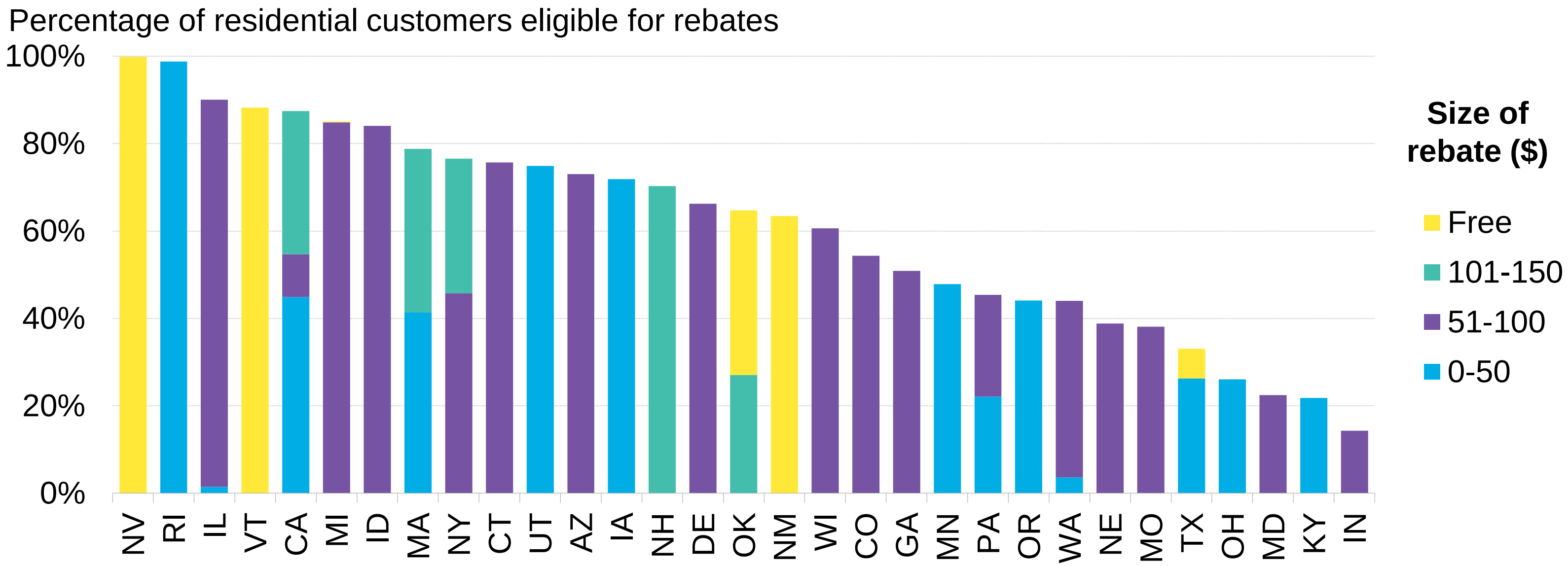
Deployment: U.S. smart thermostat rebate availability



- 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: Bloomberg New Energy Finance. 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.

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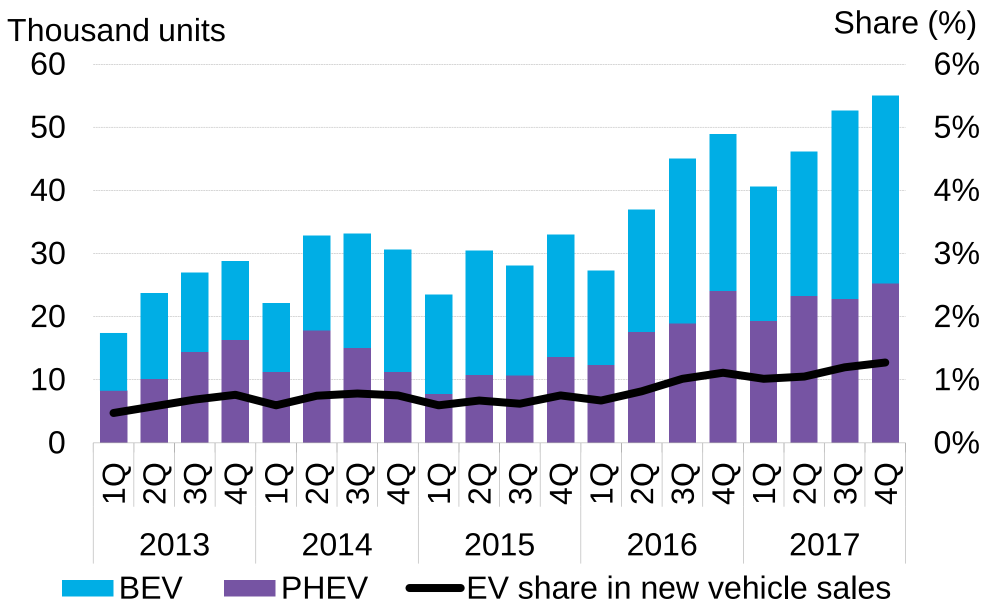
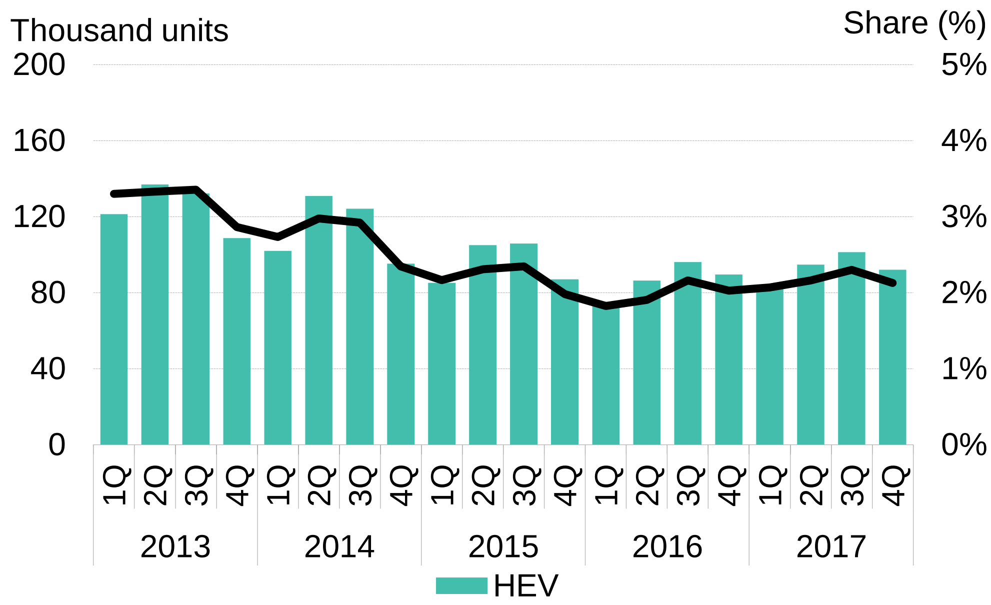
Deployment: U.S. electric vehicle and hybrid electric vehicle sales

