2017

Sustainable Energy in America

FACTBOOK

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The Business Council for Sustainable Energy®

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Overview

The 2017 Sustainable Energy in America Factbook marks the fifth year that BCSE and BNEF have collaborated to document the transformation of the US energy system and the growing contributions of sustainable energy technologies. In the past five years, these contributions have been significant, including:

- The addition of 76 gigawatts (GW) of renewable energy generating capacity, and 39GW of natural gas-fired capacity. Renewables (inclusive of large hydro) and natural gas now meet *half* of US power demand, up from only 38% in 2011.
- A 10% improvement in US energy productivity, meaning the US economy is using 10% less energy to power each unit of growth.
- A 4% drop in average retail electricity prices in real terms. In New York, Texas, and Florida, prices have fallen over 10% in that time.
- A 12% jump in total gas production, and a 79% surge in shale gas extraction since 2011.
- A 12% improvement in vehicle fuel economy, propelled by federal fuel efficiency standards.

The 2017 Factbook provides an update through the end of 2016, highlighting a number of key developments that occurred as the long-term transformation of US energy continues to unfold. The rapid pace of renewable energy deployment accelerated, consumption and export of domestic natural gas hit record levels, and the economy grew more energy efficient than ever. Utilities ramped up investments in electric and natural gas transmission, helping to create a more reliable energy system. In the face of all this change, Americans are enjoying lower energy bills and are directing less of their household income to energy spending than at any other time on record.

The Sustainable Energy in America Factbook provides a detailed look at the state of US energy and the role that a range of new technologies 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 (1 of 4): What is it and what's new

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What is it?

- Aims to augment existing, reputable sources of information on US energy
- Focuses on **renewables, efficiency, natural gas**
- **Fills important data gaps** in certain areas (eg, investment flows by sector, contribution of distributed energy)
- Contains data through the end of 2016 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 **fifth edition** (first published in January 2013)

What's new?

- **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 2017 edition is to *capture new developments that occurred in the past year*.
- **Updated analysis**: Most charts have been extended by one year to capture the latest data.
- **2016 developments**: The text in the slides highlights major changes that occurred over the past year.
- **New coverage**: This report contains data shown for the first time in the Factbook, including transmission investment, PURPA-driven solar build, battery pricing, natural gas exports, energy spending, biofuel blending and electric vehicle model availability.

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

Understanding terminology for this report

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	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 • Smart grid / demand response • Building efficiency • Industrial efficiency (aluminum) • Direct use applications for natural gas	• Electric vehicles (including hybrids) • Natural gas vehicles
OTHER CLEAN ENERGY (not covered in this report)	• Nuclear	• Wave / tidal	• Lighting • Industrial efficiency (other industries)	• Biofuels

The sub-sections within each sector

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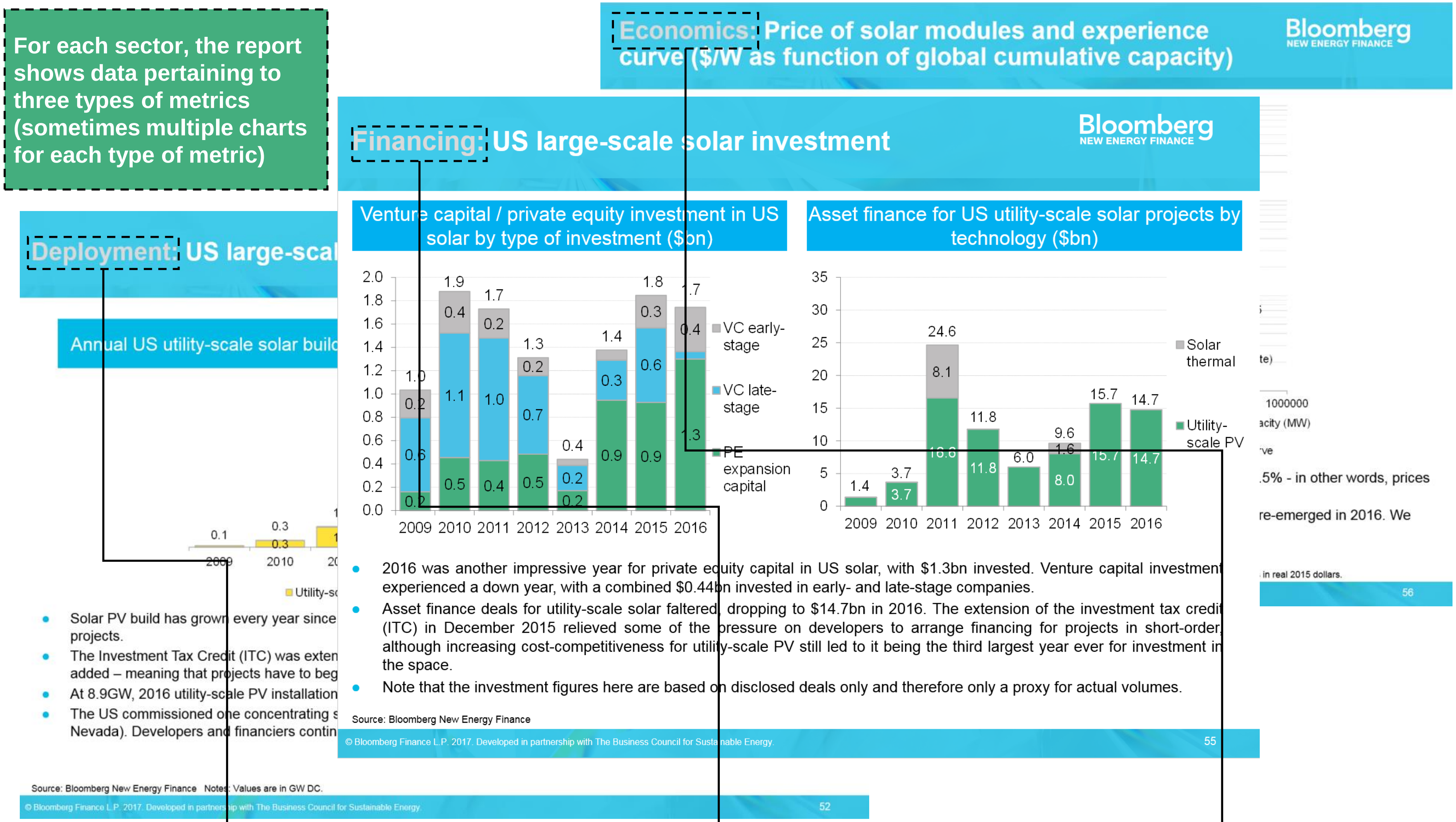
For each sector, the report shows data pertaining to three types of metrics (sometimes multiple charts for each type of metric)



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

Notes: A small number of sectors do not have slides for each of these metrics, due to scarcity of data. The section on energy efficiency also includes a set of slides dedicated to policy.

Sponsorship of this report

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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 8)

Two thousand sixteen marked yet another monumental year in the energy sector, as the US continued to transform how it produces, delivers and consumes energy. The US further decoupled its economic growth from energy consumption; meanwhile, its energy grew cleaner as renewable deployment accelerated and natural gas demand and exports achieved new highs. Utilities made critical investments to ensure reliability, and corporations made new pledges to decarbonize and reduce consumption. These efforts helped push greenhouse gas emissions to their lowest level in 25 years. At the same time, Americans dedicated a smaller share of their household income to electricity and natural gas bills than at any other time on record.

In 2016, the US surpassed a number of new milestones. We highlight the most notable achievements below:

American consumers are spending less of their incomes on energy than ever in the modern era.

- Consumers devoted less than 4% of their total annual household spending to energy in 2016, the smallest share ever recorded by the US government. Falling costs for gasoline, natural gas, and electricity, along with energy efficiency measures, have contributed to this trend.
- Retail electricity prices across the country fell 2.2% in 2016 in real terms from 2015 levels. On average, consumers now pay 4% less per kilowatt-hour for electricity than in 2007, when removing the impact of inflation. In some regions, falling wholesale energy costs and energy savings have had an even larger impact: in New York, average retail rates are now 19% below 2007 levels, and in Texas average rates have fallen 30% in real terms.
- Natural gas prices across the spectrum set or approached record lows in 2016. Retail natural gas prices continued to tumble, as prices for commercial consumers plunged to their lowest levels since 1977, in real terms. Similarly, industrial prices sank to their lowest recorded levels. Year-on-year, real commercial and industrial prices declined 3% and 28%, and they have plummeted 41% and 68% below 2007 levels, respectively. Low natural gas prices have also made natural gas-fired power plants increasingly competitive with traditional coal-fired power plants, particularly in Appalachia, the source of the shale boom. It is now cheaper to build a new natural gas plant than to build a coal plant across most of the US.
- Costs for wind and solar have fallen across the board. Utility-scale photovoltaic (PV) capex (the cost of constructing a project from start to end) has fallen from $2.65 million per megawatt (MW) in 2011 to only $1.14m/MW in 2016. The cost for wind turbines specifically has also declined, from $1.34m/MW to $1.12m/MW over the same five-year timeframe. At the same time, the performance of the equipment has also improved. Combined, this has allowed utilities and corporate buyers to sign long-term power purchase deals at under $40 per megawatt-hour (MWh) for solar power in Nevada and California. For wind, offtake prices continued to fall, with some projects fetching below $20/MWh in Texas and Oklahoma.

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Greater energy efficiency efforts have coincided with a lower cost, more sustainable energy economy.

- The US has truly 'decoupled' economic growth from energy demand: since 2007, US GDP is up 12% while overall energy consumption has fallen by 3.6%. In other words, energy productivity continues to improve as less and less energy is needed to fuel growth. In 2016, this trend continued: energy productivity improved by 1.8%, as real GDP grew 1.6% while energy consumption decreased by 0.2%.
- Within the power sector specifically, energy efficiency measures appear to be making an impact on slowing load growth. In 2016, electricity demand slipped 1.1%, compared to a 1.6% growth in GDP. Electric demand has now fallen 1.2% from its 2014 peak, while GDP has expanded by 4.2% in real terms. Meanwhile, utilities are devoting more toward efficiency every year, with $6.3bn spent on such programs in 2015 (the latest year for which data is available). Electric efficiency program spending has nearly tripled since 2007, when utilities spent $2.2bn.
- Energy efficiency investments in the natural gas system also appear to be paying dividends. Within the residential sector, natural gas consumption has held steady as the number of customers has risen, even when accounting for recent mild winters: gas consumption per customer has fallen from an average of 210 cubic feet per day (cfd) from 2002-06 to 188cfd from 2012-16. Natural gas utilities invested an estimated $1.4bn into the efficiency programs in 2015, a 350% increase over 2007's levels ($0.3bn).

Far from 'alternative', sustainable energy is the new normal in the US.

- 2016 set a new record for annual renewable energy capacity additions, as the US added a whopping 22GW of renewable generating capacity. Over half of these additions – 12.5GW – were from the country's burgeoning solar industry. Within the solar sector, a number of further records were set: the 8.9GW of utility-scale photovoltaic (PV) additions more than doubled last year's record of 4.4GW; commercial and industrial solar installs increased 34% to 1.1GW; and residential solar ticked up 14% to 2.3GW. Wind additions hit 8.5GW (similar to 2015's level), and the US installed its first-ever offshore wind farm, a 30MW project off the coast of Rhode Island. New hydroelectricity build totaled 379MW, while biomass, biogas and waste-to-energy added 132MW, and 47MW worth of stationary fuel cells were installed.
- Since 1990, over 90% of cumulative generating capacity additions have been renewable energy or natural gas, and, in the past ten years, over half (54%) of total additions have been dedicated to renewable energy resources. These installations are already having an impact on the grid: natural gas is now the number one source of power in the US, contributing 34% of the electricity mix in 2016, up from only 22% in 2007. Renewables have seen their production grow from 8% to 15% over the same timeframe. And from 2015-16 alone, renewable generation surged 12%, exceeding 600TWh for the first time, as non-hydro renewables jumped 16% and hydro rose 6% year-on-year.
- At the same time, the retirement of coal-fired power plants continues to shrink that fuel's contribution to the power mix: 2016 saw 7GW of coal-fired capacity disconnect from the grid, after a record 15GW retired in 2015. Another 12GW are currently scheduled to retire within the next five years. These retirements are due to a confluence of factors, including competition from low-priced natural gas and aging boilers. As a result, coal provides a smaller share of US power than ever recorded, with only 30% of electricity generated by coal-fired units in 2016. This figure contrasts with 48% in 2008 and represents the lowest share held by coal in at least the past 70 years.

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Improved infrastructure is critical to sustained long-term growth for sustainable energy.

- Electric transmission projects received an estimated $21.5bn in 2016, nearly double the $11.9bn invested in 2011, according to data collected by the Edison Electric Institute. Transmission investment is critical to ensuring the reliable provision of electricity to consumers, relieving grid congestion, reducing curtailment and enabling diverse and distributed resources to reach demand centers. Recent investments in large transmission networks, such as the $7bn Competitive Renewable Energy Zone in Texas (completed in 2013), and the MISO Multi-value Project (expected to be completed by 2020), will help to connect over 30GW of clean energy – mostly wind – to the grid.
- Nonetheless, curtailment of wind energy remains an issue in some regions, including the Midwest. There is some concern that new wind projects already under development in Texas will max out the transmission capacity built under CREZ, which may reintroduce grid congestion and curtailment. Meanwhile, states from New York, to Oregon, to Michigan have raised their Renewable Portfolio Standards, which set requirements for utilities to source energy from renewable projects. These goals will require more renewable energy build and, in some cases, enabling transmission infrastructure as well.
- Natural gas infrastructure remains important, along all segments of the value chain. In Appalachia, where a production boom has far outstripped the region's existing pipeline network, planned projects aim to boost pipeline capacity by 70% through 2020, allowing producers to export more to the South, Northeast and West and alleviating inter-regional price discrepancies caused by congestion constraints. A simultaneous rise in gas demand – much of it outside the Appalachian Basin – has given rise to a need for infrastructure build-out in other regions as well. In New England, for example, coal and nuclear retirements have led to greater reliance on natural gas for power, but a lag in pipeline build has led to large, localized gas price spikes and constraints in recent winters. Investment in new pipelines to bring gas into the region will be as important as Appalachian pipeline takeaway capacity.
- Farther down the value chain, expanded service and distribution pipeline networks are connecting to more households, allowing more consumers to benefit from surging supplies. Gas utilities now claim a record 68 million residential customers, up 13% over the past 10 years. All told, annual investment in natural gas infrastructure now rivals that of electric transmission: total gas utility investment across transmission, storage and distribution surged to $21.1bn in 2015, up from an average of $16-17bn over 2011-14, according to data collected by the American Gas Association.
- Other investments in enabling infrastructure are helping to target demand-side efficiency and distributed resources: smart meter deployments breached 70 million units in 2016, up 9% from 2015. Total smart meter penetration remains low compared to other nations, at only 44%, but a number of large utilities have plans to ramp up installations.
- Infrastructure to accelerate the roll-out of electric vehicles is also ramping up, with the total number of public EV charging outlets soaring 29% in 2016 from the year prior to 40,075. California is piloting a new model targeting the main market for consumer EV charging: at home. To this end, the California Public Utilities Commission approved a plan from PG&E to install 7,500 chargers in northern California alone.

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Improved infrastructure is critical to sustained long-term growth for sustainable energy (continued).

- Hydrogen infrastructure for fuel cell vehicles has also made headway in California and the northeastern United States. California's government has committed to developing at least 100 hydrogen fueling stations by 2025, with 25 retail hydrogen stations open throughout the state at the end of 2016. Toyota and Air Liquide have committed to building at least 12 hydrogen stations in the Northeast.

Low-priced oil continues to impact the transport sector, where recent gains in fuel economy are at risk of being erased.

- Sales of electric vehicles rebounded in 2016, jumping 38%. The surge was primarily driven by plug-in hybrid vehicles, such as the upgraded Chevy Volt and new models like the BMW X5 xDrive, attracting 70% more buyers. Battery electric vehicles, including the Tesla Models S and X, saw an additional 18% in units sold. Electric vehicle sales remain a small portion of total auto sales, topping 1% for the first time in Q3 2016.
- At the same time, hybrid electric vehicles (HEVs) – which compete more directly with traditional internal combustion engines – saw their sales plunge 10%, likely due to the continued pressure from low oil prices. The falloff in HEV purchases, combined with a rebound in consumer interest in large SUVs (up 22% in 2016), kept the average fuel economy of vehicles sold flat at 25 miles per gallon (mpg) for the third straight year.
- The return to less fuel efficient vehicles and low gasoline prices have resulted in two consecutive years of rising gasoline consumption. In 2016, sales of gasoline rose 3.3% to 136bn gallons, only 1.5% below the all-time peak achieved in 2005 and 7.1% above the trough achieved in 2012.
- Current Corporate Average Fuel Economy (CAFE) standards continue to require incremental improvements annually on the part of vehicle manufacturers. Although the standards through 2021 are set, those for 2022-25 underwent a midterm review in 2016. On 13 January 2017, the EPA determined to hold CAFE steady at 50.8mpg for light-duty vehicles released in model year 2025. The Trump Administration will ultimately be responsible for implementing the standard.
- Driven by the rising CAFE standards, the availability of fuel-efficient vehicles continues to climb. The market saw greater penetration of fuel-saving start-stop technologies, which automatically switch off the engine while the car is stopped to cut fuel use and reduce idling emissions. Availability of internal combustion engine (ie, traditional gasoline and diesel) models with start-stop technology exceeded 90 vehicles, or 9%, in 2016, up from less than 1% in 2012. Electric vehicle model availability is also climbing, giving consumers the option to choose among 55 EV options in 2016, including three fuel cell vehicles. Plug-in hybrid vehicles have experienced the greatest growth in the past two years, with 24 models available at the end of 2016, versus only 18 at the end of 2014.
- Natural gas continues to make inroads as a cleaner alternative to gasoline-powered vehicles, particularly within the heavy-duty vehicle segment. Industry estimates suggest that 163,000 natural gas vehicles (NGVs) were on the road at the end of 2015, including over 45,000 heavy-duty NGVs. The falloff in crude oil prices has partially eroded natural gas's price advantage; however, technological improvements continue to improve the emissions profile of NGVs: a new low-NOx "Near-Zero" heavy-duty natural gas engine released in 2016 exceeds U.S. EPA standards by 90%. Renewable natural gas (RNG), which can be used to meet federal biofuel blending standards, makes up a large share of total natural gas fuel sales for vehicles. Year-on-year, RNG use surged 25%.

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The US continues to extract near-record amounts of domestic natural gas, despite persistent low prices. Meanwhile, the country's first liquefied natural gas export terminal promises to bring new sources of demand.

- Domestic natural gas production held steady near record-highs in 2016 even as prices dropped during the first half of the year. The benchmark Henry Hub hit an 18-year low of $1.70/MMBtu in March 2016. Due to a lack of pipeline capacity, spot prices in the Appalachian Basis troughed at $0.37/MMBtu and closed above the $2/MMBtu threshold during only 40 days of the year.
- Producers responded by taking rigs off line, but selective drilling in 'sweet spots' and technological advances that allow for greater output from individual wells have allowed productivity per rig to continue rising. The Marcellus and Utica Shales, in particular, continue to see huge jumps in productivity annually. All told, this buoyed 2016 natural gas production, holding it roughly steady at 24% above 2007 levels, or just over 81Bcfd.
- 2016 marked the start of operations for the first US liquefied natural gas (LNG) export terminal, at Sabine Pass on the Louisiana/Texas border. Since February, Sabine has shipped approximately 50 cargoes of LNG to 16 destinations. Currently, LNG exports amount to a small portion of demand for US gas. With US LNG competitive in a number of markets, additional terminals are under construction and export volumes should rise significantly through 2020 if these come online as planned.

Investment in zero-carbon technologies slowed after a surge in 2015, as fewer companies sought financing in the public markets.

- Investment over the past ten years into zero-carbon technologies has been substantial, with $507bn flowing into the US clean energy sector. After $63bn worth of investment into renewable energy and energy smart technologies in 2015, investment in 2016 fell to $59bn. The falloff in spending was visible particularly within the solar sector, which dropped to $29bn from $35bn the year previous as solar costs fell and companies shunned the public markets. Wind investment rose 11% to $15.5bn, and energy smart technologies (such as smart grid and electric vehicles) saw investment ticking up by 5% to $10.6bn. The US remains the second largest destination for clean energy investment, surpassed by only China, which saw $88bn of investment in 2016.
- The decline in 2016 primarily resulted from fewer companies turning to the public markets for financing, after solar roped in a record $8.3bn in 2015. The April 2016 bankruptcy of SunEdison, which raised $2.3bn alone in 2015, and a pause in capital raising by yieldcos appear to be drivers of the falloff.
- Asset finance – which tracks money flowing into new utility-scale projects only – totaled $31.6bn, a small drop-off from 2015's $32.2bn. Financing in 2015 had surged 46% from 2014 levels, as market participants sought to lock in federal tax credits which were due to expire or step down at the end of 2016. In the eleventh hour of the 2015 Congress, the Production Tax Credit for wind and the Investment Tax Credit for solar were extended for five years apiece, effectively giving the market more time to invest, and, accordingly, 2016 declined. Almost all of the funds were directed into solar and wind, which each captured $14.7bn. Biomass financing amounted to $196m, down from $286m in 2015. Small hydro saw its first significant investment since 2011, with $77m in asset financing, and biogas received $24m. There was virtually no new financing tracked for waste-to-energy, geothermal, or carbon capture and storage in 2016.

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Key federal policies supportive of sustainable energy hit stumbling blocks in 2016, while state-level actions continued.

- The Obama Administration's flagship policy on carbon emissions from the power sector, the Clean Power Plan, was stalled in February 2016 when the US Supreme Court granted plaintiffs a stay on implementing the regulation while a lawsuit is ongoing. With a stay in place, the EPA has been unable to enforce any upcoming CPP deadlines, the first of which would have required states to submit the first draft of their implementation plans in September 2016. At the same time, the CPP's sister policy, the New Source Performance Standards (NSPS), has also been challenged in the courts. If the NSPS is overturned, it could preclude the EPA from implementing the CPP regardless of its own status (under the US Clean Air Act, the EPA must first regulate new sources of emissions before it can tackle existing sources).
- The tax credit extensions of late 2015 benefited the wind and solar sectors, but tax credits for other renewable energy and energy efficiency technologies were not extended at that time and ultimately expired at the end of 2016. Significant attempts were made to extend all the remaining energy efficiency and renewable energy tax provisions, but after the November 2016 election, congressional leaders shifted focus to tax reform, where these provisions may be addressed.
- State-level policies remain equally if not more important in driving the sustainable energy transition. Renewable Portfolio Standards (RPS) have been key tools in driving wind and solar build. States also use Energy Efficiency Resource Standards (EERS) to encourage energy savings, and states determine net energy metering policies, which can be critical to distributed solar. In 2016, a number of states made sweeping changes to each of these types of policies. Notable changes included:
  - **Illinois**, which through a major new energy bill supplemented its existing RPS with requirements for utilities to source at least 2TWh of new wind and solar each, by 2020. Additionally, the bill tightened location requirements, granting preference to in-state build. Taken together, these changes should promote new, incremental renewable build within Illinois and its neighbors. SB 2814 also created a zero-emissions credit program for the state's nuclear facilities, ramped utility ComEd's energy efficiency target to 17% by 2025 and 21.5% by 2030, and preserved the current net metering regime (which will phase out when the 5% cap is hit).
  - **Michigan**, whose legislature raised its RPS from 10% in 2015 to 15% in 2021 and expanded the program's eligibility to include geothermal heating systems. The new law also removed a cap which prohibited utilities from spending more than 2% of annual revenues on efficiency programs. Finally, it requires electricity providers to give consumers choice in selecting green programs, while directing the state's Public Service Commission to begin the process of developing a tariff for distributed generation.
  - **Massachusetts**, which set a mandate for 1.6GW of offshore wind by 2027, along with a requirement that the state's utilities procure 9.45TWh of clean energy through long-term contracts and an authorization for the state to set a storage target. Meanwhile, the state Supreme Court ruled that Massachusetts has not taken enough action on greenhouse gas emissions. In response, the state's Republican governor has proposed to raise the RPS target to 80% by 2050 and limit emissions from the transportation sector for the first time, among other recommendations.

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Key federal policies supportive of sustainable energy hit stumbling blocks in 2016, while state-level actions continued.

  - Ohio, where the governor vetoed a bill which would have made the state's renewable energy and efficiency standards voluntary through 2019. The state had already frozen its targets at 2014 levels; with the governor's veto, the targets will begin rising once again in 2017.
  - New York, where the state's "Reforming the Energy Vision" progressed with the adoption of a new Clean Energy Standard which formalizes a renewable energy generation target of 50% by 2030, as well as a zero-emissions credit program to support three of the state's struggling nuclear facilities. Additionally, Westchester Smart Power became the state's first Community Choice Aggregation (CCA) program, following the Public Service Commission's 2015 order authorizing CCAs, and the state approved $40m of financing for feasibility studies on microgrid resiliency projects.
  - California, which passed legislation requiring the state to reduce its greenhouse gas footprint by 40% below 1990 levels by 2030. A current law already mandates that the state achieve 1990 emissions levels in 2020. The largest single source of emissions in the economy is the state's transport sector, suggesting that the new goal may help drive increased demand for more fuel efficient and alternative vehicle technologies.
- More broadly, Property Assessed Clean Energy (PACE) is becoming more widely available as additional states and municipalities adopt programs or enabling legislation. PACE helps finance renewable energy and energy efficiency upgrades to buildings by allowing the owner to pay off the cost over 20 years via an addition to their property taxes. In 2016, Nevada signed off on legislation to allow for PACE financing, and Atlanta and Loudon County, VA began developing new programs. As a result, financing via PACE providers is picking up rapidly: commercial PACE financing amounted to $45m in Q3 2016, up 380% from Q3 2015 levels.

Corporates remain active, keeping a close eye on how – and from which sources – they consume energy.

- Within the US alone, corporations (eg, non-utility offtakers) signed 2.5GW worth of long-term power contracts with wind and solar projects. This tally marked a one-year decline relative to 2015's 3.7GW, but it remained well above 2014 levels. Other signs suggest corporate interest in renewable energy will continue gaining momentum: 83 companies have now signed the "RE100", a goal of sourcing 100% of their consumption from renewable energy. Notable signees include Apple, BMW, HP, Johnson & Johnson, Kingspan, and P&G. Google also announced in 2016 that it would already achieve this milestone globally by 2017. In addition, corporate customers continued to purchase stationary fuel cells to power their facilities, headquarters, and distribution centers. Announcements of new or recurring orders of stationary fuel cells in 2016 included Home Depot, Morgan Stanley, IKEA, and Pfizer.

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Corporates remain active, keeping a close eye on how – and from which sources – they consume energy (continued)

- Corporations are also increasingly concerned about using energy efficiently. More corporations are using ISO 50001, an energy management systems standard to reduce costs and carbon emissions. The US Department of Energy Superior Energy Performance program, which certifies facilities that have implemented the ISO 50001 standard, continued to expand in 2016: new buildings certified include multiple facilities from Schneider Electric and 3M, and the JW Marriott in Washington, DC. In addition, other voluntary programs encourage corporate and industrial partners to pledge to improve their energy performance. The DOE's Better Plants program asks facilities to reduce energy intensity by 25% over ten years, and the new "EP100", an initiative where companies pledge to double their energy productivity, was launched in early 2016. Member companies include Johnson Controls and Swiss Re.

The US remains one of the most competitive places for energy-intensive industries.

- Exceedingly low natural gas and electricity prices have helped to reduce costs for industrial players, particularly those in energy-intensive sectors. Despite a surge in the value of the dollar over 2015-16, the United States remains among the lowest cost markets for electricity in the world for industrial customers, beating out other large countries such as China, India, Mexico and Japan.

Greenhouse gas emissions continue to plummet, reaching new milestones despite policy uncertainty.

- Total greenhouse gas emissions in the US plunged to a 25-year low in 2016, falling to an estimated 6.5GtCO2e. Gross emissions (ie, not accounting for emissions absorbed by forests and sinks) now sit 12.1% below their peak of 7.4Gt attained in 2007, and 11.6% below 2005 levels. The 2005 level is notable because it is the benchmark against which recent national climate policies have been measured: the Paris Accord included a pledge by the US to reduce emissions between 26-28% below 2005 levels by 2025; estimates for 2016 shows that the US is almost halfway to that goal. The US is also increasingly close to hitting a 2020 target pledged by the Obama Administration in 2009, which aimed for a 17% decrease from 2005 levels.
- Within the power sector, the progress is even more noteworthy: in 2016, greenhouse gas emissions from US power plants dropped 5.3% in just one year. Since 2005, the power sector has shrunk its carbon footprint by 24% – in other words, the US is 75% of the way to the Clean Power Plan's "32% by 2030" headline target, with 14 additional years left to go. In large part, this decarbonization is due to market forces: the boom in domestic natural gas production has provided the sector with a cheap, cleaner burning source of fuel (a natural gas combined-cycle plant emits roughly 60% less carbon than a coal-fired unit); additionally, renewable energy costs have fallen dramatically and corporations have captured cost-savings through energy efficiency measures.
- The retirement of 49GW of coal-fired power plants and the construction of 104GW of natural gas, 78GW of wind and 39GW of solar over the 2005-16 timeframe should assure some permanency to US decarbonization: these changes are structural. However, operational fuel switching is still at play, and a return to a higher priced natural gas environment could reverse, at least partially, the recent downward swing in US emissions.

The 2017 Factbook in 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 US 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 (up in 2013 relative to 2012), the amount of emissions associated with that energy consumption (up), and the amount of new investment into renewable energy (down) – 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 of the Factbook was released in February 2016 and looked back on a year in which the US added record 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, as gas prices sank to the lowest levels since 1999. Coal-to-gas switching also helped to drive down power sector emissions to the lowest point since 1995. Renewable capacity including hydropower grew from 206GW to 222GW, 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.

This most recent update to the Factbook covers 2016, a year in which natural gas generation overtook coal, the growth of renewables accelerated, and utilities put more dollars into transmission and natural gas infrastructure to improve reliability. As the transformation of the sector plays out, consumers are spending less of their household income on energy – under 4% in 2016, the smallest share on record.

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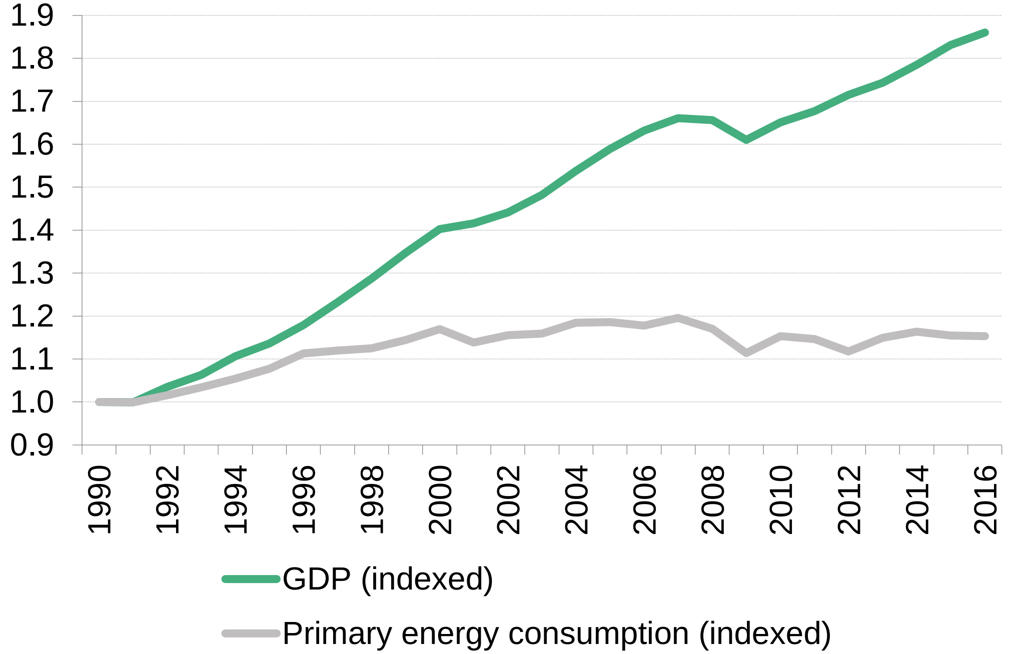
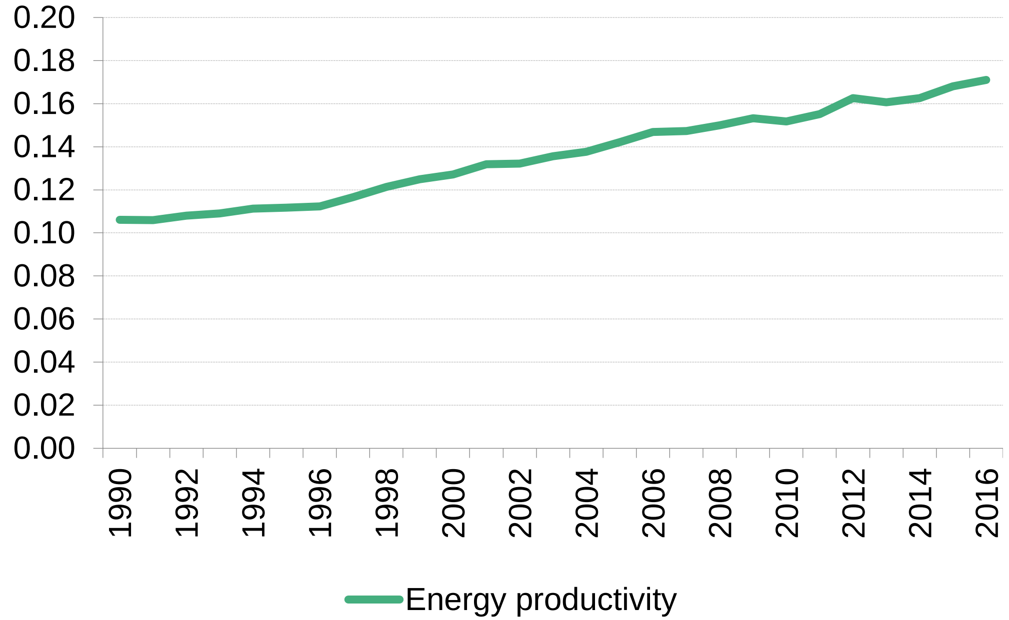
Economy's energy productivity

US GDP and primary energy consumption (indexed to 1990 levels)



US energy productivity ($ trillion of GDP / quadrillion Btu of energy)



- The US economy continues to become more energy productive, as total energy consumption plateaus while GDP advances. Over the past 25 years, real GDP has accelerated by 80%, while primary energy consumption has risen by only 14%. Within the past 10 years, this decoupling is even more evident: GDP has grown by 12%, while energy consumption has declined 3.6%.
- By another measure (US GDP per unit of energy consumed), productivity has soared 58% since 1992, 16% since 2007, and 1.8% since 2015. While the shifting composition of the US economy is a key driver, estimates put forward by the American Council for an Energy Efficient Economy in 2015 indicate that efficiency gains are responsible for as much as 60% of the energy intensity improvements seen since 1980.

Source: US Energy Information Administration (EIA), Bureau of Economic Analysis, Bloomberg Terminal

Notes: Values for 2016 energy consumption are projected, accounting for seasonality, based on latest monthly values from EIA (data available through October 2016). GDP is real and chained (2009 dollars); annual growth rate for GDP for 2016 is based on consensus of economic forecasts gathered on the Bloomberg Terminal as of January 2017.

US energy overview:
Energy and electricity consumption

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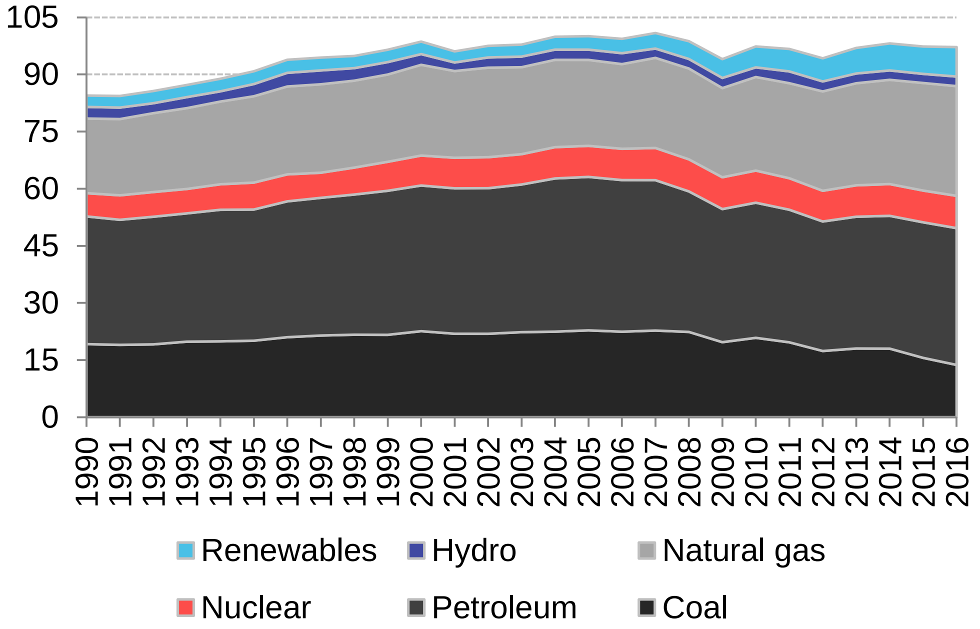
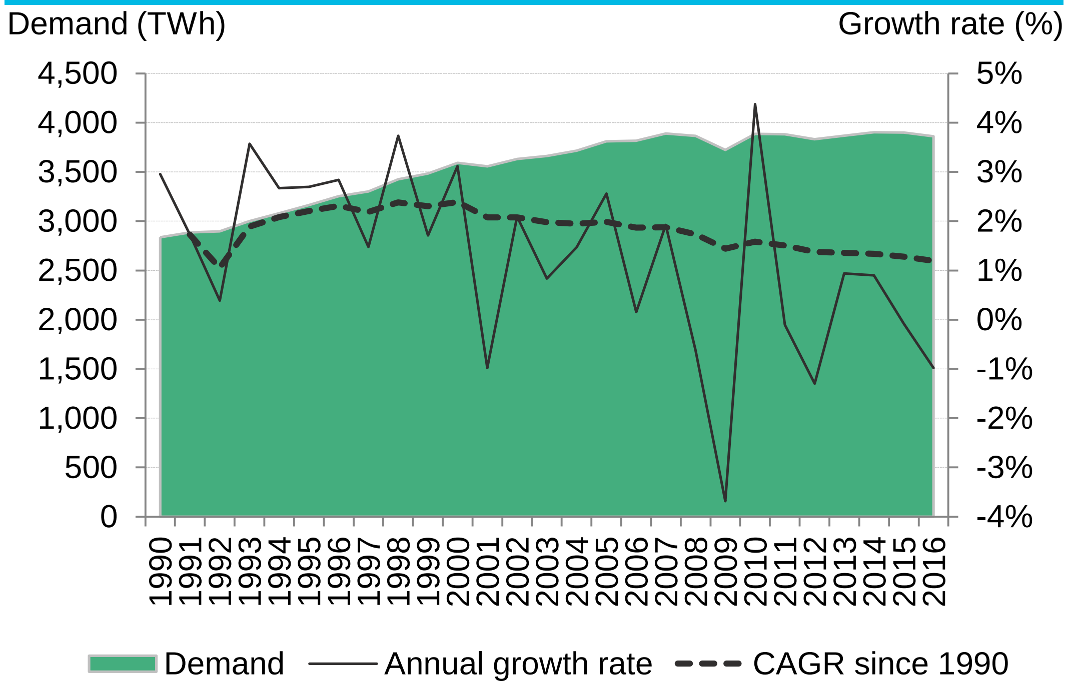
US primary energy consumption by fuel type (quadrillion Btu)



US electricity demand



- Energy consumption dipped for a second consecutive year in 2016, falling by 0.2% even as GDP grew 1.6%. In 2015, consumption had tumbled 0.8% while the economy expanded at a 2.6% clip.
- At the same time, the energy mix has transitioned towards lower-carbon sources:
  - Coal's contribution to total energy collapsed to 14% in 2016, from 23% in 2007.
  - Natural gas climbed from 23% to nearly 30%, while renewables (including hydropower) surged to over 10%, from 6.5%.
- Annualized electricity growth has been declining, from 5.9% in 1950-1990, to 1.9% in 1990-2007, to -0.1% since 2007.

Source: EIA Notes: CAGR is compound annual growth rate. Values for 2016 are projected, accounting for seasonality, based on latest monthly values from EIA (data available through October 2016)

US energy overview:
Electricity generation mix

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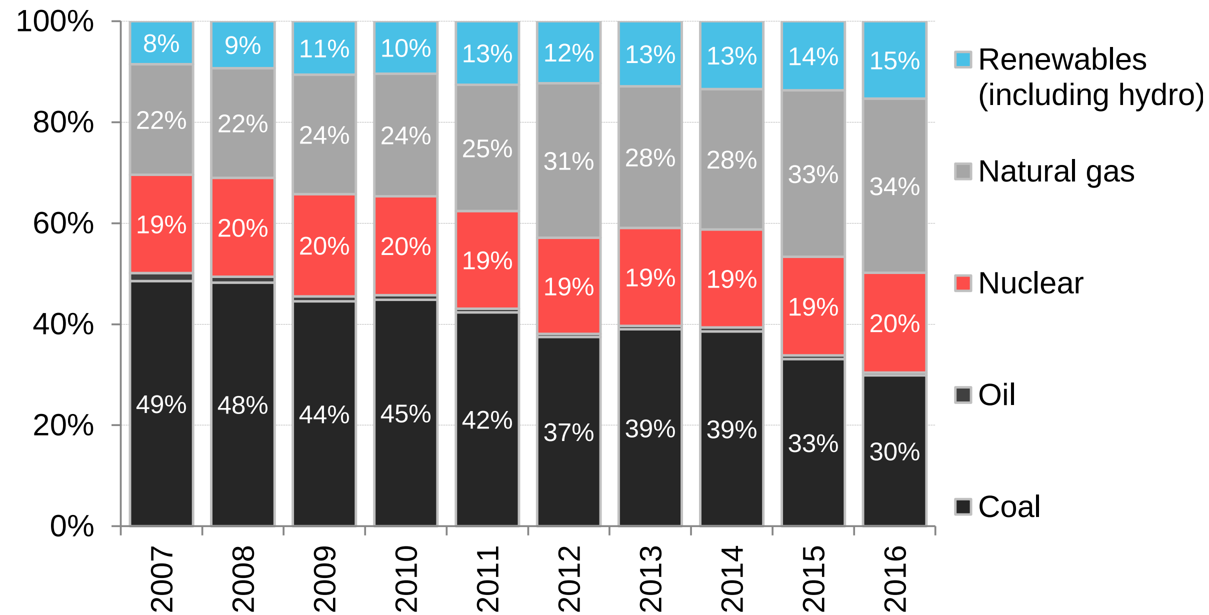
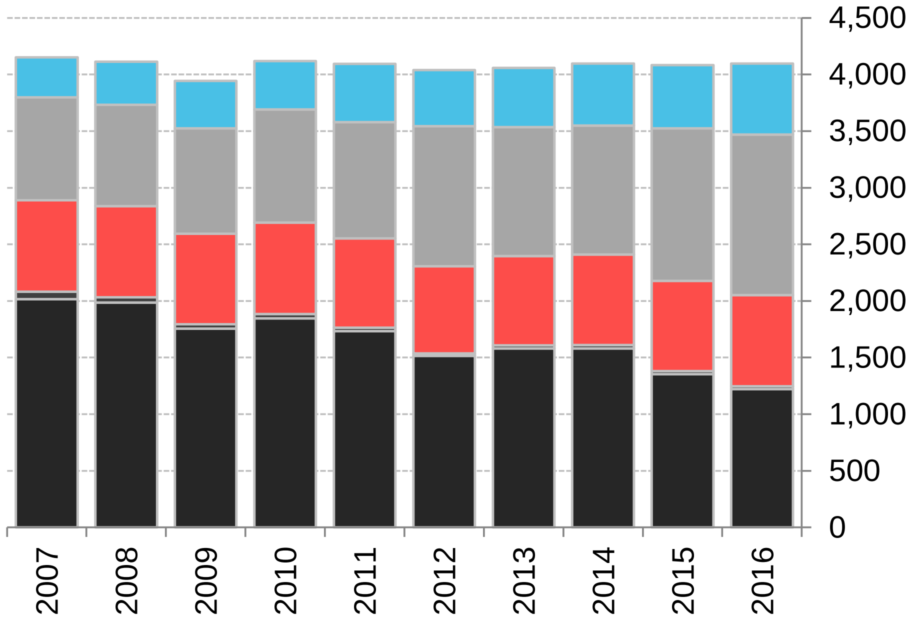
US electricity generation by fuel type (%)



US electricity generation by fuel type (TWh)



- Natural gas has eclipsed coal as the largest contributor to the US electricity mix, hitting 34% in 2016, as aging coal-fired units retired and natural gas prices remained low. Coal sank to second place, providing 30% of the mix – its lowest share on record. Year-on-year, coal-fired power plants generated 10% less, slipping to 1,219TWh from 1,352TWh in 2015.
- Renewable generation topped 15% for the first time as the record-breaking drought in the West eased, boosting hydro generation, and as more solar and wind were connected to the grid.
- Since 2007, the US power sector has made large strides towards a decarbonized grid: coal's share plummeted from 49% to 30%, while natural gas's grew from 22% to 34% and renewables from 8% to 15%. On an absolute basis, coal generation sank 39% and natural gas generation rocketed 56% over the same timeframe.

Source: EIA

Notes: Values for 2016 are projected, accounting for seasonality, based on latest monthly values from EIA (data available through November 2016). In chart at left, contribution from 'Other' is not shown; the amount is minimal and consists of miscellaneous technologies including hydrogen and non-renewable waste. The hydropower portion of 'Renewables' includes negative generation from pumped storage.