U.S. EV sales



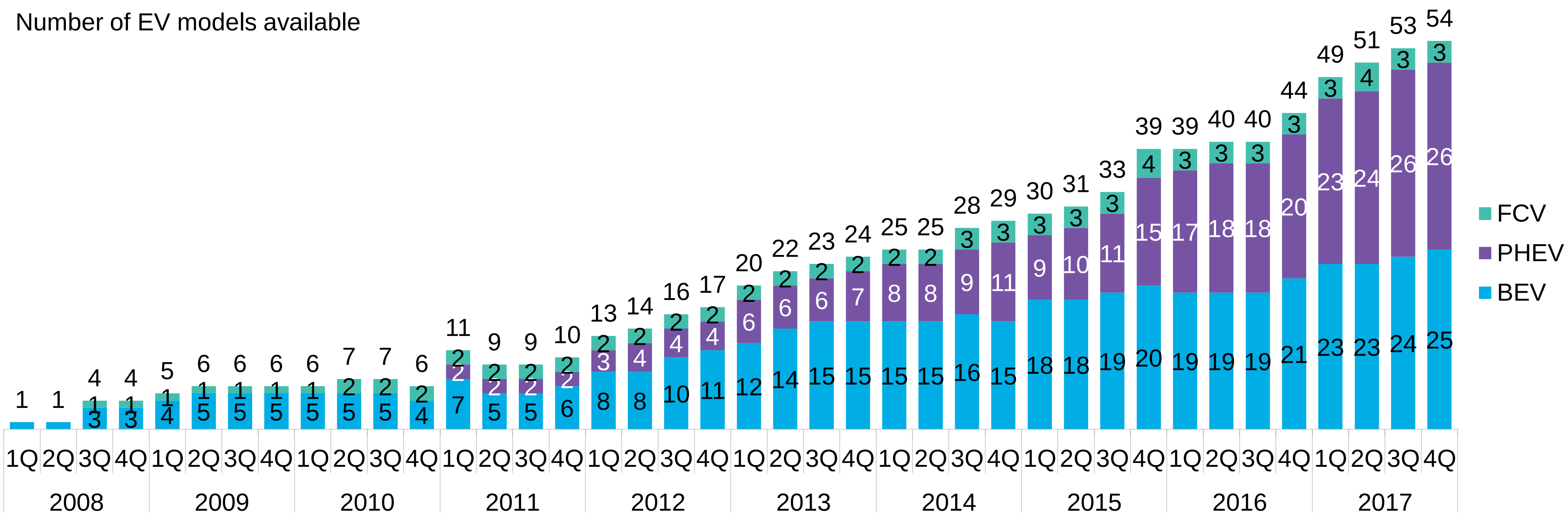
U.S. HEV sales



- Sales of electric vehicles – a category that includes battery electric vehicles (BEV) and plug-in hybrid electric vehicles (PHEV) – increased 23% to over 194,000 units in 2017, from 158,000 units in 2016. Sales of EV models from three automakers – General Motors, Tesla and Toyota – accounted for 59% of total U.S. sales in 2017. Longer range versions of known models (e.g., the Toyota Prius Prime), long-range affordable BEVs (e.g., the Chevrolet Bolt), and newer electrified car segments (e.g., the Tesla Model X) are responsible for increasing EV sales.
- PHEV sales rose the most in percentage terms, up 24% year-on-year on the back of continued consumer interest in the Chevrolet Volt and the well-priced Toyota Prius Prime. BEVs saw a 22% jump in sales and sustained their advantage over PHEVs by over 13,000 units in 2017.
- Sales of hybrid electric vehicles (HEV) totalled just over 371,000 units in 2017 – a 7% increase compared to 2016. Toyota Prius was the best-selling model in 2017 with over 65,600 units, followed by the Ford Fusion and the Toyota RAV4.

Source: Bloomberg New Energy Finance

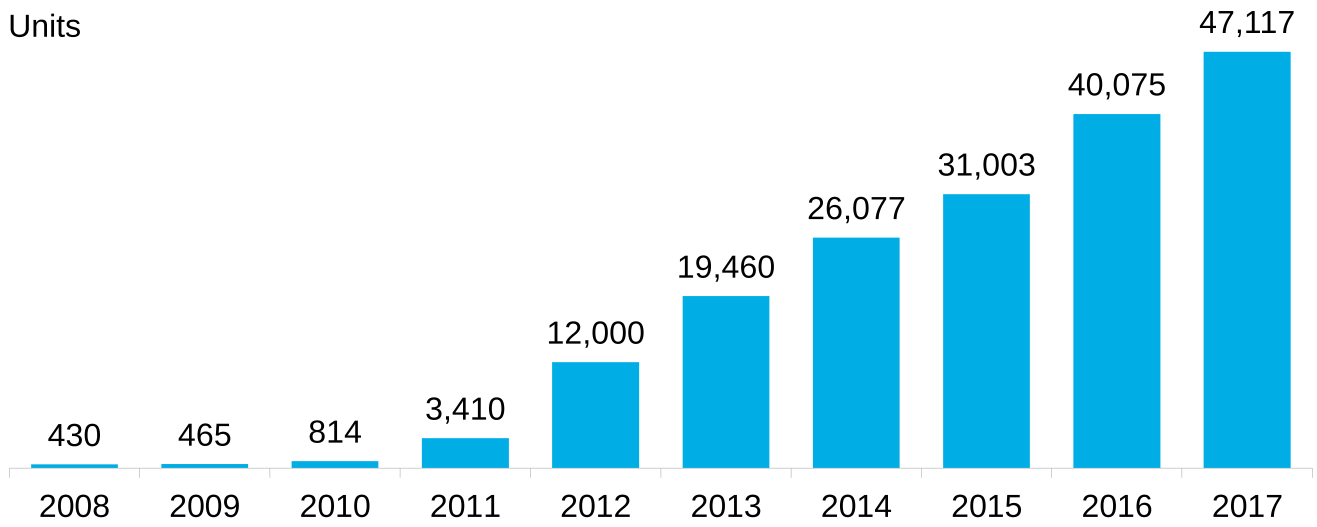
Deployment: EV model availability in North America



- By Q4 2017, 54 EV models were available to North American consumers, including three fuel cell electric vehicles (FCVs), 26 PHEVs, and 25 BEVs.
- The number of PHEV models has been growing steadily in the last three years, from 38% of all EVs on offer in Q4 2015 to 48% in Q4 2017, taking share from fully electric vehicles. This shift towards partial electrification takes place as automakers face stringent fuel efficiency requirements in their core markets (EU, China and the U.S.) and cater to consumers' preference for having the option of both combustion and electric powertrains.
- New EV models launched in 2017 include the Tesla Model 3, the second-generation Nissan Leaf and the Toyota Prius PHEV.

Source: Bloomberg New Energy Finance, MarkLines Note: FCV= fuel cell electric vehicles, PHEV= plug-in hybrid electric vehicles and BEV=battery electric vehicles; models available in North America (Canada and U.S.) are available in the U.S.; CAFE stands for Corporate Average Fuel Economy

Deployment: U.S. public electric vehicle charging outlets



- There are currently 47,117 public and workplace charging outlets in the U.S., including 6,270 fast charging outlets. The number of charging sites in the country grew 18% in 2017 compared to 2016.
- Over 81% of public charging outlets in the U.S. are Level 2 J1772 (delivering around 7.2kW). This is largely a reflection of the EV fleet in the country, where 45% of electric vehicles come equipped with J1772 outlets. (The majority of EV charging takes place at home, usually with Level 1 or Level 2 J1772 outlets.) Another 13% of the charging outlets is split between different rapid charging standards – CHAdeMO (30%), CCS (23%) and Tesla Supercharger (45%). Some 6% of public charging outlets are Level 1.
- The Volkswagen Group, under the terms of a legal settlement with the State of California and the U.S. Environmental Protection Agency (EPA), created a subsidiary called Electrify America that will spend a total of $0.8 billion over ten years to deploy charging infrastructure within California and $1.2 billion over a decade outside California.

Source: Alternative Fuels Data Center, Bloomberg New Energy Finance Notes: Does not include residential electric charging infrastructure.

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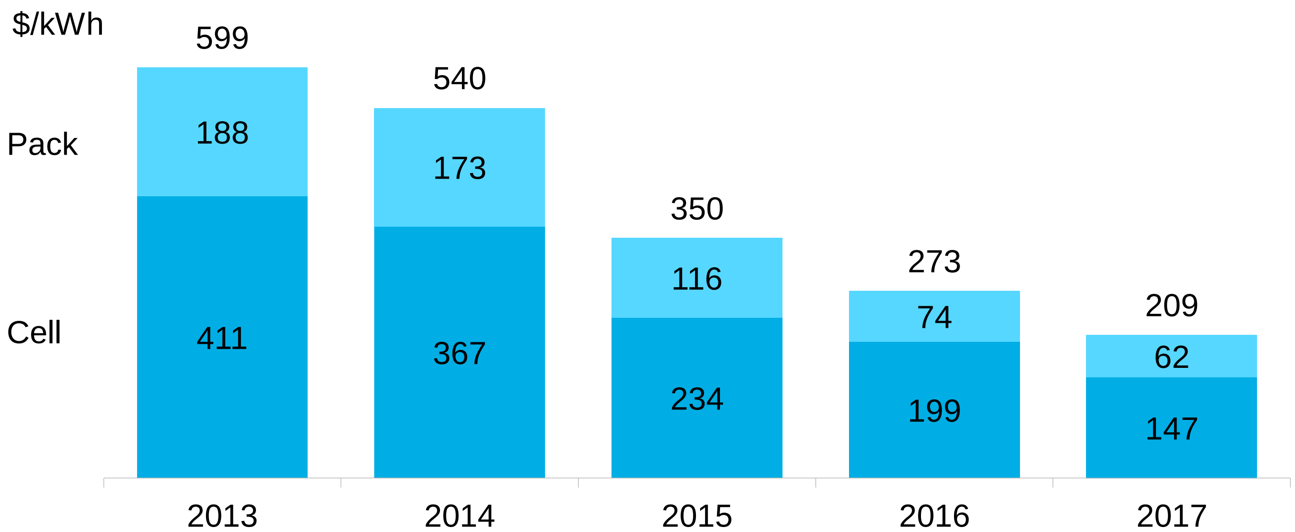
Economics: Lithium-ion battery pack prices