US energy overview:
Electric generating capacity build by fuel type (GW)

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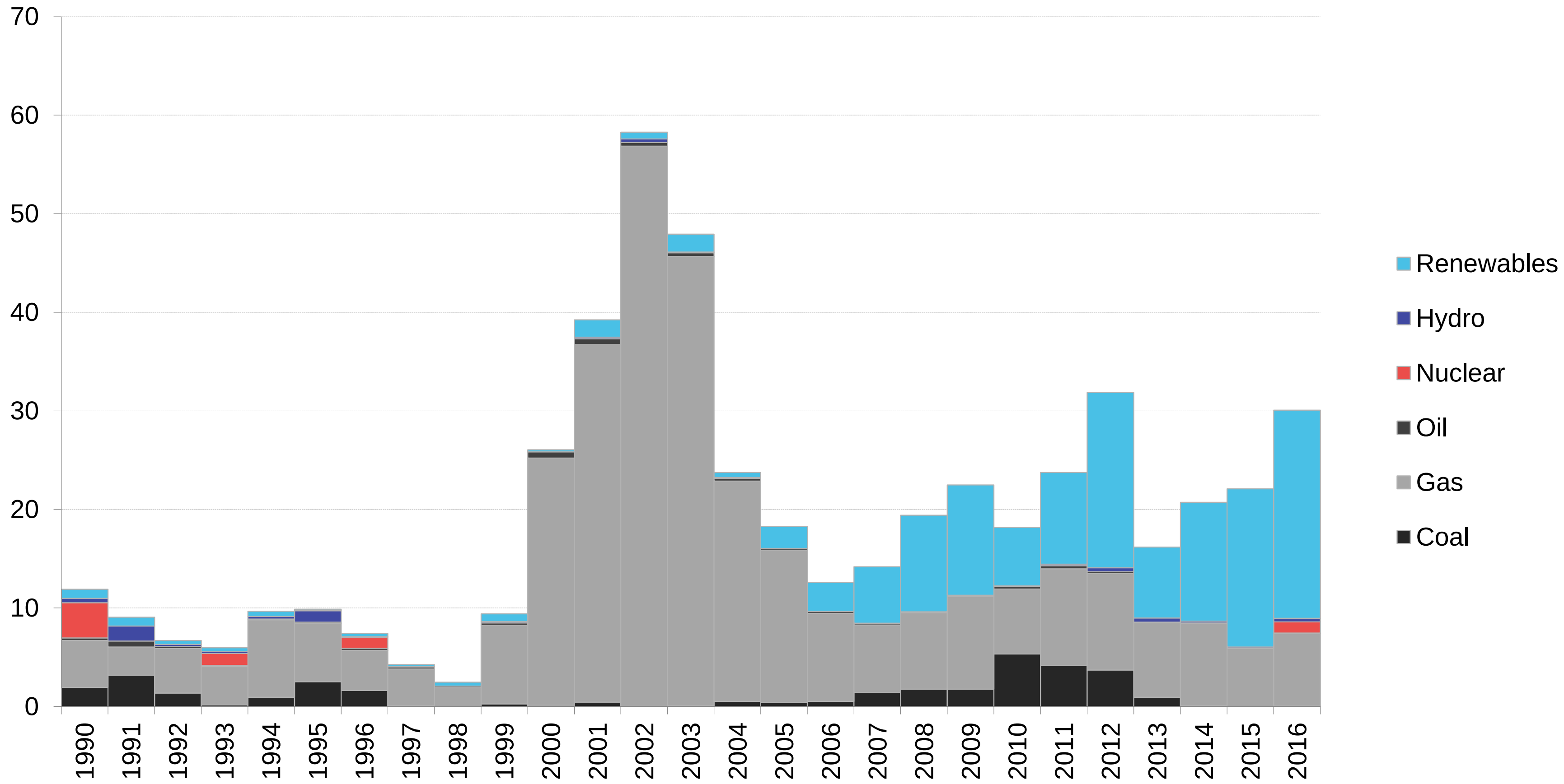
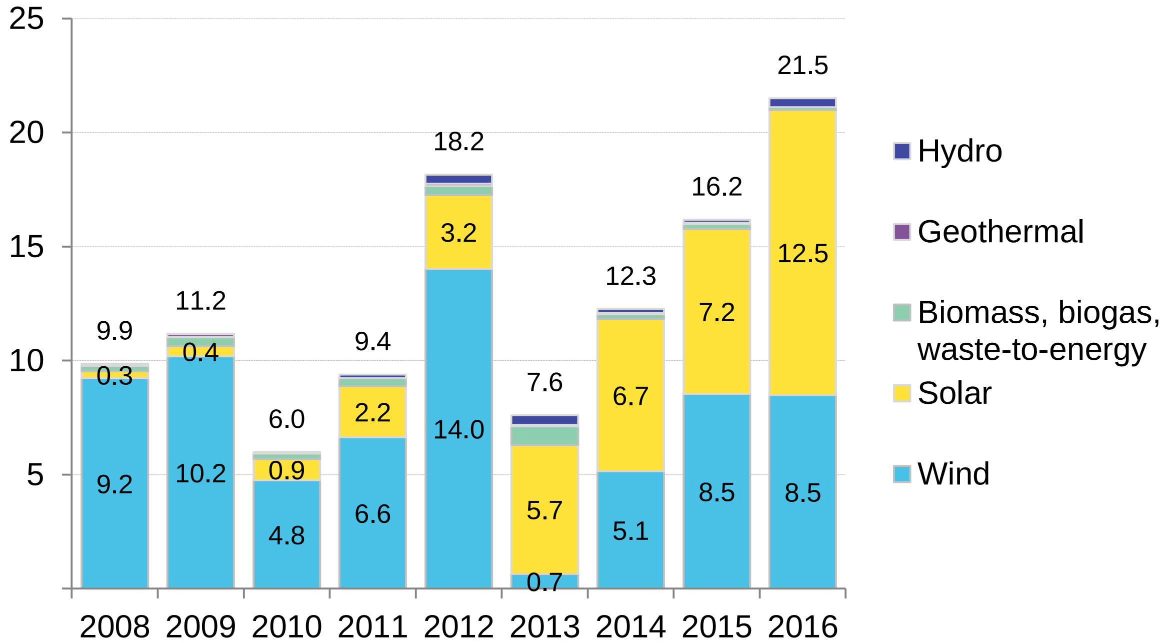


- In the past five years, renewable energy projects, including hydro, have made up 62% of new capacity additions in the US.
- Additionally, within the past 25 years, 92% of new power capacity built in the US has been natural gas plants or renewable energy projects, again including hydro.
- In 2016, non-hydro renewables continued to represent the largest share of build, adding 21GW of capacity, or roughly 70% of total build for the second straight year. Gas build totaled 7.4GW, and for the first time since the 1990s, there was also nuclear build of 1.1GW.

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. Last year’s Factbook included anticipated nuclear build; however, the Watts Bar reactor was in fact turned on in 2016; accordingly, the nuclear build is shown here in 2016.

US energy overview:
Renewable energy capacity build by technology (GW)



- Solar build boomed in 2016, as the industry installed 12.5GW – a 73% increase over the previous year, and the largest addition from any single technology in 2016.
- Utility-scale solar PV ramped up the fastest, as developers installed 8.9GW, more than double 2015's 4.4GW. The upswing in build was partly driven by the previously anticipated expiration of the Investment Tax Credit (ITC): the ITC was due to drop from 30% to 10% at the end of 2016, prompting many to bring forward development to capture the full credit. With the five-year extension granted in late 2015, urgency diminished, but a slew of projects that had already broken ground proceeded.
- Small-scale solar added 3.4GW, as falling costs make it increasingly competitive with retail rates in certain parts of the country.
- Wind build held steady at 8.5GW. Like solar, the wind industry benefited from an eleventh-hour extension of the Production Tax Credit, which now applies to projects that begin construction by end-2019. For the first time, the US also saw offshore wind build, as the 30MW Block Island wind farm switched on in December.
- Other sectors (biomass, biogas, waste-to-energy, geothermal, hydro) are idling without 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.

US energy overview:
Cumulative renewable energy capacity by technology

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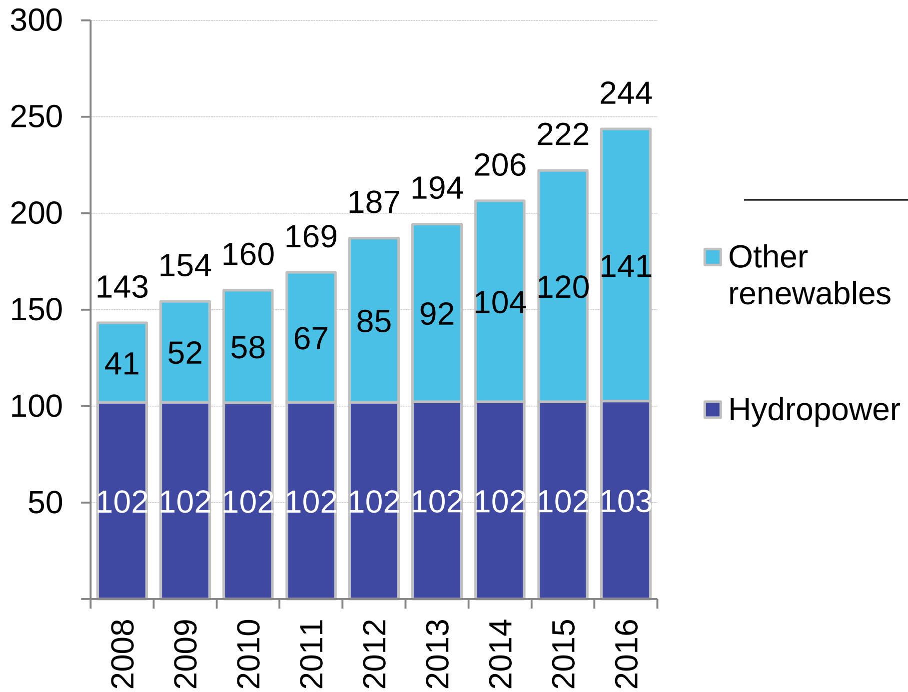
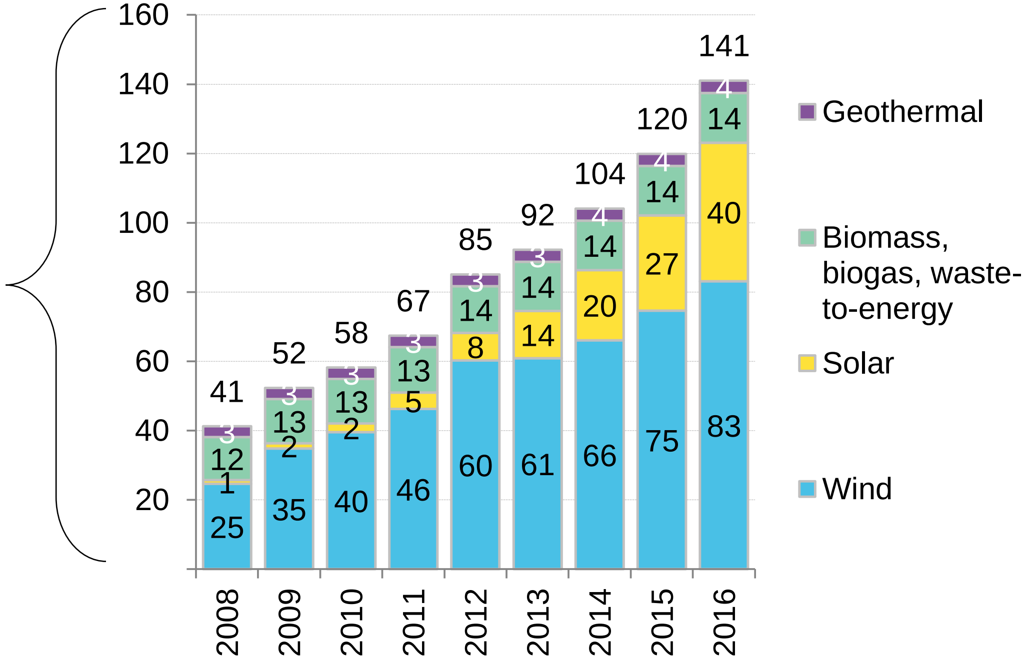
US cumulative renewable capacity by technology (including hydropower) (GW)



US cumulative non-hydropower renewable capacity by technology (GW)



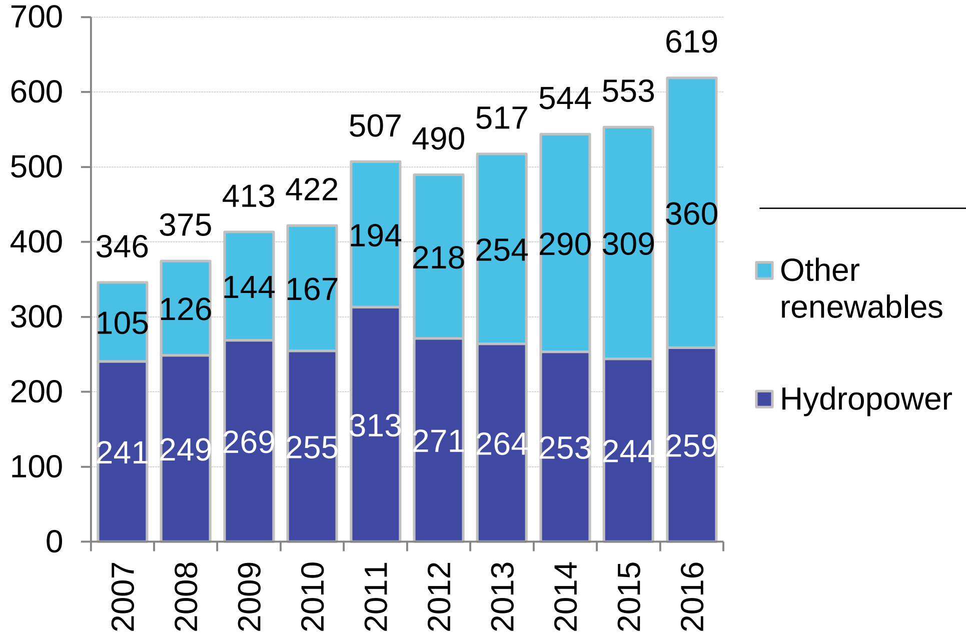
- Total renewable capacity has increased 70% since 2008, reaching 244GW in 2016. Year-on-year, hydropower capacity ticked up slightly to 103GW and other renewables grew by 21.1GW, or 18%. Wind and solar build in particular continues to climb due to supportive tax policies, state-level renewable portfolio standards (RPS) and falling system costs.
- Since 2008, new wind and solar build have almost quintupled their total installed capacity, expanding from only 26GW to 123GW at the end of 2016. The bulk of solar's additions have come within the past five years (35GW from 2012-16), as costs fell precipitously.

Source: Bloomberg New Energy Finance, EIA

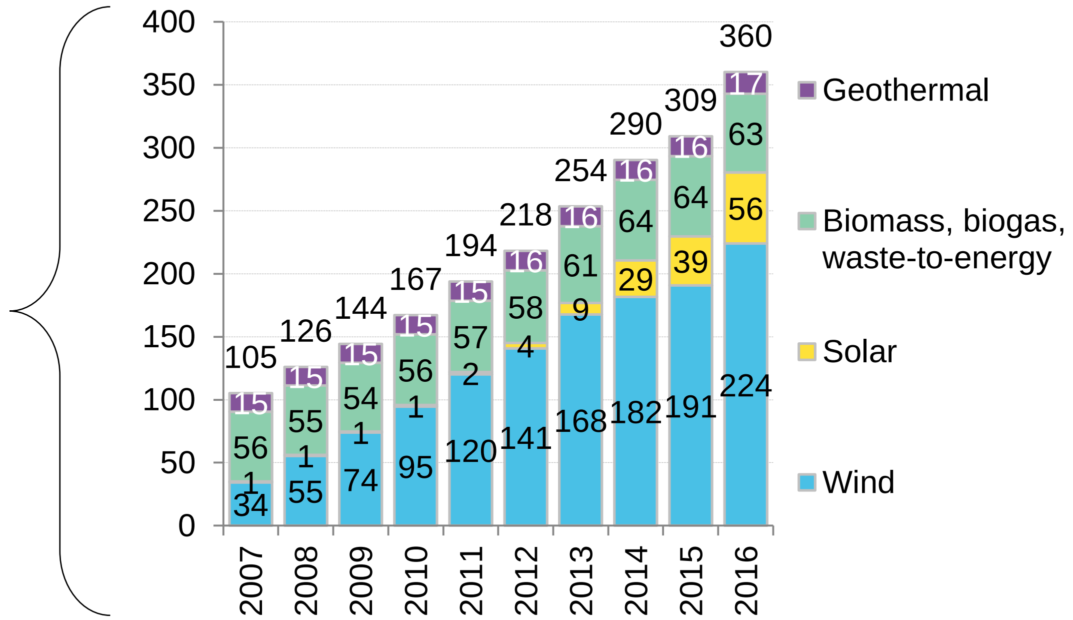
Notes: All values are shown in AC except solar, which is included as DC capacity. Hydropower capacity includes pumped hydropower storage facilities. Totals may not sum due to rounding.

US energy overview:
Renewable energy generation by technology

US renewable generation by technology (including hydropower) (TWh)



US non-hydropower renewable generation by technology (TWh)



- Total renewable generation swelled in 2016, increasing 12% over 2015 levels. Newly built wind and solar projects added 50TWh of incremental carbon-free generation, and at the same time, an easing drought out West boosted hydro output to its highest level in three years. Hydropower remains the largest single source of renewable generation (42%), but wind (36%) is catching up quickly.
- Non-hydro renewable generation has more than tripled over the past ten years. The largest growth was exhibited within the wind and solar sectors: wind generation has multiplied almost seven times over, while solar generation grew from virtually nothing to hit 56TWh in 2016.

Source: Bloomberg New Energy Finance, EIA

Notes: Values for 2016 are projected, accounting for seasonality, based on latest monthly values from EIA (data available through November 2016). Includes net energy consumption by pumped hydropower storage facilities. Totals may not sum due to rounding. Beginning in 2014, numbers include estimated generation from distributed solar; generation from other distributed resources is not included.

US energy overview:
Greenhouse gas emissions, power sector, energy sector and economy-wide (MtCO2e)

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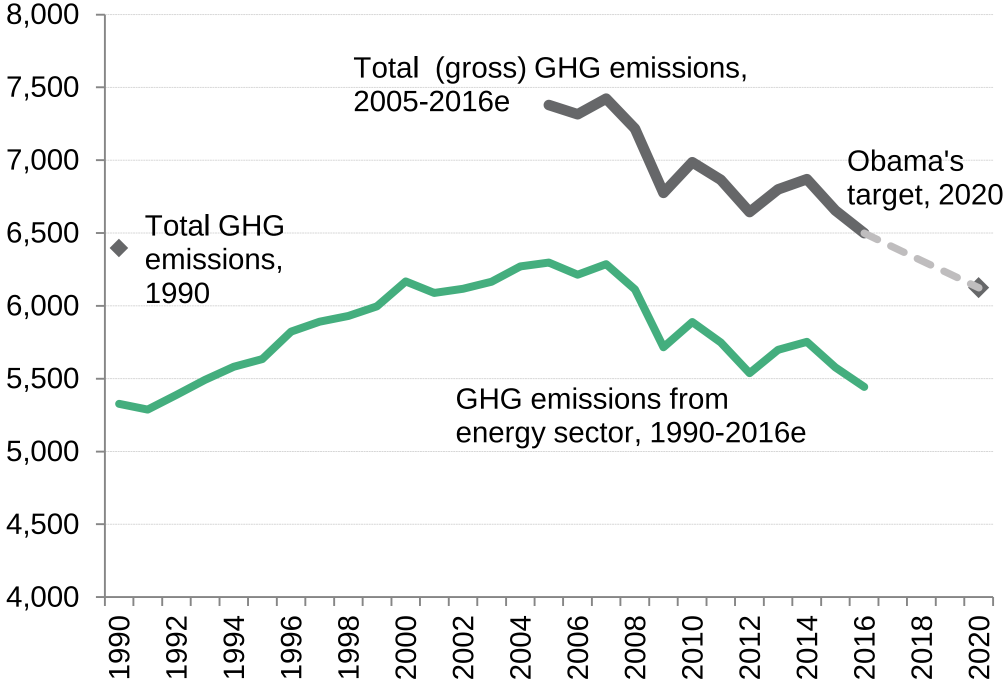
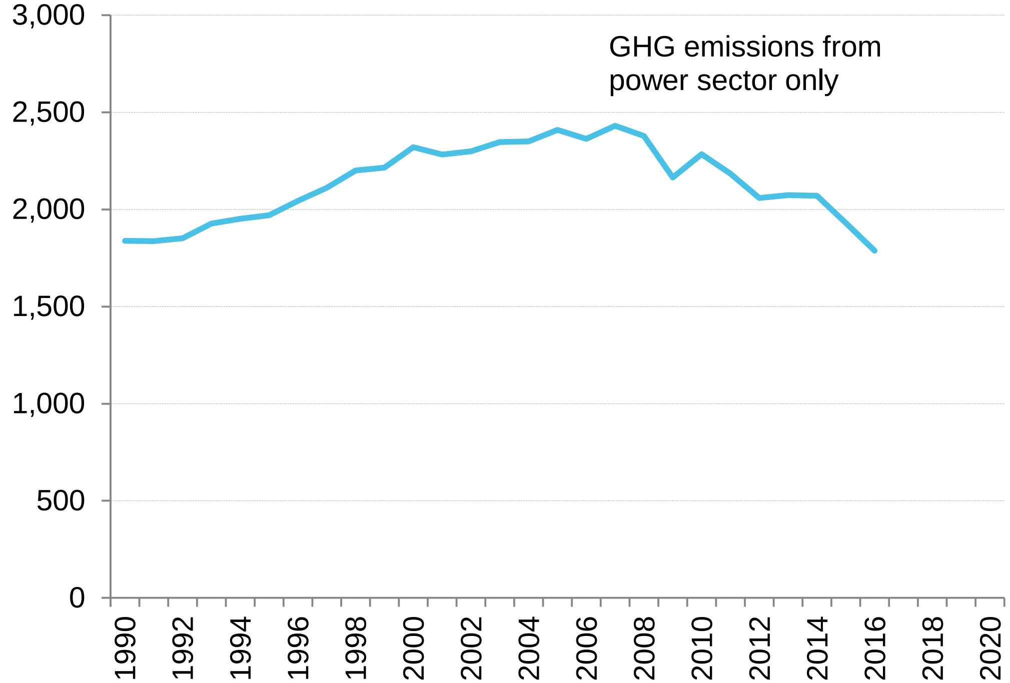




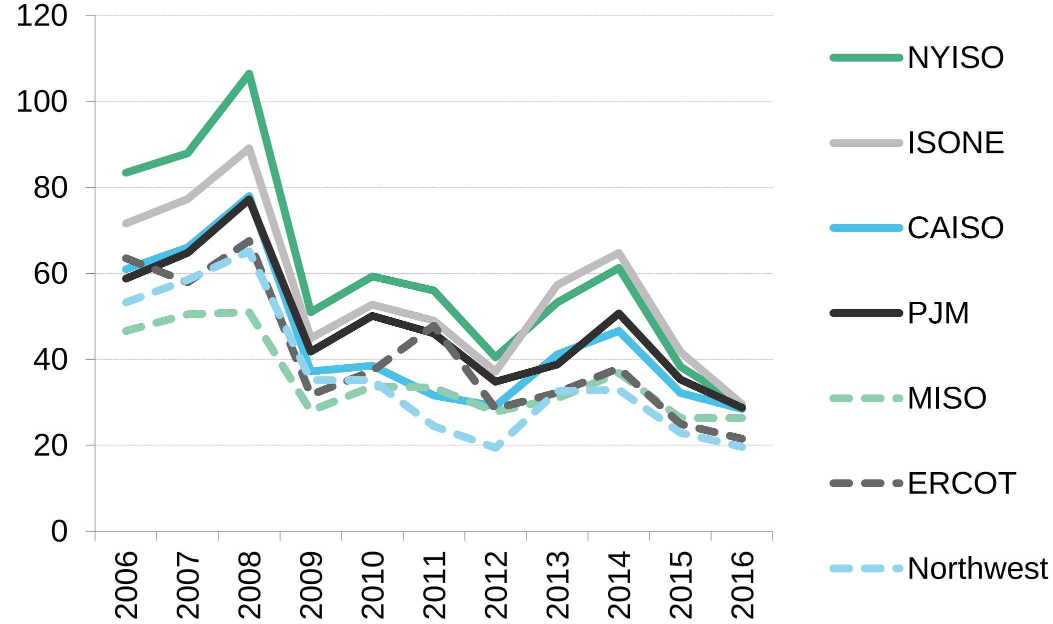
- US GHG emissions are projected to be at their lowest levels in 25 years, falling to an estimated 6.5GtCO2e in 2016 – close to levels observed in 1992. All told, total GHG emissions (excluding sinks) are approximately 12% below 2005 levels, the baseline used in the Obama Administration's climate commitments, and nearly halfway to the US' Paris goal of a 26-28% cut by 2025, as set out under President Obama.
- Total GHG emissions fell an estimated 2.0% year-on-year, following on the heels of a 3.2% decrease the year prior. The power sector has been a significant driver of the economy's decarbonization, primarily due to the switch to cleaner-burning natural gas. In 2016, power-sector emissions shrank 5.3% year on year, bringing them to 24.1% below 2005 levels.

Source: Bloomberg New Energy Finance, EIA, EPA

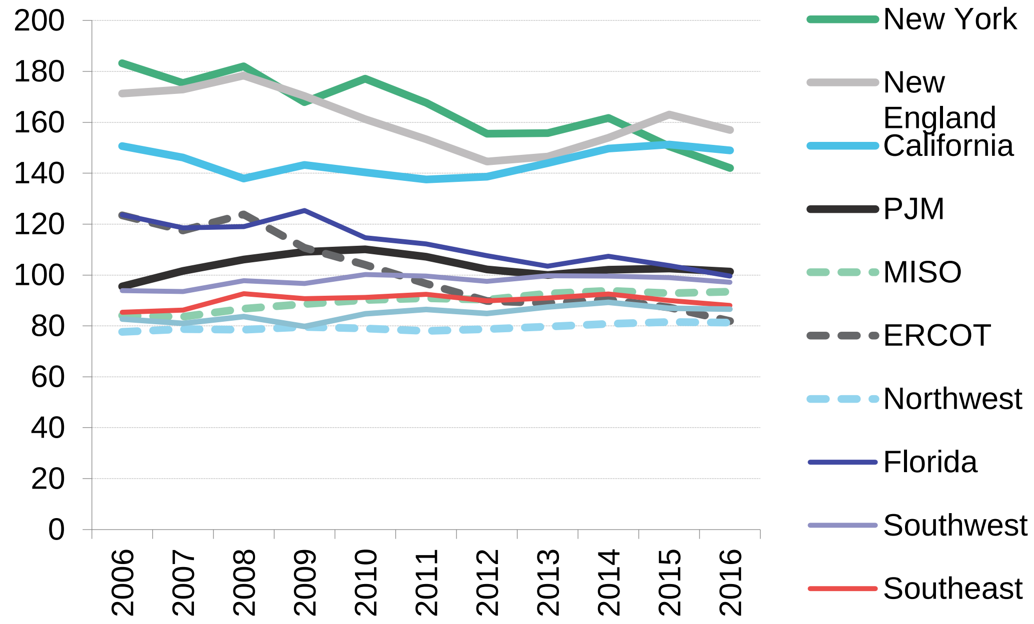
Notes: 'Sinks' refer to forests and green areas which absorb carbon dioxide. Values may differ from last year's, due to recalculations and revisions published by the EPA, primarily to methane emissions. Values for 2016 are projected, accounting for seasonality, based on latest monthly values from EIA (data available through October 2016). 'Obama's target' refers to a pledge made in Copenhagen climate talks in 2009. The target shown here assumes 17% reduction by 2020 on 2005 levels of total GHG emissions, but the actual language of the announcement left vague whether the reductions applied to economy-wide emissions or just emissions of certain sectors. Data for total GHG emissions comes from EPA's Inventory of US Greenhouse Gas Emissions and Sinks (1990-2014), published April 2016. Data for CO2 emissions from the energy sector comes from the EIA's Monthly Energy Review.

US energy overview:
Retail and wholesale power prices (2016 $/MWh)

Wholesale power prices (2016 $/MWh)



Average retail power prices (2016 $/MWh)

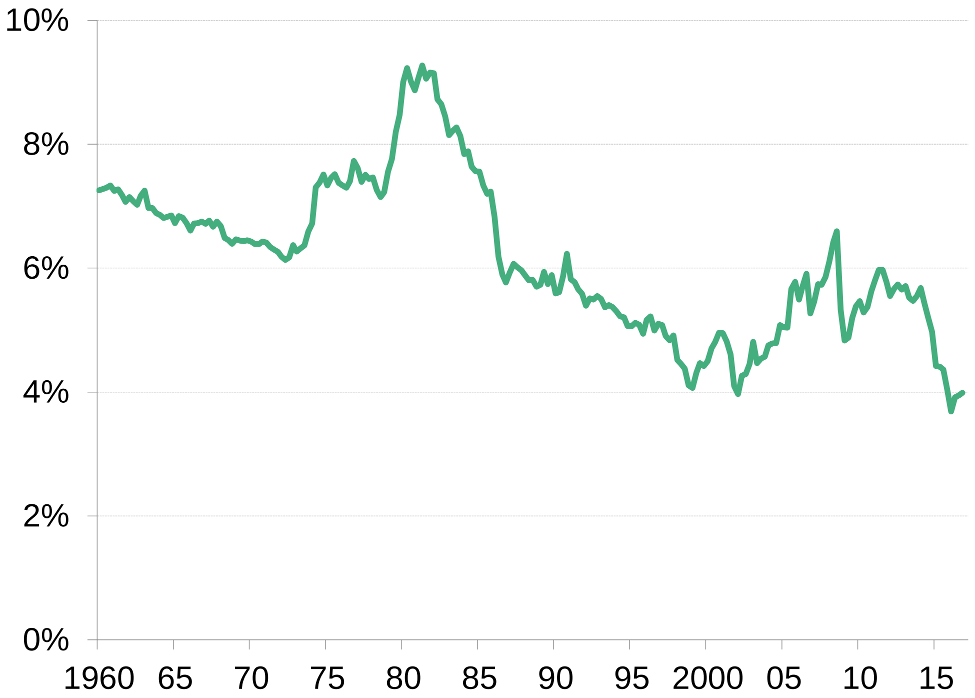


- Wholesale power prices continued their descent in 2016, as natural gas prices touched an 18-year low in March and more zero-marginal cost renewables bid into the market. Year-on-year, around-the-clock prices dropped by as much as 29% in New England (ISONE), 23% in New York (NYISO) and 18% in PJM in real terms. In the Midwest (MISO), prices held relatively flat, falling 0.2% year-on-year. The declines in 2016 followed after roughly 30% slides in 2015 for most regions.
- Retail prices also declined, at an average clip of 2.2% across the country. Regionally, the falloff in retail prices was most visible in New York and Texas (ERCOT), which saw decreases of 5.6% and 6.2%, respectively. Retail prices are typically less responsive to changes in the fuel mix or in fuel prices, because wholesale power costs make up only a portion of retail bills.
- Since 2005, US average retail prices have risen only 1.4% in real terms. Prices are down 7% from their 2008 peak.

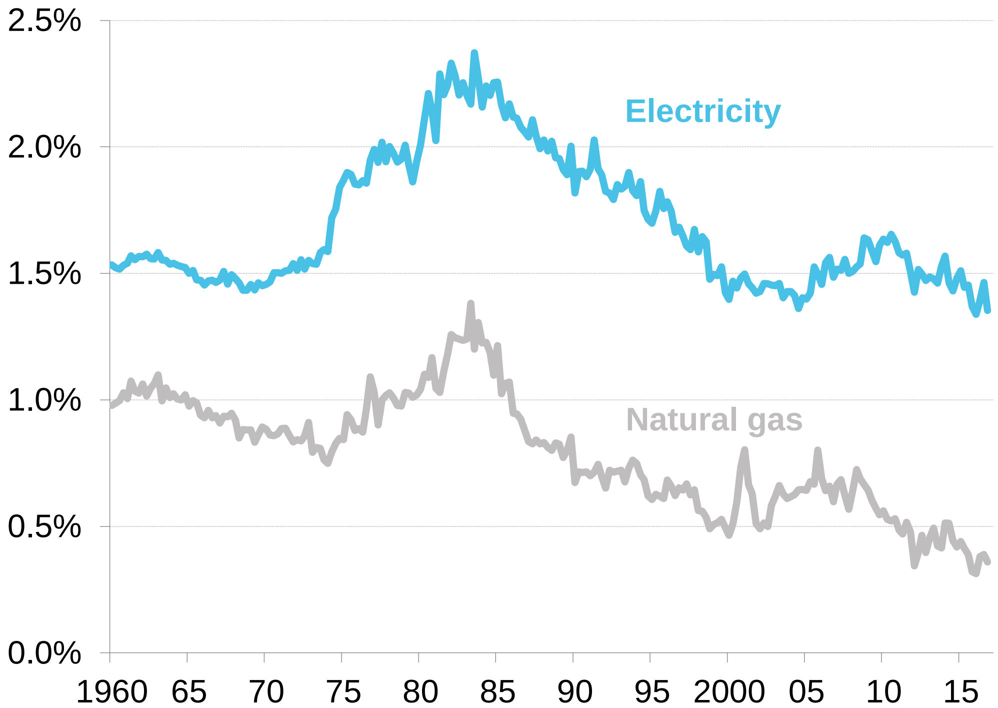
Source: Bloomberg New Energy Finance, EIA, Bloomberg Terminal Notes: Wholesale prices are taken from proxy power hubs in each ISO and are updated through end-2016. The retail power prices shown here are not exact retail rates, but weighted averages across all rate classes by state, as published by EIA 826. Retail prices are updated through end-November 2016. All prices are in real 2016 dollars.

Energy as share of total US personal consumption expenditure

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



Electricity and natural gas as a share of total consumption expenditure



- Americans are dedicating less of their household spending to energy than at any other time on record: energy consumption as a share of total consumption expenditures averaged 3.9% in 2016, the first year in which this measure came in below 4% since the Bureau of Economic Analysis began reporting data in 1959.
- Consumption costs for natural gas and electricity reflect a similar trend: natural gas represented under 0.4% of total spending, and electricity came in at 1.4%, both the lowest totals on record.
- The falloff spending is likely a result of falling fuel costs as well as energy efficiency measures.

Source: Bureau of Economic Analysis, Bloomberg New Energy Finance Notes: Values for the fourth quarter of 2016 are preliminary.

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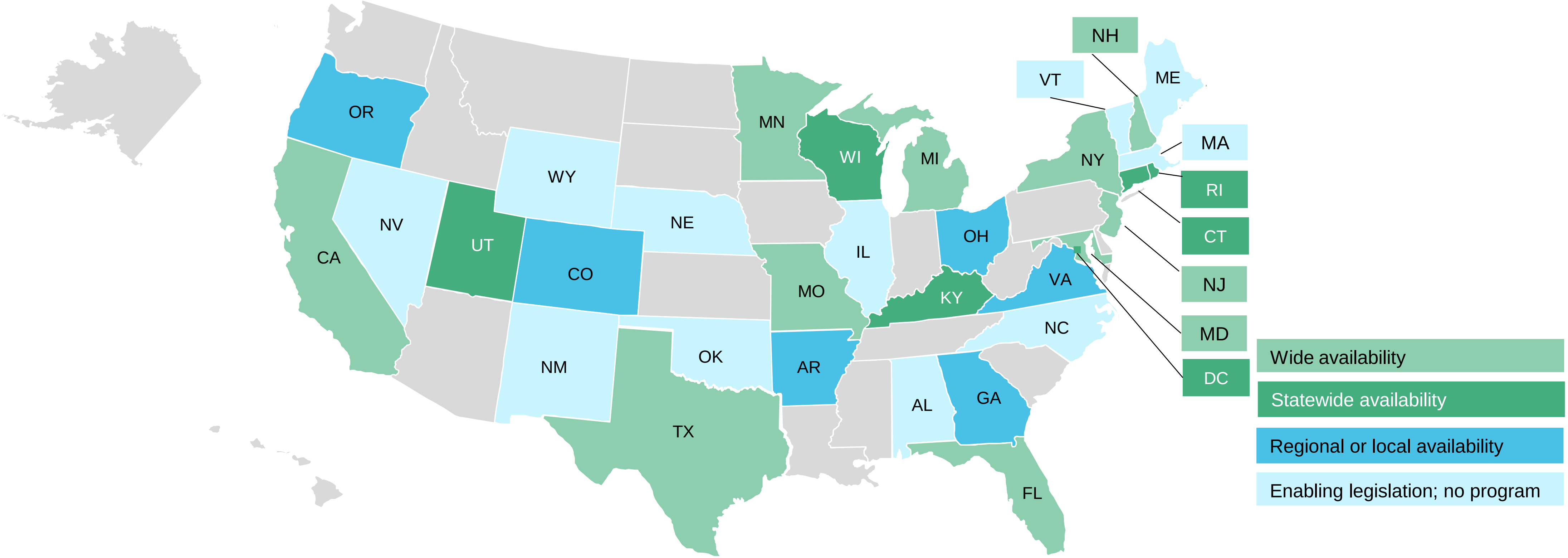
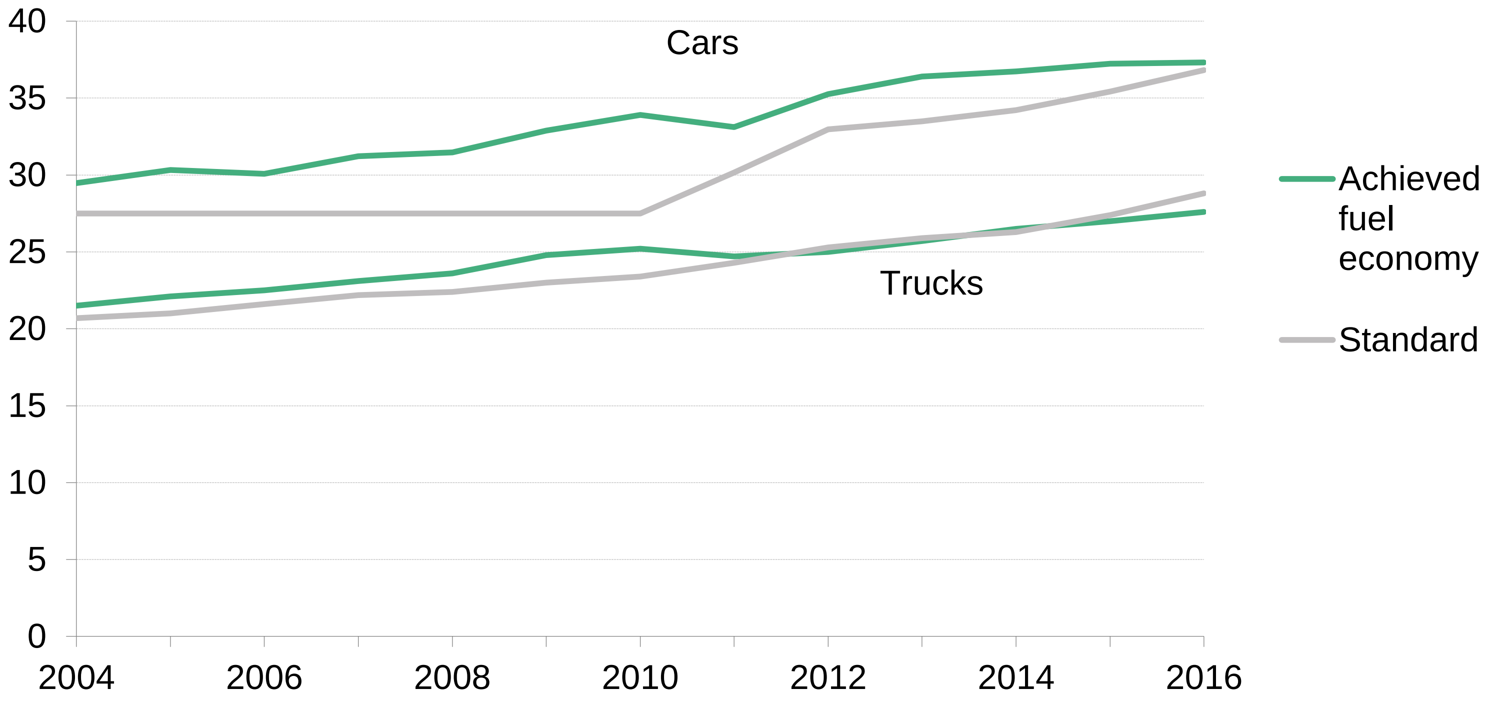
Policy – key sustainable energy policy developments in 2015 (1 of 5): Availability of PACE financing, 2016



- Property Assessed Clean Energy (PACE) is a mechanism to help finance renewable energy and energy efficiency upgrades to buildings, by allowing the owner to pay off the cost over 20 years via an addition to property taxes.
- PACE is becoming more widely available across the country, as states and municipalities pass enabling legislation. In 2016, Nevada signed off on legislation to allow for PACE financing, and Atlanta and Loudon County, VA began developing new PACE programs. Financing via PACE providers is picking up rapidly: commercial PACE financing amounted to $45m in Q3 2016, up 380% from Q3 2015 levels.
- A number of other PACE developments occurred in 2016. In June, Renovate America closed the securitization of $305m in PACE bonds, the largest securitization to date. In July, the Internal Revenue Service found that, subject to restrictions, the interest portion of a PACE payment may be deducted from personal income taxes. And in August, the US's largest agricultural PACE project to date, a $4m financing of a farm-to-plate hog-raising facility, was completed in Missouri.

Source: PACENation, Bloomberg New Energy Finance

Policy – key sustainable energy policy developments in 2015 (2 of 5): US vehicle fleet fuel economy vs. Federal standard, 2004-2016 (miles/gallon)



- The efficiency of fossil-fueled vehicles continues to improve as a result of increasingly stringent federal and state standards. Cars have outperformed the federal Corporate Average Fuel Economy (CAFE) target in every year since 2004, although this outperformance gap has narrowed in recent years. Trucks have been at risk of non-compliance several times over the past five years and came in 1.2mpg below the standard in 2016.
- Growing adoption of technologies such as start-stop systems, turbocharging and cylinder deactivation have maintained the market appeal of internal combustion vehicles while increasing their fuel economy. Sales of alternatively-fueled vehicles have also helped automakers to meet the standards.

Source: Bloomberg New Energy Finance

Policy – key sustainable energy policy developments in 2015 (3 of 5): Mid-term evaluation of fleet fuel efficiency standards for 2022-2025 vehicles

June 2016
Agencies issued draft Technical Assessment Report on current technology and market status.

November 2016
EPA made proposed determination that standards are 'appropriate.'

January 2017
After comment period, EPA finalized determination that standards are 'appropriate.'

Q1 2020
Final rule must be in place no later than 18 months before model-year 2022 vehicles become available.

- The Mid-Term Evaluation for the Corporate Average Fuel Economy (CAFE) standards, a part of EPA's regulations governing the emissions of model year 2017-2025 light-duty vehicles, offered the agency an opportunity to address unforeseen market and technology changes that might impact the progression of CAFE standards.
- On 13 January 2017, EPA determined that the standards are appropriate. However, implementation will rest in the hands of the Trump Administration.
- The current standard calls for light-duty vehicles to hit 50.8mpg in 2025, up from 35.3mpg in 2016.

Source: EPA documents, Bloomberg New Energy Finance

 US transmission infrastructure

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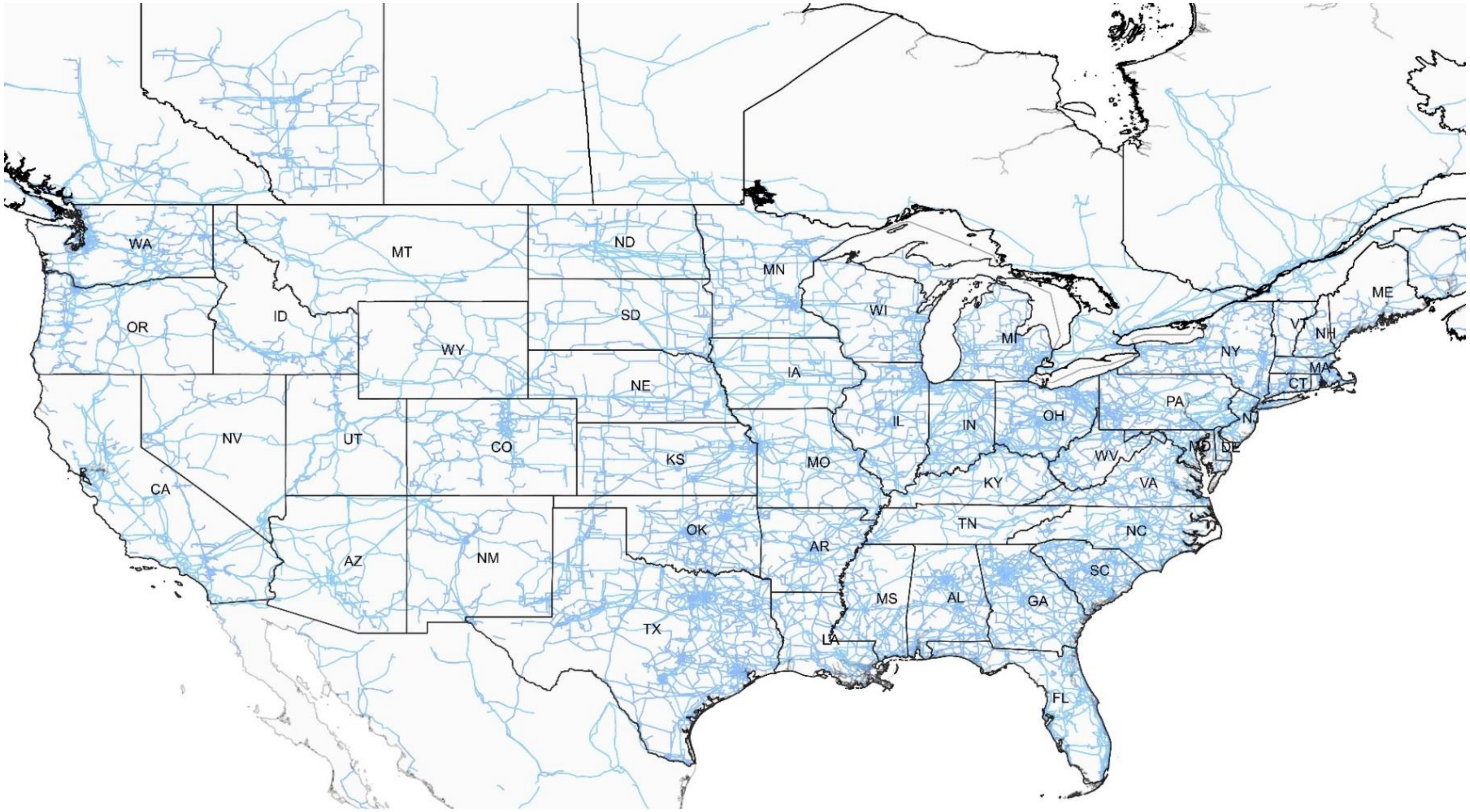
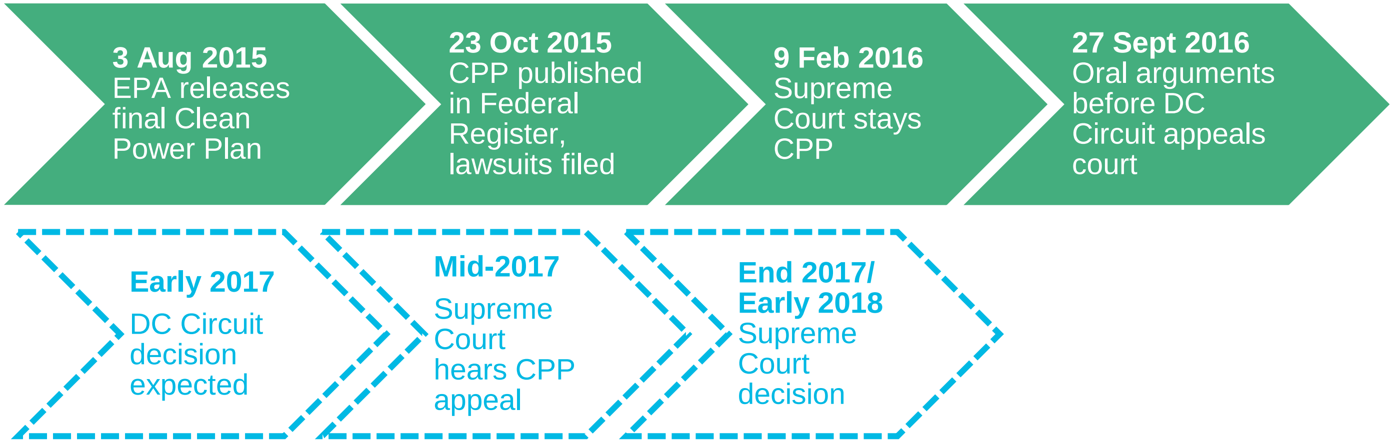
US transmission infrastructure asset map



- The aging US transmission system has seen increasing investment in recent years and may continue to be a major area of spending. For example, the transmission lines of AEP, the largest transmission owner in the US, have an average age of 52 years. AEP estimates that it would need to invest $2.5bn per year simply to maintain the current asset age profile of the over 40,000 miles of transmission lines under its ownership.
- President Trump has pledged to invest in modernizing and improving the reliability of the US electricity grid as part of his infrastructure plan.

Source: AEP company reports, campaign website of Donald Trump, Bloomberg New Energy Finance

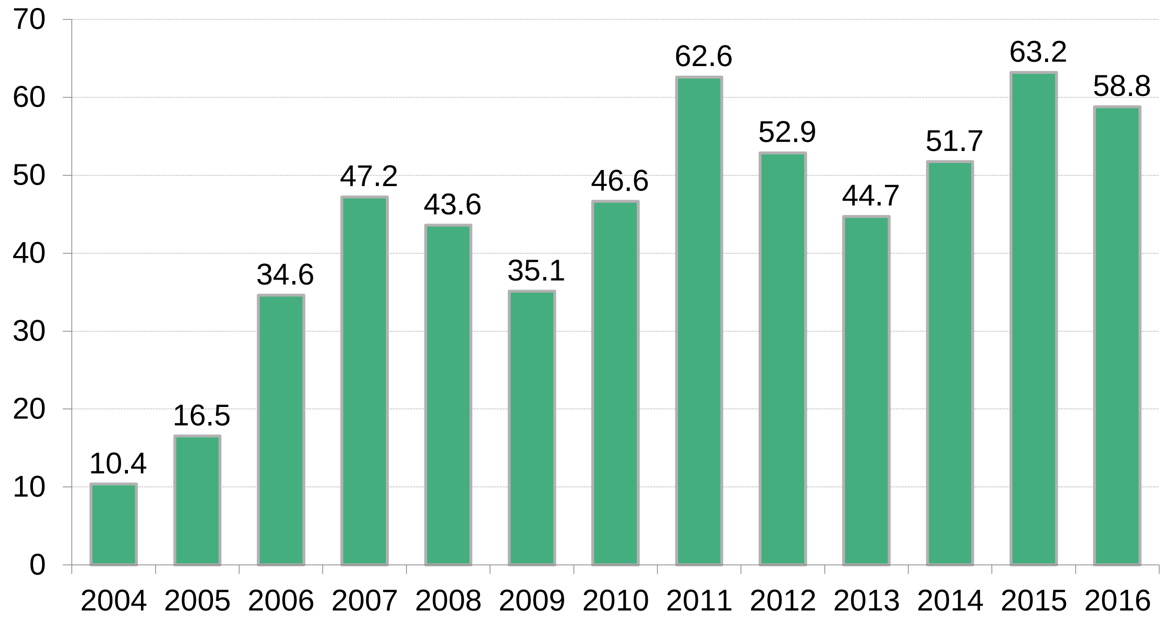
Policy – key sustainable energy policy developments in 2015 (5 of 5): Clean Power Plan history and outlook



- The Clean Power Plan (CPP) aims for a national reduction of 32% of power sector CO2 emissions (from 2005 levels) by 2030 and delegates the responsibility for doing so to individual states. In 2016, power-sector emissions were already to 24.1% below 2005 levels, according to preliminary government data.
- The plan brought legal challenges from business operators, coal companies, state governments and utilities. It was stayed by the Supreme Court in February 2016, pending review by a federal appeals court.
- The CPP's roll-out has been postponed until the legal cases are resolved. Interim compliance deadlines, including those for states to submit their initial implementation plans in September 2016, have been suspended.
- Regardless of the legal outcome, the CPP in its present form is subject to revision or replacement by the Trump Administration, which took office in January 2017.