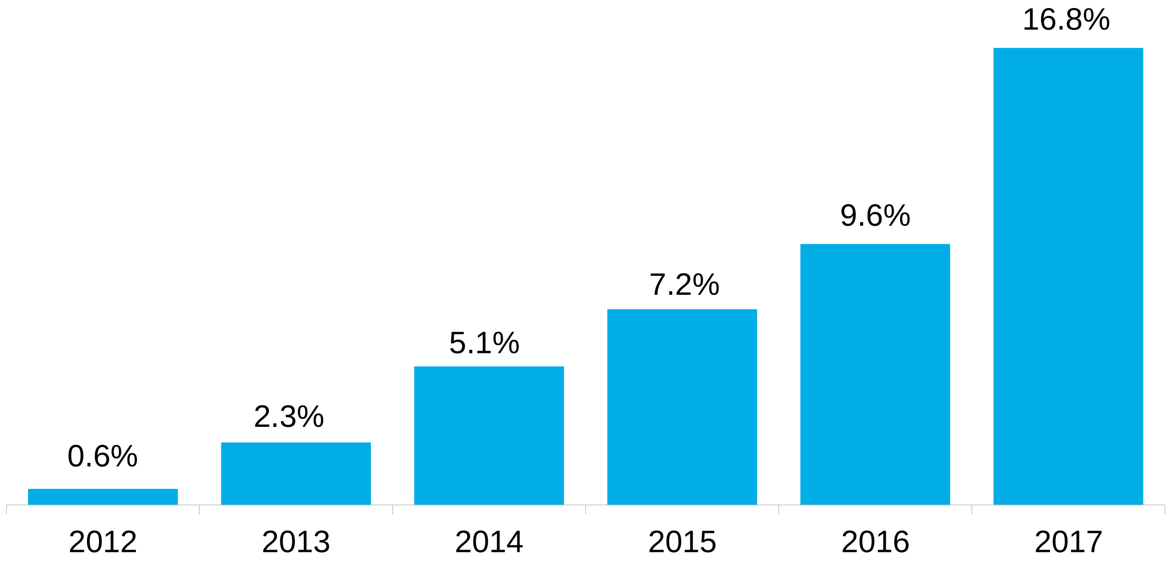


- Lithium-ion battery prices have fallen 65% since 2013, hitting $209/kWh in 2017. The diminishing cost of battery packs is the driving force behind the falling cost of BEVs.
- Battery packs consist of cells and the equipment that make up the rest of the pack. For BEV batteries, the pack consists of the battery management system, wiring, pack housing, and the thermal management system.
- From 2016 to 2017, declining cell costs drove most of the price decline—cell prices shrank 26% ($52/kWh), while pack prices fell by a smaller 16% ($12/kWh). Cells account for around 70% of the total pack price, on average.
- In the past year, economies of scale, greater cell energy density, and improvements to pack design continued play major roles in reducing costs.
- Stationary storage systems use similar cells. However, because of smaller order volumes, the price of a pack for stationary storage developers is closer to $300/kWh, or 51% greater than for automakers.

Source: Bloomberg New Energy Finance. 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 above include cell and pack prices for electric vehicles.