Source: Bloomberg New Energy Finance, EIA

Finance: US clean energy investment (1 of 2) – total new investment, all asset classes ($bn)



- US investment in clean energy fell slightly in 2016, dropping to $58.8bn, a 7% decline from 2015's all-time record of $63.2bn. The drop in 2016 stems primarily from a drop in public markets funding, as solar companies turned to other funding avenues. It also reflects a return to normalcy after the 2015 rush to finance wind and solar projects before what was then seen as the expiration of the ITC and PTC (which were ultimately extended in late 2015).
- As with 2015, the majority of new investment in 2016 flowed into solar ($29.3bn, or 50% of the total). Wind came in second, with $15.5bn, or 26%. Energy smart technologies (EST) ranked third with $10.6bn, or 18%.
- Clean energy investment has averaged $54.3bn annually after 2011. High levels of investment in 2011 came on the back of spending under the American Recovery and Reinvestment Act, and a push to build wind projects in advance of what would have been the end of the Production Tax Credit in 2012, if Congress had not authorized its extension.

Source: Bloomberg New Energy Finance

Notes: Chart displays total clean energy investment in the US across all asset classes (asset finance, public markets, venture capital / private equity, corporate and government R&D, and small distributed capacity (rooftop solar)). The definition of 'clean energy' used here is renewable energy, energy smart technologies (digital energy, energy storage, electrified transportation) and other low-carbon technologies and activities (carbon markets value chain, companies providing services to the clean energy industry). Values include estimates for undisclosed deals and are adjusted to account for re-invested equity. Values are in nominal dollars.

Finance: US clean energy investment (2 of 2) – new investment by asset class by sector ($bn)

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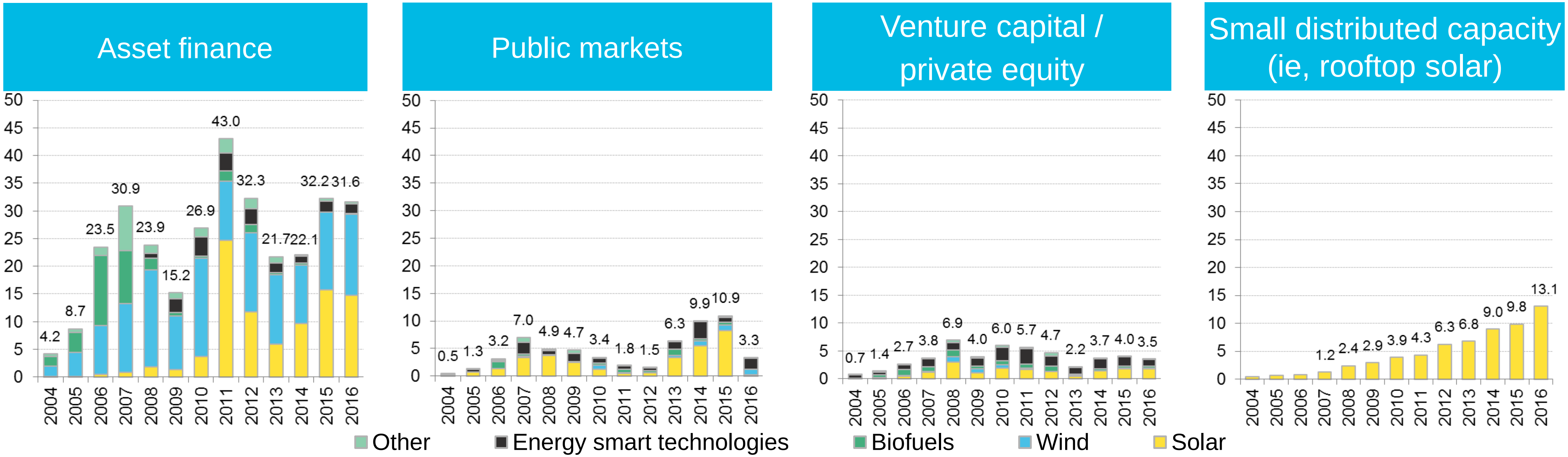

- Utility-scale solar and wind dominated asset finance in 2016, as they have since 2006. Investments flowing to wind through this avenue were up $0.7bn (+5%) from 2015, while those going to solar declined by $1bn (-6%) as costs fell.
- Public market transactions plummeted 70% from the previous year, in large part because the solar sector barely tapped this source in 2016 after raising $8.3bn in 2015. The record-level 2015 activity had relied in large part on SunEdison and its yieldco, Terraform Global, which together raised $2.7bn between Q1 and Q3 2015. SunEdison declared bankruptcy in April 2016. Wind and energy smart technologies (EST) topped public market activity in 2016 instead, as NextEra raised $252m in Q1 and $353m in Q3, while Tesla raised $1.7bn in Q2. The large amount raised by Tesla means that yet again, electrified transport dominated funds raised by EST companies through public markets.
- Venture capital and private equity investment totaled $3.5bn in 2016, down $0.5bn from 2015. Solar and EST were again the major VC/PE targets, absorbing 50% and 34% of the funding, respectively.
- Investment in rooftop solar hit $13.1bn in 2016, up $3.2bn from 2015.

Source: Bloomberg New Energy Finance Notes: See previous slide for definition of 'clean energy'. Values are in nominal dollars and include estimates for undisclosed deals. The asset finance, public markets, VC/PE and small distributed capacity figures do not add up to the total investment figure on the previous slide, as the total also includes R&D (corporate and government) and subtracts out re-invested equity.

Finance: US transmission investment by investor-owned utilities and independent transmission developers ($bn)

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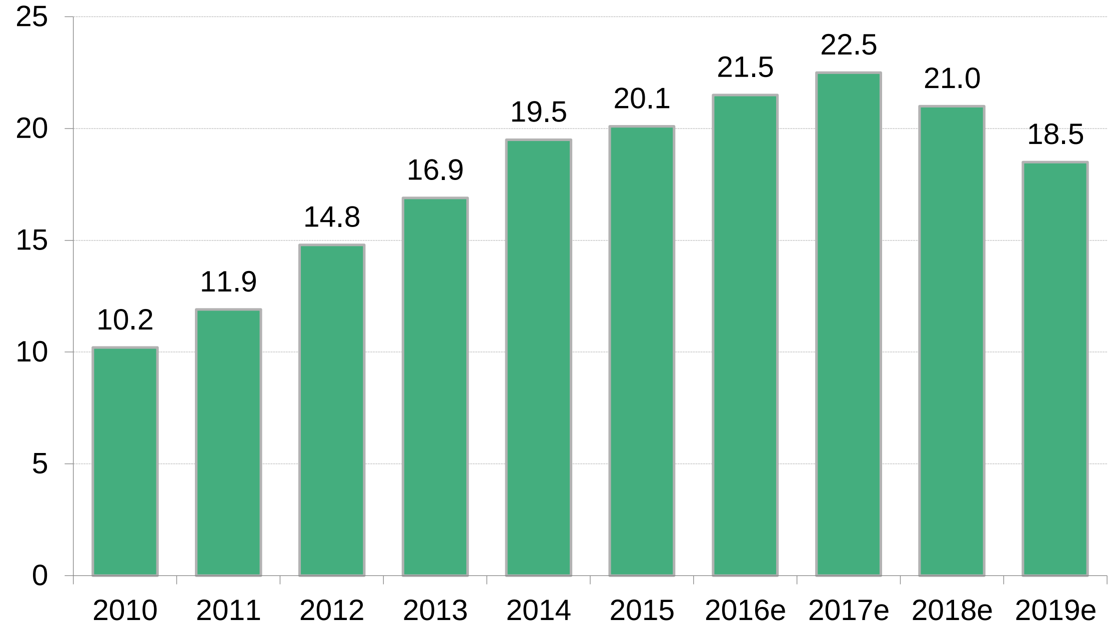
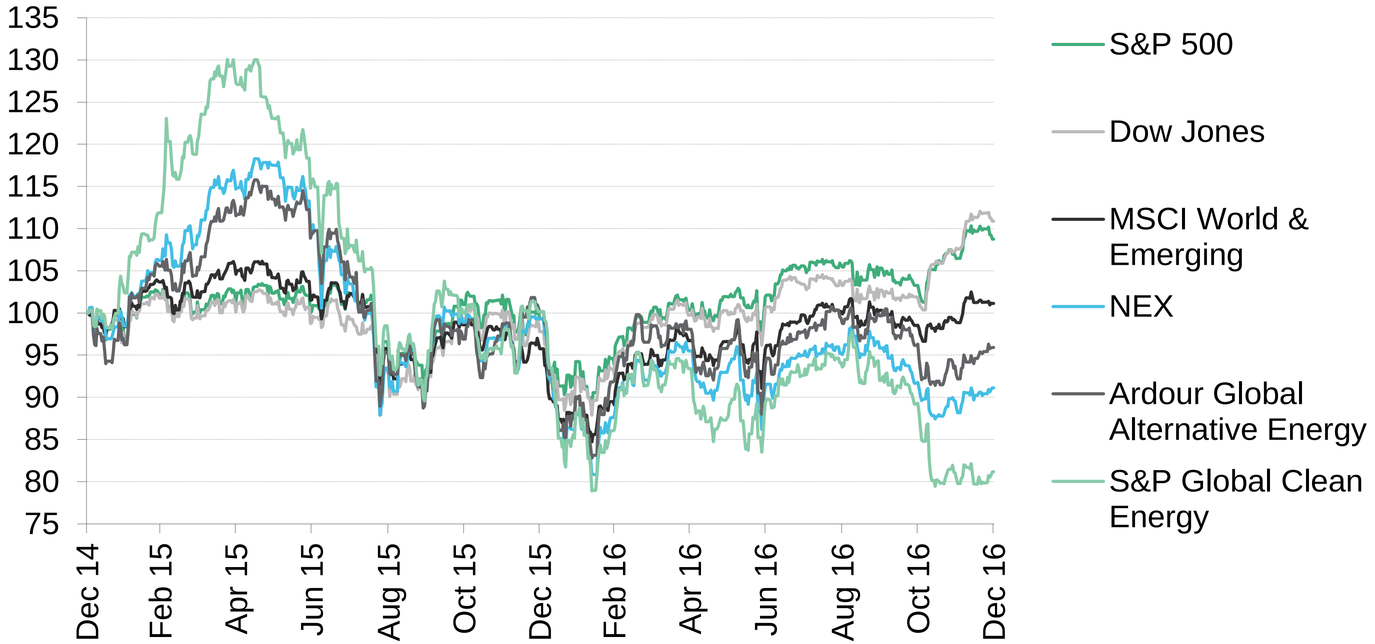


- Investment in electric transmission by investor-owned utilities and independent transmission developers hit a new peak of $20.1bn in 2015, up 3% from 2014 levels and nearly double what was observed in 2010.
- Based on company reports, investor presentations and a survey conducted by the Edison Electric Institute (EEI), transmission investment is likely to grow another 7% in 2016. Current capex plans suggest that investment will peak at $22.5bn in 2017; 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, safe power. These include a need to replace and upgrade aging power lines, resiliency planning in response to recent natural disasters, the integration of renewable resources and congestion reduction.

Source: Edison Electric Institute, Bloomberg New Energy Finance   Note: Values are in nominal dollars.

Finance: Returns of global clean energy indices relative to benchmarks



- Global stock markets generally rallied through 2016, following a bearish second-half of 2015.
- While clean energy indices (represented here using the NEX, S&P Global Clean Energy, and Ardour Global Alternative Energy Index) followed the broader market upward for most of 2016 (benchmarked here by the S&P 500, Dow Jones and MSCI World & Emerging), recovery was much more gradual. The bankruptcy of US solar company SunEdison in April 2016 contributed to this slow recovery.
- In the last quarter of 2016, clean energy indices plummeted in the wake of the US election results, further widening the gap between the relative performance of these indices against the broader market indices.

Source: Bloomberg New Energy Finance, Bloomberg Terminal

Notes: Indices normalized to 100 on 1 January 2015. The NEX is the BNEF Wilderhill New Energy Global Innovation Index.

Economics: Global levelized costs of electricity (*unsubsidized* across power generation technologies, H2 2016 ($/MWh)

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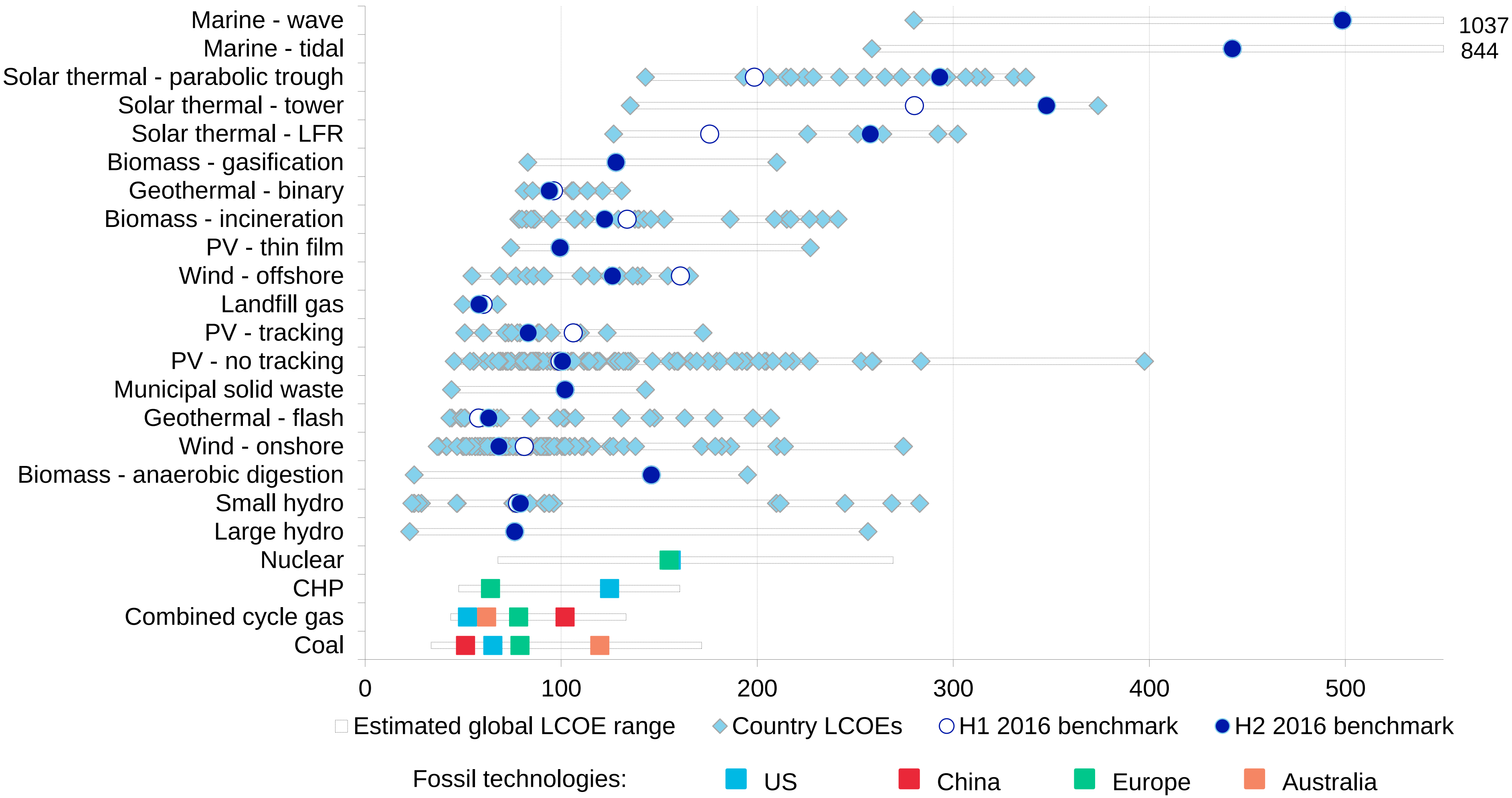
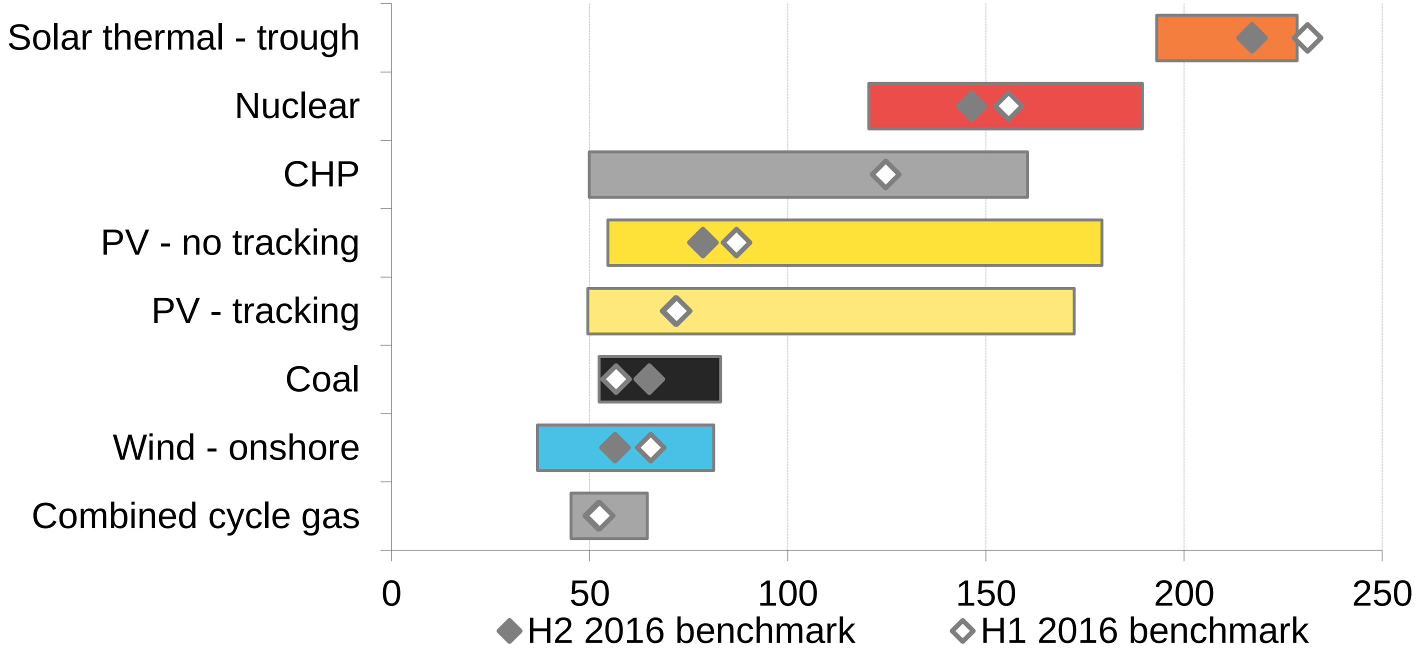


- A number of renewable energies have comparable and, at times, cheaper LCOEs than "conventional" power sources.

Source: Bloomberg New Energy Finance, EIA Notes: LCOE is the per-MWh inflation-adjusted lifecycle cost of producing electricity from a technology assuming a certain hurdle rate (ie, 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. Analysis is 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 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 US-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: US levelized cost of electricity (*unsubsidized* across power generation technologies, H2 2016 ($/MWh)

Bloomberg NEW ENERGY FINANCE



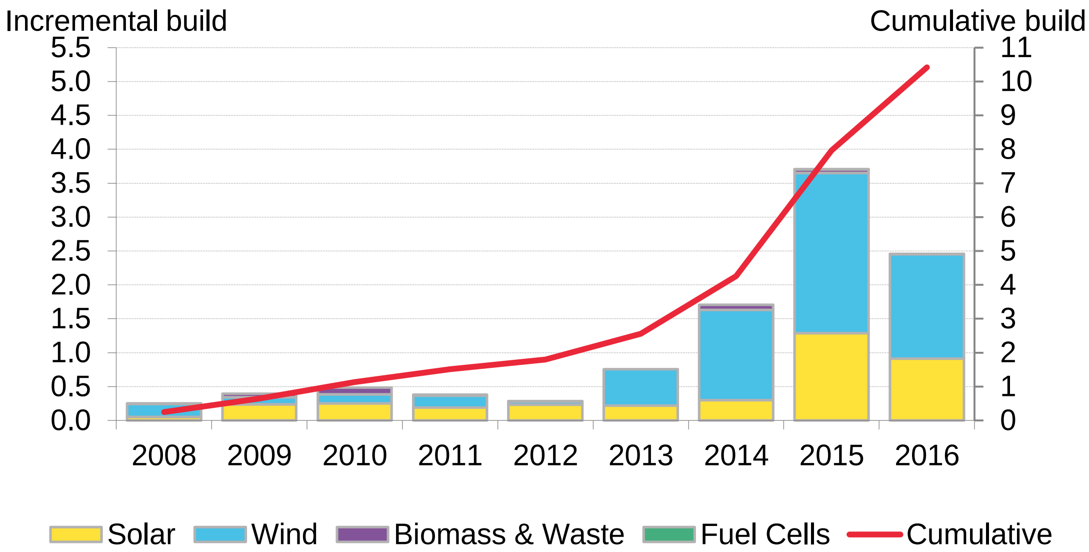
- Since H1 2016, our US benchmark LCOE estimates have come down for renewable energy technologies, but increased for coal by $8/MWh. Competition from natural gas-fired generators and renewable energy have displaced coal generation, pushing down coal's average capacity factor and raising its LCOE.
- The US wind LCOE fell by $9/MWh from H1 2016 to reach $56/MWh in the second half of the year. In some US markets, average capacity factors for pipeline wind projects improved 3 percentage points. The *unsubsidized* LCOE for wind came in as low as $37/MWh in Texas, beating that of combined-cycle natural gas. The Production Tax Credit (PTC) and accelerated depreciation (MACRS), which are not factored into the analysis shown above, can make wind even more competitive on a $/MWh basis, with a 'subsidized' wind LCOE as low as $22/MWh.
- US solar PV (no tracking) saw its benchmark LCOE drop to $79/MWh. PV with tracking technology faces slightly higher capex costs, but its ability to capture more sunlight throughout the day raises its capacity factor, making it slightly cheaper than a similar array without tracking technology. In some regions of the country (the Southwest, Texas), solar PV can be built for $50/MWh – even without accounting for the value of the Investment Tax Credit (ITC) and MACRS.
- The LCOE for combined-cycle natural gas came in at $52/MWh, roughly unchanged from the first half of the year. The US has one of the lowest natural gas LCOEs in the Americas, due to its access to low-cost gas.

Source: Bloomberg New Energy Finance, EIA

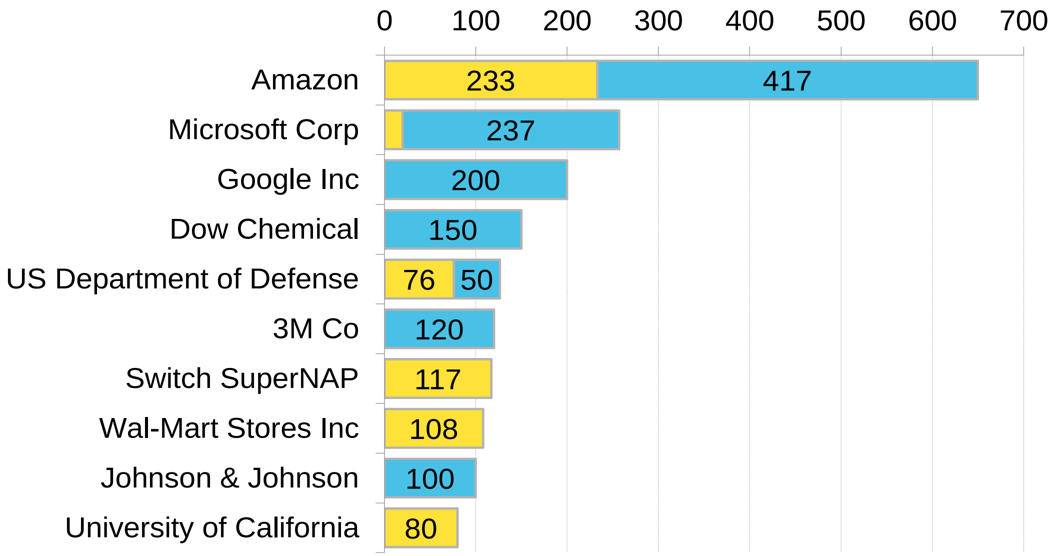
Finance: Corporate procurement of clean energy

Bloomberg NEW ENERGY FINANCE

Renewable capacity contracted by corporations, by technology, 2008-16 (MW)



Largest corporate offtakers, 2016 (MW)



- Corporate PPA volumes fell to 2.5GW in 2016, from the 2015 record of 3.7GW. The extension of the ITC and PTC relieved the pressure for offtakers and developers to finalize deals, which was one of the major factors driving high activity in 2015.
- Low power prices also continue to undermine the economic incentives for corporates to sign long-term virtual PPAs. But ERCOT and SPP have emerged as hotspots for corporates signing such contracts, since wind costs are lower in these regions.
- Corporate sustainability remains a key driver of activity in the space.
- Amazon signed PPAs for 0.65GW of clean energy in 2016, more than double the amount of the second largest company, Microsoft. Amazon's 228MW PPA with Lincoln Clean Energy for the Amazon Wind Farm Texas was the largest signed in 2016 and brings Amazon's cumulative US deals to 1.2GW. Companies like Google (1.9GW signed in total), Microsoft (0.5GW) and Wal-Mart (0.5GW) also continue to lead in this space.
- Green tariff programs have emerged as a common way for corporates to buy clean energy in regulated utility service territories.

Source: Bloomberg New Energy Finance, company announcements

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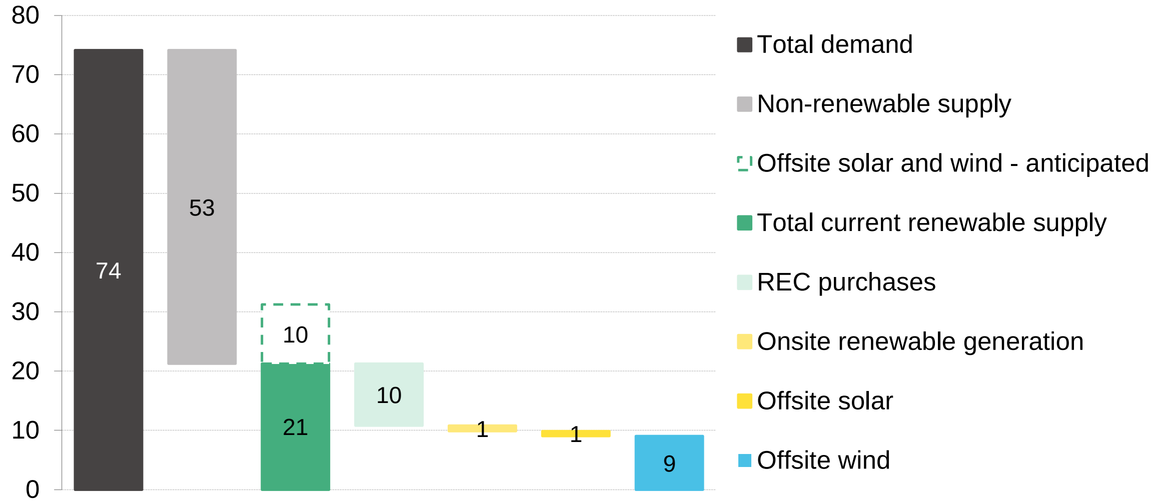
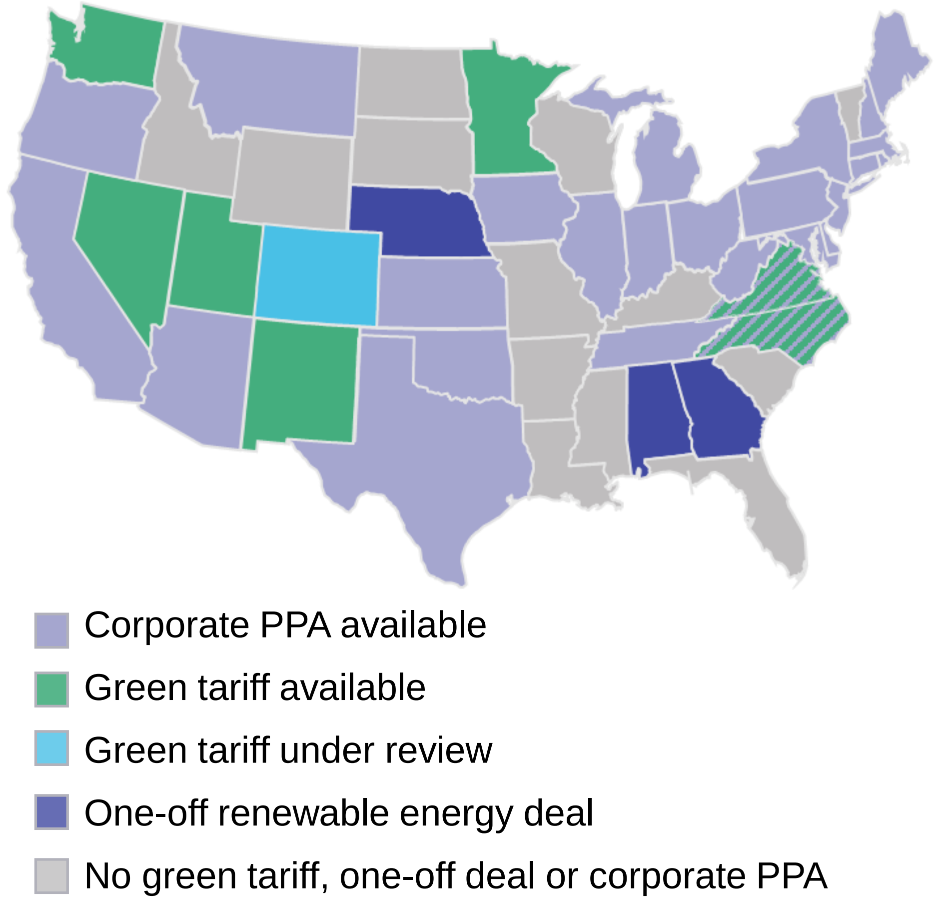
Global and US electricity supply and demand fundamentals of 50 'first-movers', 2016 (TWh)



How corporates procure clean energy, by state



- 50 corporates that account for almost 2% of US electricity demand contracted approximately 9TWh of offsite wind and 1TWh offsite solar in 2016. This volume will at least double by 2018, as offsite projects contracted in 2016 come online. Nonetheless, these corporates remain far from achieving 100% renewable electricity procurement – an increasingly common sustainability goal. Currently, these corporates still buy approximately 53TWh of brown wholesale power.
- Regulations pertaining to corporate procurement vary by state. Corporations can sign power purchase agreements in deregulated states and green tariffs in some regulated states.

Source: Bloomberg New Energy Finance, company announcements

Notes: 'Onsite renewable generation' includes fuel cells and solar PV. 'First-movers' refers to a diverse, cross-sector sample of 50 companies with operations in the US that have joined the RE100, signed the Corporate Renewable Energy Buyers' Principles or set an ambitious renewable electricity target. 'Offsite solar and wind – anticipated' refers to power to be produced from projects contracted in 2016 but not expected to come online until 2017 or 2018.

Finance: Corporate procurement of clean energy and energy efficiency

Key players: corporate clean energy procurement

Retail	Target, IKEA, amazon.com, Walmart
Financial & Insurance	Kaiser Permanente, BNP Paribas, Barclays
Tech	Google, Apple, Facebook, Microsoft
Manu-facturing	P&G, GM, VW, Johnson & Johnson

Key players: corporate energy efficiency

Manu-facturing	Johnson Controls, 3M, Curtiss-Wright
Automotives	Nissan, Volvo, Detroit
Hospitality	Marriott, Hilton
Other	Schneider Electric, Swiss Re

- Corporate clean energy procurement has continued to gain momentum. 83 companies have pledged to source 100% of their energy consumption from renewables by signing onto the “RE100” initiative. Notable signees include Apple, BMW, HP, Johnson & Johnson, Kingspan, and P&G. Google also announced in 2016 that it is on track to meet this milestone by 2017.
- Corporations are also increasingly taking action on energy efficiency, with more companies adopting ISO 50001, an energy management systems standard for reducing costs and carbon emissions. The US Department of Energy Superior Energy Performance program, which certifies facilities that have implemented the ISO 50001 standard, continued to expand in 2016: new buildings certified include multiple facilities from Schneider Electric and 3M, and the JW Marriott in Washington, DC. In addition, the new “EP100”, an initiative where companies pledge to double their energy productivity, launched in early 2016. Member companies include Johnson Controls and Swiss Re.

Source: Bloomberg New Energy Finance, 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.

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Policy: US coal power plant retirements completed and announced by year (GW)

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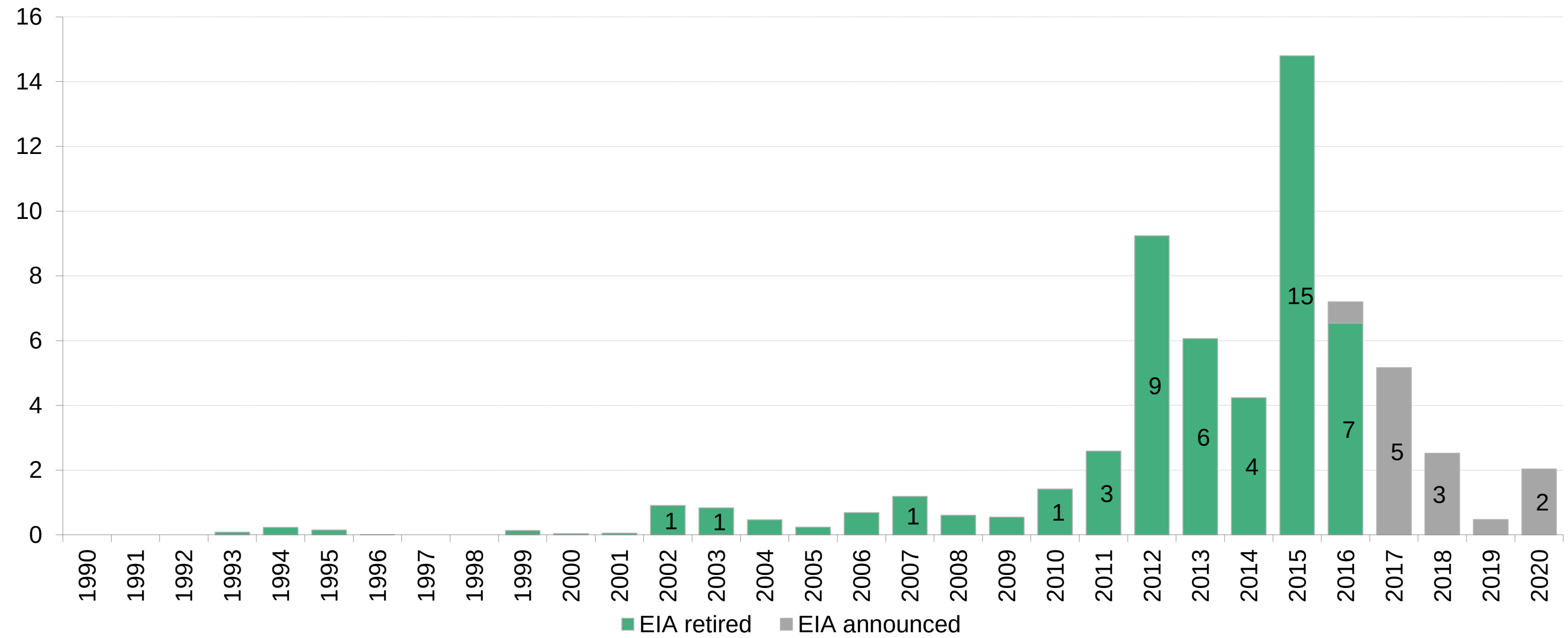

- After 2015 marked the largest single year of coal retirements ever (at just under 15GW), 2016 saw another 7.2GW of coal-fired power plants drop offline. An additional, as-yet undetermined number of plants (likely less than 2GW in total) also converted from burning coal to burning natural gas. Since 2011, the coal fleet has shrunk 12% from its peak size of 308GW.
- Persistently low gas prices have increased the competition faced by coal plants, leading many to run less frequently and to receive lower revenues for their output. At the same time, boilers are aging: 29GW worth of plants with no reported retirement or conversion date are already over 50 years old. These two factors, combined with rising operating costs – partly due to US 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.
- The Mercury and Air Toxics Standard (MATS), one such EPA regulation, remains in place in the midst of an ongoing lawsuit. The Supreme Court denied a request for a 'stay' (ie, to put the regulation on hold) in March 2016, a month after it agreed to place a stay on the Clean Power Plan.

Source: Bloomberg New Energy Finance, EIA

Notes: 'Retirements' does not include conversions from coal to natural gas or biomass; includes retirements or announced retirements reported to the EIA through end-November 2016.

Deployment: US natural gas production and gas-directed rig count

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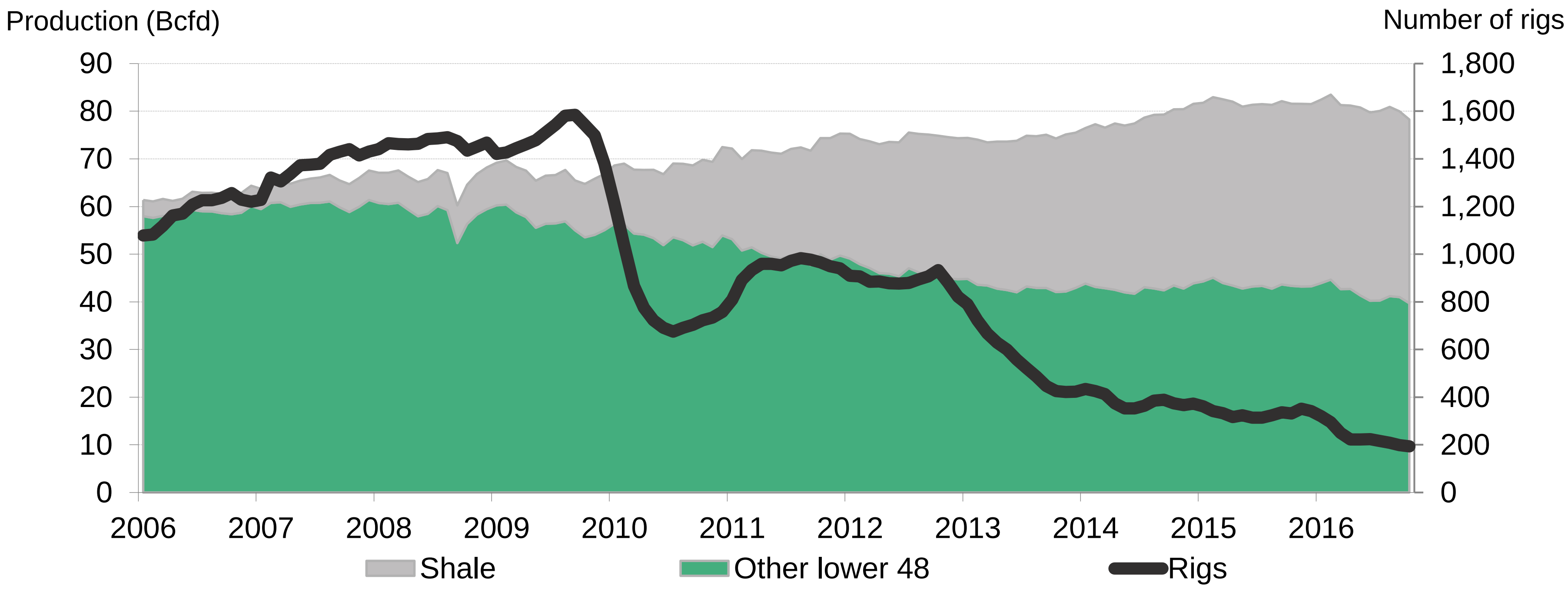
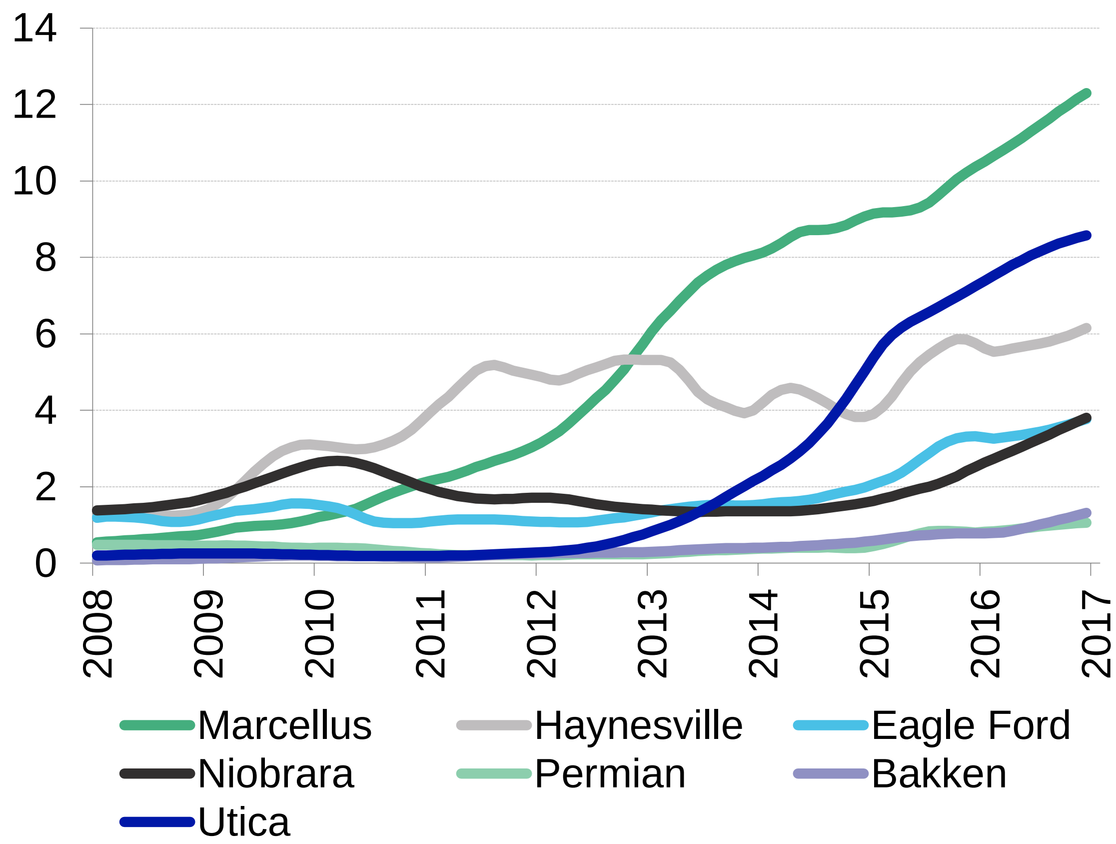


- Rig count continued to shrink in 2016, falling 48% between December 2015 and the end of the following year as producers struggled to cope with the low-price environment.
- However, total US natural gas production held steady. This is due to a few reasons:
  - Producers are selectively drilling in productive 'sweet spots' and turning to an inventory of drilled but uncompleted wells (DUCs) to cost-effectively extract gas.
  - Technological improvements in efficiencies (like pad drilling and longer laterals) are shrinking well completion time, making it easier to speed up production and expand capacity for each well.

Source: Bloomberg New Energy Finance, EIA, Baker Hughes. Data up through the latest comprehensive numbers available (October 2016).

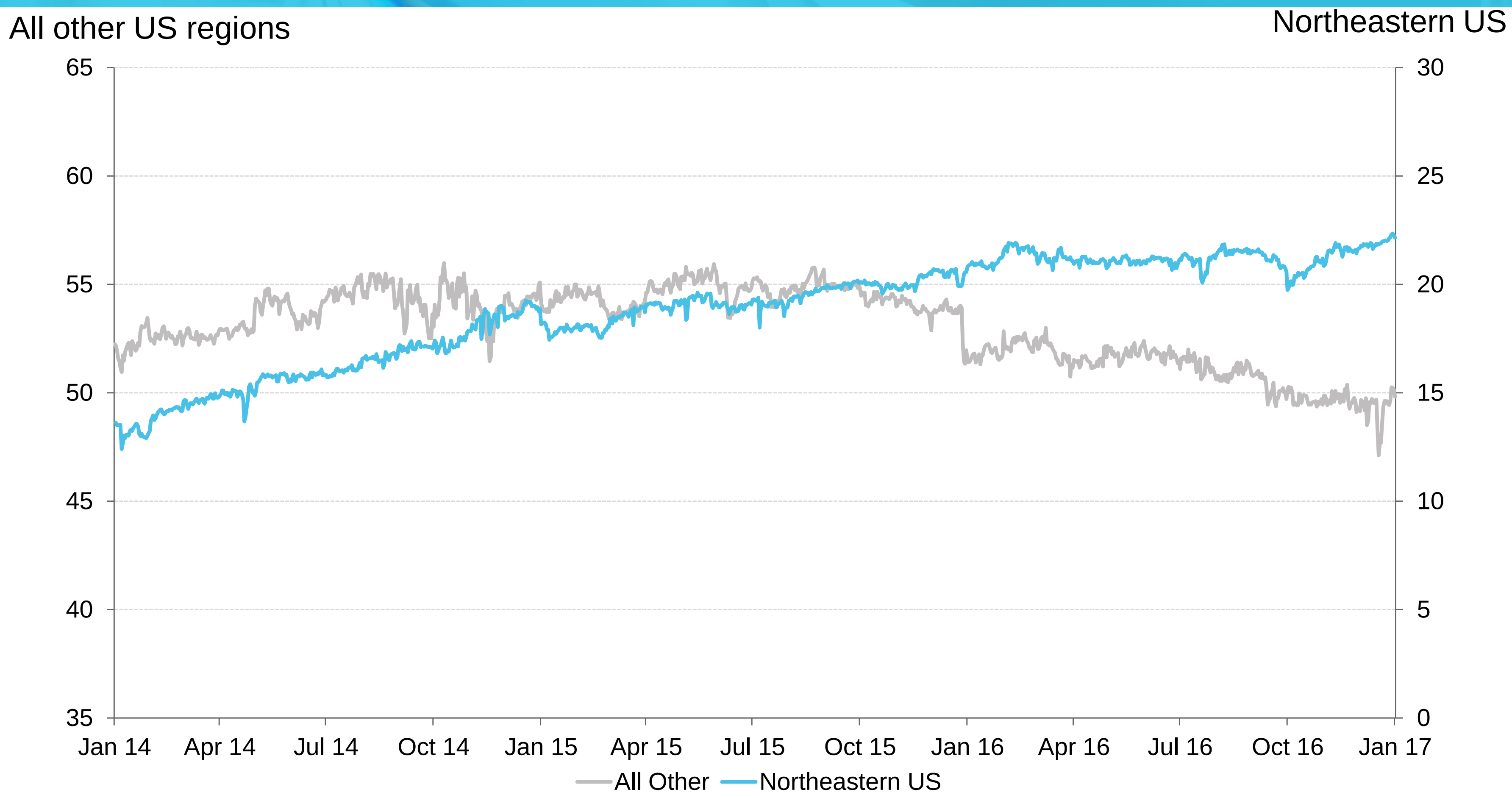
Deployment: US natural gas productivity (production per rig) by shale formation (MMcfd)



- Producers have continued to improve productivity, especially in the Marcellus and Utica, which both outpaced the Haynesville for the past two years. The most economical dry and wet gas regions are located here, and the area experienced the greatest advances in rig productivity.
- Meanwhile, productivity in the Haynesville and Eagle Ford plateaued this past year; wellhead economics there are not as strong as in other regions. The Niobrara continues to see gains.

Source: Bloomberg New Energy Finance, EIA

Deployment: Gas production in the continental US (Bcfd)



- Northeast US natural gas production has slowed but continues to hold firm, even as producers shut wells to ride out unfavorable economics caused by a lack of takeaway capacity.
- Production in other plays declined in 2016 because the current low oil and gas price environment renders many plays uneconomical; further, the Northeast has become a net supplier to surrounding regions, in light of the new pipeline projects and reversals emerging out of the region.

Source: Bloomberg New Energy Finance

Notes: Eastern US production is mostly comprised of output from the Marcellus and Utica shales.

Deployment: US natural gas pipeline installations and materials (million miles)

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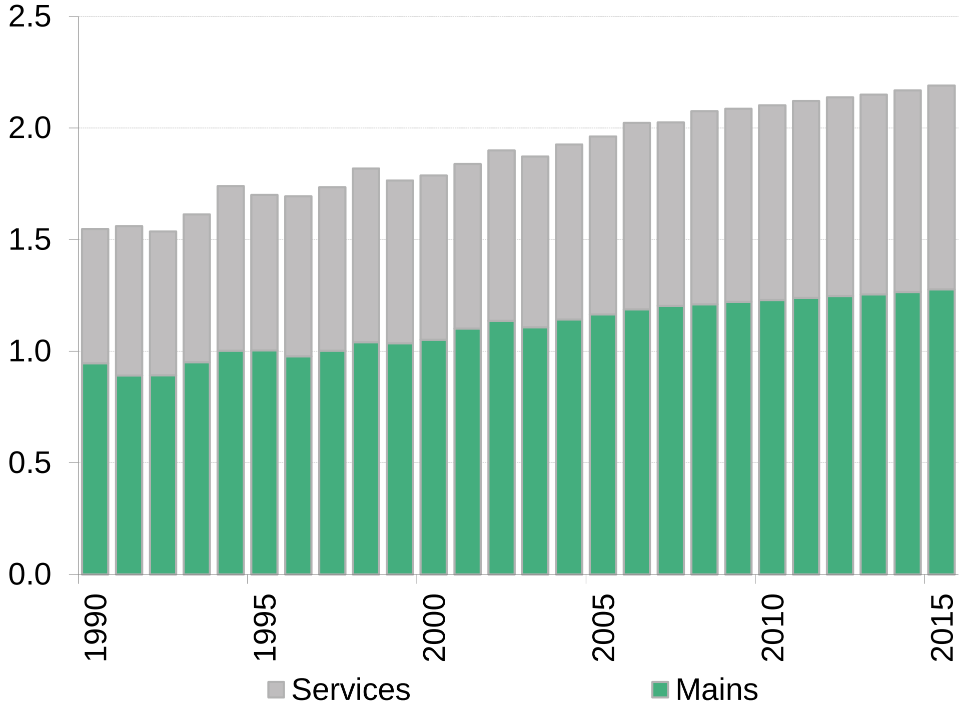
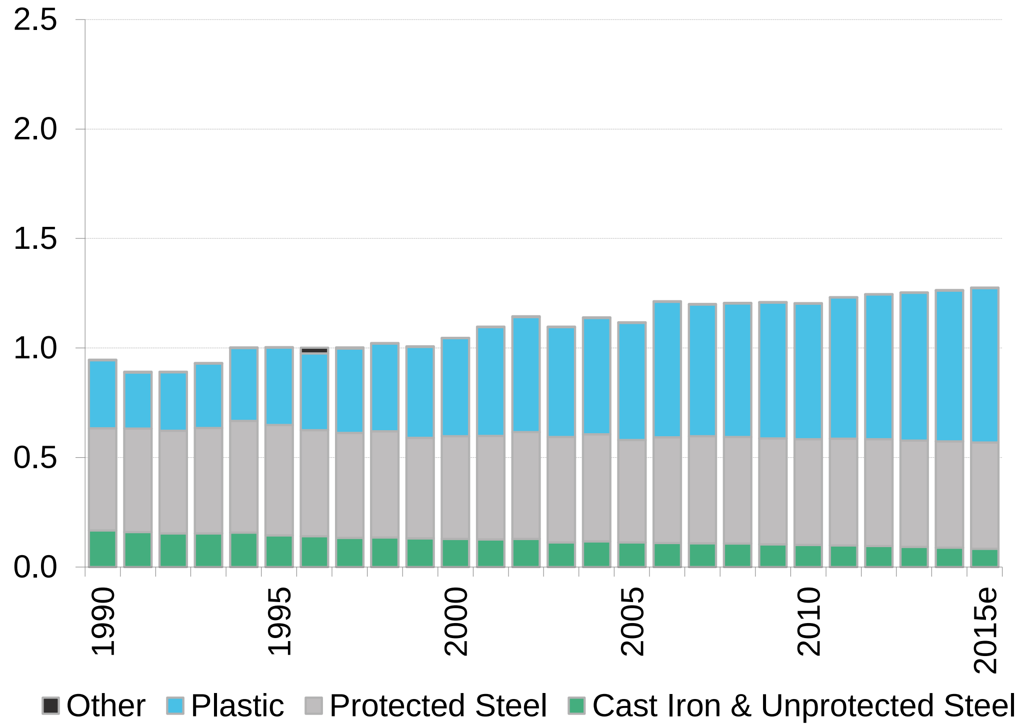
US existing natural gas distribution pipeline



US natural gas distribution mainline material

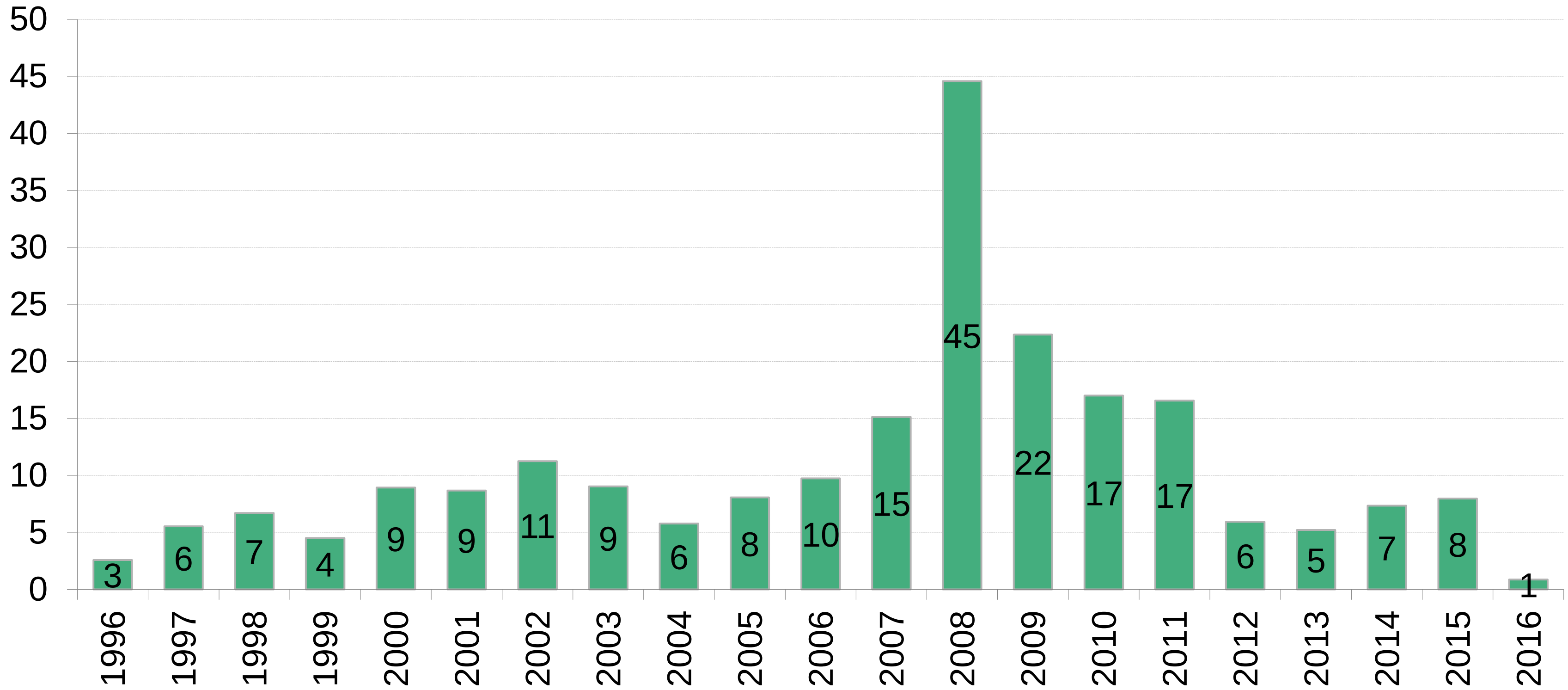


- Service and distribution pipelines that bring gas from transmission lines to end-users continue to grow steadily.
- Plastic is the material of choice for replacement and expansion efforts as US pipelines are upgraded with more modern materials. Companies are removing older networks, which are made 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: Bloomberg New Energy Finance, US Department of Transportation, American Gas Association

Notes: 'Mains' refer to pipelines to which customers' service lines are attached; 'Services' refer to pipes which carry gas from the distribution pipelines to the customer's meter. 2015 mainline material data is an estimate.

Deployment: US transmission pipeline capacity additions (Bcfd)



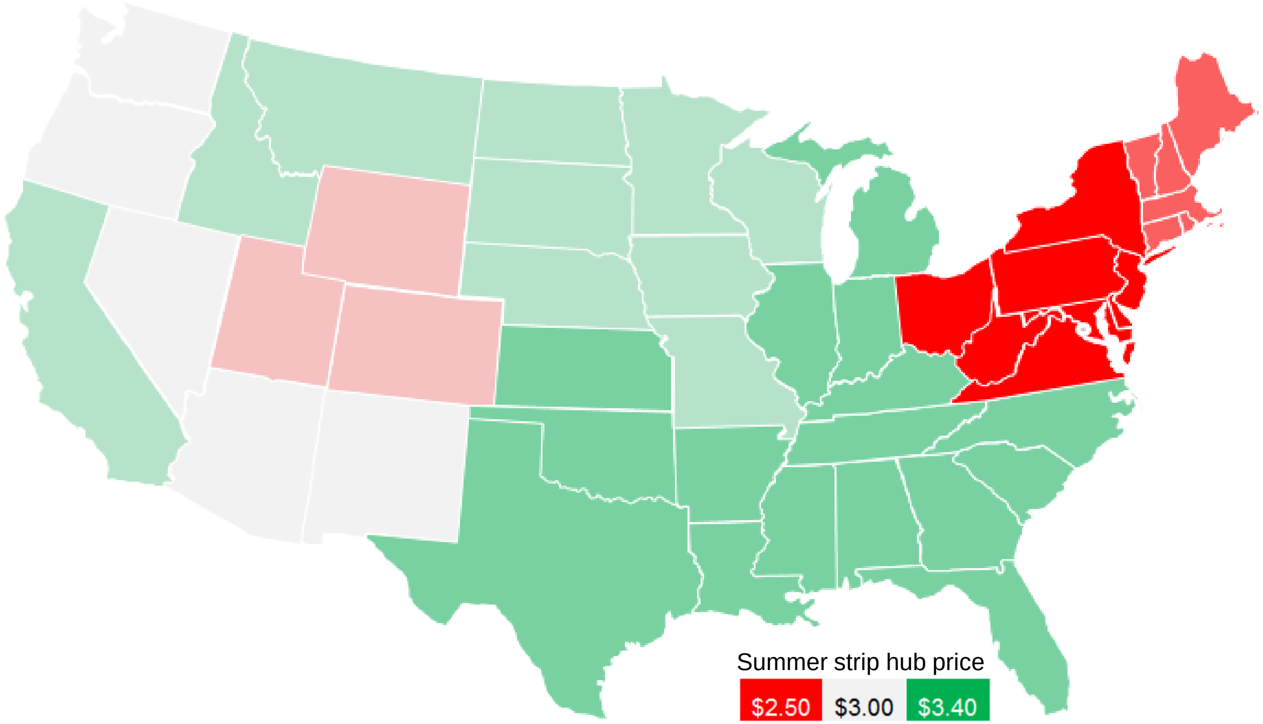
- Pipeline companies completed 8Bcfd of pipeline capacity in 2015, below the 11Bcfd planned. In 2016, they only added a further 1Bcfd of capacity.
- A number of delays pushed the online date of many substantial projects from 2015-2016 into 2017-2018.
- US-Mexico border capacity is currently just over 6Bcfd. Moving forward, capacity will be growing at unprecedented rates, with proposed capacity in 2020 exceeding 15Bcfd.

Source: Bloomberg New Energy Finance, EIA

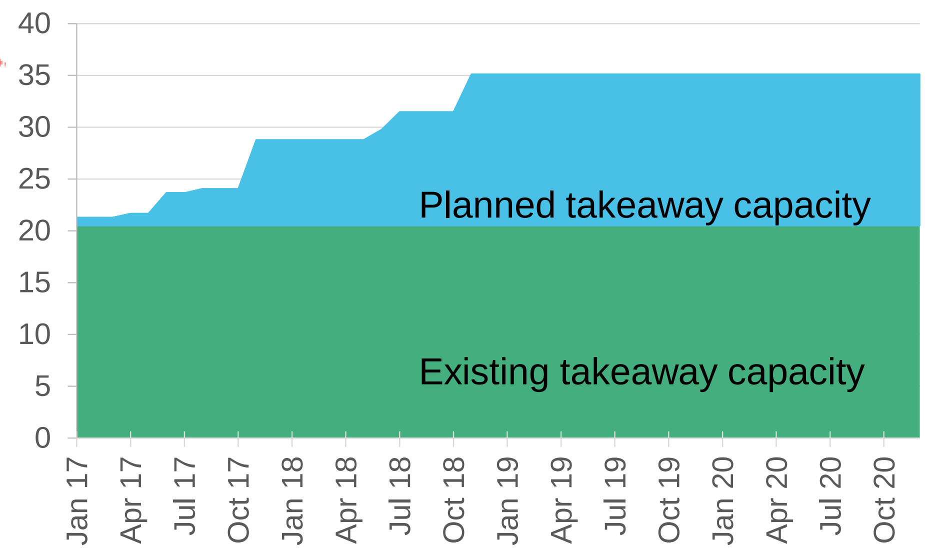
Note: EIA data used here includes both first-mile takeaway capacity and other pipeline additions that do not impact takeaway capacity.

Deployment: Planned additions to Appalachian Basin takeaway capacity (Bcfd)

Summer 2017 hub price variation



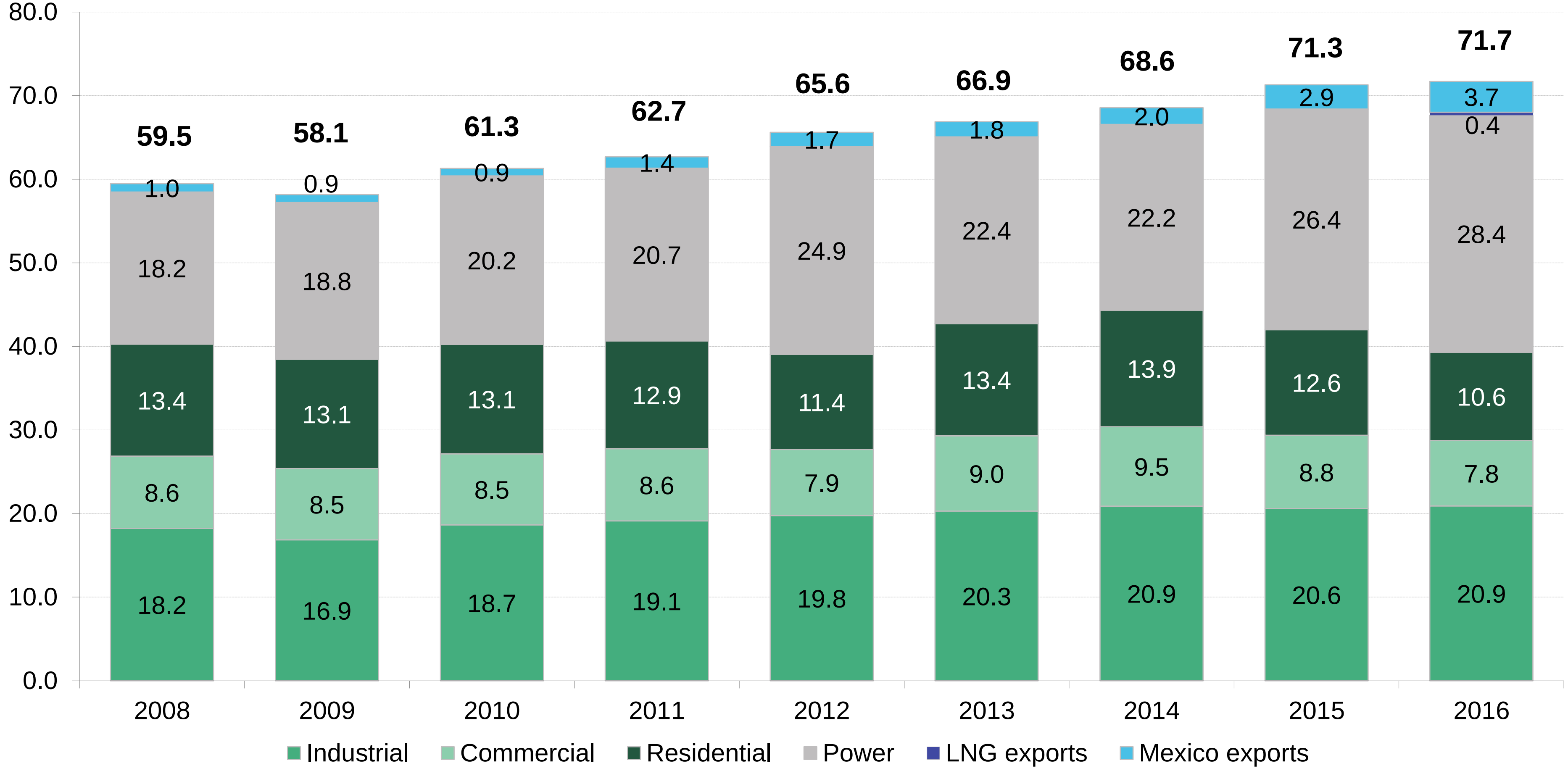
App basin takeaway capacity (Bcfd)



- Gas production in the Marcellus and Utica Appalachian basins has grown faster than the necessary takeaway infrastructure. As a result, summer 2017 futures prices for Dominion South (in southwest Pennsylvania) are the lowest in the country, trading at over a dollar discount to Henry Hub as of mid-January 2017.
- Producers in this region are eager to reach customers in other markets. Over a dozen pipeline projects have been planned for the next few years, to bring more Appalachian gas to markets in the South, West and Northeast. These projects aim to boost capacity 70% from current levels by 2020, which will help alleviate the negative hub basis in this region by allowing gas to flow more freely to the most attractively priced market.
- Takeaway capacity is only one part of the story – a build-out in next-mile delivery pipelines is also needed to bring the gas into constrained regions, such as New England, which experiences high prices due to constraints in winter.

Source: Bloomberg New Energy Finance, EIA

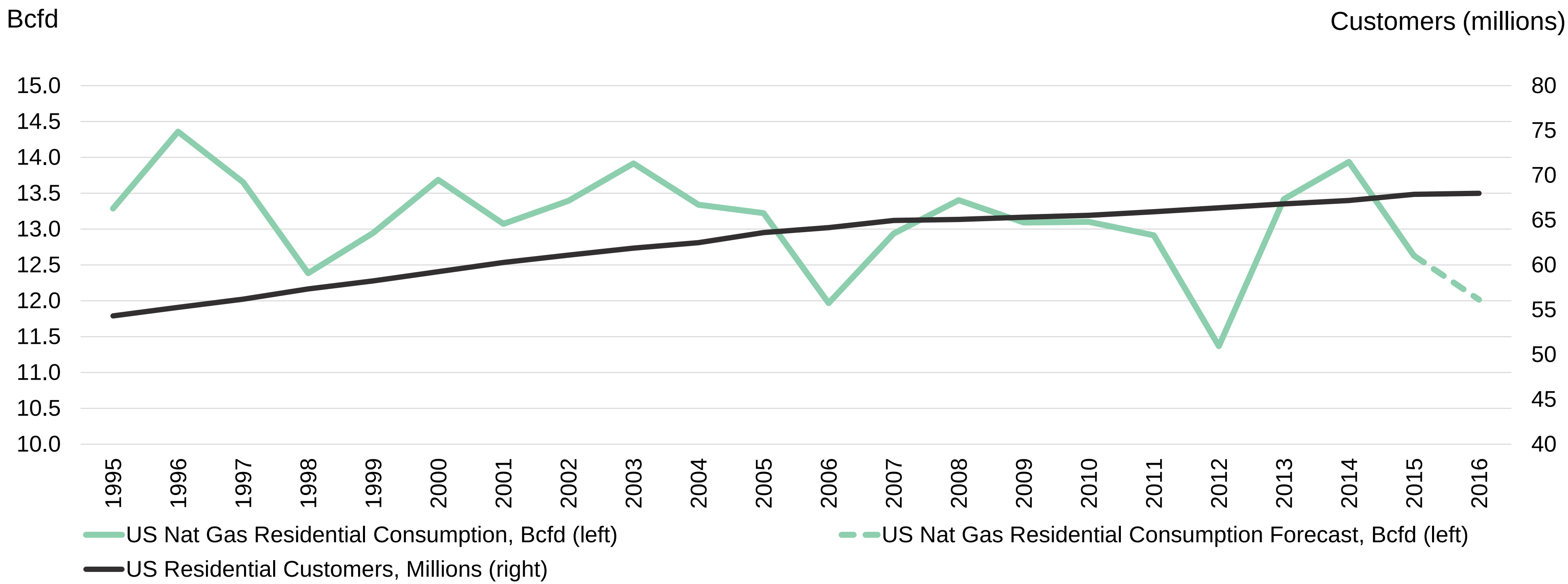
Deployment: US natural gas demand by end use (Bcfd)



- Total US annual gas demand continues to grow slowly: 2016 demand represented a 21% increase from 2008 levels, and a slight year-on-year rise from 2015.
- The power sector drove domestic demand growth, offsetting declines in residential and commercial demand. Power sector gas consumption jumped 7% compared to 2015.
- Foreign demand also helped to buoy US gas demand. Pipeline exports to Mexico have nearly quadrupled since 2008, and the US started exporting liquefied natural gas (LNG) this past year.

Source: Bloomberg New Energy Finance, EIA Note: Values for 2016 are projected based upon the latest available data (October 2016).

Deployment: US natural gas residential customers vs. residential consumption

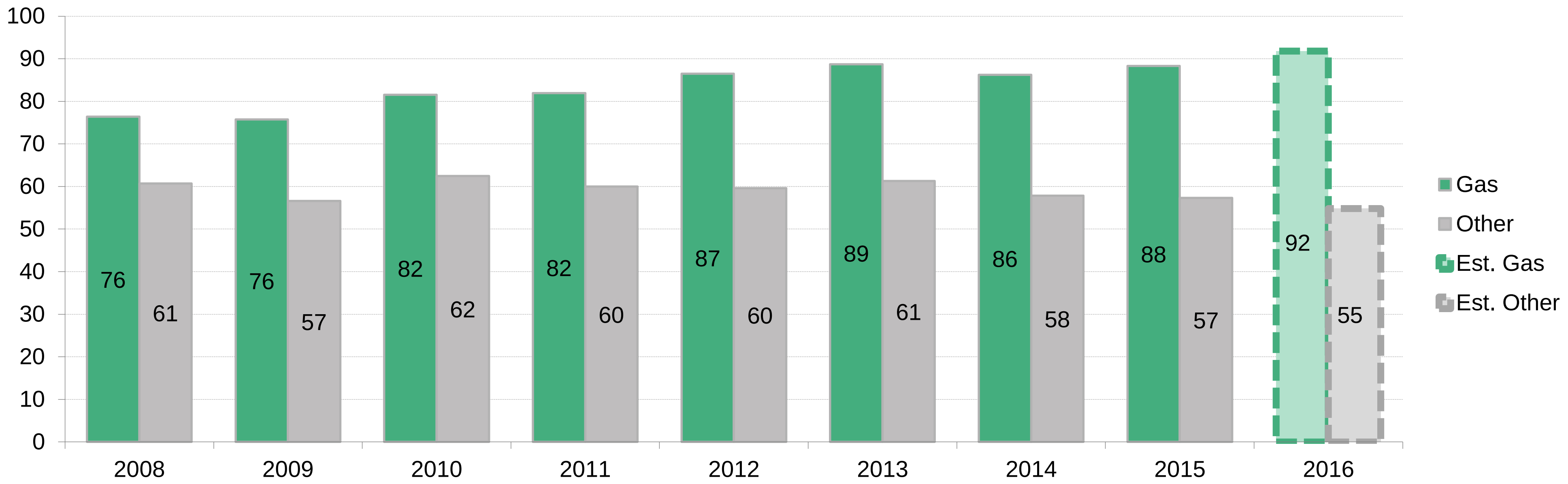


- Due to energy efficiency efforts, residential consumption has fallen even as the number of customers has seen moderate growth. As a result, per capita consumption has been steadily declining since the mid-1990s.
- Residential consumption dropped during the abnormally mild winter of 2011-12, then jumped during the polar vortices in 2013 and 2014. 2015's mild winter temperatures saw residential consumption return to its longer term, downward trend.
- Residential consumption has continued to decline and, in 2016, fell 6% from 2015 levels.

Source: Bloomberg New Energy Finance, EIA

Notes: Values for 2016 are projected, accounting for seasonality, based on latest monthly values from EIA (data available through October 2016).

Deployment: US industrial electricity production from on-site generation by source (TWh)

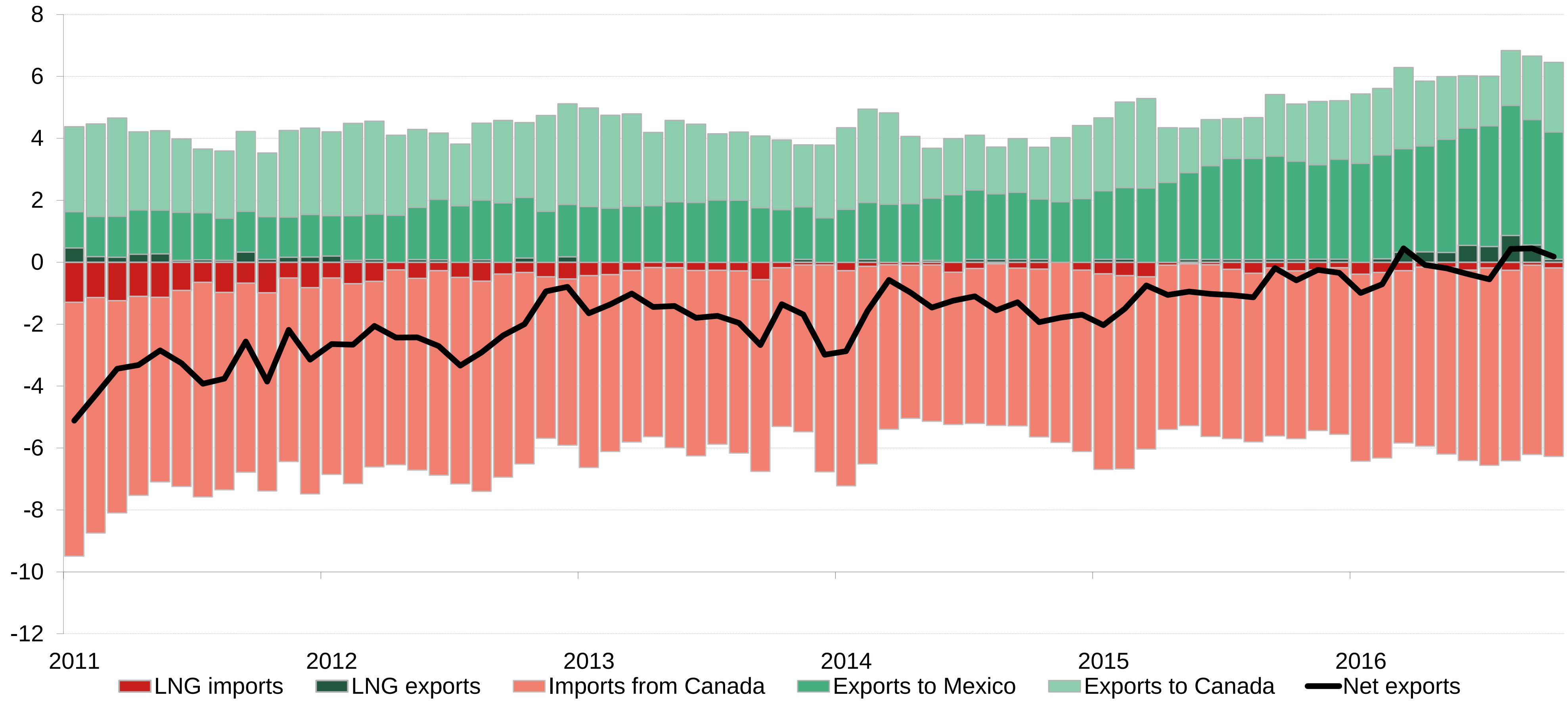


- Rising industrial sector on-site generation has boosted electric-sector gas consumption since 2008.
- Estimates indicate that overall industrial sector on-site generation rose in 2016, driven by the highest level of gas-powered on-site generation since EIA records began in 2001. This is due to existing projects and new facilities (new chemical and fertilizer plants) taking advantage of low natural gas prices.
- In 2016, natural gas was responsible for an estimated 92TWh of on-site generation, with 55TWh provided by other sources.

Source: Bloomberg New Energy Finance, EIA

Notes: Values for 2016 are projected, accounting for seasonality, based on latest monthly values from EIA (data available through October 2016).

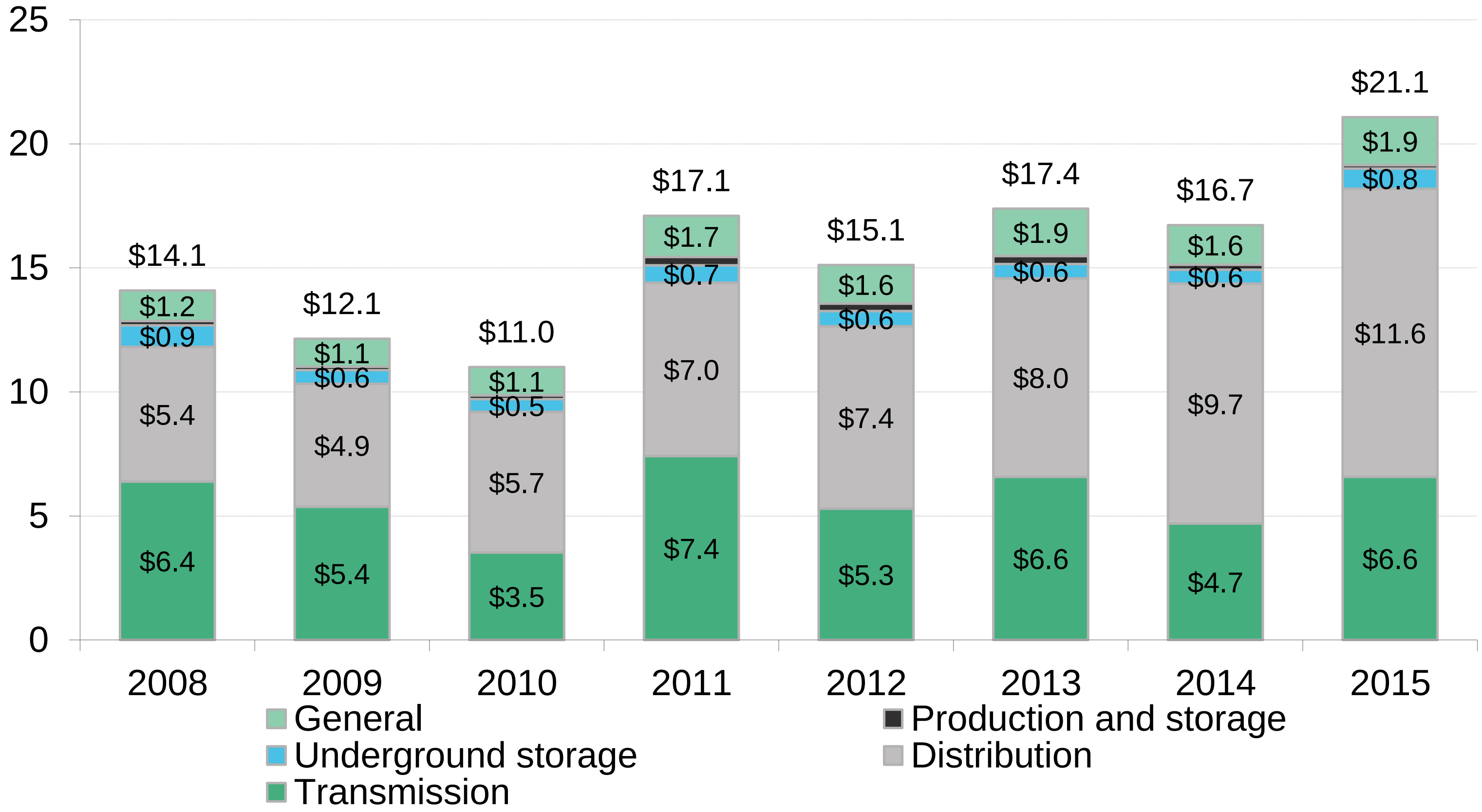
Deployment: US natural gas net exports (Bcfd)



- US natural gas net exports have been trending up since 2011, due in part to growing exports to Mexico as the deregulation of the energy market there continues to drive demand for US gas.
- In addition, 2016 marked the opening of two trains at the Sabine Pass LNG export terminal, which, combined with a decrease in imports, made the US a net LNG exporter.
- New, planned pipelines and LNG terminals will look to increase the US' role as an exporter going forward.

Source: Bloomberg New Energy Finance, EIA

Financing: US midstream gas construction expenditures ($bn)



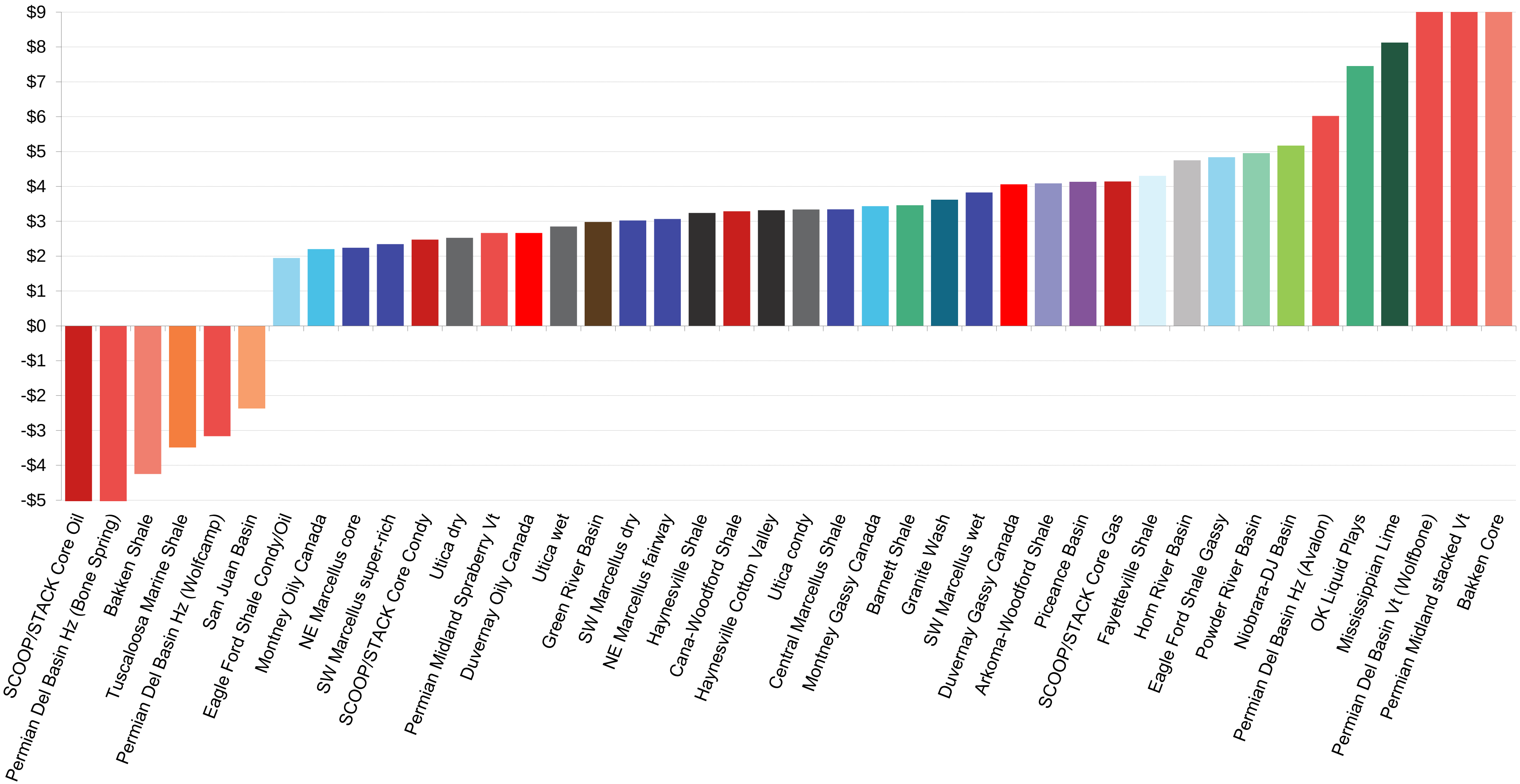
- Midstream expenditures increased 26% year-on-year in 2015, with the largest percentage growth coming from underground storage and transmission expenditure.
- Distribution spending rose to its highest level yet, at $11.6bn, a 20% increase over 2014 levels, as more customers connected to the grid and utilities invested in upgrading networks.

Source: Bloomberg New Energy Finance, American Gas Association

Notes: Values reflect expenditures 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.

Economics: Gas breakevens by play and basin ($/MMBtu)

Bloomberg NEW ENERGY FINANCE

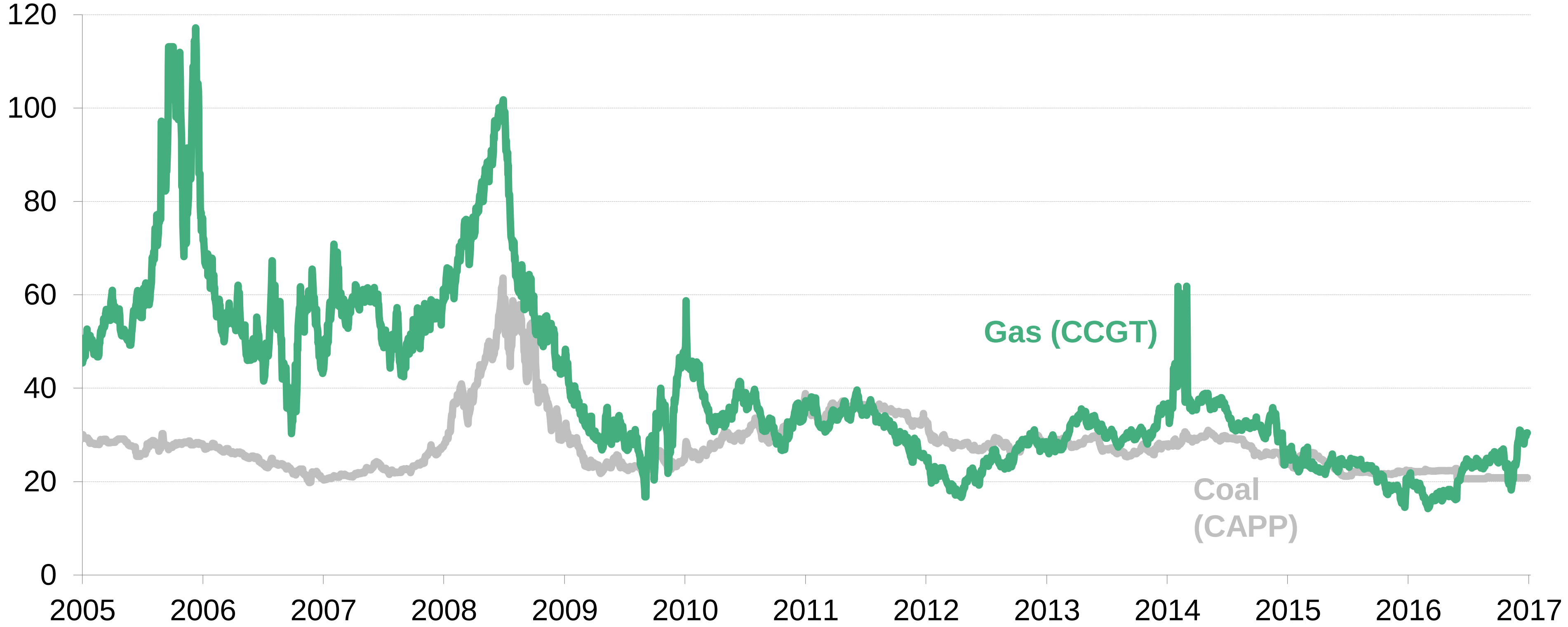


- Producers have seen strong efficiency gains and reductions in drilling and completion (D&C) costs over the past two years, resulting in “breakeven” prices as low as $2-4/MMBtu. Plays with negative breakevens are those that also extract revenue from oil production.
- Breakeven prices do not take into 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

Economics: Cost of generating electricity in the US from natural gas vs. coal ($/MWh)

Bloomberg NEW ENERGY FINANCE

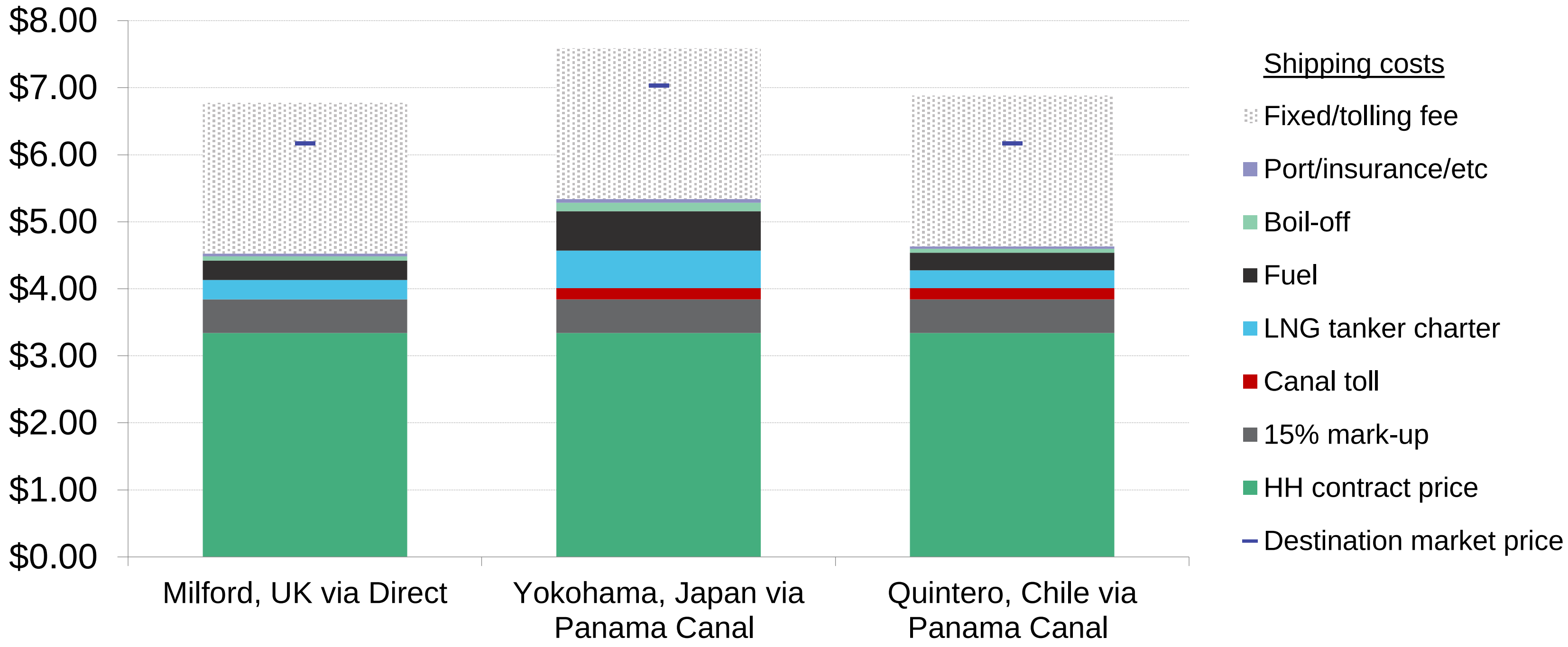


- Power has served as the swing demand source for natural gas: when the price of gas falls below that of coal, gas burn rises until the differential (in $/MWh) between the two fuels closes.
- As gas becomes consistently cheaper than coal, it creates a strong impetus for coal-to-gas switching. The US observed this switching in 2012 and again throughout 2015 and 2016, when gas-fired power plants, on average, were cheaper to run than coal-fired units. At the end of 2016, a rally in gas prices due to higher demand made coal-fired power plants once again competitive.
- Power burn in PJM has the greatest sensitivity to gas prices and also faces lower gas prices than Henry Hub (which is shown 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.

Economics: US LNG landed cost breakdown ($/MMBtu)



- Sabine Pass exported its first cargo of LNG on 21 February 2016 and since then, it has shipped approximately 50 cargoes of LNG to 16 destinations. Over half of these cargoes have gone to Latin America. India has also been a consumer of US LNG.
- Sabine plans to begin operations at two more trains in 2017, bringing total US export capacity to 2.4Bcfd by the end of 2017. 97% of this capacity is committed in offtake agreements, so the cargoes will likely ship if the economics continue to make them attractive to world markets.
- US LNG from Sabine Pass is currently competitive when compared to destination market prices. The short-run landed price of US LNG includes purchases of gas and shipping costs. The fixed liquefaction fee of $2.25/MMBtu is considered a sunk cost and therefore irrelevant to marginal cost decisions.

Source: Bloomberg New Energy Finance

Notes: Data is as of January 2017. NBP is used as the destination market price for the UK and Chile. JKM is used as the destination market price for Japan.