Deployment: Share of vehicles with start/stop technologies

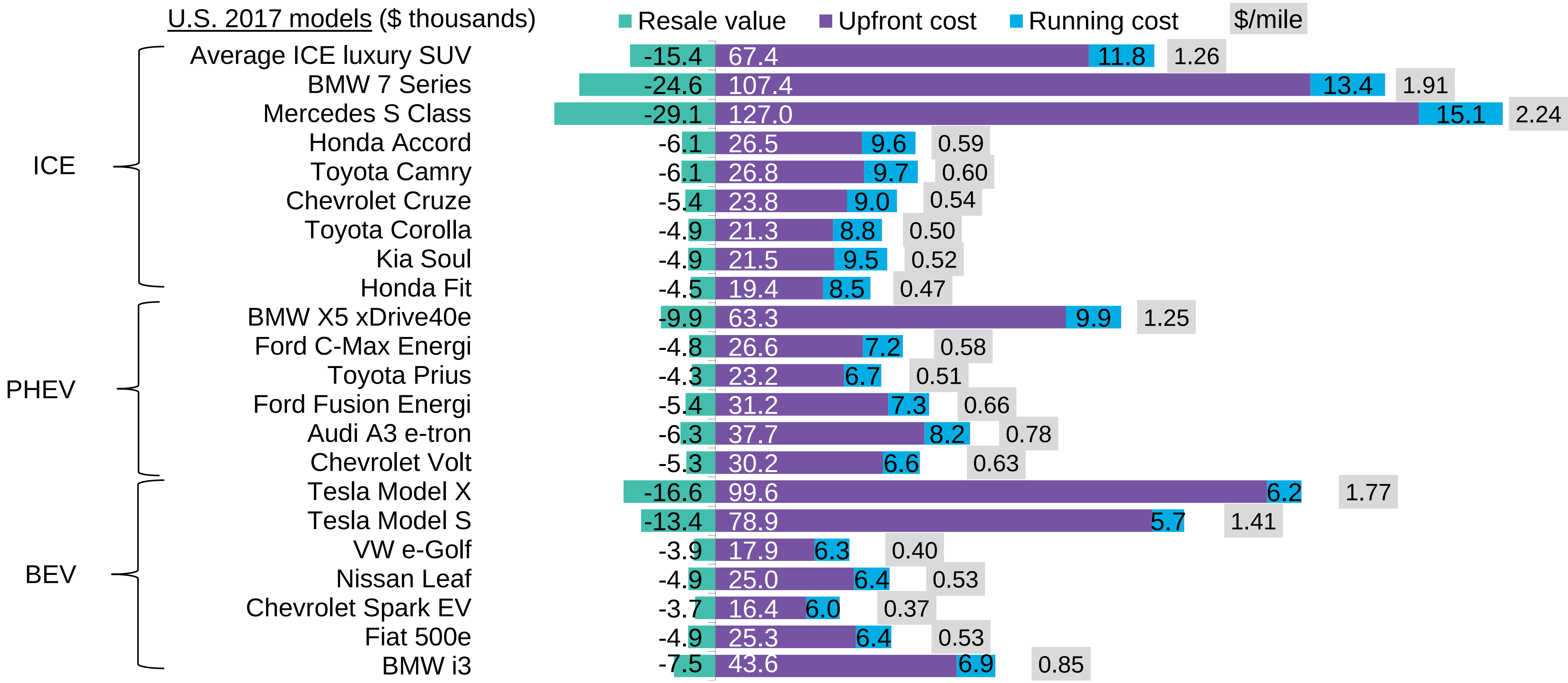
Share of new vehicles sold with stop/start systems in the U.S.



- 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. leapt to 16.8% in 2017, up from 9.6% in 2016.
- The deployment share corresponds to start/stop systems in non-hybrid vehicles. Hybrids typically include a start/stop function as part of the electrified drivetrain; including hybrids, the total share of start/stop would be closer to 20%.

Source: EPA, Bloomberg New Energy Finance

Economics: Total cost of ownership for BEVs, PHEVs, and ICE vehicles, accounting for purchasing credit incentives

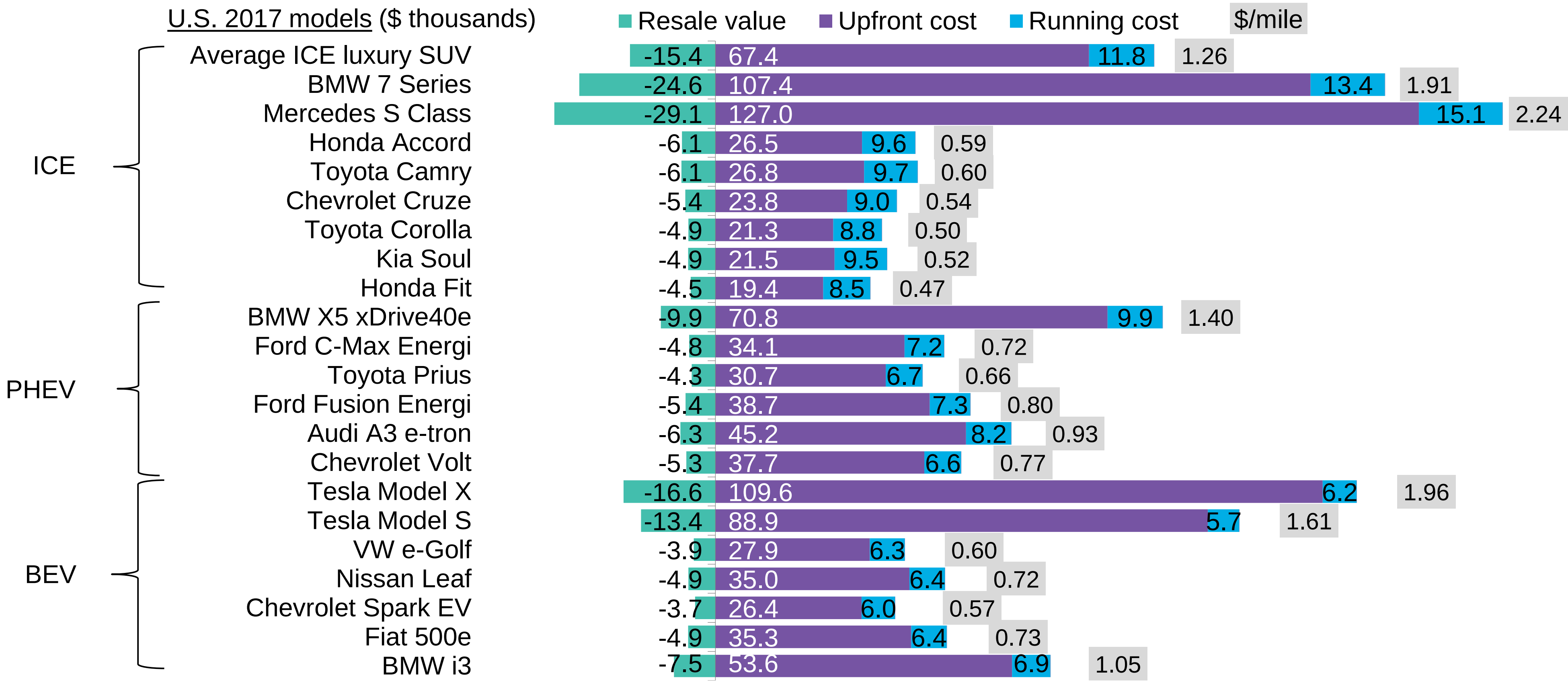


- Battery electric vehicles cost up to a third less than owning equivalent gasoline cars for all segments – small, medium and large vehicles – other than luxury SUVs. Both capital and fuel costs are lower for BEVs; capital costs benefit from up to $10,000 in federal and state incentives.
- Plug-in hybrids typically cost more than midsize gasoline cars. Prices for PHEVs are higher, incentives are lower and gasoline adds further fuel costs compared to BEVs.