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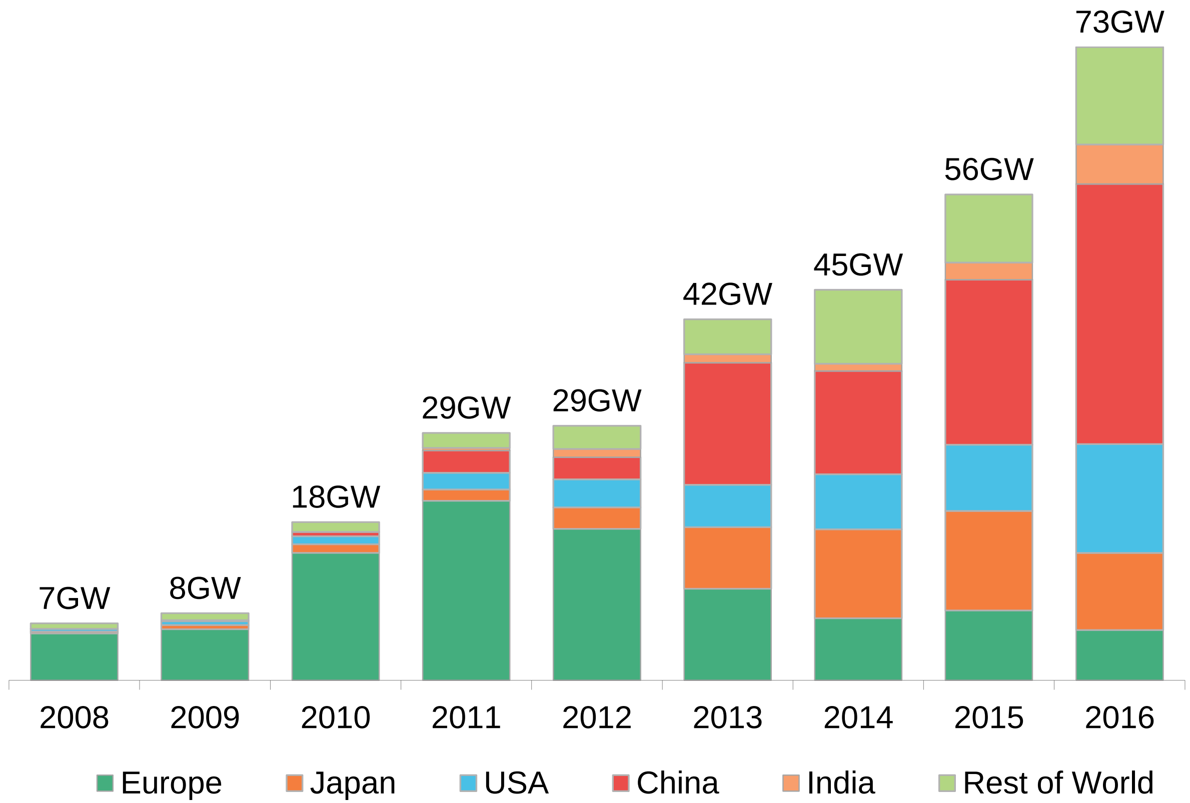
Deployment: Global solar PV build (GW)

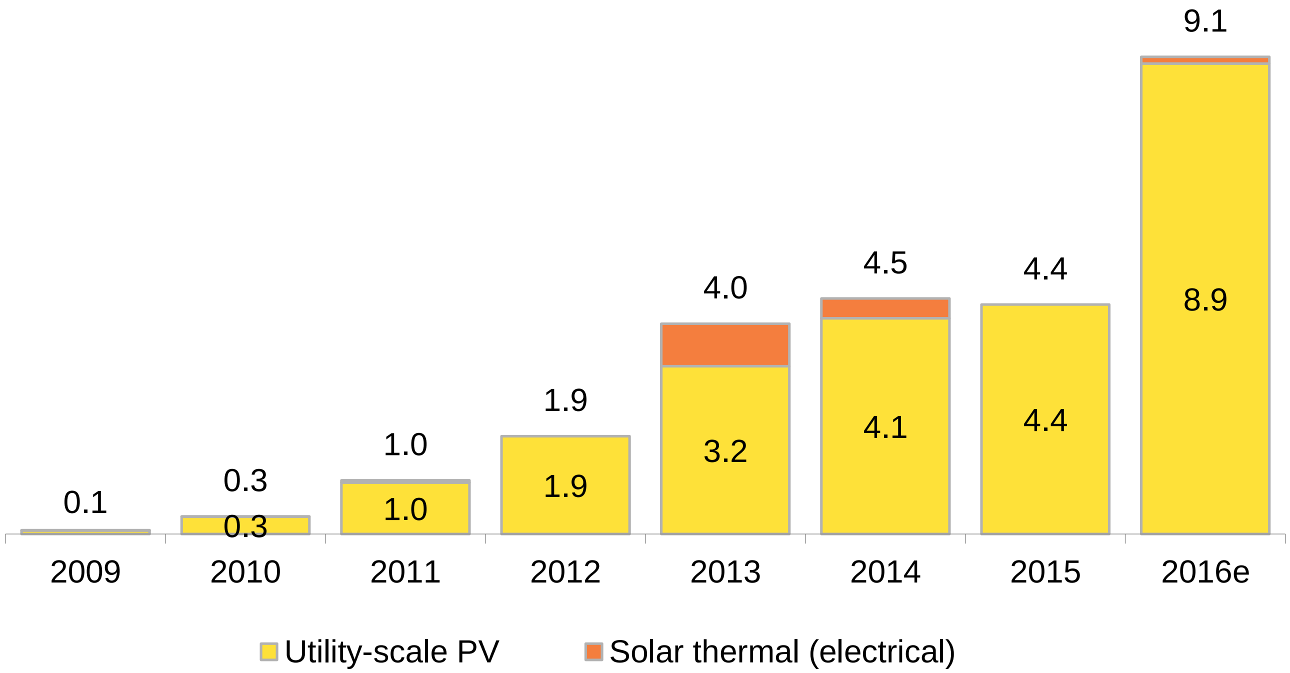


- Driven by record high volumes and record low prices, the global photovoltaic (PV) market saw yet another year of expansion in 2016, rising 30% year-on-year to 73GW. China and the US were particular bright spots, with China adding 30GW alone.
- The US government maintained tariffs on Chinese and Taiwanese solar products (which still account for much of the market). Nevertheless, low-cost Chinese producers have largely held onto market share in the US. On a global basis, module oversupply and manufacturing improvements continue to push equipment costs down, spurring uptake.

Source: Bloomberg New Energy Finance

Notes: Values are in GW DC. 2016 values represent an average of optimistic and conservative analyst estimates.

Deployment: US large-scale solar build (GW)



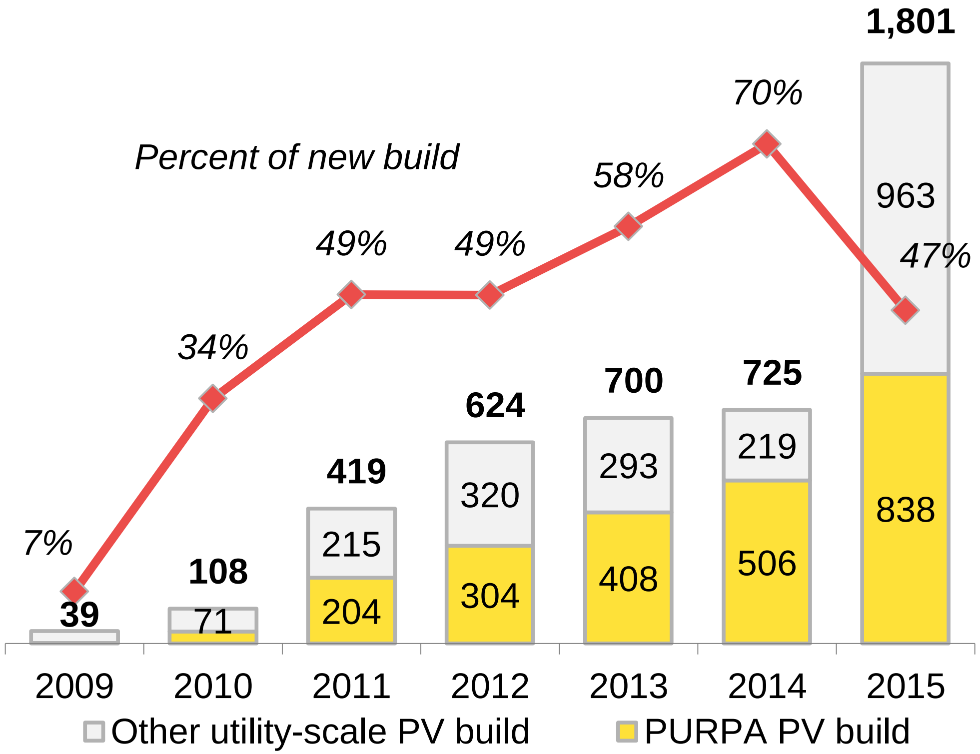
- Solar PV build has grown every year since 2009, while solar thermal build has been lumpy and dependent upon a few projects.
- The Investment Tax Credit (ITC) was extended for five years at the end of 2015, and 'commence construction' language added – meaning that projects have to begin construction, rather than achieve commercial operations, by the deadlines.
- At 8.9GW, 2016 utility-scale PV installations more than doubled the prior record of 4.4GW set in 2015.
- The US commissioned one concentrating solar power (solar thermal) plant in 2016 (the 125MW Crescent Dunes facility in Nevada). Developers and financiers continue to focus their attention on PV.

Source: Bloomberg New Energy Finance   Notes: Values are in GW DC.

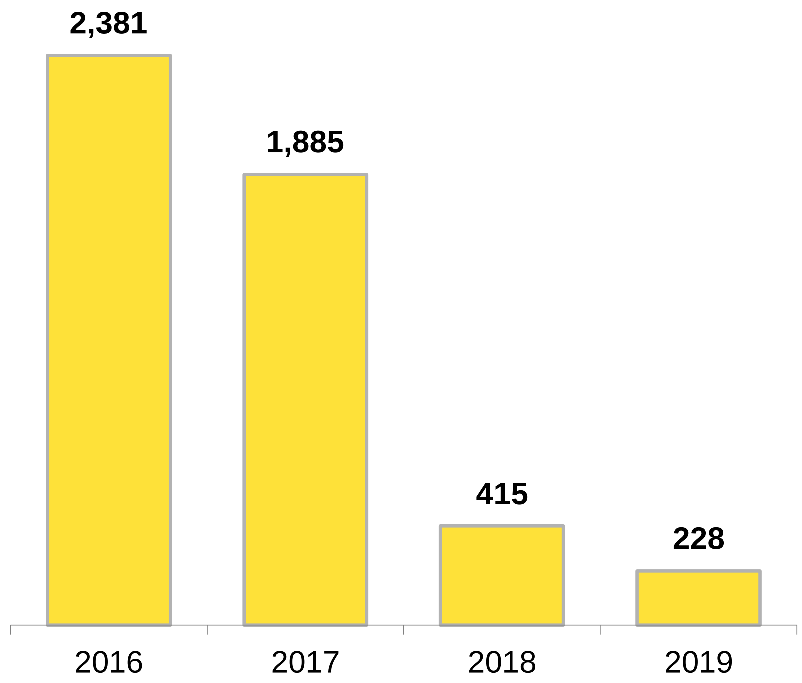
Deployment: US solar qualifying facility build (MW)

Bloomberg NEW ENERGY FINANCE

PURPA solar build in regulated states, relative to total utility-scale PV build, 2009-15



Planned PURPA solar projects, 2016-2019



- Qualifying facilities (QF) under the Public Utility Regulatory Policy Act (PURPA) made up 52% of utility-scale PV build in regulated utility territories between 2009 and 2015. As technology costs have plummeted, developers are increasingly seeking guaranteed interconnection with regulated utilities through PURPA. A rise in green tariffs and a push from developers and utilities to sign PPAs before the ITC step-down overshadowed PURPA in 2015, but build still reached record highs.
- The PURPA solar pipeline is made up of over 4.9GW of projects that have filed for interconnection between 2016 and 2019. Most of these projects are in the Northwestern and Southeastern US; in the Southeast, regulated utilities are forecasting flat or declining electricity demand in the coming years.

Source: Bloomberg New Energy Finance

Note: Values are in MW DC. Planned projects data is representative of current volumes; 2018-2019 pipelines will eventually see increases.

Policy: Recent regulatory amendments in the five largest PURPA states

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State	Historical PURPA capacity	Planned PURPA capacity	Additional Information
Oregon	234	710	In March 2016, the Oregon Public Utility Commission rejected proposals to lower the state's standard contract to three years and decrease the maximum size to 100kW.
North Carolina	1,301	703	In January 2015, the North Carolina Utilities Commission rejected a utility proposal to reduce the maximum project capacity to 100kW and the standard PPA term to 10 years.
Utah	175	608	In January 2016, regulators approved a request to reduce PURPA contracts from 20 years to two.
Montana	188	513	In June 2016, the Montana Public Utilities Commission suspended all PURPA rates for qualified facilities, meaning IPPs will be forced to negotiate each PPA with the relevant utility. However, in December 2016, FERC overturned the suspension.
South Carolina	20	328	There is a ceiling of 2MW for standard contracts under PURPA. Any contract for projects larger than 2MW is negotiable, including contract length.

- The surge of solar projects flooding interconnection queues has propelled backlash from regulated utilities.
- In order to avoid being locked into outdated offtake prices in the long term, utilities are petitioning their state public utility commissions to reduce the project capacity thresholds for securing standard contracts under PURPA, as well as the lengths of these contracts.
- Changes to PURPA at the state level as a result of this backlash have forced developers to look to new states.

Source: Bloomberg New Energy Finance

Financing: US large-scale solar investment ($bn)

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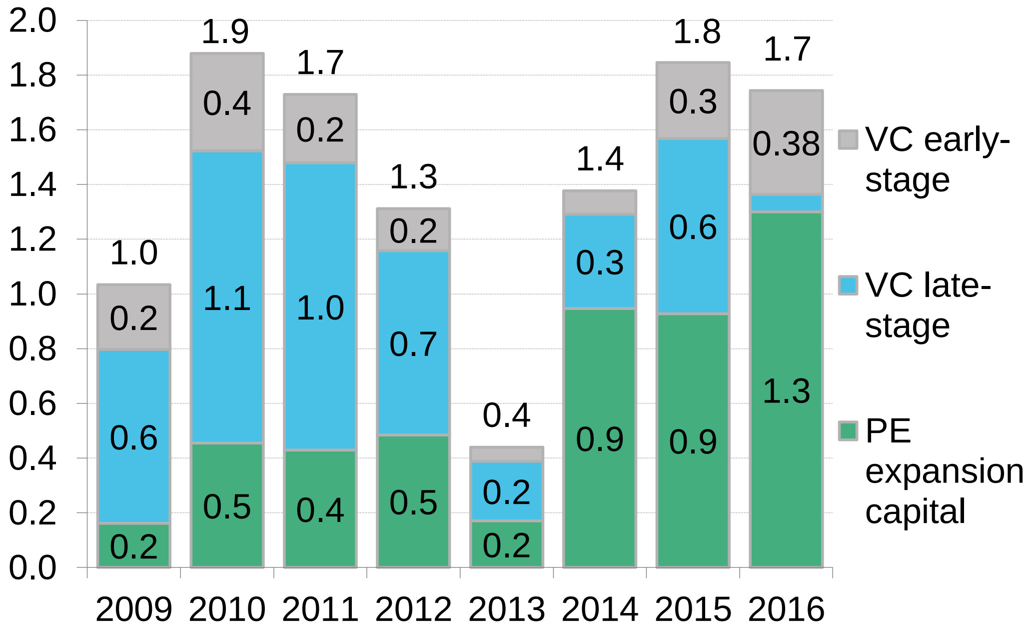
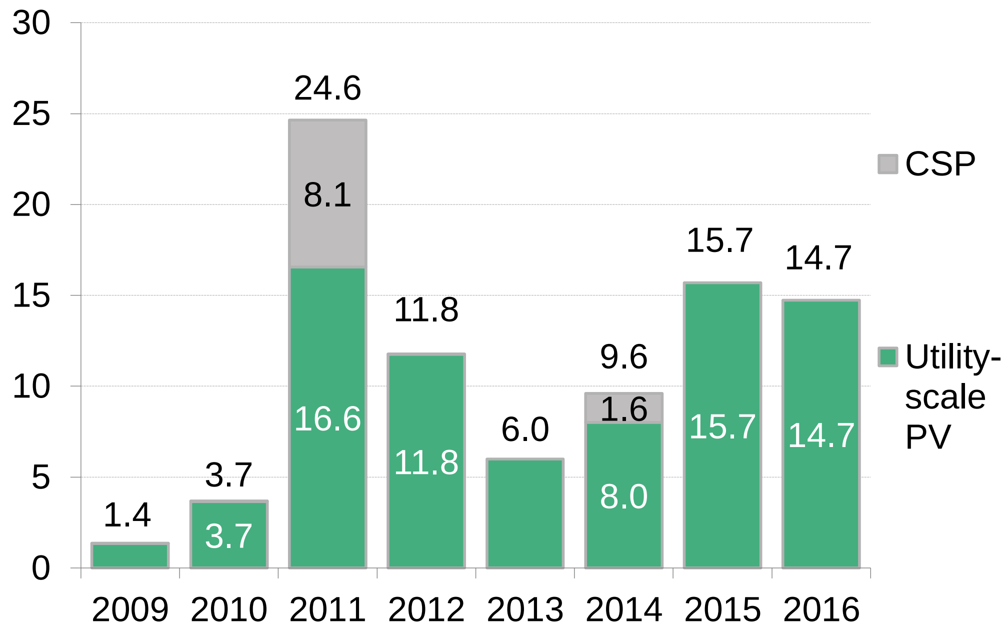
Venture capital / private equity investment in US solar by type of investment



Asset finance for US utility-scale solar projects by technology



- 2016 was another impressive year for private equity capital in US solar, with $1.3bn invested. Venture capital investment experienced a down year, with a combined $0.44bn invested in early- and late-stage companies.
- Asset finance deals for utility-scale solar faltered, slightly dropping to $14.7bn in 2016. The extension of the investment tax credit (ITC) in December 2015 relieved some of the pressure on developers to arrange financing for projects in short-order, although increasing cost-competitiveness for utility-scale PV still led to it being the third-largest year ever for investment in the space.

Source: Bloomberg New Energy Finance Notes: Values are in nominal dollars and include estimates for undisclosed deals.

Economics: Price of solar modules and experience curve (2015$/W as function of global cumulative capacity)

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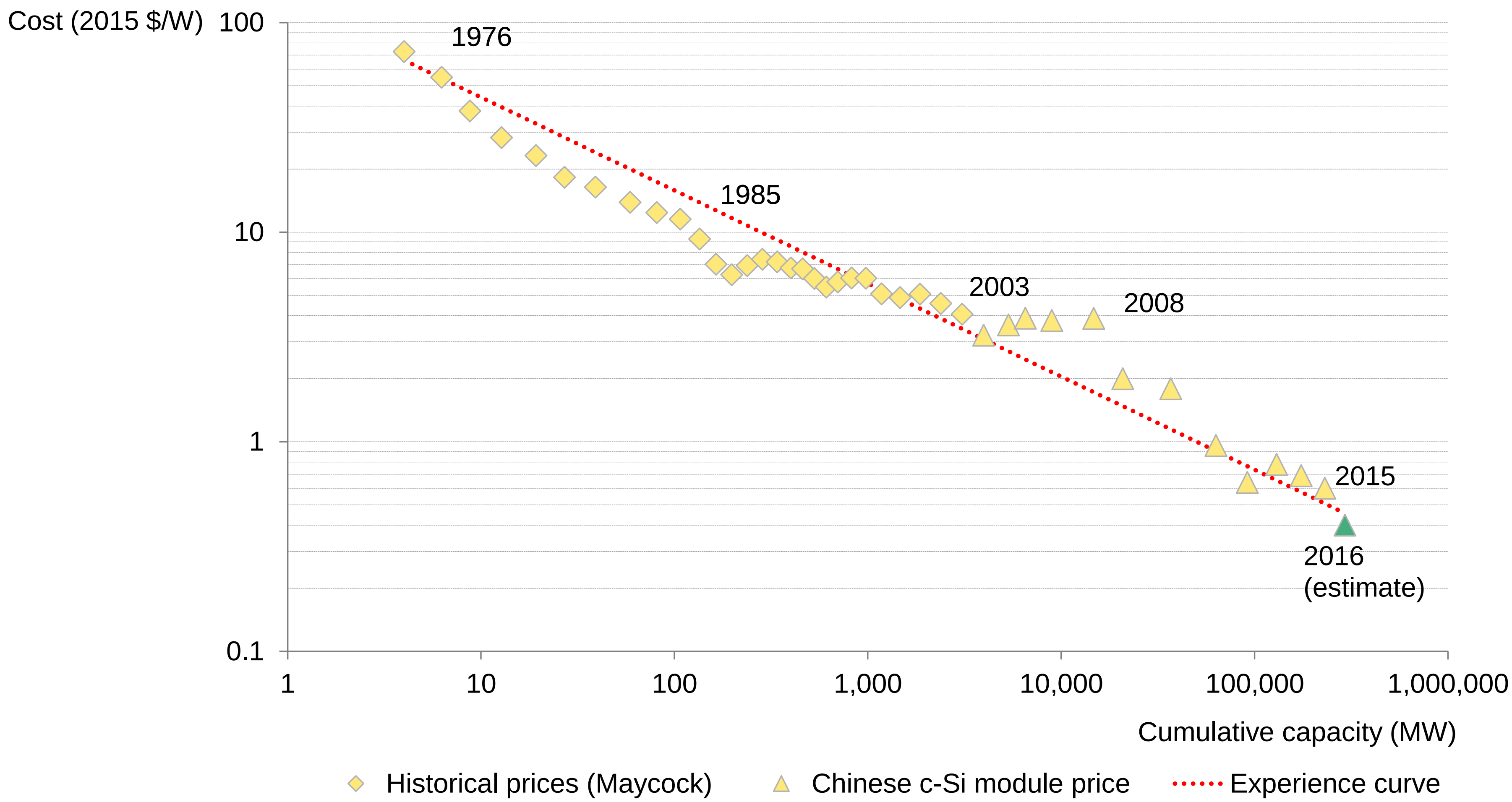
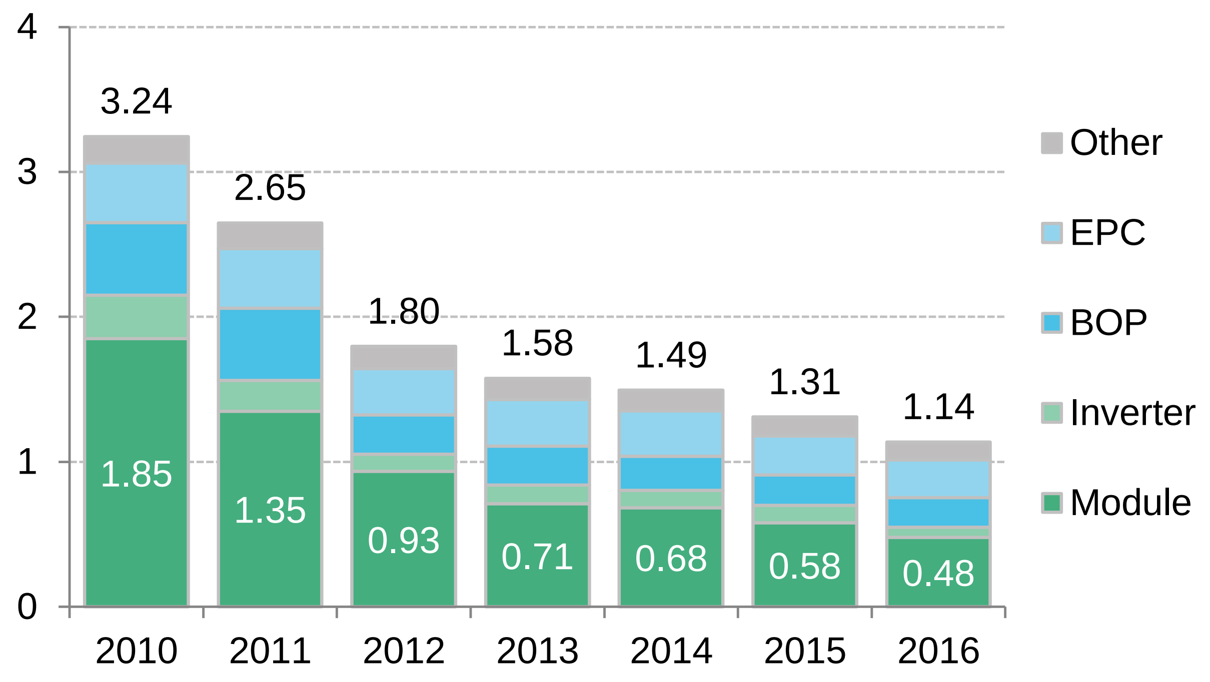


- The price of PV modules has roughly followed an experience curve with a learning rate of 26.5% - in other words, prices have fallen 26.5% for every doubling of cumulative installed capacity.
- From 2008 to 2009, module prices tumbled dramatically due to global oversupply, a dynamic that re-emerged in 2016. We estimate a global average module price of around $0.41/W in Q4 2016 and Q1 2017.

Source: Bloomberg New Energy Finance, Paul Maycock

Notes: The precise learning rate depends on the end-point chosen, but we believe $0.41/W to be slightly below the experience curve at the end of 2016. Figures in real 2015 dollars.

Economics: Best-in-class global capex for utility-scale PV (2015$/W)



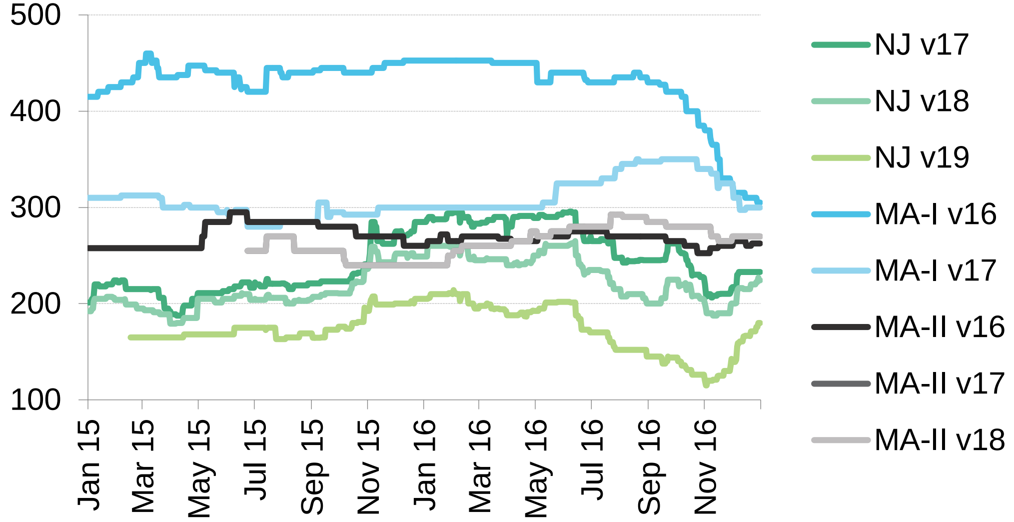
- The cost of building a utility-scale PV facility declined dramatically from 2010 to 2012 (based on the global benchmark for mature markets) before leveling off to more modest annual cost reductions from 2012 to 2015. However, cost declines picked up again in 2016, falling 13% year-on-year.
- Germany, a mature market, sets the best-in-class capex. The US is closing the gap on what has historically been higher costs for best-in-class utility-scale PV.
- Lower capex translates into lower levelized costs: utility-scale solar plants in Nevada and California have recently secured PPAs to sell power at long-term rates below $40/MWh (with the help of incentives); for reference, PPAs for similar projects in California went for over three times this amount just five years ago.

Source: Bloomberg New Energy Finance

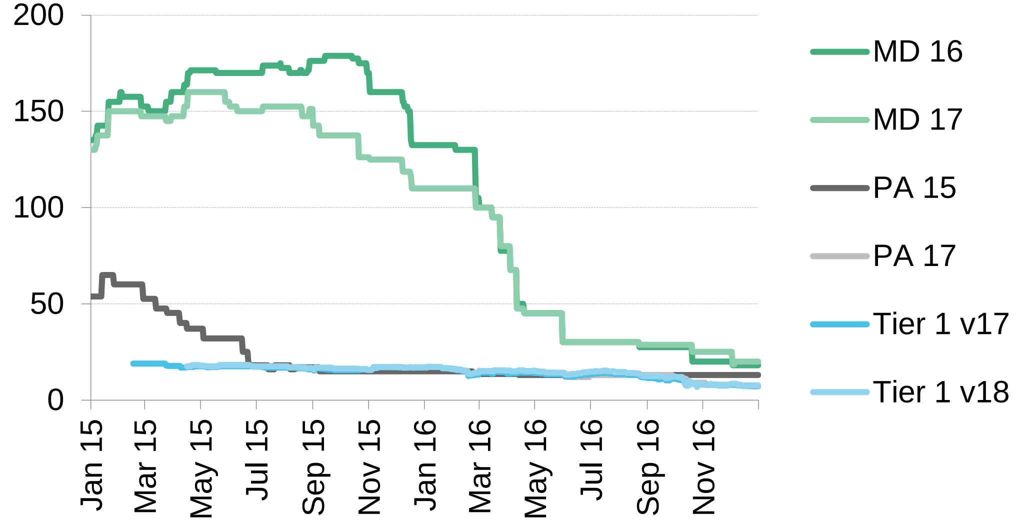
Notes: ‘EPC’ refers to ‘engineering, procurement and construction’; ‘BOP’ refers to ‘balance of plant.’ Figures in real 2015 dollars.

Economics: Solar REC prices in selected US state markets by vintage year ($/MWh)

Massachusetts SREC-I/II and New Jersey SREC prices ($/MWh)



Maryland and Pennsylvania SREC and PJM Tier 1 REC prices ($/MWh)



Source: Bloomberg New Energy Finance, ICAP, SRECTrade, The Intercontinental Exchange (ICE) Notes: Some data in chart above is from ICAP; for that data, the disclaimer below applies; 'v' refers to credit vintage; 'MA-I' and 'MA-II' refer to Massachusetts' SREC-I and SREC-II programs; 'Tier 1' represents PJM Tier 1 prices.

- Overall, SREC prices declined aross major markets in 2016, due to oversupply.
- **Massachusetts:** SREC-I and SREC-II credits remain above $300/MWh and $200/MWh, respectively, but eligibility for both programs has essentially closed.
- **New Jersey:** Vintage 2017-18 credits traded at the alternative compliance payment (ACP) level for most of 2016 before wavering in the second half of the year. NJ SRECs capped 2016 with a rally.
- **Maryland:** Prices saw modest declines on the threat of new utility-scale build in late-2015, before heading into freefall in the aftermath of the ITC extension. MD SRECs have continued to trade below $30/MWh since August 2016.
- **Pennsylvania:** Oversupply has led PA SRECs to gravitate towards PJM's Tier 1 price.

Source: Bloomberg New Energy Finance, Bloomberg Terminal, ICAP Notes: Data in the charts above ("SREC prices") are 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: US large-scale wind build (GW)

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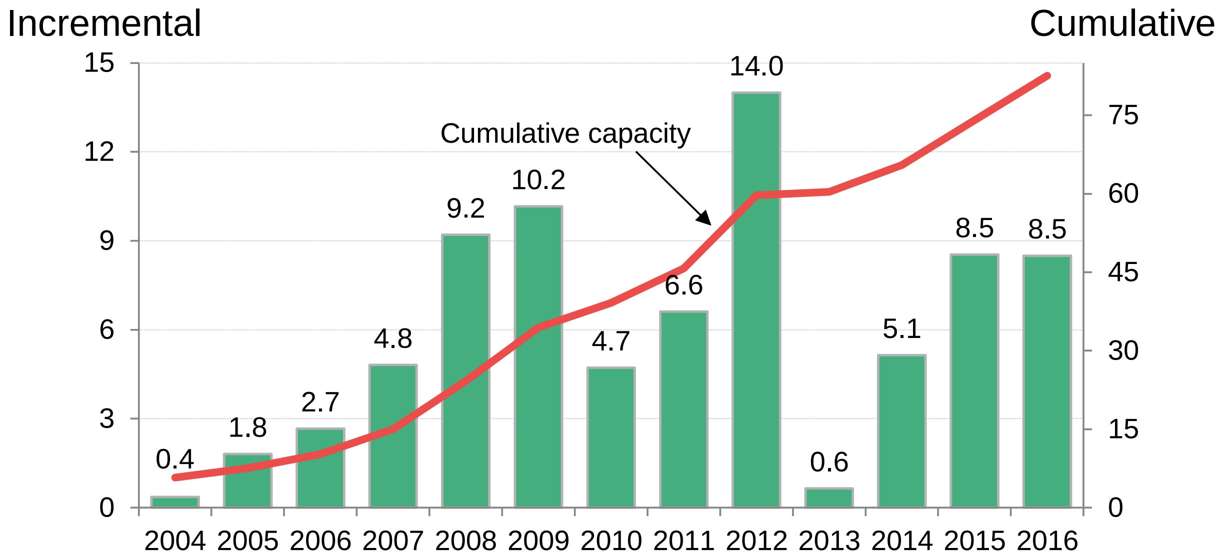
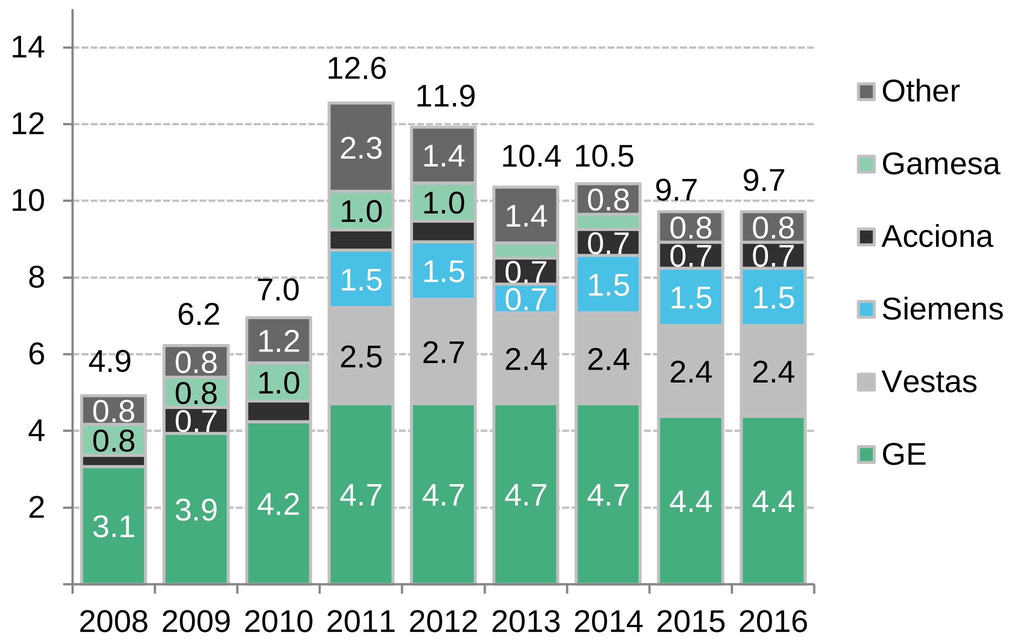


- Build has historically seesawed based on the extension and expiration of the Production Tax Credit (PTC) – the key federal incentive for wind in the US. In 2012, both the PTC and the 1603 Treasury Program (which allowed developers to receive 30% of a project's cost back in cash, in lieu of the tax credit) were set to expire at year-end, which prompted a rush to build. While the cash grant was never renewed, the PTC was extended for one year in January 2013, and a project's requirement for credit qualification was changed from completion to 'start construction.' By January, however, the pipeline had dried up.
- After the tax credit expired again in December 2013, it was 'retroactively' renewed in December 2014 and set to expire again two weeks later, at the end of 2014.
- Finally, the PTC was again extended in December 2015 for projects commencing construction through 2019, with a phase-out for projects beginning after 2016. There is a four-year build window to qualify, so build is expected to peak around 2020.
- A majority of the build continues to occur in Texas, thanks to a $7bn transmission build-out in 2013 to connect windy regions in the Panhandle and West Texas to demand centers farther east. Due to high capacity factors (>50%) and low cost to build, wind in Texas is among the cheapest in the country, with subsidized levelized cost of electricity reaching as low as $22/MWh.
- Corporates have joined utilities as offtakers for wind, signing purchasing power agreements with 12 wind projects this year in Texas for just over 850MW. Wind capacity has also received a boost from long-term power hedges with financial institutions.

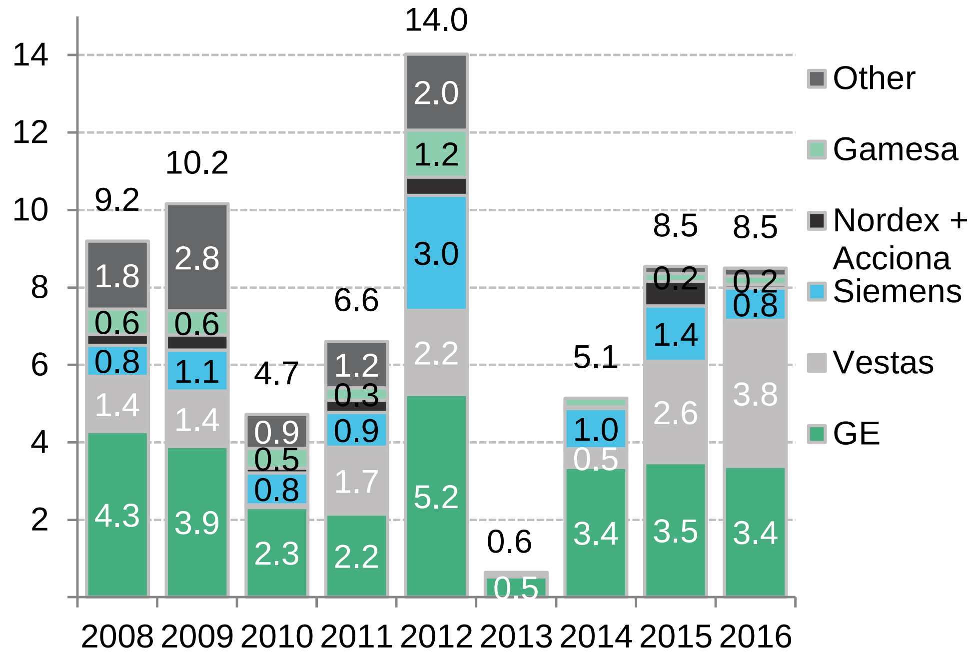
Source: Bloomberg New Energy Finance
Notes: Includes all utility-scale wind development, excluding partially commissioned projects, including distributed turbines that are above 1MW (Bloomberg New Energy Finance threshold for utility-scale).

Deployment: US wind turbine production and contracting

US wind turbine production capacity by manufacturer (GW)



US wind turbine supply contracts for commissioned projects by commissioning year, by manufacturer (GW)



- Several manufacturers have closed nacelle assembly facilities in the US since 2012, including Clipper, Nordex, and Mitsubishi. Several others laid off workers in 2012 and rehired them in 2013 after the PTC was extended. More recently, Gamesa has shuttered its US production, and Alstom and GE have combined following the close of GE's acquisition of Alstom in October 2015. GE, Vestas and Siemens are the dominant manufacturers in the US market. Other manufacturers have had a difficult time due to the lower overall demand for turbines.
- The recent PTC extension may provide some business-planning certainty for wind developers and manufacturers, allowing them to avoid expensive cycles of layoffs and rehiring. We do not expect additional factories in the US to open for onshore wind, due to the expected end of the PTC following its phase-out.

Source: Bloomberg New Energy Finance

Notes: Production capacity measured by nacelle assembly on US soil.

Deployment: US wind ownership and development

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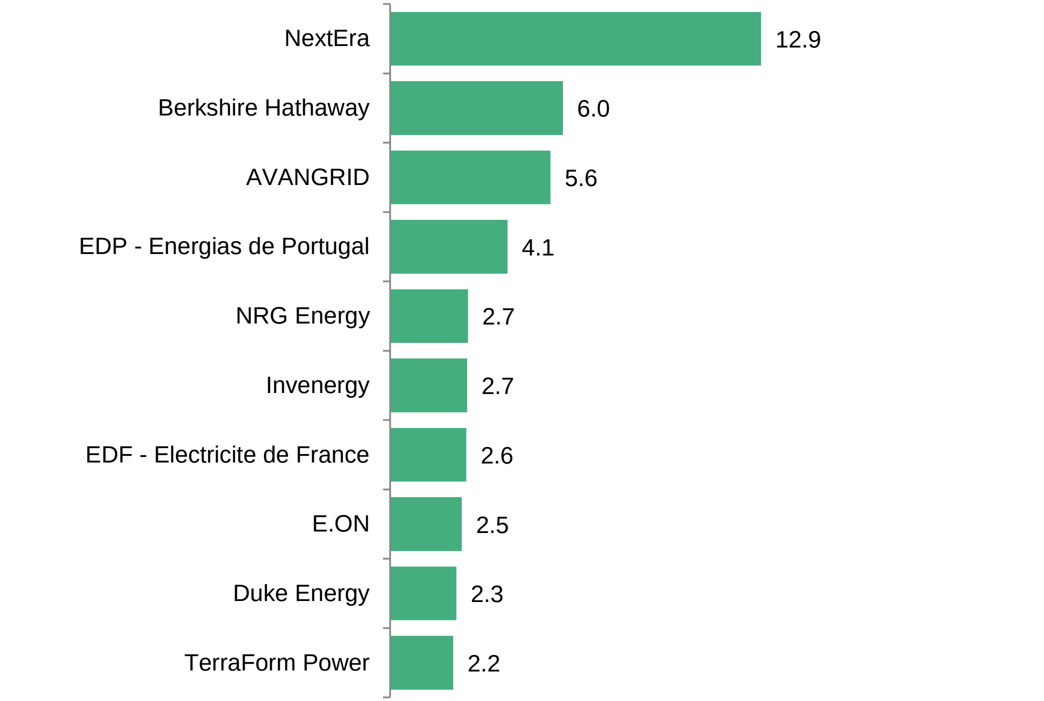
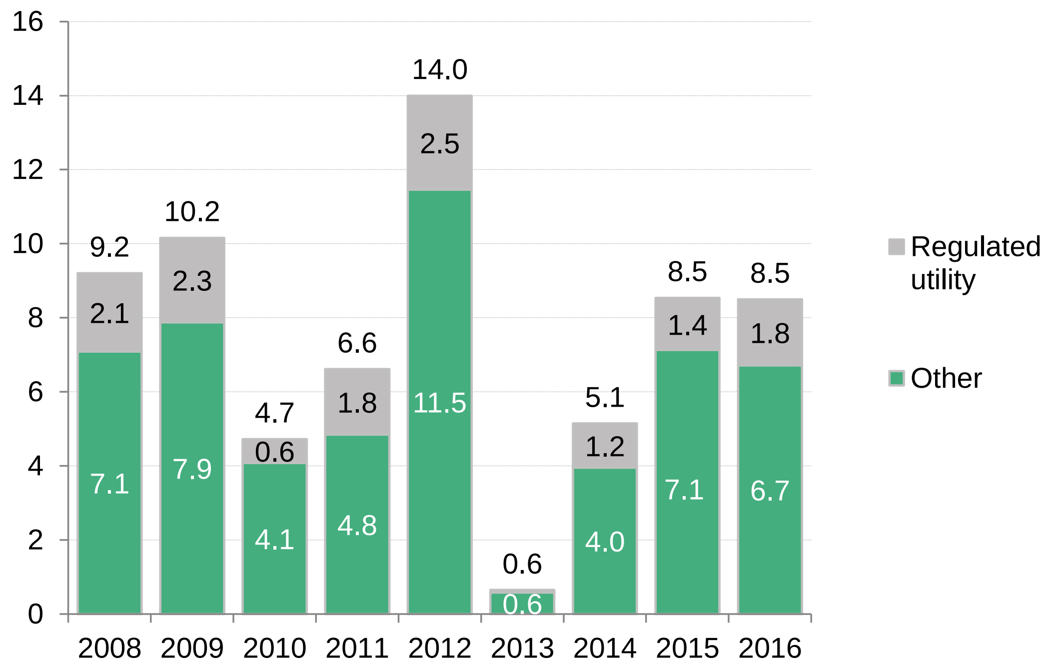
Top 10 US wind owners, as of end-2016 (GW)



US wind capacity commissioned by type of developer (GW)



- NextEra Energy remains the dominant wind developer in the US market. Next in line are Berkshire Hathaway Energy (the holding company that includes both PacifiCorp and MidAmerican) and AVANGRID (formerly Iberdrola).
- Regulated utilities are responsible for building only a small share of wind assets in the US; historically, most have preferred to sign power purchase agreements (PPAs) with independent generators rather than build and own projects.

Source: Bloomberg New Energy Finance

Notes: In chart at left, ownership is based on BNEF League Tables. In chart at right, 'Other' includes projects built by non-utilities such as independent power producers and also includes projects built by the non-regulated development arms of utilities such as Duke or NextEra; in those cases, the projects are not supplying power to the regulated utilities' ratepayers but rather to a third party.

Deployment: US wind curtailment (% of wind generation)

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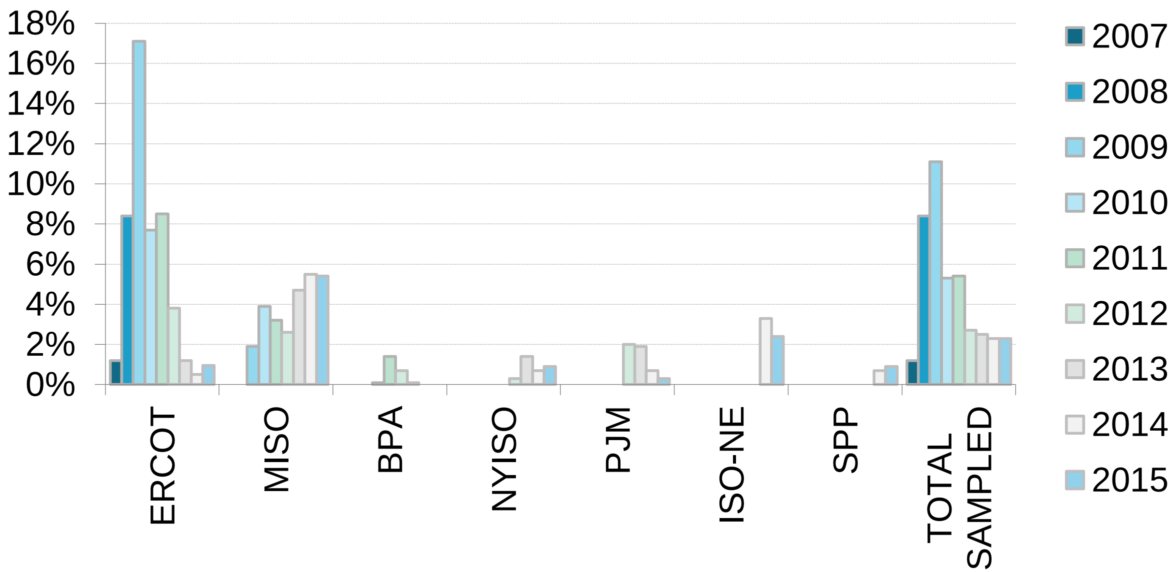
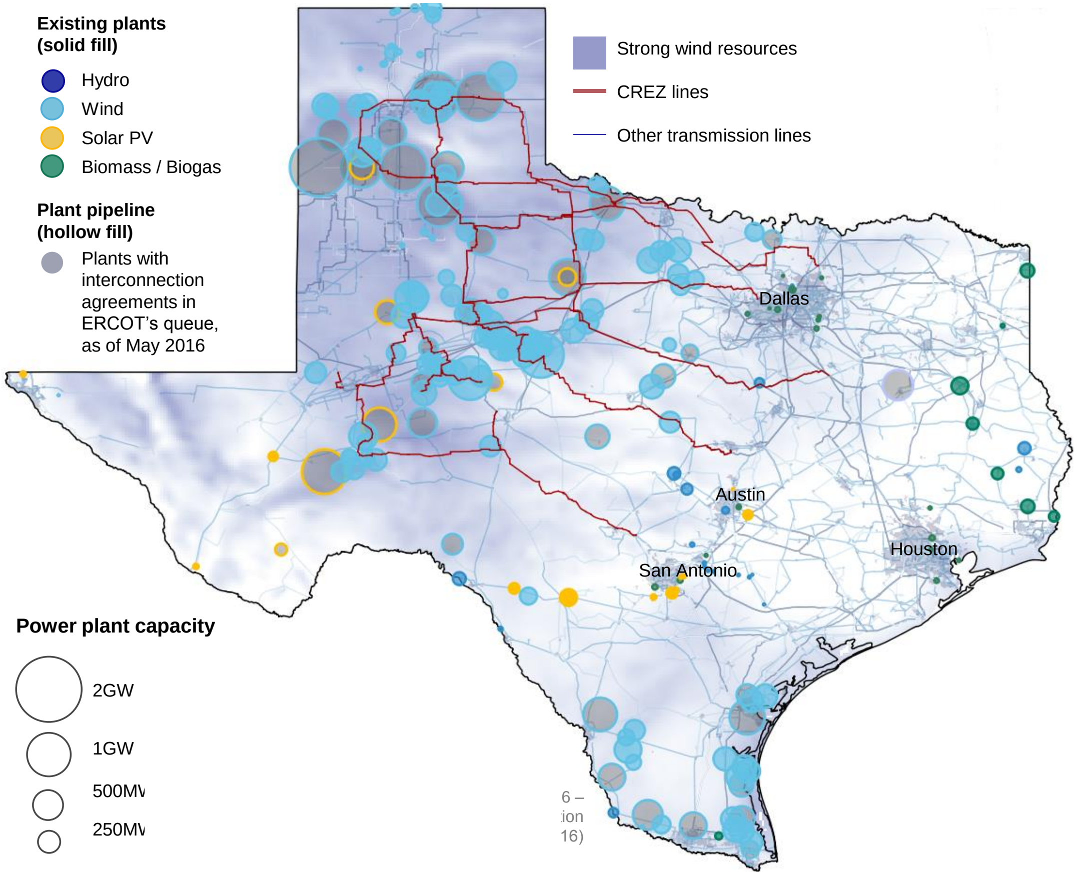


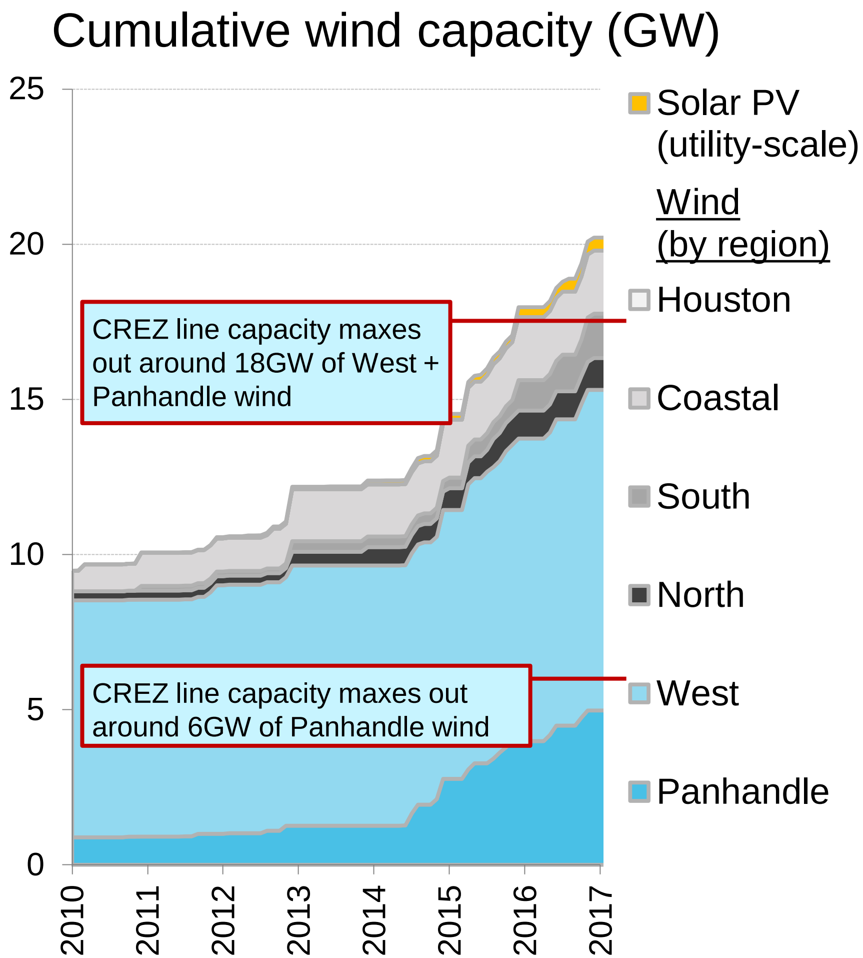
- Curtailment can occur due to transmission constraints, inflexibilities in the grid and environmental or generation restrictions.
- This was a significant problem in ERCOT (Texas) from 2008-2013, but the build-out and upgrade of the Competitive Renewable Energy Zone (CREZ) transmission lines and increased efficiency in ERCOT's wholesale electricity market addressed the problem. Curtailment fell from a peak of 17% in 2009 to 0.5% in 2014, and stayed just under 1% for 2015.
- PJM saw the lowest curtailment of any region in 2015, at 0.3%.* MISO and New England, on the other hand, have experienced higher curtailment than other regions. Like ERCOT before CREZ, MISO's transmission investment has not kept pace with the rapid build-out of wind projects, and annual curtailment numbers continue to rise. MISO is currently building transmission in order to alleviate congestion. New England's curtailment levels in 2015 dropped to 2.4% from 3.3% in 2014. Even so, this is still over double that of SPP and NYISO.
- In aggregate, total curtailment has shrunk since 2009. However, time-varying influences also played a role: in 2015, for example, the western and interior US experienced below-normal wind speeds, reducing generation and therefore the need to curtail in constrained regions.

Source: Bloomberg New Energy Finance, Lawrence Berkeley National Laboratory

Notes: *Except for BPA, data represents forced and economic curtailment. BPA's 2014-15 estimates were unavailable, and data for 2010-2013 are partly estimated. PJM's 2012 figure is June-December only. SPP's 2014 figure is March-December only. ISO-NE and SPP are included only for 2014 onward, as the ISOs did not previously report curtailment data.

Deployment: ERCOT's Competitive Renewable Energy Zone (CREZ)

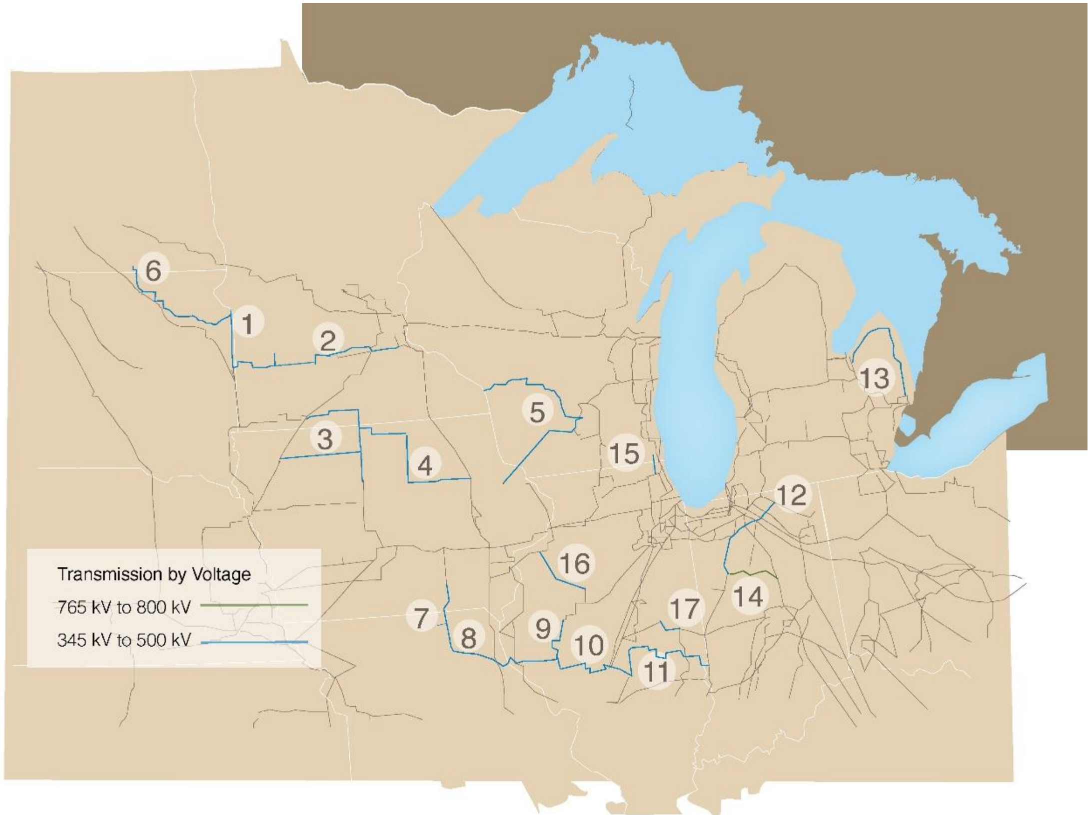




- Texas is home to one-quarter of America's installed wind capacity (over 18GW of 76GW installed as of November 2016).
- The majority was enabled by a $7bn investment in the Competitive Renewable Energy Zone (CREZ) transmission lines, which connect West Zone and Panhandle wind to load centers in the East.
- The CREZ lines can accommodate roughly 18GW of West + Panhandle wind before significant curtailment (and congestion pricing) comes back into play—and West + Panhandle wind is within 3 GW of reaching CREZ's maximum capacity.

Source: Bloomberg New Energy Finance, ERCOT

Deployment: Transmission build-out in MISO



- MISO currently has the most transmission build underway for wind, which will alleviate congestion and create new opportunities for wind development. MISO's Multi Value Project (MVP) Portfolio, the result of an extended transmission analysis, includes 17 projects, some of which are interstate (shown above).
- Additionally, across the US (and sometimes connecting into Canada), there has been a number of proposals for high-voltage direct current (HVDC) transmission lines. However, none of these have yet begun construction. Generally, transmission build *within* a specific state or region receives full approval faster than those that cross multiple jurisdictions. Nearly 21GW-worth of HVDC transmission projects with at least a portion in the US are currently under development or under construction. Much of this will not be built.

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–Merdosia–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.

Financing: Asset finance for US large-scale wind projects ($bn)

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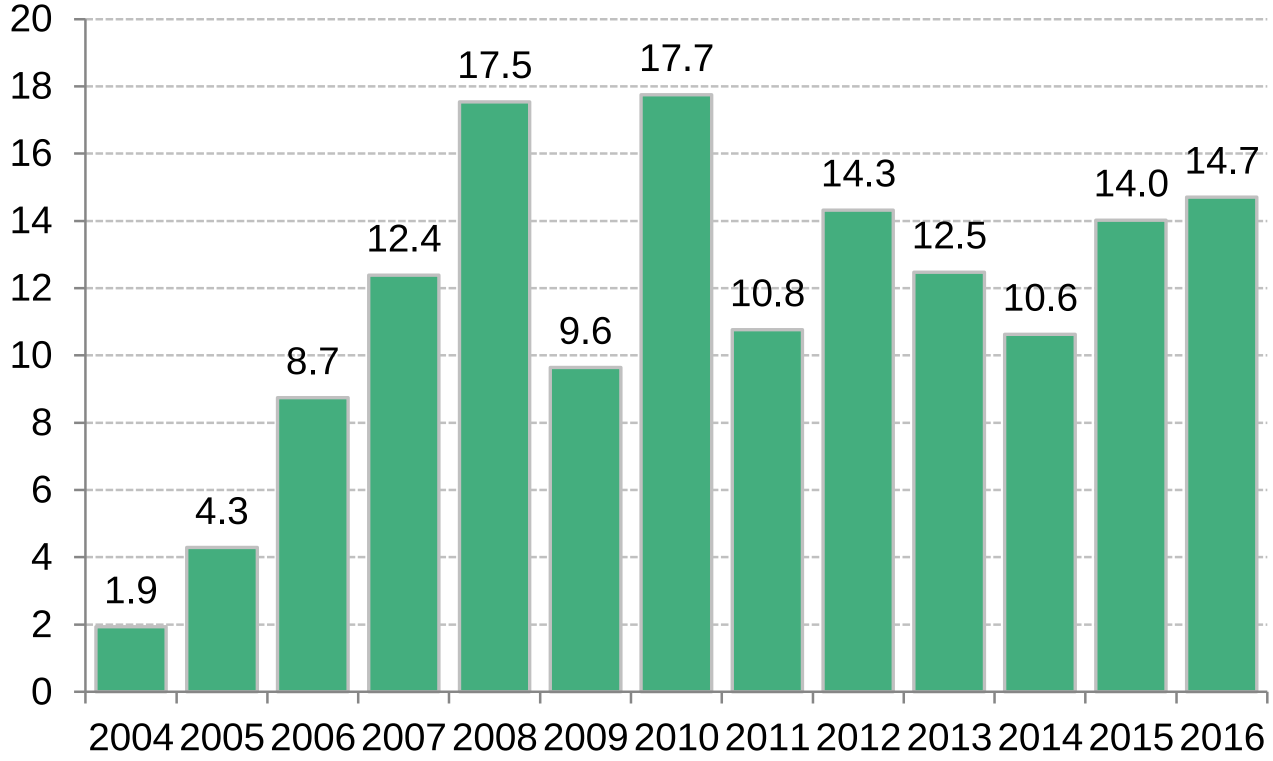

- The 2016-20 wind pipeline is very healthy: a large portion of the $14.7bn in financing secured in 2016 is for wind projects to be commissioned in 2017-2020.
- Asset financing has tracked closely with the status of the Production Tax Credit (PTC), which has expired and been retroactively extended multiple times since 2012. After developers rushed to secure construction financing in 2012 and 2013 prior to the PTC expiration dates, financing for new wind in 2014 declined. The rebound in 2015 was once again PTC-driven, as developers sought to ensure project completion by the end of 2016 – the expected end of the PTC qualification period before it was once again renewed by Congress in mid-December 2015. 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: Wind turbine price index by turbine type and delivery date ($m/MW)

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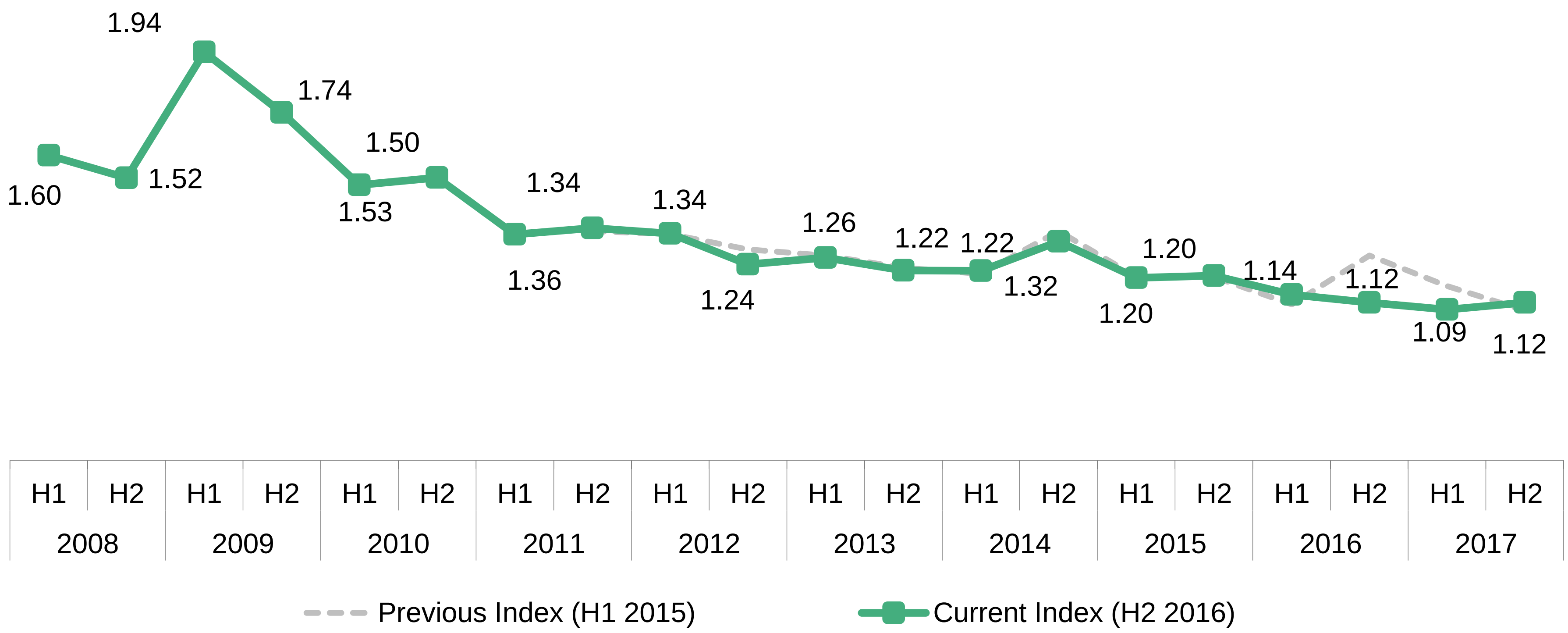
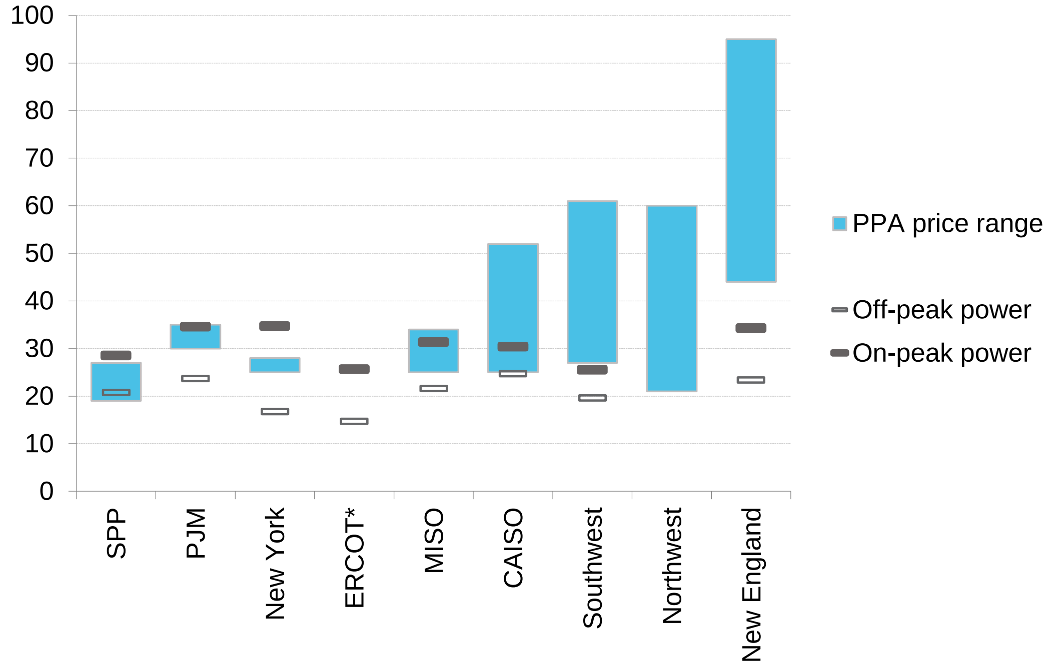


- Turbine prices fell 42% from $1.94m/MW in H1 2009 to $1.12m/MW in H2 2016. The global oversupply of turbines continues to suppress prices. However, turbine oversupply occurs primarily in Europe.
- Global onshore installations are estimated to fall 7% from 58.6GW in 2015 to 54.7GW in 2016.
- We continue to see decreasing prices per MWh, especially as several projects with very high capacity factors reach delivery stage. The global average capacity factor in 2016 was 39%.

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: US wind PPA prices compared to wholesale power prices in selected markets ($/MWh)



- Prices for wind power purchase agreements (PPAs) have fallen dramatically as levelized costs declined. According to interviews with project developers, projects secured PPAs as low as $19/MWh in SPP in 2016. For comparison, data reported to the Federal Energy Regulatory Commission indicate that the average offtake price for contracts signed in 2011 was $47/MWh.
- The top regions for utility PPAs are high wind-speed regions with low development costs like SPP, MISO and ERCOT. An ERCOT price range is not included in the chart above due to insufficient data; however, the region offers some of the lowest levelized costs for wind in the US, with projects in West and North Texas boasting costs as low as those in SPP.
- 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 into 2016, with an additional 1.5GW contracted.

Source: Bloomberg New Energy Finance, SEC filings, interviews, analyst estimates Notes: *ERCOT PPA information is missing due to insufficient data. MISO is the Midwest region; PJM is the Mid-Atlantic region; SPP is the Southwest Power Pool, covering the central southern US; NEPOOL is the New England region; ERCOT is most of Texas. Wholesale power price is average of quarterly future power prices (based on Bloomberg Commodity Fair Value curve) maturing in calendar year 2016 for selected nodes within the region.

Economics: 'Class I' REC prices in selected US state markets ($/MWh)

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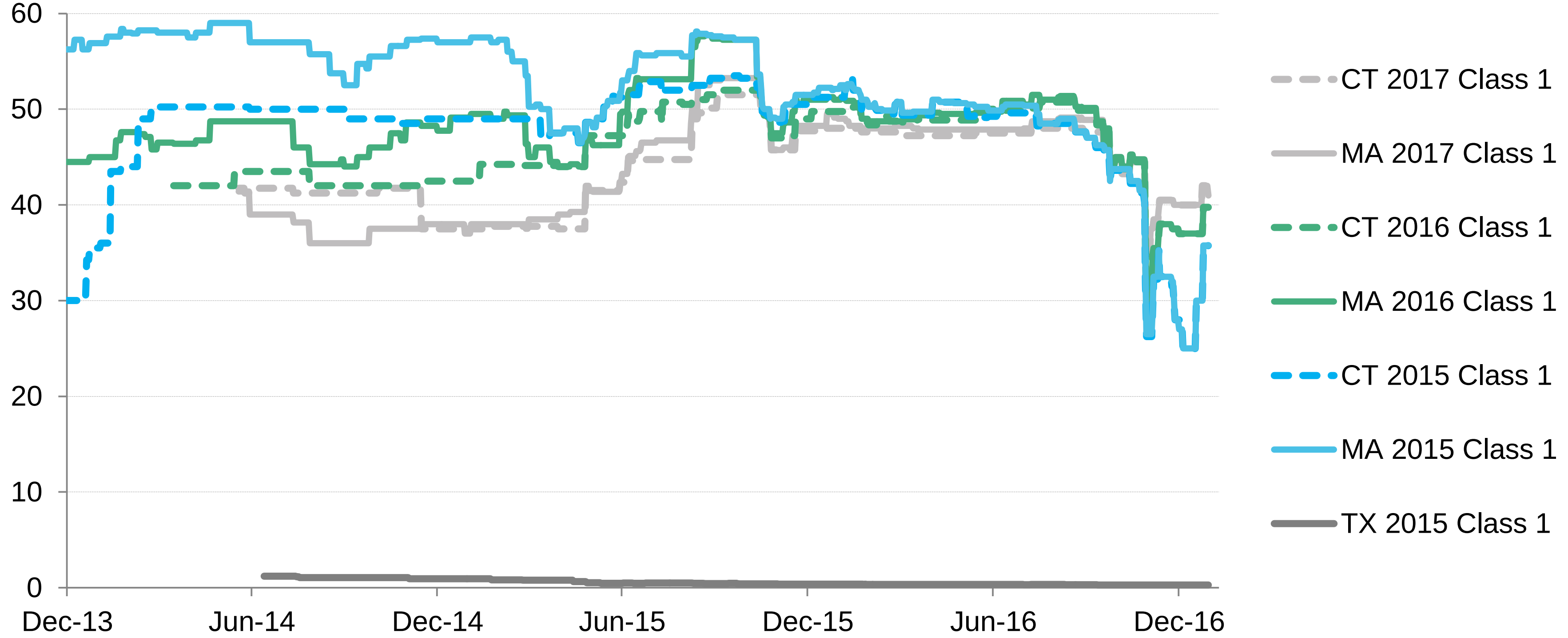

- Renewable Energy Credits (RECs) provide an additional revenue stream for qualified renewable projects, thereby improving project economics. However, oversupply drove down REC prices in major markets in 2016.
- New England Class 1 REC prices converged in 2016 due to oversupply. The region's prices plunged in the second half of the year in anticipation of additional supply from New England's Clean Energy Request for Proposals (RFP), before entering a partial correction around the end of the year.
- Texas has the greatest wind capacity in the country, resulting in a REC oversupply that has severely depressed prices.
- The PJM REC market remains oversupplied, and prices are guided by the value of use during potential future 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: US bioenergy build and cumulative capacity

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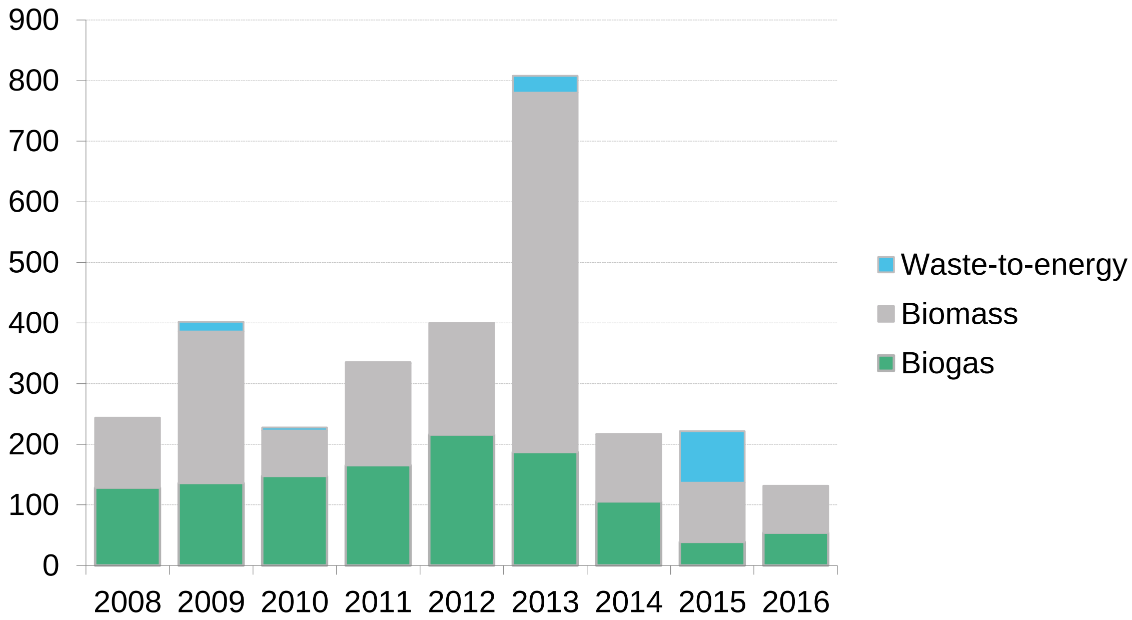
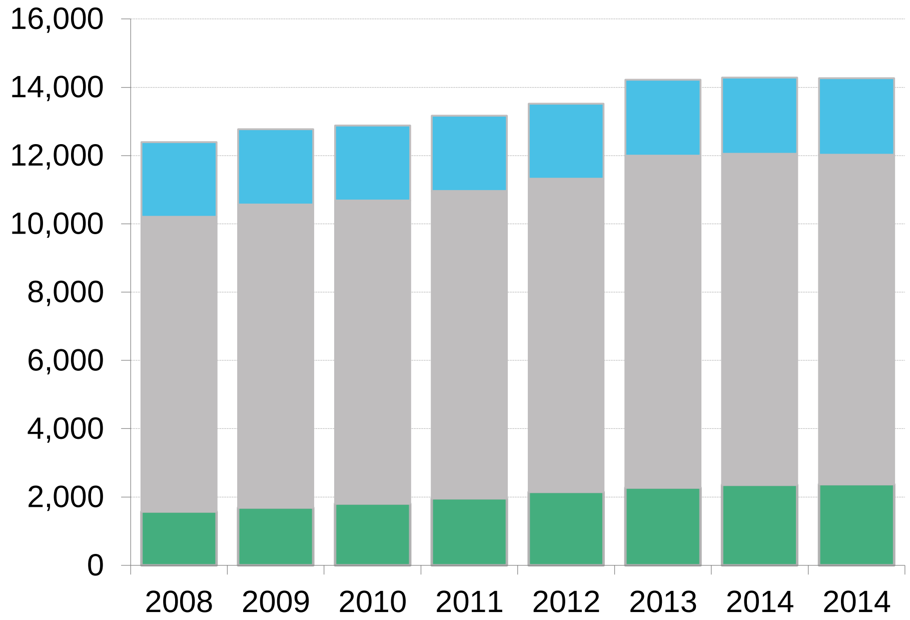
Annual build (MW)



Cumulative capacity (MW)



- Bioenergy build has tapered since 2013, when the Production and Investment Tax Credits spurred nearly 600MW of biomass installations. New biogas capacity has been declining since 2012, partially because low natural gas prices improved the competitiveness of natural gas generators.
- In 2016, the US installed 77MW of biomass and 54MW of biogas. The US installed no new waste-to-energy plants in 2016, following the construction of the 85MW Palm Beach Renewable Energy Facility Unit 2 in 2015. 10 small bioenergy units (totaling 39MW) retired in 2016.
- Other developed countries, such as the UK, have more supportive policies that have promoted installing waste-to-energy plants: in 2015 alone, England installed five new facilities totaling 180MW in electrical generating capacity and 70MW of export steam capacity.

Source: Bloomberg New Energy Finance, EIA, company announcements Notes: Biomass Includes black liquor. Biogas category includes anaerobic digestion (projects 1MW and above except wastewater treatment facilities) and landfill gas power. 2016 results include historical installs through November, planned build thereafter.

Financing: US bioenergy asset finance

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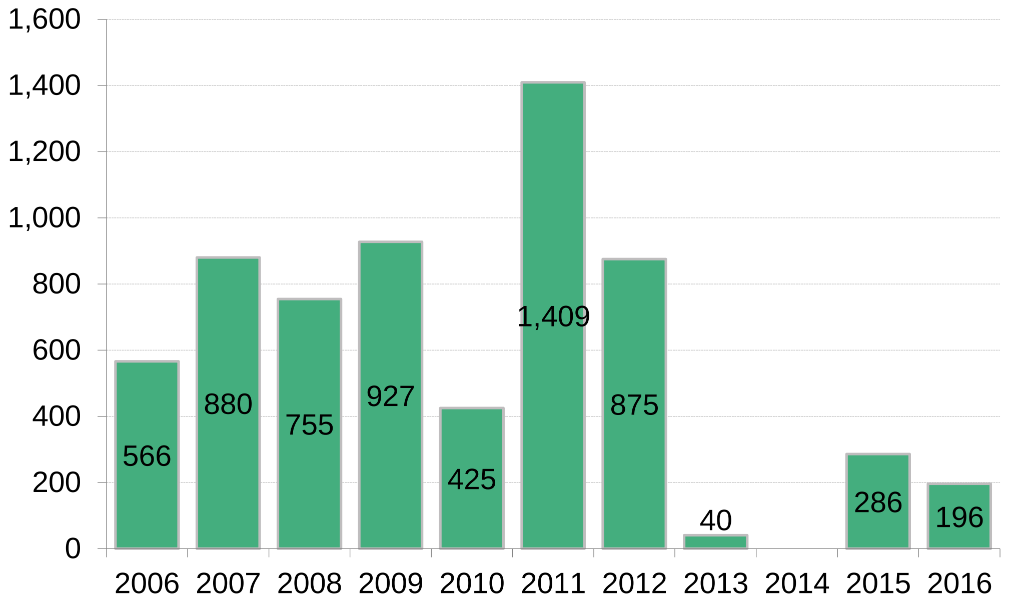
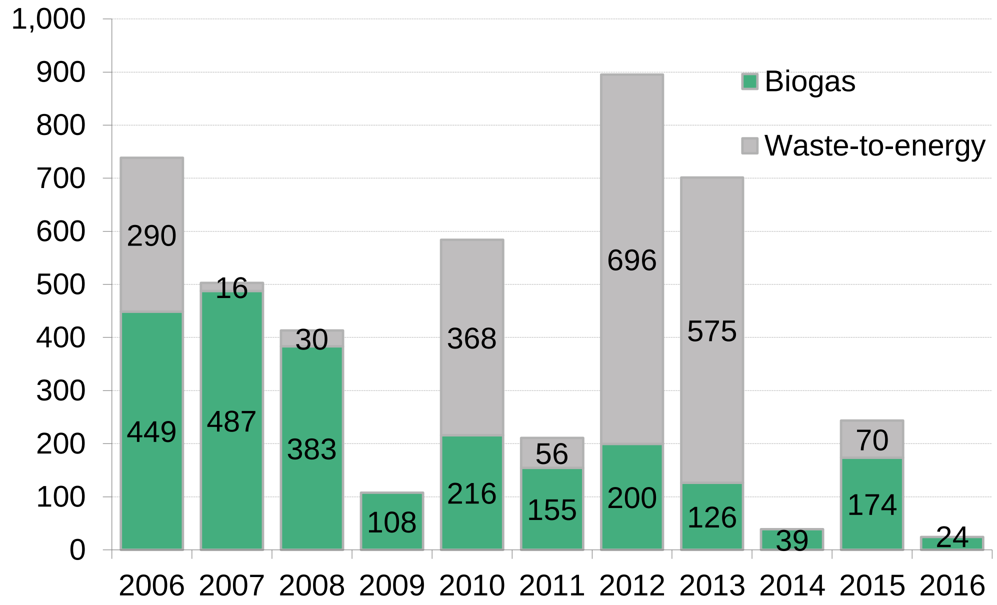
Asset finance for US biomass ($m)



Asset finance for US biogas and waste-to-energy ($m)



- Asset finance for new-build biomass dropped in 2016 to $196m, all of which was associated with one project: the US Army's 50MW Schofield Barracks biomass plant in Hawaii, which is expected to be commissioned in 2018. Biogas received $24m, which went towards the CR&R Perris biomethane plant in California. There was no financing reported for waste-to-energy.
- The largest waste-to-energy (WTE) deals in recent years were the $677m in financing secured in 2012 for the Palm Beach Biomass Plant Facility Unit 2, and the $575m that went towards the Energy Answers Fairfield plant in 2013. Financing for WTE has been muted in the past three years, with only the 25MW Constellation Hyperion plant receiving $70m in 2015.
- Low levels of investment from 2013-2016 continue to suggest relatively low new build for the next few years. Plants take two to four years to complete construction and be commissioned; investment acts as a leading indicator for capacity.

Source: Bloomberg New Energy Finance, EIA Notes: Biomass category includes black liquor. Biogas category includes anaerobic digestion (projects 1MW and above except wastewater treatment facilities) and landfill gas power. Waste-to-energy includes municipal/industrial waste. Values are nominal and include estimates for undisclosed deals.

Economics: Biomass feedstock prices; biogas and waste-to-energy capex

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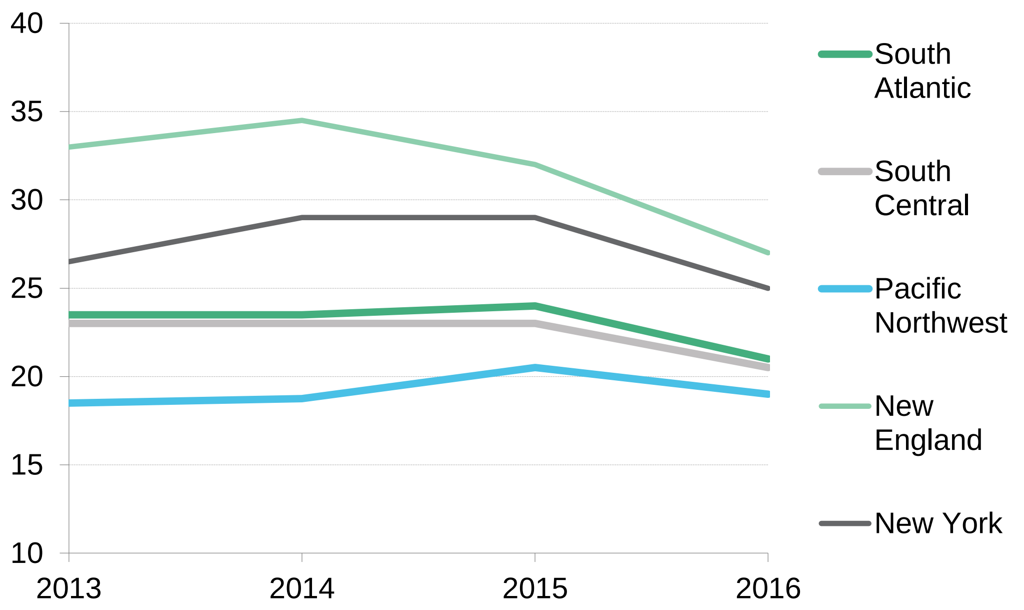
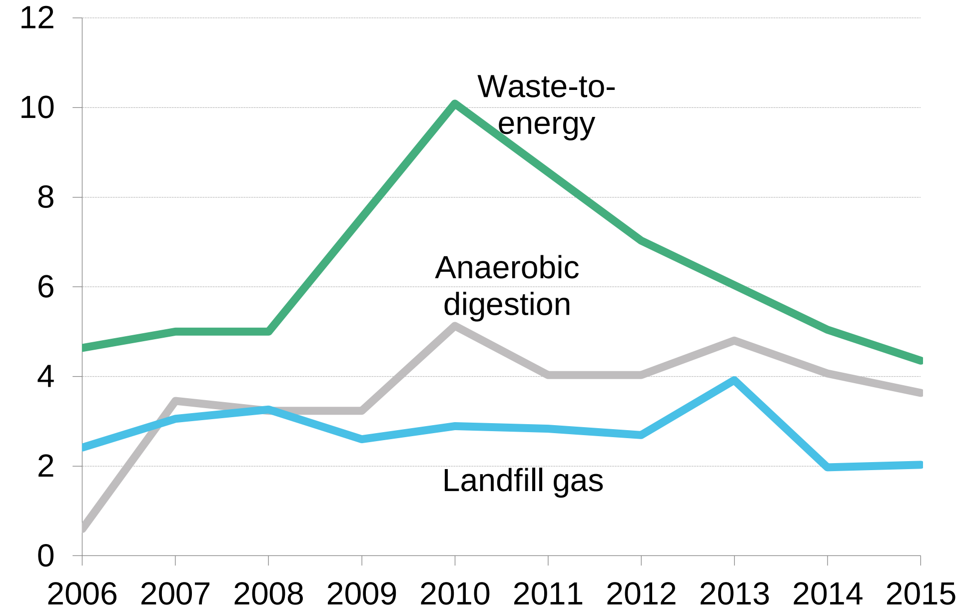
Biomass feedstock prices in selected US markets, 2013–16 ($/green ton)



Capex for biogas and waste-to-energy projects by type ($m/MW)



- Biomass feedstock prices in 2016 fell across the country, by as much as 16% in New England and 14% in New York. Price movements were more muted in the Pacific Northwest, which saw declines of 7%.
- Capex for waste-to-energy and anaerobic digestion decreased slightly in 2015. Annual changes in these figures can be strongly influenced by costs in individual projects since there are relatively few projects under development in biogas and waste-to-energy at any given time.

Source: Bloomberg New Energy Finance, US Department of Agriculture, EIA, RISI

Notes: Prices are nominal. Biogas category includes anaerobic digestion (projects 1MW and above except wastewater treatment facilities) and landfill gas power.

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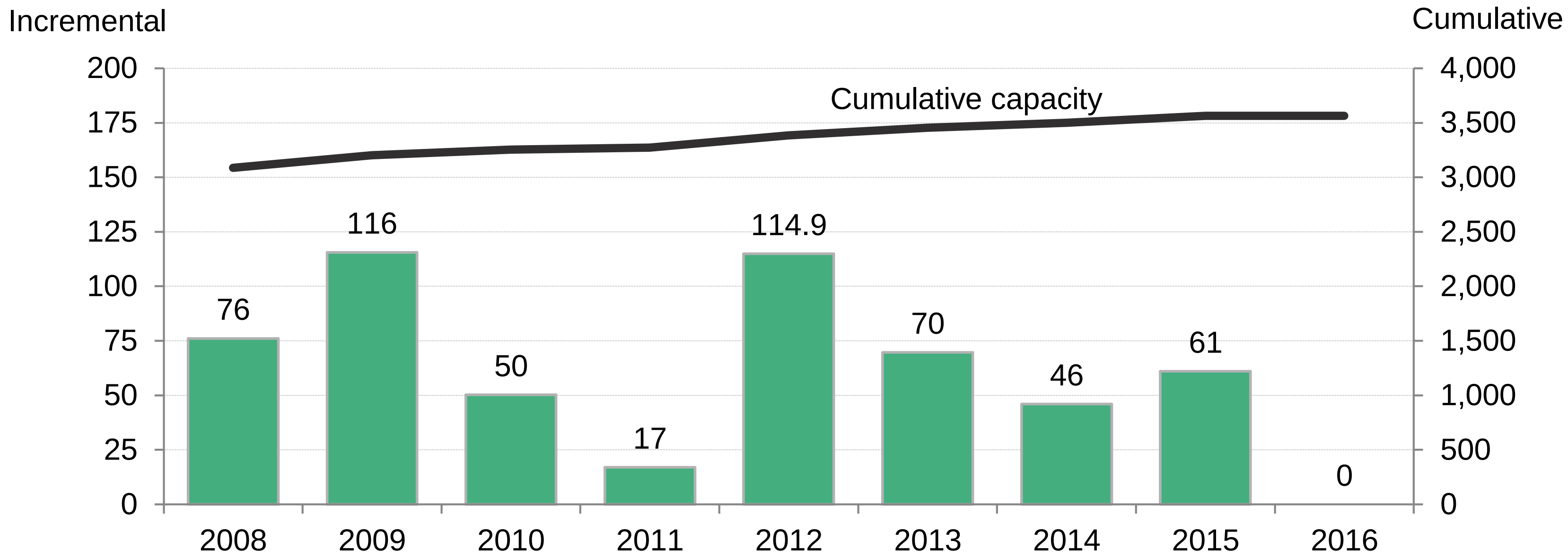
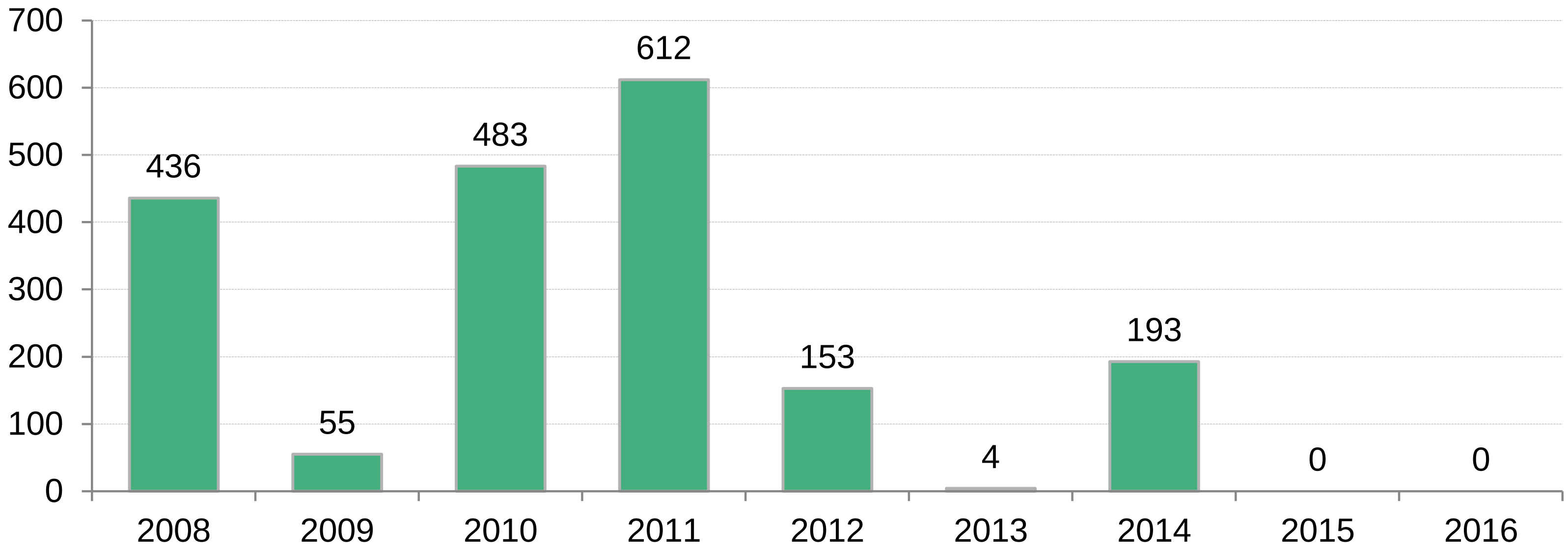
Deployment: US geothermal build (MW)



- New US geothermal build lags behind that of other renewables due to long project completion periods (4-7 years), high costs of development, and lack of policy support. All this has contributed to a dearth of geothermal development, with no new projects commissioned in 2016. Further, only one project, Cyrq Energy's Soda Lake 3, moved forward with development after awarding an engineering, procurement and construction (EPC) contract to Ormat.
- However, 2016 also brought new hope for the sector – the Bureau of Land Management auctioned off new geothermal land leases in Nevada, Utah and Oregon. In Nevada, 14 of 22 leases cleared – with Ormat snapping up the majority. In addition, a new lease was granted to develop capacity in California's Salton Sea. These new leases for development could replenish the pipeline for geothermal projects in the US.
- The majority of activity has been from experiment with hybridization – the use of another technology alongside geothermal to enhance the overall performance of the plant. Two such facilities are operated by Enel Green Power North America, Inc. (EGP-NA). The first is at its triple-hybrid Stillwater plant in Nevada, where the company in 2015 commissioned a new solar thermal component that had been added to its existing photovoltaic and geothermal hybrid. The second project took place at EGP-NA's existing Cove Fort geothermal power plant in Utah, where the company in 2016 commissioned a hydroelectric generator newly added to an injection well.

Source: Bloomberg New Energy Finance

Financing: Asset finance for US geothermal projects ($m)

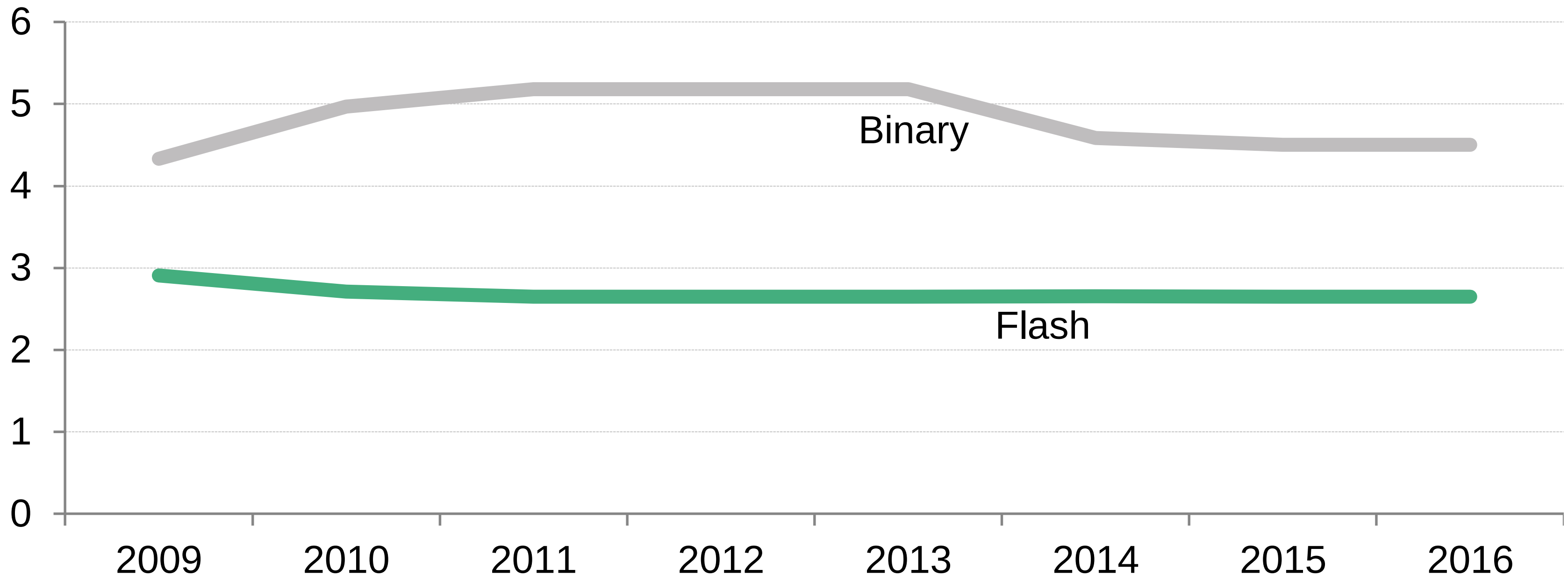


- With the lack of additional projects moving forward, 2016 was the second year in a row without new asset financing for US geothermal projects.
- One project, Ormat's Don A Campbell Phase II in Nevada, was refinanced in 2016. Ormat raised USD 44m in equity as Northleaf Capital Partners bought a 36.75% stake, and another USD 55m in debt from bond issuance.
- The US Department of Energy also awarded $29m for research into enhanced geothermal systems, which would use hydraulic fracturing to stimulate geothermal resources in areas which have less water, heat or permeability. Sandia National Laboratories and the University of Utah will undertake this research.

Source: Bloomberg New Energy Finance

Notes: Values include estimates for undisclosed deals and are in nominal dollars.

Economics: Capex for geothermal projects by type ($m/MW)



- With no new projects commissioned in 2016, there are no updates to the capex for geothermal projects in the United States.
- Globally, the levelized cost of electricity from binary power plants, which produce electricity from cooler reservoirs, has declined in 2016. Geothermal projects in the US and abroad are increasingly employing binary technology, and this focus has driven down the cost of developing such projects.
- Ultimately, binary remains more expensive than flash or steam technologies – which target higher-temperature resources.

Source: Bloomberg New Energy Finance Notes: values are in nominal dollars.