Source: Bloomberg New Energy Finance. 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 10,100 miles driven per year, $2.6/gallon cost of gasoline and $0.105/kWh cost of electricity.

Bloomberg New Energy Finance

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

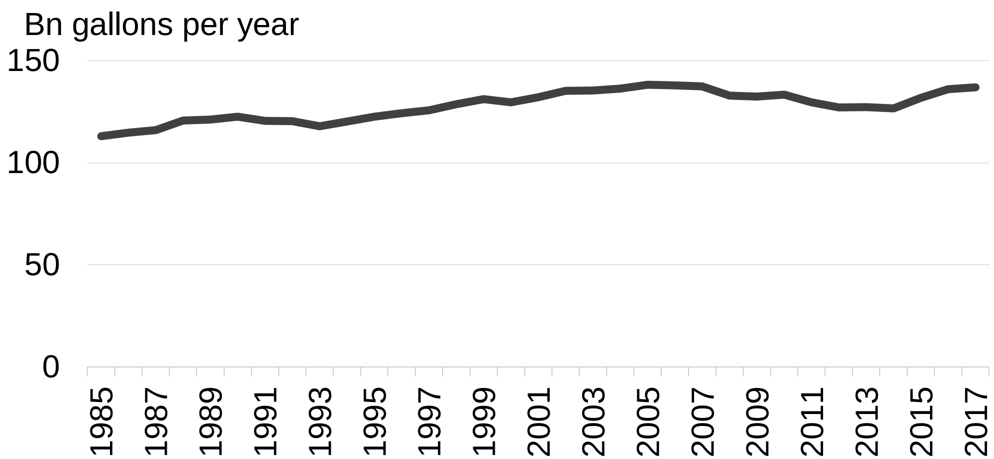


- Without price subsidies:
  - Current BEV models can be up to 28% more expensive than small and midsize gasoline cars, but more than half as costly to own and operate as luxury SUVs.
  - Midsize plug-in hybrids are a third more expensive than equivalent gasoline cars, but in the SUV segment PHEVs are more than 15% cheaper.

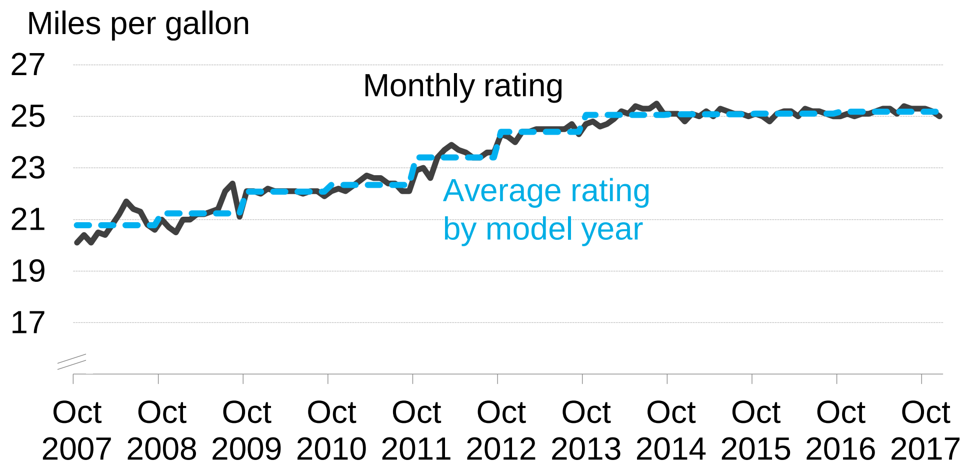
Source: Bloomberg New Energy Finance. Notes: Upfront cost includes down payment, financing and sales tax and is net of incentives; running costs consist of road tax, insurance, maintenance and fuel. Calculations assume 10,100 miles driven per year, $2.5/gallon cost of gasoline and $0.125/kWh cost of electricity.

Deployment: U.S. gasoline consumption and fuel economy

U.S. gasoline consumption



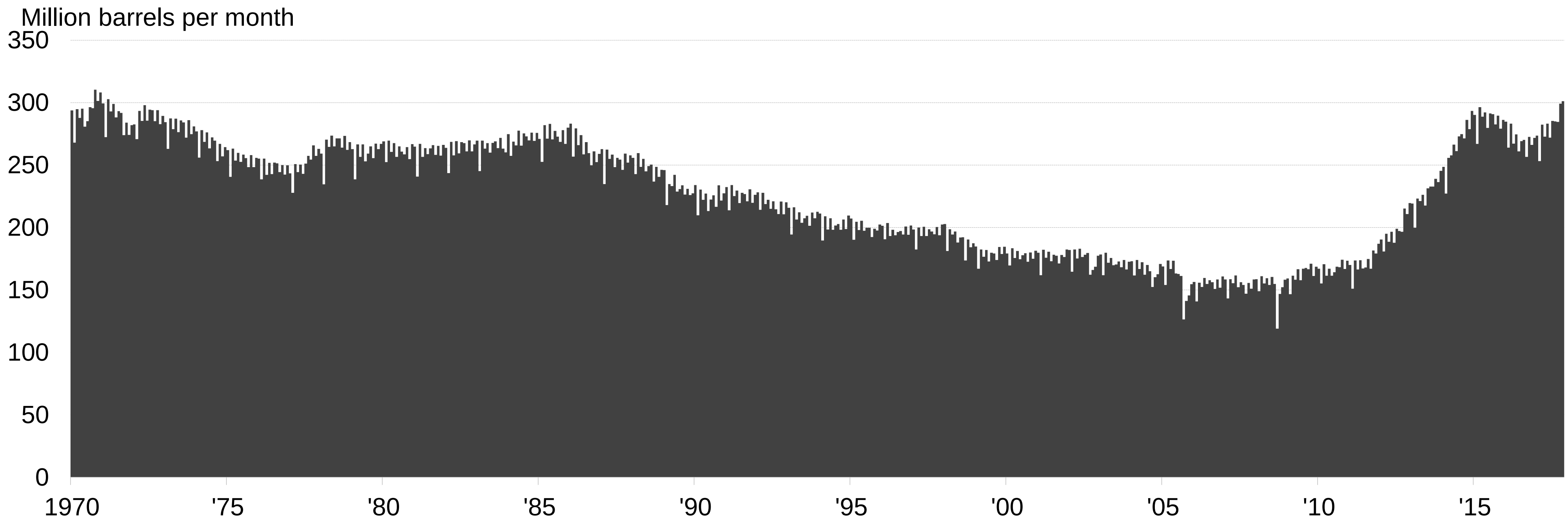
U.S. average fuel-economy rating (weighted by sales) of purchased new vehicles



- Gasoline consumption rose for the third consecutive year, but growth slowed. Consumption inched up 0.7%, or 0.95bn gallons, year-on-year, to 137bn gallons by the end of 2017. This was substantially slower than 2016, when consumption expanded 3%, or 4.3bn gallons, year-on-year,. Tightening federal fuel economy standards may have helped to offset some of the impact of low gasoline prices, and gasoline prices also began to rise in 2017.
- Consumption has climbed 8% since the 2014 trough on the back of low prices, and is only 0.8% from the all-time peak reached in 2005.
- Average U.S. vehicle fuel economy made little gains in 2017, leaving this the third year in which average vehicle fuel economy has held at around 25mpg. Though federal corporate average fuel economy regulations have tightened, cheaper gasoline prices have also incentivized Americans to purchase less fuel-efficient vehicles.

Source: EIA, UMTRI, Bloomberg New Energy Finance Notes: Analysis of gasoline consumption is based on daily averages of "total gasoline all sales / deliveries by prime supplier." Values for 2017 are projected, accounting for seasonality, based on the latest monthly values from EIA (data available through November 2017). Average fuel-economy rating relies on combined city/highway EPA fuel economy ratings.

Deployment: U.S. oil production



- For the first eleven months of 2017, U.S. crude oil production rebounded 4% compared to the same period last year. Production averaged 9.2 million barrels per day, the highest level since the 1970s.
- West Texas Intermediate oil prices breached $60/barrel by the end of 2017, after dipping during the first half of the year from $55/barrel to a low of $44/barrel in June.
- Oil prices do not directly impact the majority of sustainable energy technologies in the U.S. Most of those technologies operate in the power sector, while oil in the U.S. is used mainly for transportation and only rarely for power. However, more affordable gasoline at the pump has stalled gains in the average U.S. vehicle fuel economy as consumers have opted for less fuel-efficient vehicles.

Source: EIA, Bloomberg Terminal   Notes: EIA production data available through November 2017.

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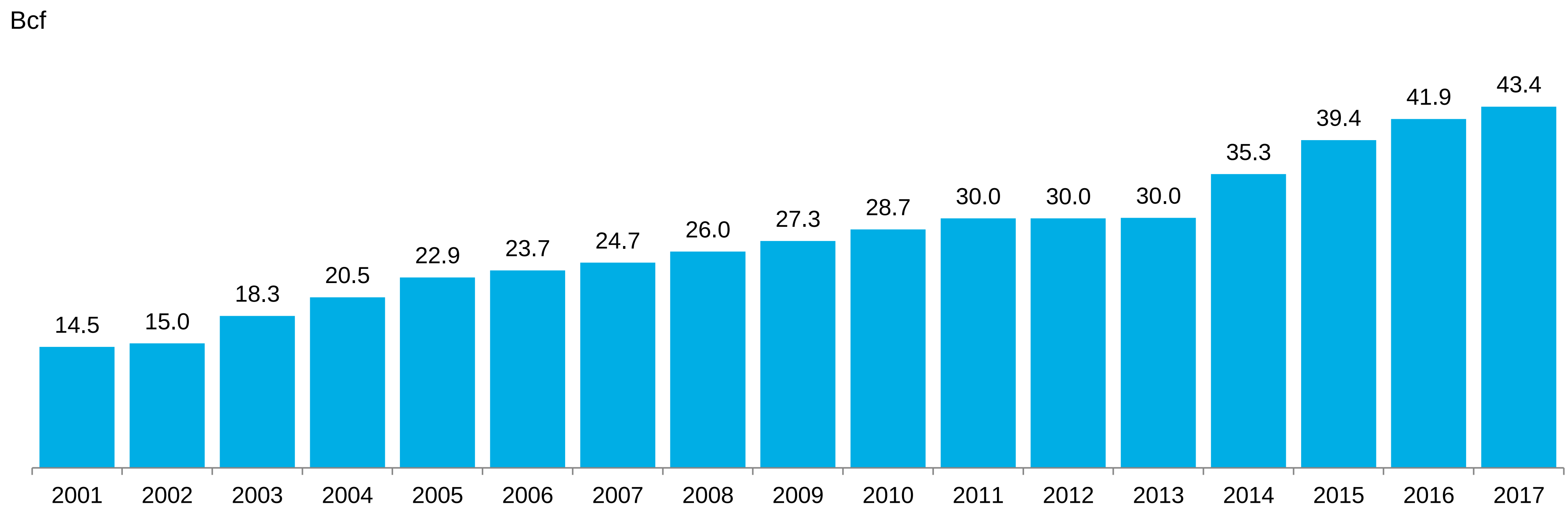
Deployment: U.S. natural gas demand from natural gas vehicles