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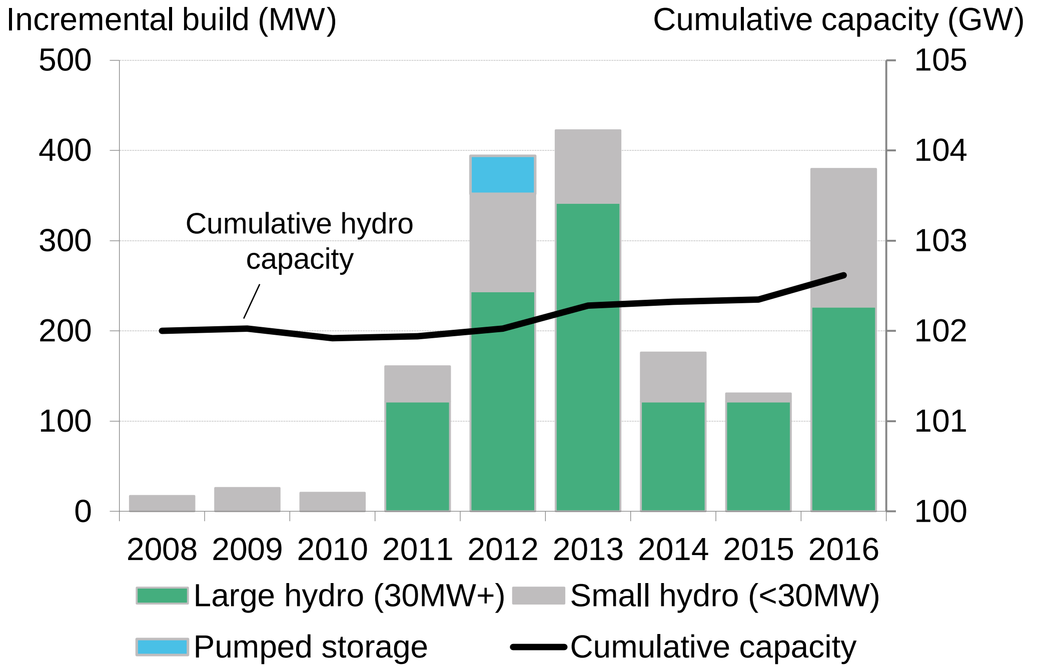
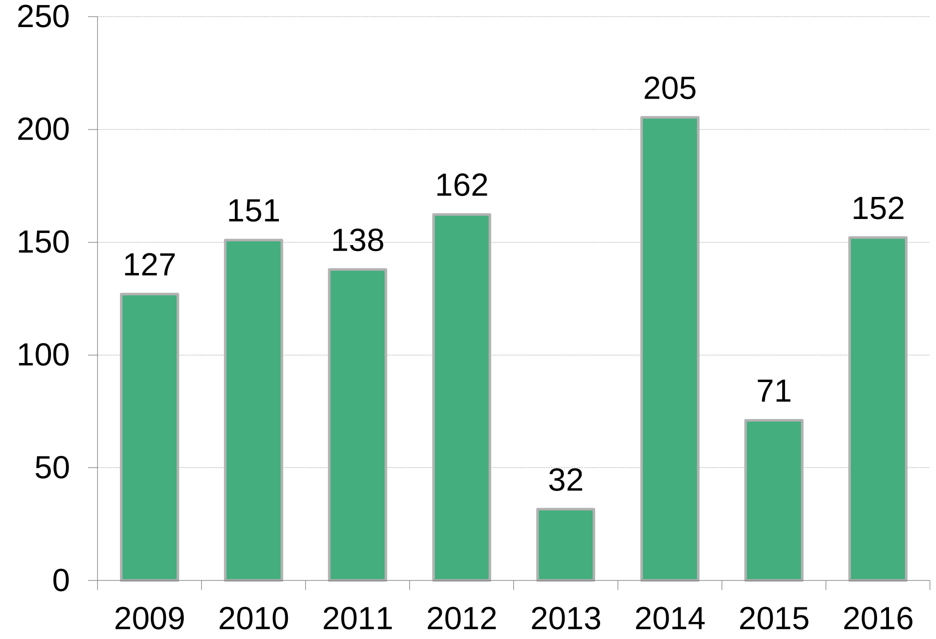
Deployment: US hydropower build and licensed capacity

Bloomberg NEW ENERGY FINANCE

US hydropower



US new hydropower capacity licensed or exempted by FERC (MW)



- New commissioned capacity in hydropower jumped in 2016 after a two-year lull. Although the largest single hydroelectric generator installed was tied to a dam repair effort (the 120MW Wanapum unit in Washington), 2016 also featured two of the first substantial greenfield projects in some years: the 105MW Meldahl Hydro Project and 88MW Cannelton Hydro Project, both on the Ohio River in Kentucky.
- Most new development is focused on unlocking the potential in existing non-powered dams. According to the Department of Energy, the largest 100 such dams could offer as much as 8GW.
- Hydro projects that began construction before the end of 2016 were able to claim PTC eligibility. FERC approved licenses or exemptions for 152MW through October 2016.

Source: Bloomberg New Energy Finance, EIA
Notes: 2016 data are as of end-November 2016.

Source: Bloomberg New Energy Finance, FERC
Notes: The licensing figures exclude pumped storage licenses. 2016 data are as of October 2016.

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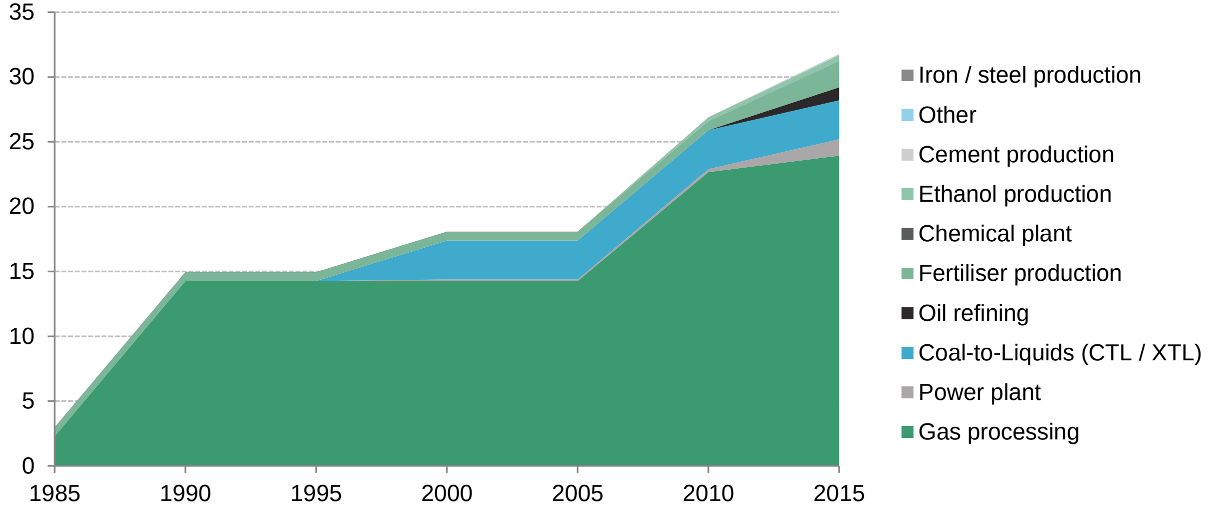
Bloomberg NEW ENERGY FINANCE

Deployment: Cumulative CO_2 captured by source within the US (MtCO2/year)

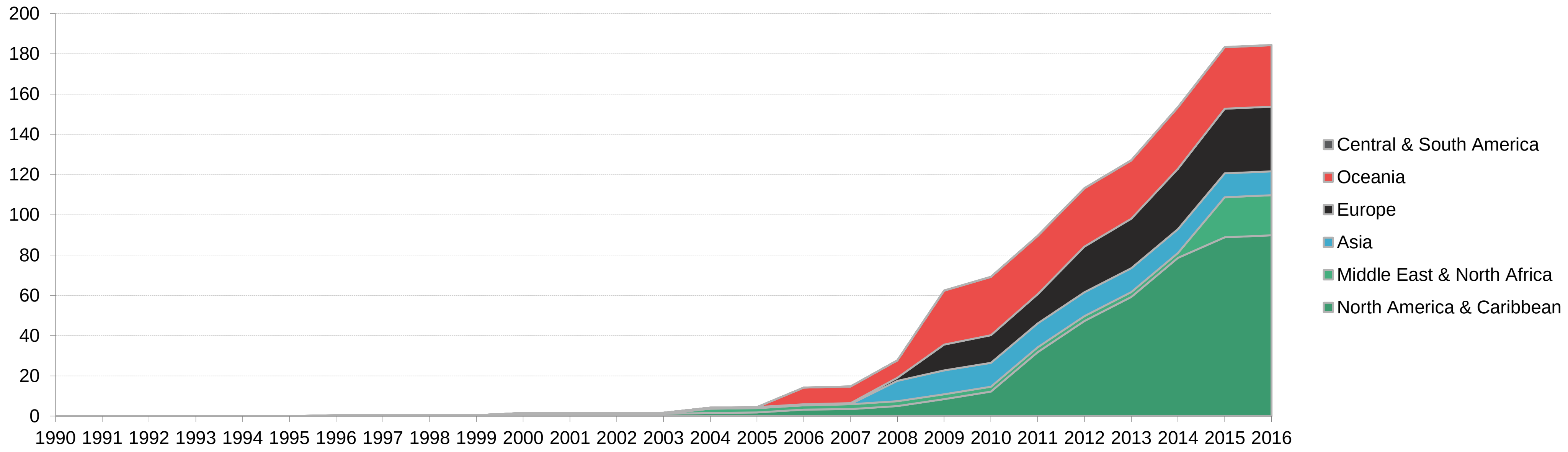


- There are more than 60 integrated CCS projects in the US, 30 of which are operational. Overall, 38 projects are intended to send CO_2 towards enhanced oil recovery (EOR). Most operational US CCS projects are at natural gas processing facilities. China has more than 25 integrated CCS projects, eight of which are operating. 12 of those in China are intended to send CO_2 for EOR or methane recovery.
- No new CCS projects for power generation passed final investment decision in 2016. The PetraNova CCS plant, at the W.A. Parish Generating Station near Houston, Texas, came online in January 2017. It will capture CO_2 from a 240MW flue-stream. Mississippi Power's 563MW Kemper project in the US will begin CCS operations in the coming months. The utility has faced problems with cost overruns and delays through construction—costs were first estimated at under $2bn for the plant and carbon capture, but this has since risen to $6.7bn. The developers initially expected to commission the plant in 2015. The problems have to do with the complexity of building a large project, rather than with CCS-specific concerns.
- The most positive development in 2016 for CCS occurred in Abu Dhabi, for the Al Reyadah steel plant. The project is designed to capture 0.8MtCO2 a year for EOR. In addition, Norway announced plans for the first large-scale industrial CCS project that will create a CCS hub delivering CO_2 from an ammonia plant owned by Yara, a cement plant owned by Norcem and a waste-to-power plant in Oslo. The carbon will be captured for offshore storage.
- World-wide prospects for CCS look quite limited at this time. The funding gap is still too high and levels of government support or other revenue streams (eg, avoided cost of carbon or enhanced oil recovery) are still not enough to bridge it. This could change if more public funding was announced, mandates for coal and carbon capture were implemented or if carbon prices rose to the $50–100/t$CO_2$ range. Some emissions pricing initiatives that are in the works hold some promise for helping to close the funding gap – for example, Canada is establishing a national carbon tax that will reach CAD 50 by the early 2020s, and China is introducing a national carbon market in 2017.

Source: Bloomberg New Energy Finance

Financing: Asset finance for US CCS projects that passed post-financial investment decision, by region ($m)

Bloomberg NEW ENERGY FINANCE



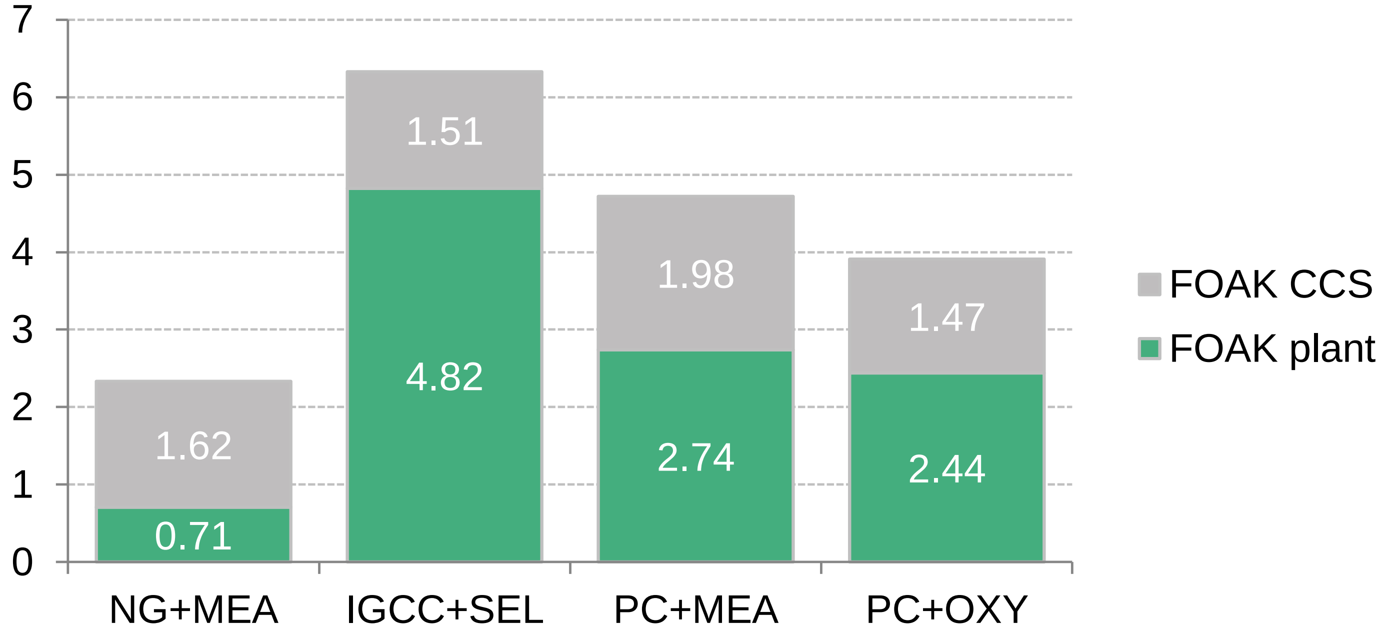
- There was no new investment for large US projects in 2016. Cumulative investment in CCS has been flat for a second year at just over $180bn.
- CCS projects have high costs and only a small number of projects have been financed, although minimal levels of research and development continue. China has developed a wide range of pilot projects targeting both power and industrial sources of CO2. Norway is progressing with preparations for a full-scale industrial CCS project that will use ships for CO2 transportation.
- From 2007-2016, 49% of global asset finance into CCS occurred in the US.

Source: Bloomberg New Energy Finance

Notes: Includes demonstration and commercial scale projects (projects above 100MW or 1MtCO2/yr) post-final investment decision only. Values do not include estimates for undisclosed deals and are in nominal dollars.

Economics: Estimated first-of-a-kind (FOAK) capital cost for CCS projects ($m/MW)

Bloomberg NEW ENERGY FINANCE



- First-of-a-kind (FOAK) costs are much higher than 'mature' costs.
- Deployment in the tens of GWs may be needed to bring down technology costs, so 'mature' costs do not necessarily represent the best estimates of FOAKs.
- Globally, no new large-scale power-related projects came online in 2016. One large-scale project linked to steel manufacturing did commission – the one associated with the Emirates Steel Industries' Mussafah plant in the UAE.

Source: Bloomberg New Energy Finance

Notes: Based on same analysis as in 2014/15 Factbook. Costs are based on 250MWe base plant and capture. NG+MEA refers to natural gas combined-cycle plants with post-combustion (amine) capture; IGCC+SEL refers to integrated gasification combined cycle plant with pre-combustion (Selexol) capture; PC+MEA is pulverized coal with post-combustion (amine) capture; and PC+OXY is coal oxycombustion plant with cryogenic CO2 capture.

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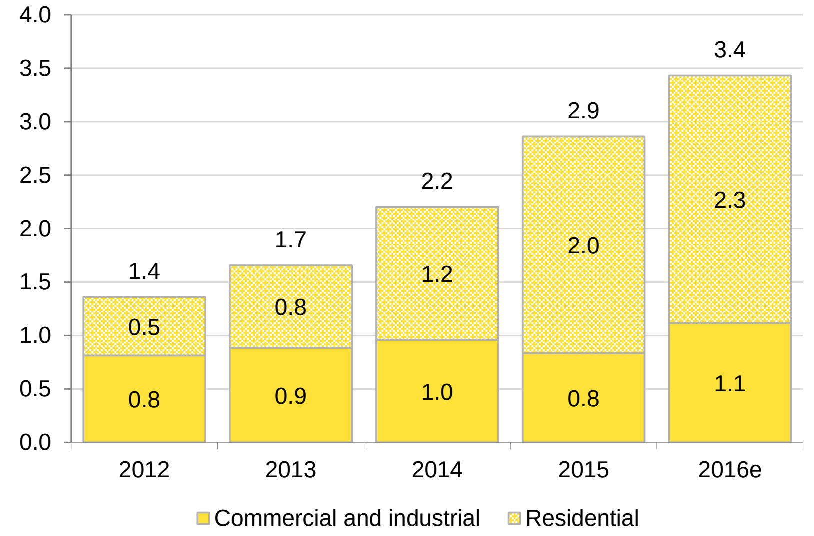
Bloomberg NEW ENERGY FINANCE

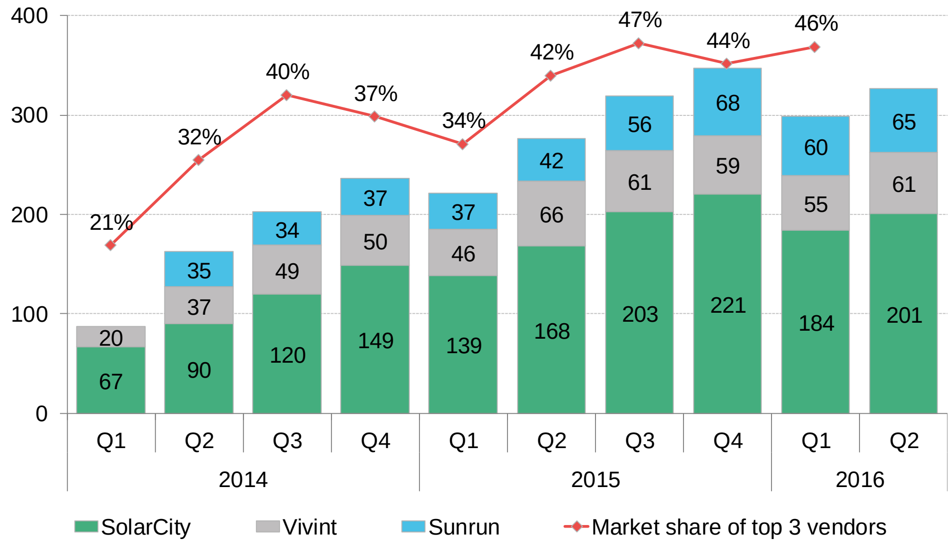
Deployment: US small-scale solar build by type (GW)

Bloomberg NEW ENERGY FINANCE

Annual US residential and C&I PV build, 2012-2016 (GW)



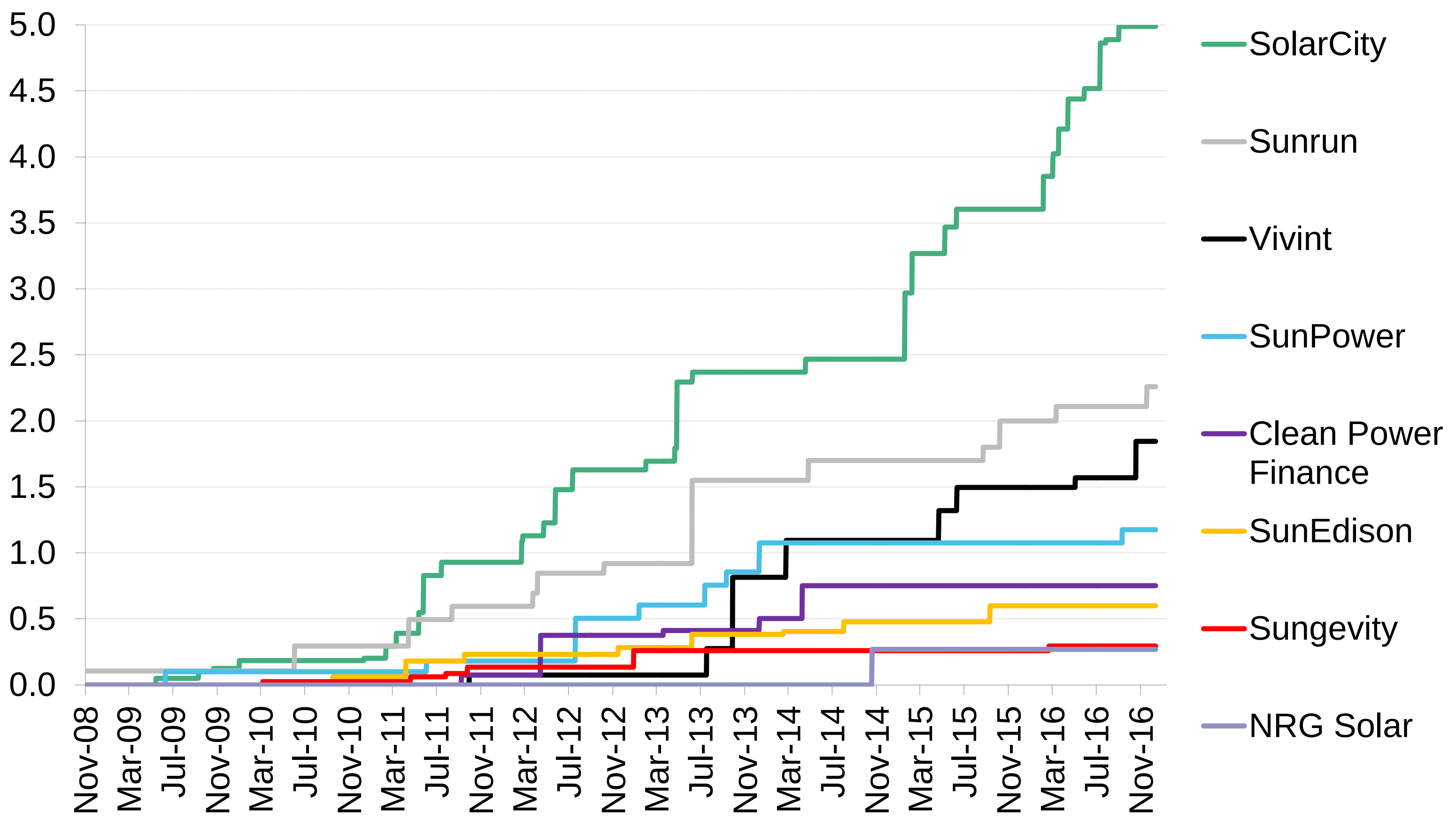
Quarterly installations of top three residential PV vendors, Q1 2014-Q2 2016 (MW)



- The small-scale PV markets achieved yet another record in 2016, installing approximately 3.4GW of solar capacity for US homes and businesses. 12 states experienced more than a 100% growth in residential PV build, based on estimated end-year 2016 numbers.
- However, the markets are giving early indications of a transformation. The residential PV market is evolving in response to the endless onslaught of net metering proceedings and saturation effects in the more mature markets. Vendors and installers are looking beyond California and the Southwest to find new growth opportunities.
- The C&I market is finally showing signs of sustainable growth, with increasing activity both onsite and offsite. The rooftop C&I market has been slow to develop, but offsite corporate procurement has given US businesses a menu of solar options.
- Small-scale PV uptake is supported by compelling economics – it benefits from the falling technology costs of utility-scale solar, but competes against premium retail electricity rates. There is also a secondary, behavioral driver, in which more households become open to considering small-scale solar as more households and businesses install it.

Source: Bloomberg New Energy Finance Note: 2016 US residential and C&I PV build figures are estimated.

Financing: Cumulative funds closed by selected US third-party PV financiers ($bn)



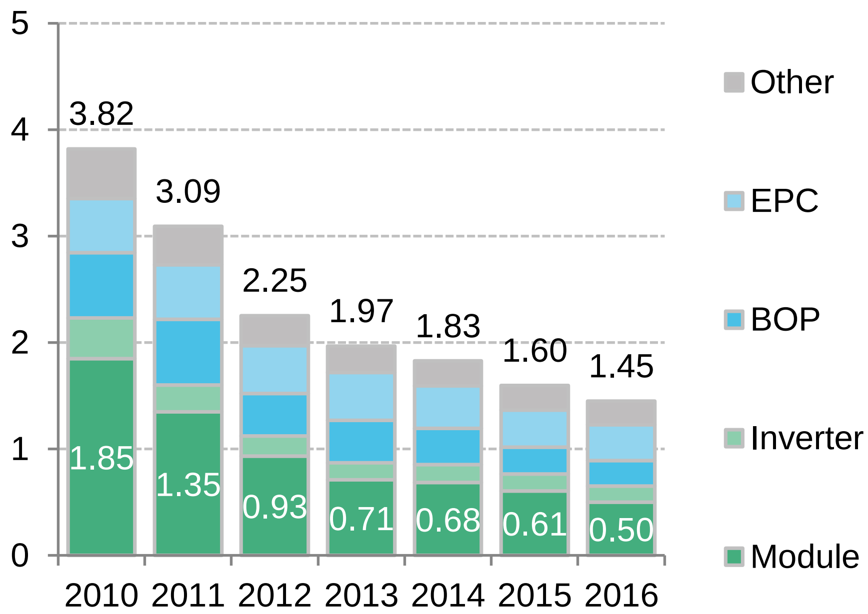
- In 2016, tax equity funds totaled an estimated $2.13bn, eclipsing the $1.96bn raised in 2015. Only SolarCity, Sunrun, Vivint, SunPower and Sungevity raised capital, with SolarCity responsible for nearly $1.4bn of the total. SolarCity was officially acquired by Tesla on 21 November 2016.
- To start off 2017, Spruce Financial, a residential solar and efficiency financing firm, raised $200m. Vivint's tax equity fund also raised a further $100m.

Source: Bloomberg New Energy Finance

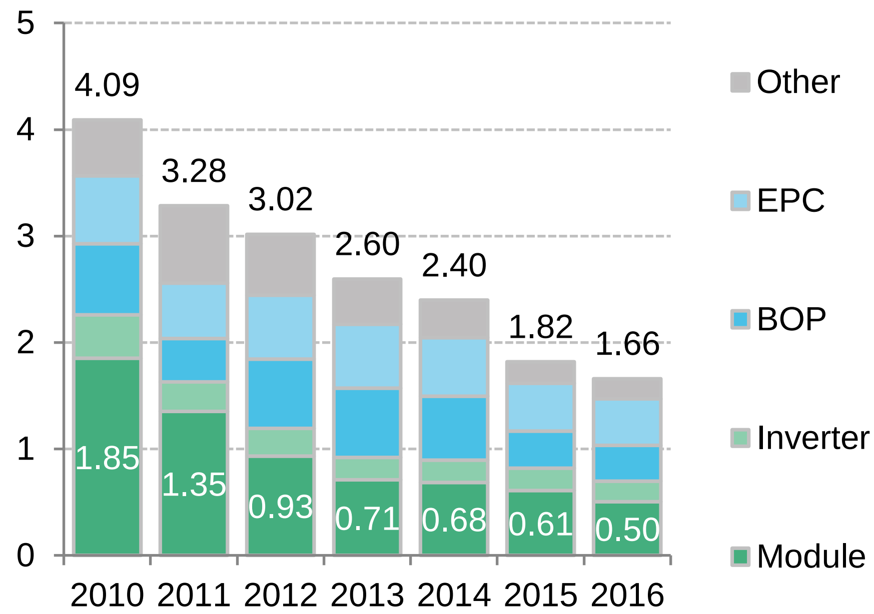
Notes: This represents fund size; actual capital invested is lower and non-public. Data is from publicly available documents and submissions from investors; this figure does not capture any undisclosed deals. Each fund contains an unknown combination of equity, tax equity, or debt (or an absence of tax equity or debt). Vivint and Clean Power Finance totals include cash equity. Figures are nominal.

Economics: Best-in-class capex of small-scale solar (2015$/W)

Best-in-class global capex of commercial-scale PV



Best-in-class global capex of residential PV



- Capex for commercial-scale PV, according to the global benchmark, has declined to $1.45/W, driven largely by falling module prices and declines in ‘balance of plant’ (BOP) costs. Capex for residential PV continues to experience strong declines as well on a global basis.
- The values shown here reflect best-in-class benchmarks for PV in mature markets such as Germany. In the US, capex is often higher than the global benchmark for many reasons, such as fragmented regulatory regimes, the prevalence of third-party owned solar, longer build time, higher acquisition costs and greater profit margins.

Source: Bloomberg New Energy Finance

Notes: ‘EPC’ refers to ‘engineering, procurement and construction’; ‘BOP’ refers to ‘balance of plant.’ Figures are in real 2015 dollars.

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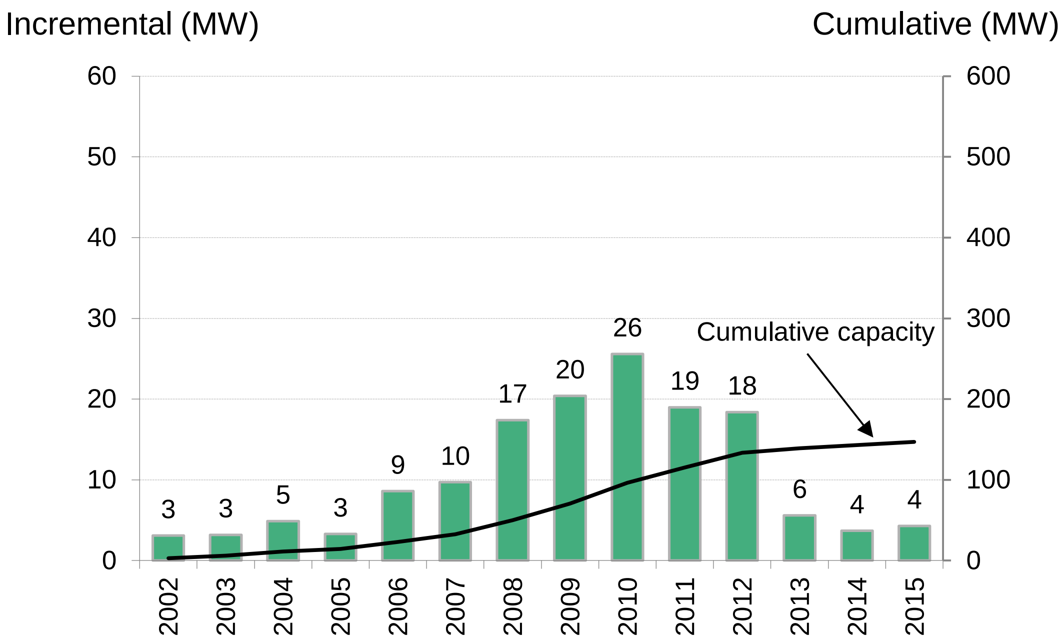
Bloomberg NEW ENERGY FINANCE

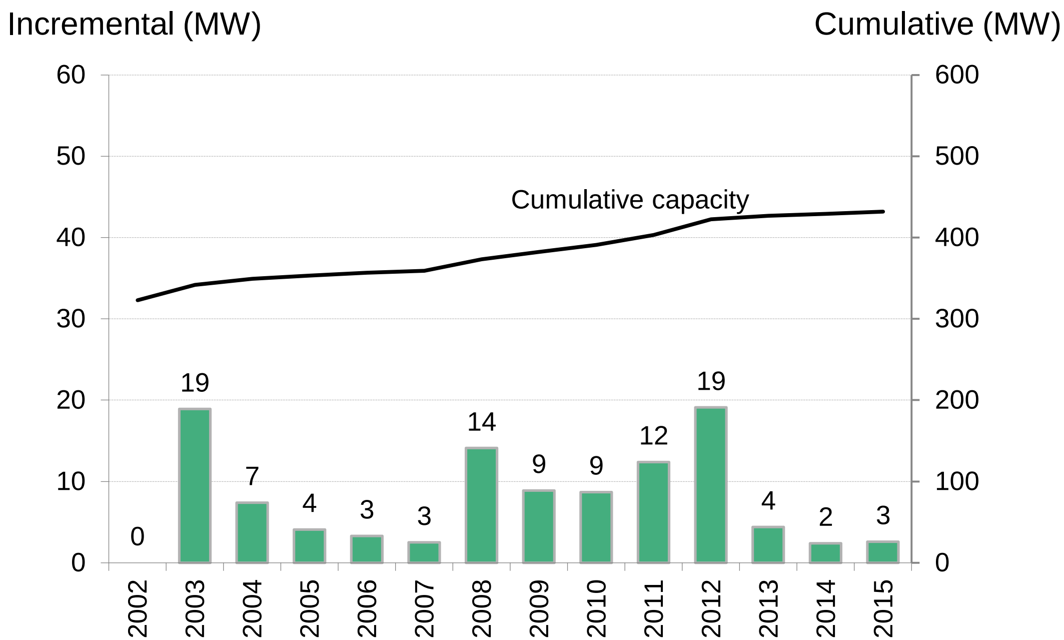
Deployment: US small- and medium-scale wind build (MW)

Bloomberg NEW ENERGY FINANCE

US small-scale (≤100kW) wind build



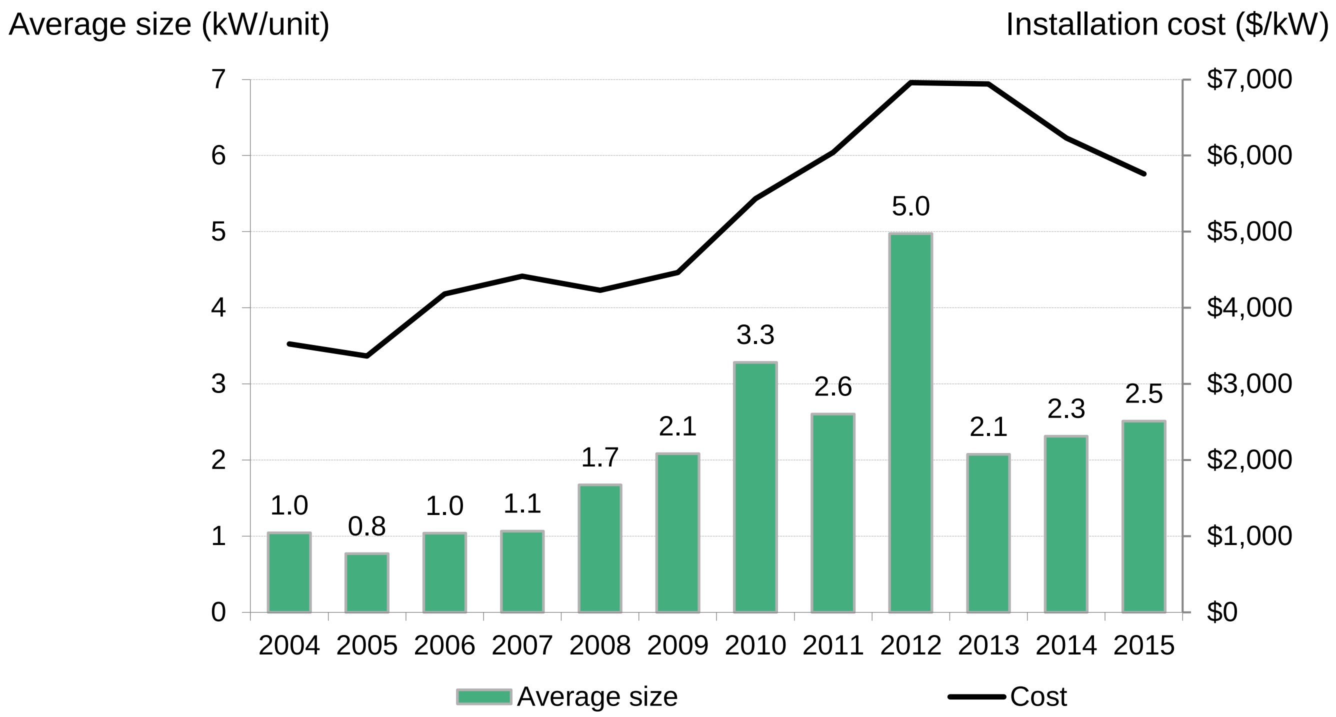
US medium-scale (101kW-1MW) wind build



- In 2015, total build for wind projects below 1MW in size remained limited, with 7MW commissioned. Small- and medium-scale wind deployment has been muted since 2012; capacity additions fell 70% for the small-scale and 77% for the medium-scale category from 2012 to 2013, and have remained low since.
- Cumulative capacity for small- and medium-scale wind thus only made minor advances to 147MW and 432MW, respectively, in 2015.

Source: US DOE 2015 Distributed Wind Market Report, published August 2016 (and previous editions of this report)

Economics: US small-scale (≤100kW) wind turbine average size and installation cost



- Through 2012, installation costs had risen as the average size of small-scale wind turbine installations climbed. In 2013, costs flatlined as the average size fell by more than half compared to the previous year and capacity additions dropped. In 2015, out of contracts for 1,713 units for distributed wind, 1,695 were for units up through 100kW.
- Costs vary widely between projects depending on factors such as siting, available wind resource, tower height, obstructions in the area, etc.
- For 2013-2014, the average levelized cost of electricity for small-scale distributed wind installations was 12¢/kWh ($120/MWh). This dropped slightly in 2015, to 11¢/kWh ($111/MWh). The figure was calculated by the US Department of Energy in its report on distributed wind, using a sample size of 1.45MW from 73 projects in 2013-14 and 1.24MW from 50 projects in 2015.

Source: US DOE 2015 Distributed Wind Market Report, published August 2016 (and previous editions of this report). Note: Installation cost figures are nominal.

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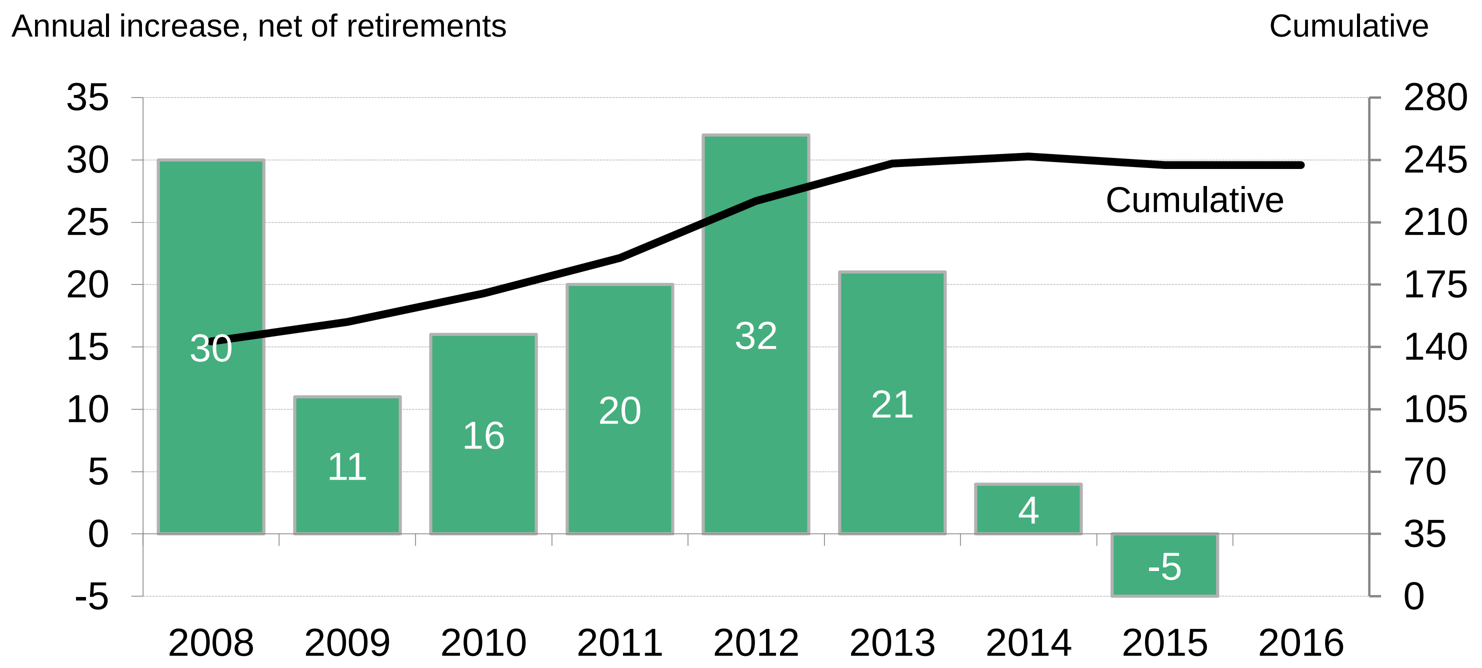
Bloomberg NEW ENERGY FINANCE

Deployment: US anaerobic digester operational projects at commercial livestock farms (number of projects)

Bloomberg NEW ENERGY FINANCE



- Growth of the small anaerobic digester market has stalled out, as more projects were retired (eight) than completed (three) in 2015. As of May 2016, no new projects had been completed for 2016, although three were under construction.
- Prior to 2014 (when seven projects were built), build ranged between 19-36 additions annually, partially offset by retirements.
- The falloff in installations from 2014-2016 likely reflects both a lag in reporting projects to the voluntary EPA AgSTAR registry, and the fact that anaerobic digesters face high capital costs and competition from natural gas. This competition intensified as natural gas prices touched 18-year lows in 2015-16.
- Build in 2012-13 may also have been encouraged by state policies such as the inclusion of anaerobic digestion within North Carolina's RPS and the launch of the California cap-and-trade program in 2013, which accepts offset credits from livestock methane projects.

Source: US EPA AgSTAR program

Notes: Columns show annual net increase (accounting for retirements). Data as of May 2016 (release date of the most recent EPA AgSTAR registry).

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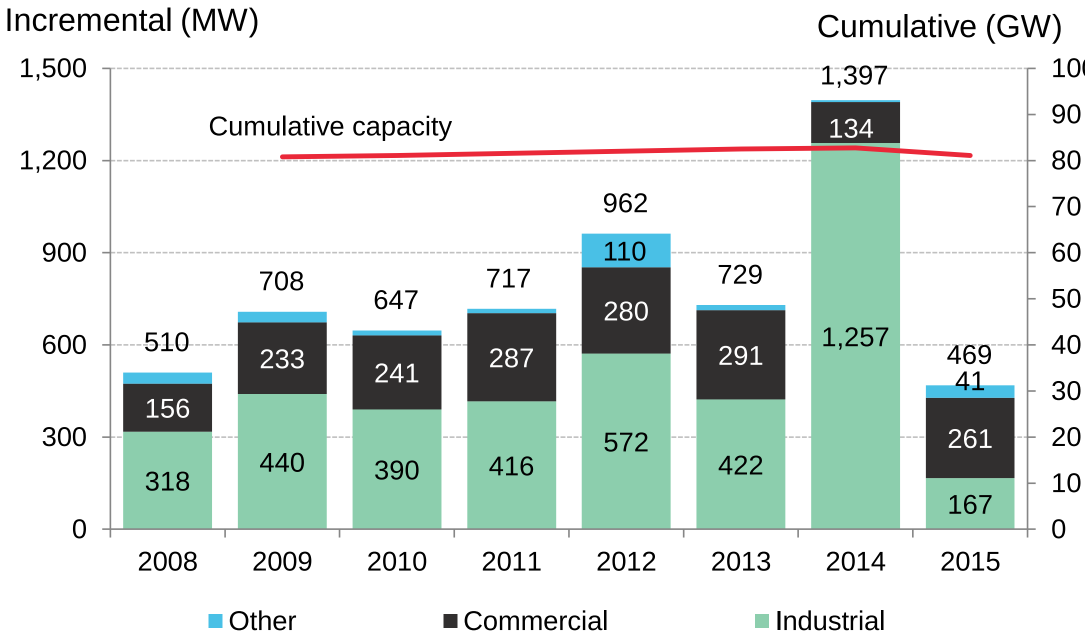
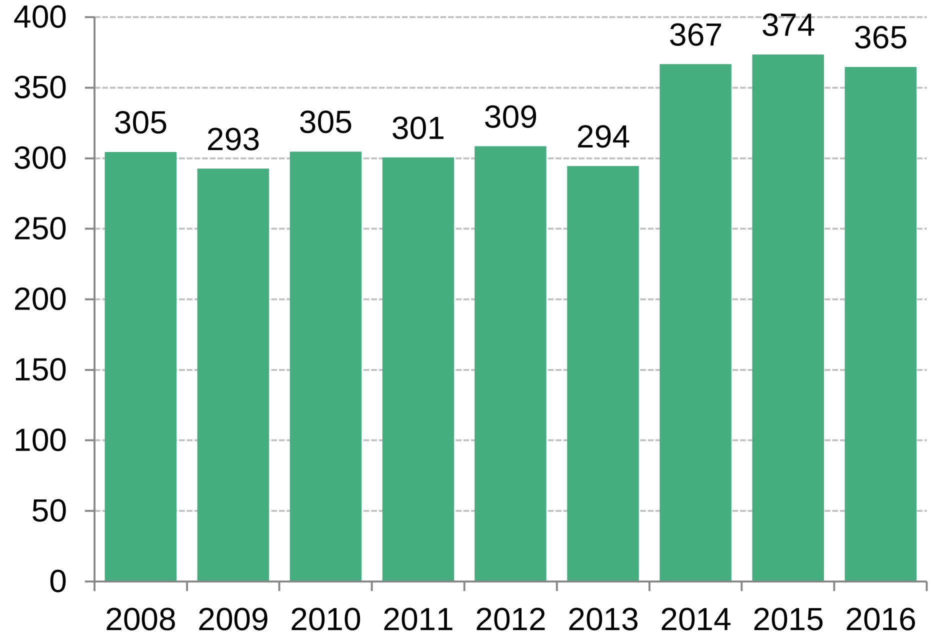
Deployment: US CHP build and generation

US CHP build (MW) and capacity (GW)



US CHP generation (from plants tracked by EIA generation data) (TWh)

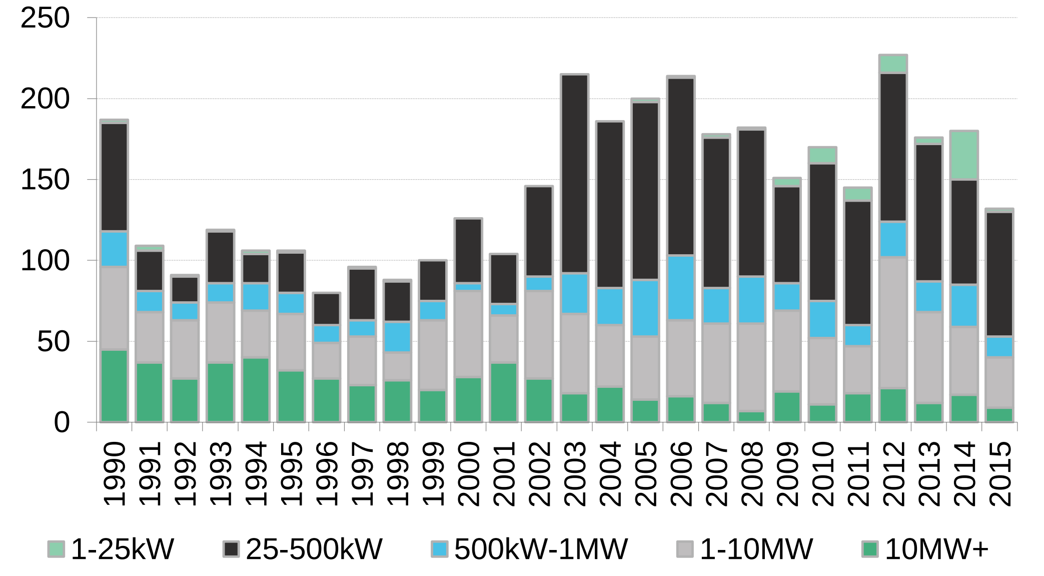


- Installations sunk in 2015 to 469MW, following a 2014 peak of 1,397MW. The drop-off came on the back of a 87% year-on-year decline in industrial installments.
- Cumulative capacity for CHP dipped from 82.7GW to 81.1GW due to site retirements and industrial plant closures.
- The exceptional CHP build in 2014 was accompanied by a corresponding uptick in generation, which persisted in 2015. 2016 generation is expected to remain close to the previous year’s level and contribute 9% of total US generation.
- Data may underestimate total CHP production because they do not reflect some newer installations, which tend to be smaller in size and excluded from EIA estimates (see notes below).