- Natural gas use in vehicles has grown steadily since 2013. In 2017, the amount of natural gas used for this purpose rose 4% year-on-year to 43.4Bcf. This represents a 44.5% increase over 2013 levels, and a 5.9% compounded annual growth rate over the last decade (since 2008). The pick-up in 2014 coincided with the start of a period of low natural gas prices across 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 January 18, 2018, there were 1,676 CNG stations across the U.S., compared to 137 LNG stations (including public and private stations).
- The number of CNG and LNG stations shrank slightly from 2016, when the CNG station count had hit 1,725 and the number of LNG stations hit 140.

Source: EIA, Alternative Fuels Data Center Notes: Values for natural gas demand in 2017 are projected, accounting for seasonality, based on latest monthly values from EIA (data available through October 2017). Data excludes gas consumed in the operation of pipelines.

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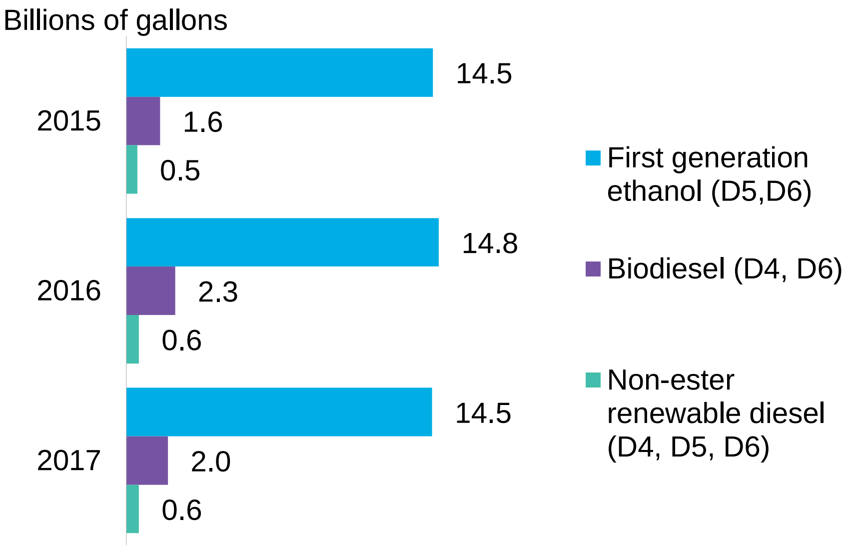
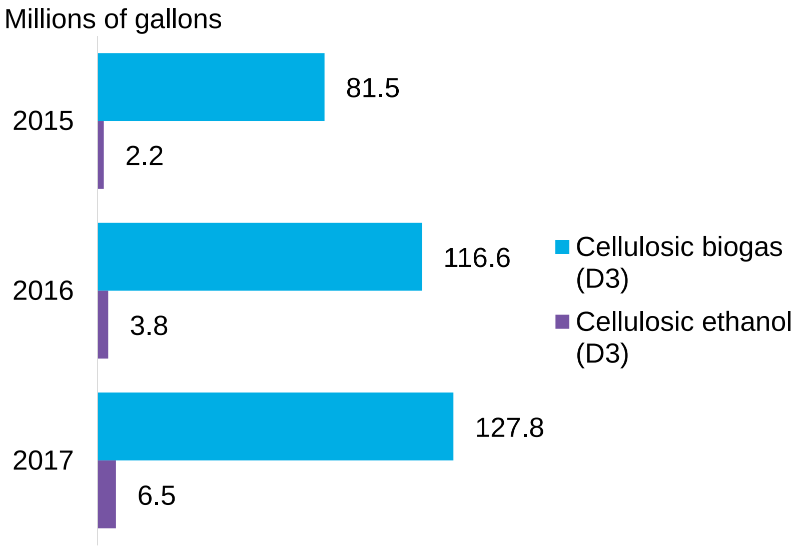
Deployment: Volumes of biofuels blended under the federal Renewable Fuels Standard

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 is in force through 2022. The EPA administers the program and sets annual blending targets split by fuel type.
- The highest value biofuels under the RFS2 are cellulosic biofuels or "next-generation" biofuels. These include cellulosic ethanol, cellulosic diesel and cellulosic biogas, which are made from non-food feedstocks and possess low carbon footprints.
- Each biofuel receives a renewable identification number (RIN) upon blending, which the blender can count towards its annual mandated targets, or sell to other blenders who otherwise would not meet targets. Biomass-based diesel and Advanced Biofuel RINs (D4 and D5) have traded as high as $1.14 and $1.13 in 2017, respectively, compared with $0.98 for ethanol (D6). Cellulosic biofuel RINs (D3) traded as high as $2.92.
- The biofuel blending targets for 2017 were 19bn physical gallons (of which 312m was the cellulosic target). For 2018, the mandate is kept flat at 19bn gallons.

Source: Bloomberg New Energy Finance, Bloomberg Terminal, EPA Notes: 2017 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.

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