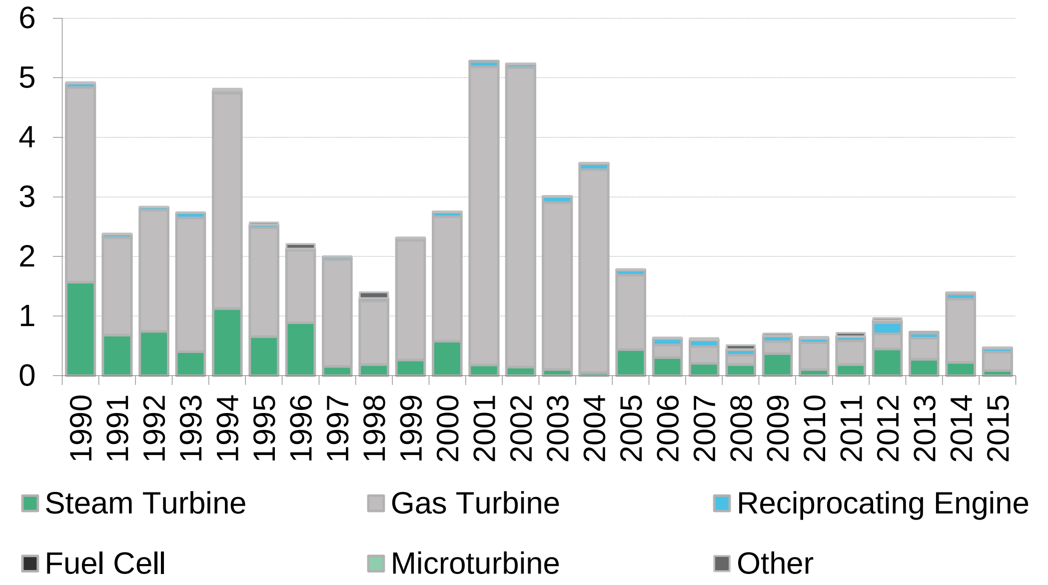
Source: Bloomberg New Energy Finance, DOE CHP Installation Database (maintained by ICF, Inc.) Notes: EIA is the best available source for generation data. However, EIA data on CHP is not comprehensive and so the generation figures are underestimated. Specifically, EIA does not collect data for sites <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 2016 are projected, accounting for seasonality, based on latest monthly values from EIA (data available through November 2016).

Deployment: US small-scale CHP build

US Annual CHP build by system size (# of projects)



US Annual CHP build by technology (GW)

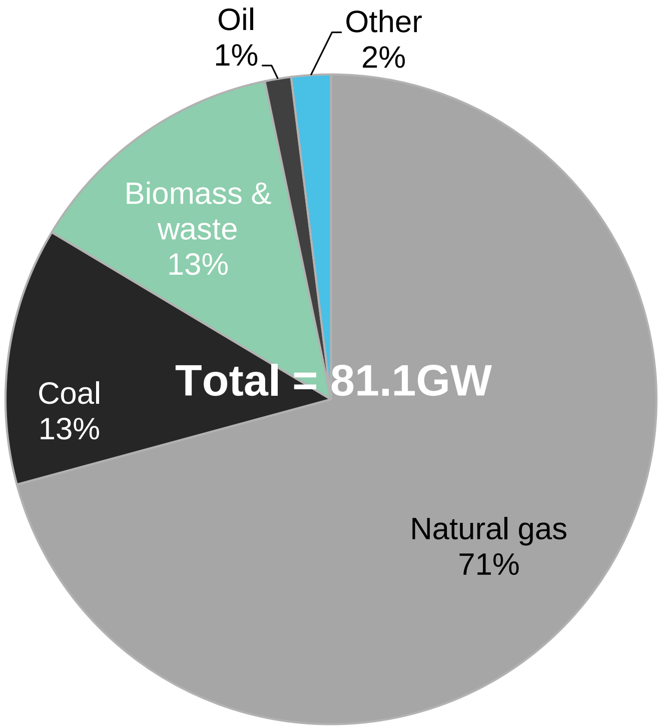


- In 2015, the average CHP system size continued to fall. Installations for both large systems (500kW-10MW) and small ones (1-25kW) failed to match the levels seen in 2014.
- While gas turbines were still the preferred technology for CHP build in 2015, its number of installations have dropped.

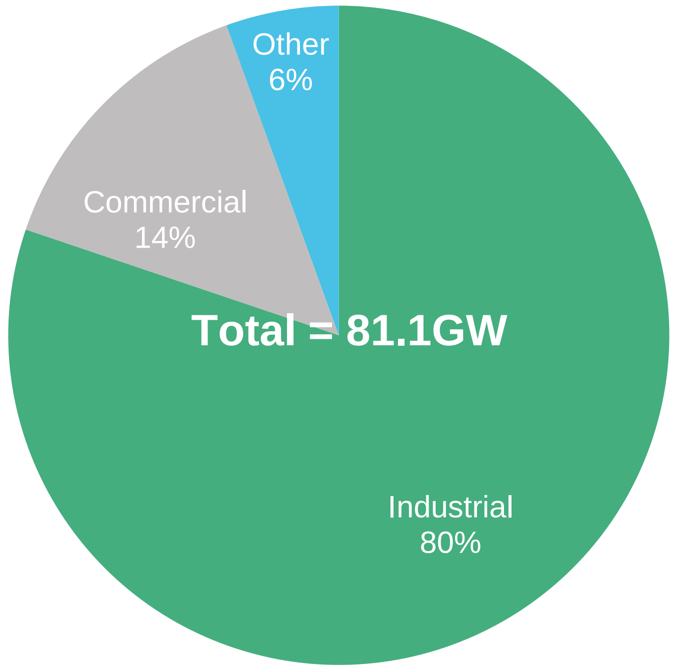
Source: Bloomberg New Energy Finance, DOE CHP Installation Database (maintained by ICF, Inc.)

Deployment: US CHP deployment by fuel and by sector, 2015

US CHP deployment by fuel source



US CHP deployment by sector



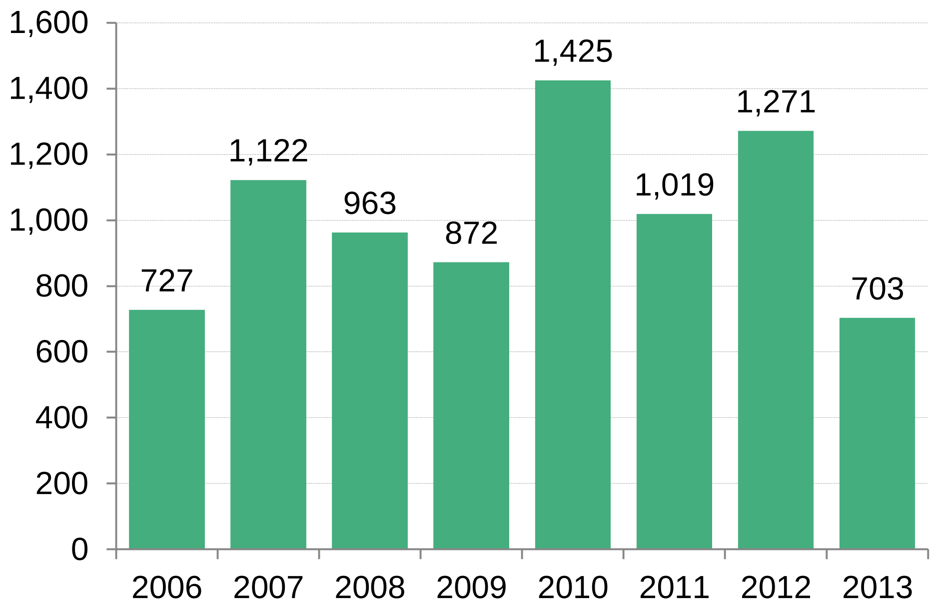
- Natural gas and biomass have taken small chunks of the market from coal, reflecting a broader transition away from coal-fired power. Natural gas remains the most popular source for cogeneration by far, representing 71% of installed CHP capacity.
- More broadly, growth across the CHP sector has also stalled: cumulative capacity has fluctuated around 82GW for the past five years.

Source: Bloomberg New Energy Finance, DOE CHP Installation Database (maintained by ICF, Inc.)

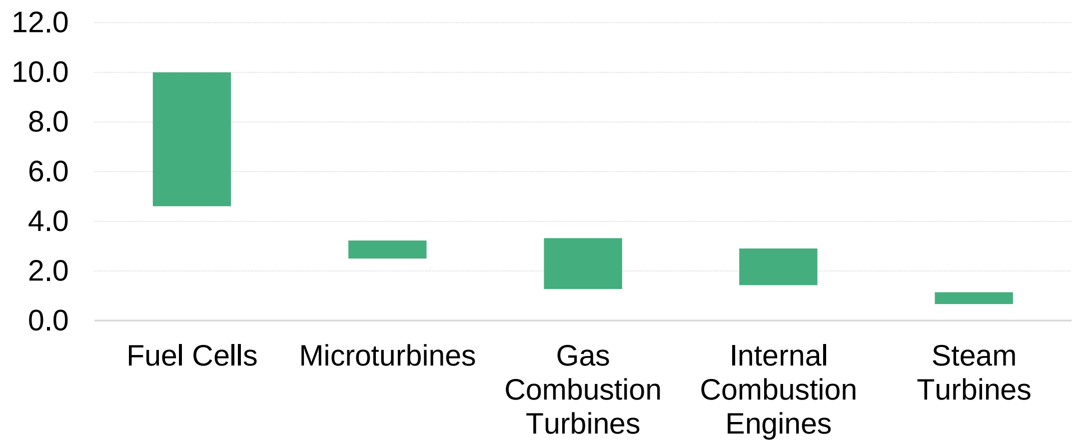
Financing and economics: US CHP asset finance and capex

Bloomberg NEW ENERGY FINANCE

Asset finance for US CHP ($m)



Capital cost of CHP by technology ($/W)



- Steam turbines, internal combustion engines and gas combustion turbines remain the cheapest to build.
- The price range of microturbines has continued to tighten.

Source: Bloomberg New Energy Finance, DOE CHP Installation Database (maintained by ICF, Inc.)

Notes: Values are estimated assuming a two-year lag between financing and deployment, and assuming a weighted average capex of $1.7m/MW in 2006, falling to $1.4m/MW by 2009, and then increasing to $1.5m/MW in 2010 to reflect a recent trend toward smaller systems. Financing figures are only available through 2013 since deployment figures are only available through 2015 (and there is an assumed two-year lag between financing and deployment). Values are in nominal dollars.

Source: Bloomberg New Energy Finance; EPA Combined Heat and Power Partnership, Catalogue of CHP Technologies, prepared by ICF, Inc.

Notes: ICF, Inc. 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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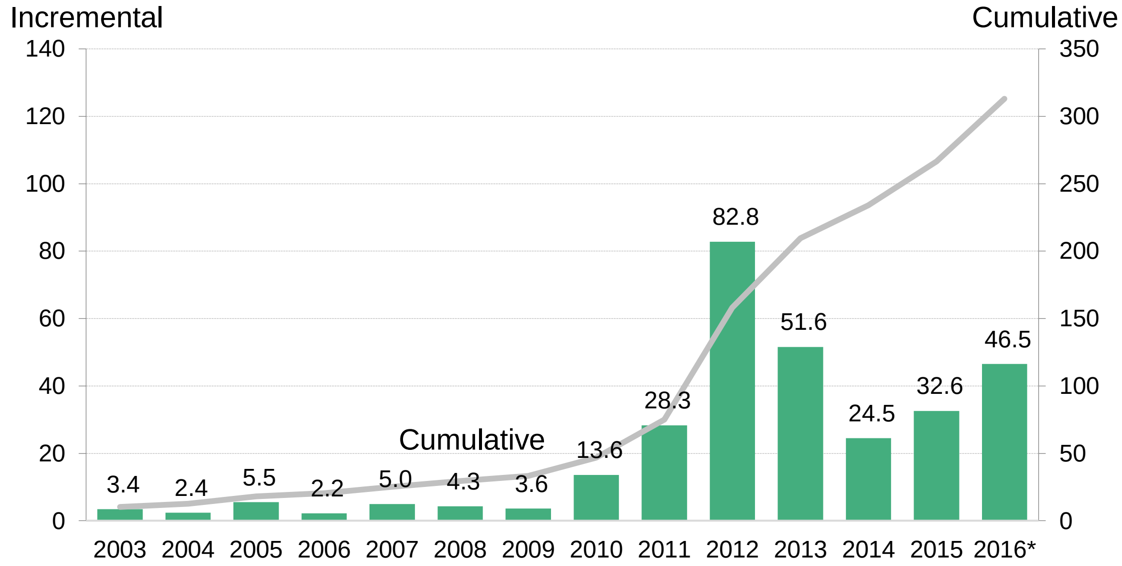
Deployment: Comparison of fuel cell technology performance and applications

Fuel cell technology	Typical system size (kW)	Fuel type	Electrical efficiency	Combined heat and power capable	Applications	Notable US vendors
Molten carbonate (MCFC)	300-3,000	Natural gas, hydrogen, biogas	45-50%	Yes	Distributed generation, utility	FuelCell Energy
Solid oxide (SOFC)	200-10,000	Natural gas, hydrogen, biogas	53-65%	Yes, but typically heat is used internally with the system to increase electrical efficiency	Distributed generation, utility	Bloom Energy, Edgewise Energy
Phosphoric acid (PAFC)	100-500	Natural gas, hydrogen, biogas	43%	Yes, up to 90% overall system efficiency	Distributed generation, utility	Doosan Fuel Cell America
Alkaline (AFC)	10-100	Hydrogen	60%	No	Military, space	
Polymer electrolyte membrane (PEM)	1-100	Hydrogen	35-60%	No	Backup power, distributed generation, transportation, telecom, material handling equipment	Plug Power, Altergy Systems, Nuvera Fuel Cells
Direct methanol fuel cell (DMFC)	<10	Methanol	<40%	No	Auxiliary power, telecom	Oorja Protonics, PolyFuel

Source: Bloomberg New Energy Finance, US Department of Energy, vendors

Notes: Most stationary fuel cells, regardless of fuel or chemistry, have capacity factors of 40-50% with over 99% availability. Fuel cells are scalable, and installation sizes can be very big; the sizes shown here are typical numbers and in some cases reflect product sizes.

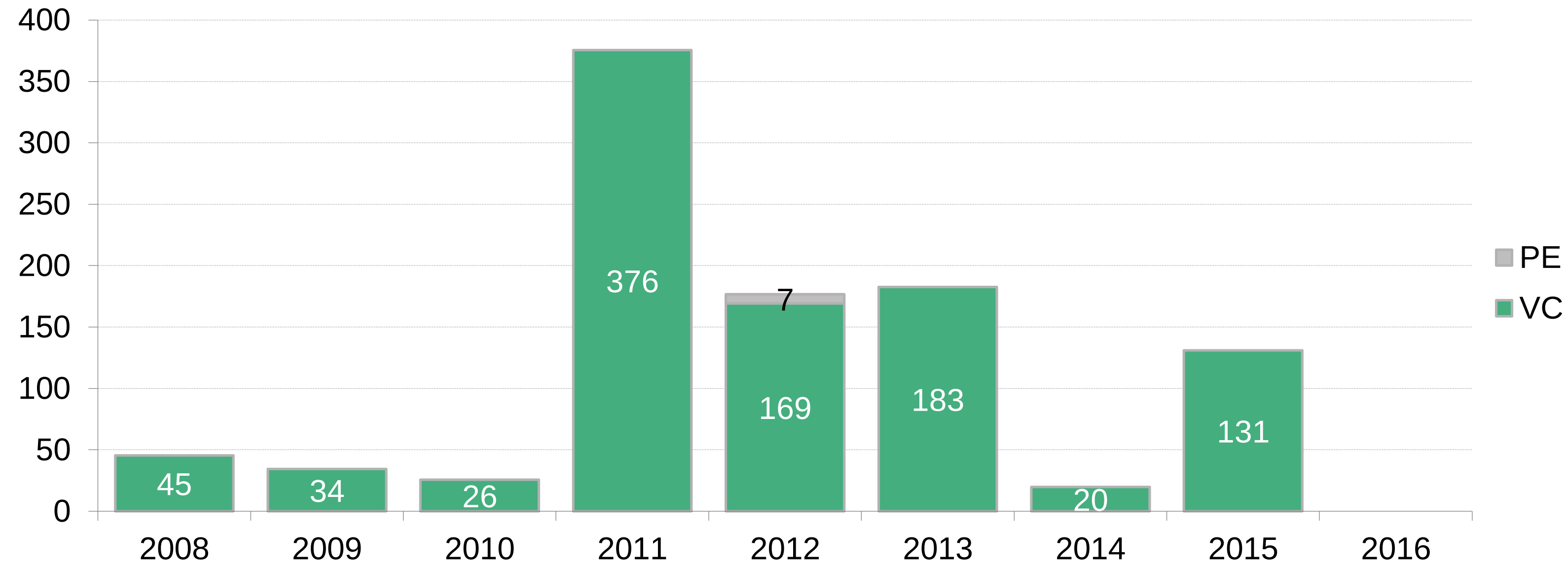
Deployment: US stationary fuel cell build (MW)



- The 30% ITC for fuel cells was not extended beyond 2016 as part of the December 2015 budget bill.
- Fuel cell technology in the US has seen a decline in annual installs since reaching an all-time high in 2012. Installations did, however, pick up between 2014 and 2016. Key developments in 2016 included:
  - Bloom Energy announced a strategic alliance with PowerSecure to deploy 50MW of Bloom's fuel cells at C&I sites through long-term PPAs with customers such as Home Depot.
  - FuelCell Energy's 63.3MW Beacon Falls Connecticut project with O&G Industries and CT Energy & Technology is due to be the largest fuel cell project in the US if completed. It did not secure a PPA under the state's recent RFP but is continuing to move forward on a separate development path and project permitting has been completed. FuelCell Energy also completed the installation of a 5.6 MW facility at the Pfizer Research Center in Groton, Connecticut in 2016.
- Most fuel cell activity in the US is concentrated in five states: California, Connecticut, Delaware, New York and North Carolina.
- California's Self-Generation Incentive Program (SGIP) historically subsidized many deployments in the state. But it will be reduced starting 2017 (from $1.65/W for fuel cell CHP and $1.45/W for electric only in 2015 to $0.60/W for both). On the other hand, a bill passed at the end of 2016 (AB 1637) extended a net energy metering program for fuel cells for an additional five years and lifted the cap on eligible projects from 1MW to 5MW.

Source: Fuel Cells 2000, SGIP, Bloom Energy, Bloomberg New Energy Finance   Notes: Fuel cells installed before 2003 are excluded due to their expected 10-year lifetime. *2016 data is preliminary.

Financing: Venture capital / private equity investment in US fuel cell companies ($m)



- In 2011, investment hit a peak of $390m, with $250m directed toward Bloom Energy.
- Venture capital investment fell after 2011 but generally remained higher than in prior years. Bloom once again led the pack in 2013, raising $130m from Credit Suisse. The other large investment in 2013 was a $36m round raised by ClearEdge Power; that company was acquired by Doosan in July 2014, after raising $5m of VC funding earlier in the year.
- There was no venture capital / private equity investment in US-based fuel cell companies tracked in 2016 as of December 2016.
- Increased activities from companies like Bloom Energy, FuelCell Energy and acquisitions such as Korea-based Doosan's acquisition of United technologies Corp (UTC) in 2014 suggest bigger companies are using alternative forms of growth to finance fuel cell project activities.

Source: Bloomberg New Energy Finance

Notes: Values include estimates for undisclosed deals and are in nominal dollars.

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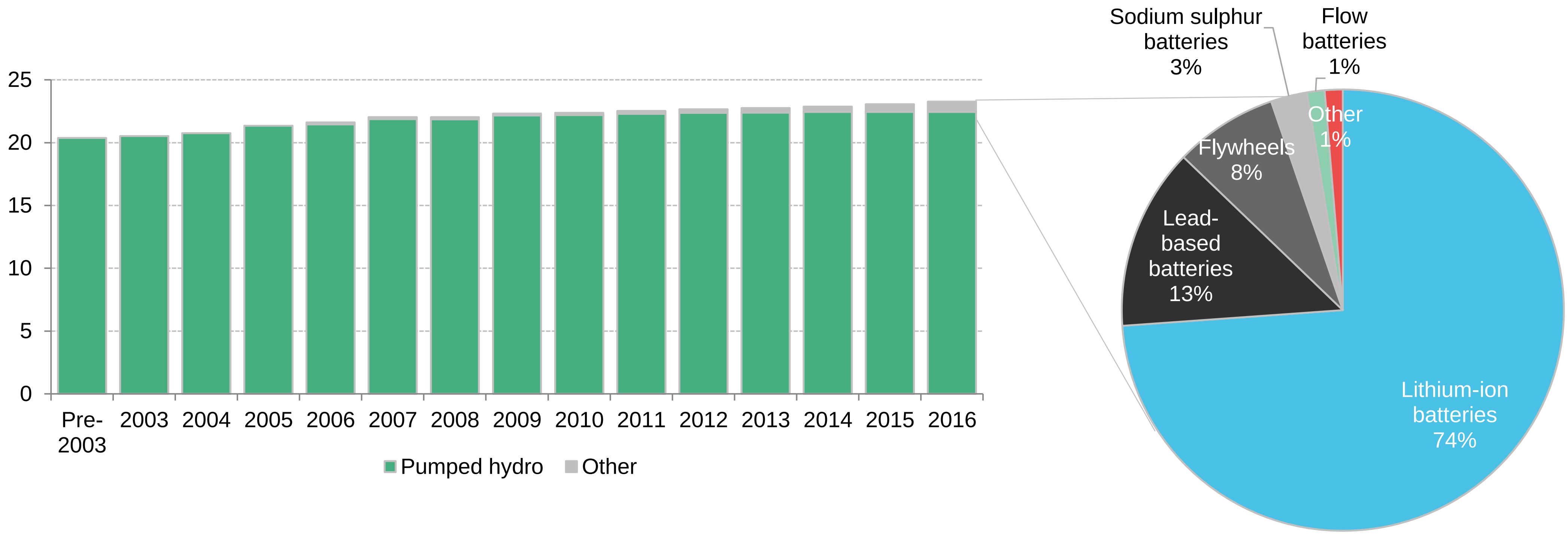
Deployment: US cumulative energy storage (GW)



- Pumped hydropower storage projects account for roughly 97% of installed energy storage capacity in the US. While pumped hydro will remain the bulk of energy storage capacity in the US, new capacity additions since 2011 have been dominated by other technologies, mainly lithium-ion batteries.
- State-level energy storage mandates or solicitations generally exclude pumped storage.
- As of January 2017, FERC had pending licenses for nearly 2GW of new pumped storage capacity. The largest project is a closed-loop facility in Utah.
- On 17 November 2016, FERC issued a notice of a proposed rulemaking concerning the role of energy storage and distributed energy resource (DER) aggregation in US wholesale markets. The proposal aims to remove barriers for these new energy resources and bring a measure of consistency to how they participate across organized power markets. FERC will issue a final regulation after reviewing public feedback.

Source: EIA, FERC, Bloomberg New Energy Finance

Deployment: US announced and commissioned energy storage projects, as of December 2016 (MW)

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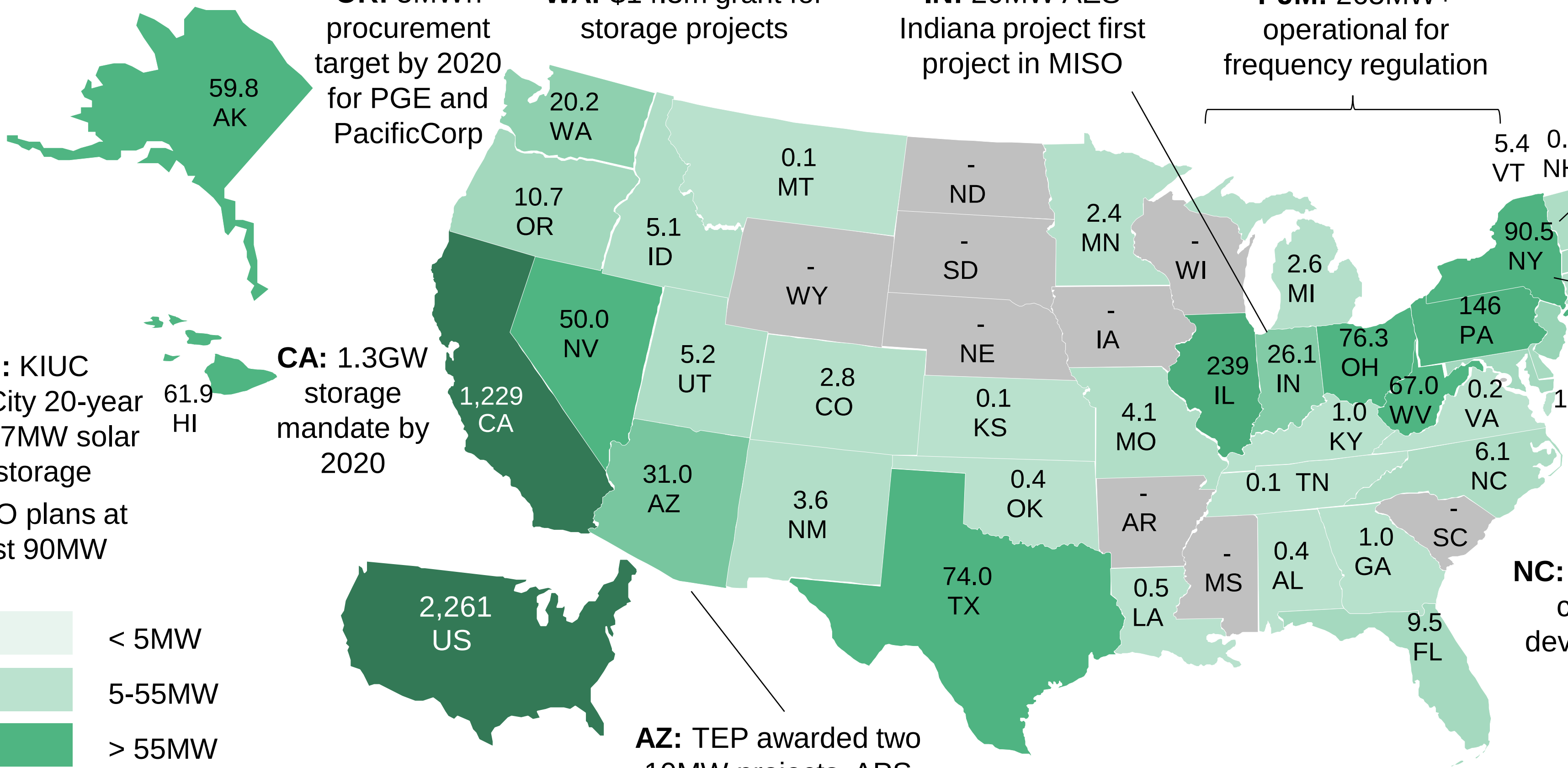

OR: 5MWh procurement target by 2020 for PGE and PacificCorp

WA: $14.3m grant for storage projects

IN: 20MW AES Indiana project first project in MISO

PJM: 265MW+ operational for frequency regulation

VT: 4.3MW installed in microgrid projects

MA: DOER agrees to have an energy storage mandate

NY: Brooklyn-Queens Demand Management contracts storage for distribution deferral

HI: KIUC SolarCity 20-year PPA 17MW solar + storage

HECO plans at least 90MW

CA: 1.3GW storage mandate by 2020

AZ: TEP awarded two 10MW projects, APS develops two 2MW projects

NC: Duke Energy commits to develop at least 5MW

FL: FPL BMW second life Miami energy storage pilot

- < 5MW
- 5-55MW
- > 55MW
- No storage

Source: Bloomberg New Energy Finance Note: Does not include underground compressed air energy storage, pumped hydro, or lead-acid batteries for non-grid applications; minimum threshold for projects is either 100kW or 100kWh, includes projects announced up through December 2016. Note that the whole Alevo's 200MW project with Customized Energy Solutions is not included because its exact locations are not yet announced.

Deployment: US non-hydropower announced energy storage capacity (MW)

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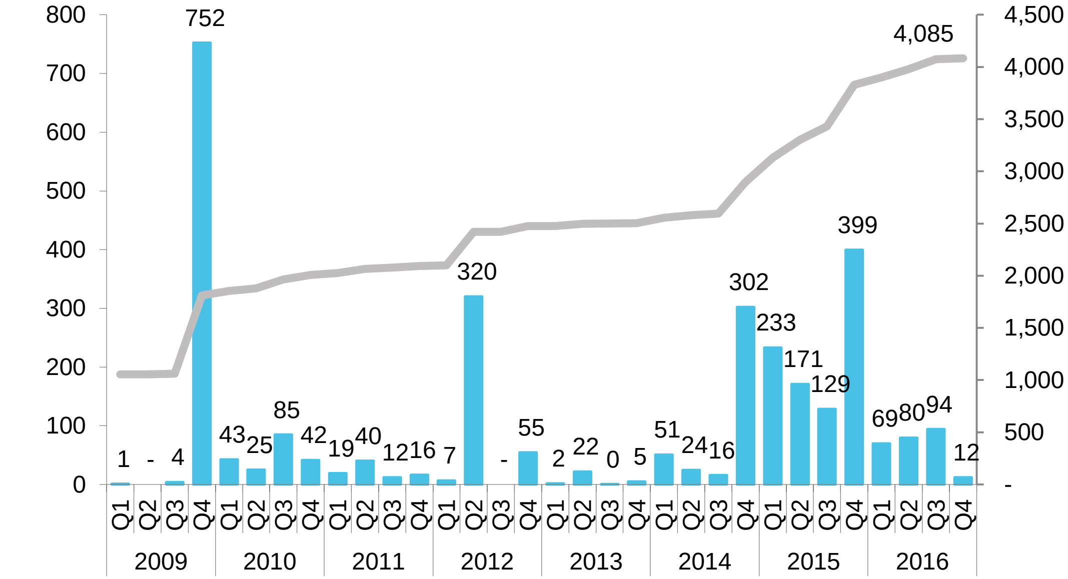
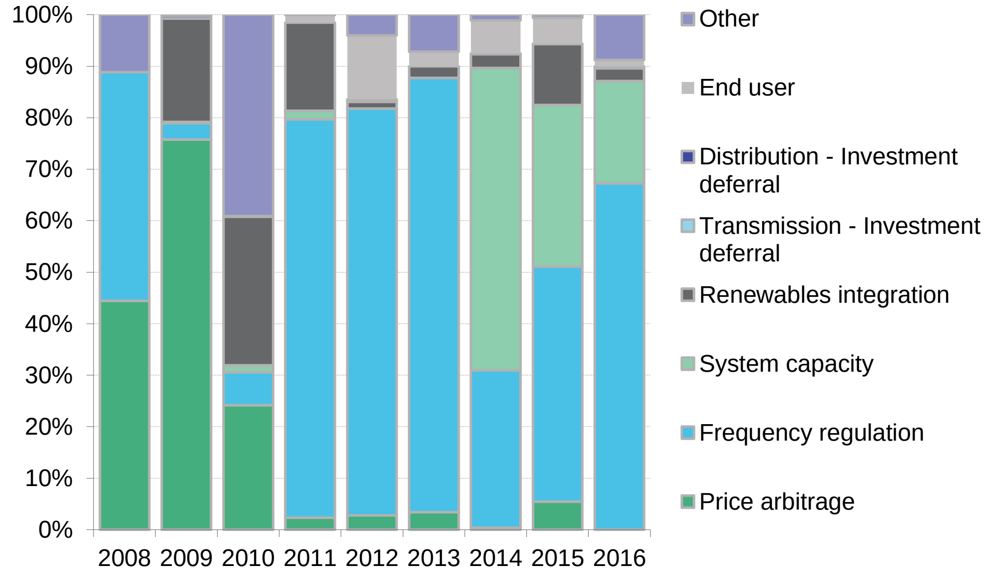
Announced



Mix of *applications* for announced projects (% by MW)

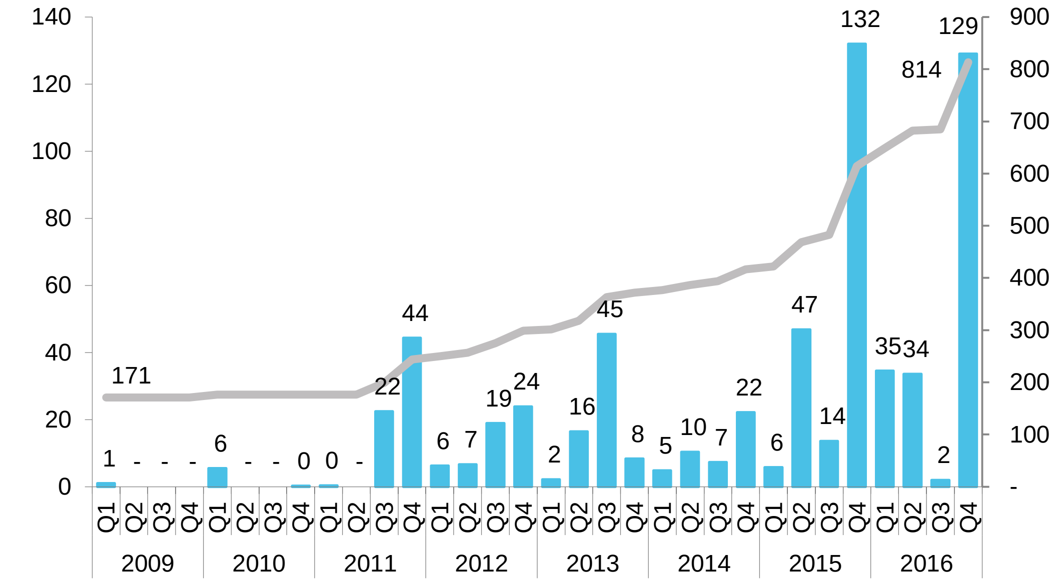


- The US remains the most dynamic energy storage market globally, with a variety of new business and financing models being deployed across the sector. Project activity has tended to be erratic, but new announced projects grew markedly in 2014-16.
- Most activity between 2009-2014 was policy-driven. The 2009 American Recovery and Reinvestment Act (ARRA) funded the majority of projects commissioned between 2011 and 2014.
- Since 2014, however, energy storage procurements in California have focused on contracting projects to supply Resource Adequacy (for system capacity) for the Californian grid, many of which will be delivered after 2019. In 2016, California additionally contracted 67MW-196.6MWh of energy storage projects to mitigate expected gas shortages due to the earlier leaks from the Aliso Canyon gas storage facility. These were delivered in four months, a record time from contracting to delivery. Most were expected to be commissioned by December 31.

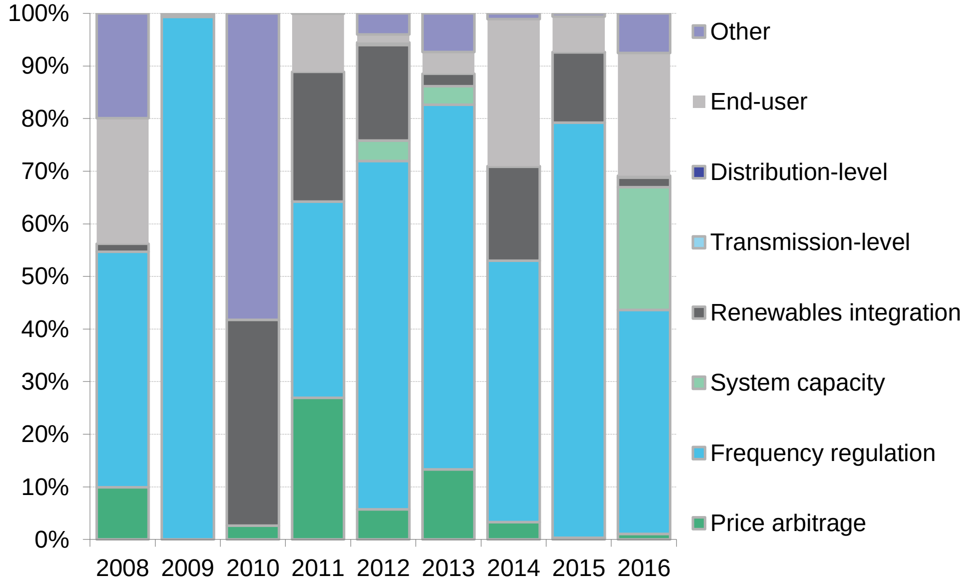
Source: Bloomberg New Energy Finance Notes: Does not include pumped hydropower, underground compressed air energy storage, or flooded lead-acid batteries. Minimum project size for inclusion in this analysis is 100kW or 100kWh.

Deployment: US non-hydropower commissioned energy storage capacity (MW)

Commissioned



Mix of *applications* for commissioned projects (% by MW)



- Most of the commissioned energy storage capacity in the US since 2012 has been for the PJM frequency regulation market. There is over 280MW of energy storage providing frequency regulation in the PJM RegD market, which saw a rush of projects commissioned in 2015 and early 2016.
- In the end of 2016, at least 55MW/220MWh of energy storage projects were commissioned in California to support the gas shortages expected from Aliso Canyon gas storage facility leak mitigation efforts.
- Beyond California and PJM, there have been many smaller projects commissioned in many other states such as Hawaii, Washington, New York and Massachusetts.

Source: Bloomberg New Energy Finance Notes: Does not include pumped hydropower, underground compressed air energy storage, or flooded lead-acid batteries. Minimum project size for inclusion in this analysis is 100kW or 100kWh.

Deployment: Mix of *technologies* for US non-hydropower energy storage for announced projects (% by MW)

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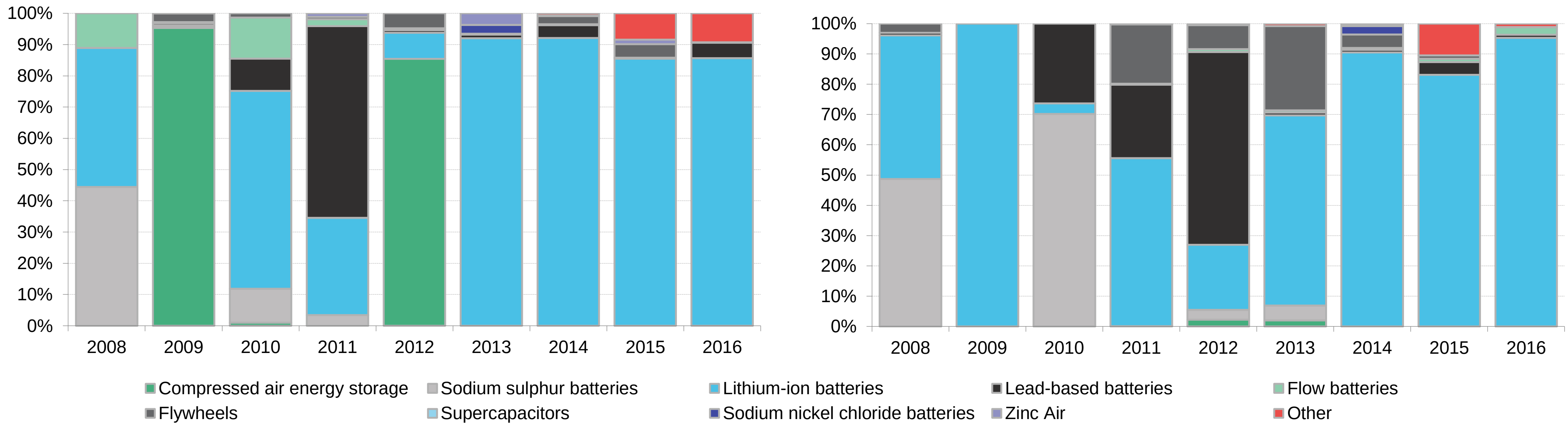
Announced | Commissioned



- 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 (eg frequency regulation) and up to four hours of energy capacity for longer-duration applications (eg investment deferral, arbitrage);
  - It has a long track record of reliability and high performance;
  - Projects using batteries produced by larger lithium-ion manufacturers 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.
- New technologies are in the works, receiving some investment and securing a few commercial-scale contracts.

Source: Bloomberg New Energy Finance Notes: Pumped hydropower storage is not included in this chart 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. The application categories have been revised since last year's edition of the Factbook to better represent market terminology and trends.

Financing: Venture capital / private equity investment in US energy storage companies ($m)

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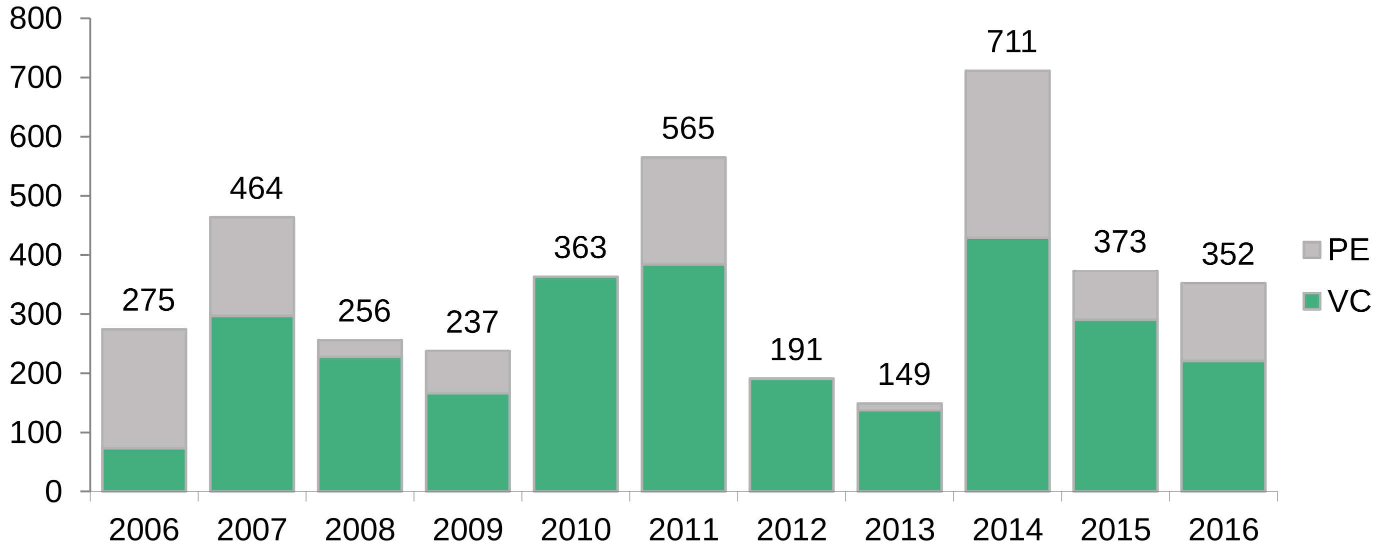

- There has been nearly $4bn invested by VC/PEs in US energy storage companies since 2006, including $352m in 2016 according to the latest available data.
- The top four disclosed investments for stationary storage in 2016 were:
  - $36.5m for Sunverge, a California-based distributed solar and storage provider which received a third round of investment from the Australian utility AGL Energy, as well as from Siemens Venture Capital, Softbank China Venture Capital and Australian Renewable Energy Agency;
  - $33.2m for Aquion Energy, a Pennsylvania-based saltwater battery manufacturer designed for daily deep cycling, which received this funding from undisclosed investors;
  - $23m in Eos Energy Storage, a zinc air battery company that received investment from Yorktown Partners and AltEnergy
  - $16m for ViZn Energy Systems, a zinc-iron redox flow battery technology developer that also received its funding from undisclosed investors.
- There was renewed interest in alternative technologies to lithium-ion throughout 2016. Energy storage software providers and management companies also secured considerable funding over the same period, which underlined their growing importance. These companies included Stem ($15m) and Geli ($7m).

Source: Bloomberg New Energy Finance Note: Values include estimates for undisclosed deals and are in nominal dollars.

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Policy: US states with EERS and decoupling legislation for electricity and natural gas, 2016 (number of states)

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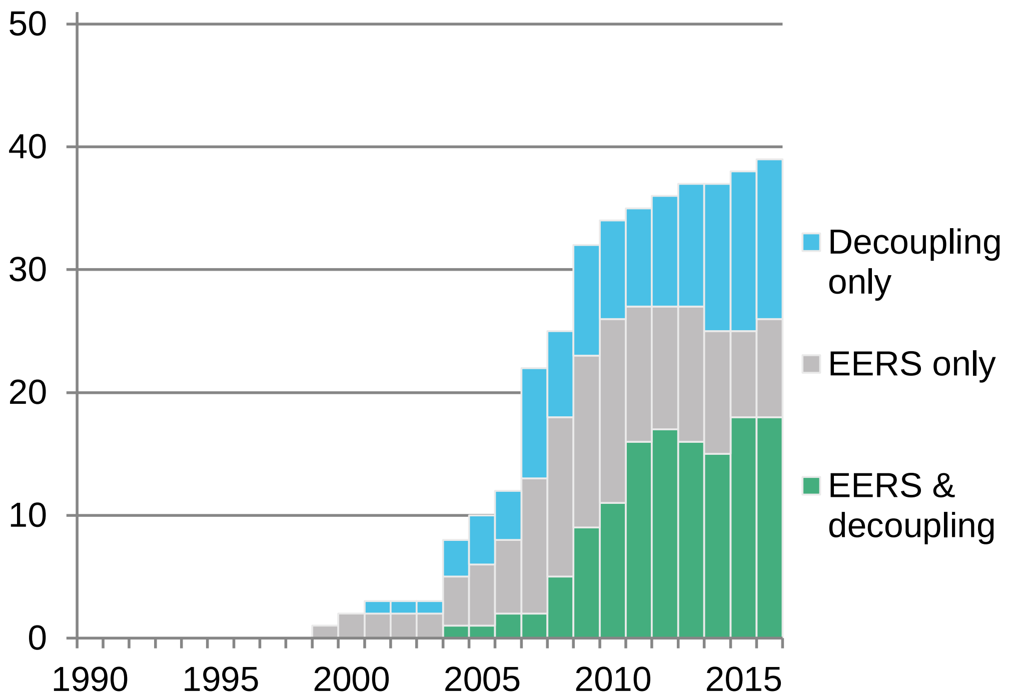
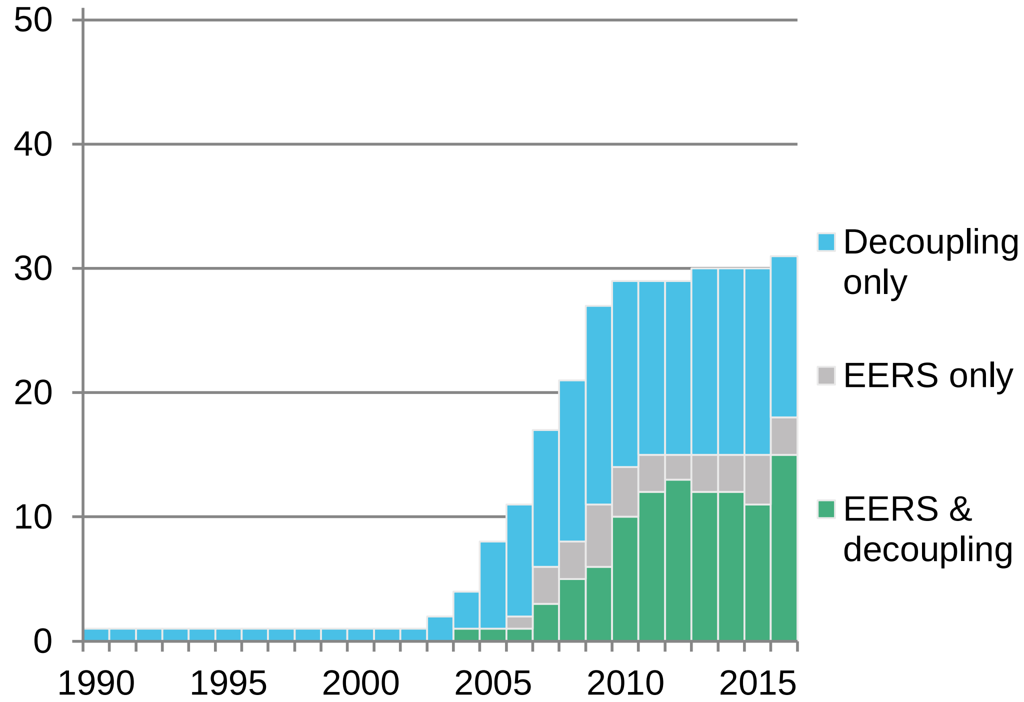
Electricity



Natural Gas



- Energy efficiency resource standards (EERS) and decoupling are both key drivers for utility spending on energy efficiency, which makes up the bulk of formal energy efficiency spending in the US.
- New Hampshire was the only state to introduce a new electricity EERS in 2016. Illinois raised the efficiency target of its largest utility, Commonwealth Edison. New Hampshire introduced a natural gas EERS in 2016, and Vermont's scheme is in the implementation process. Ohio removed its EERS freeze, effective 2017.
- Unlike in 2014 and 2015, there were no states to turn their back on EERS targets in 2016. The uptake of EERS has slowed in the past few years, but there is currently no momentum for its reversal either.

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 US state and region, and electrical efficiency savings by state, 2015 (%)

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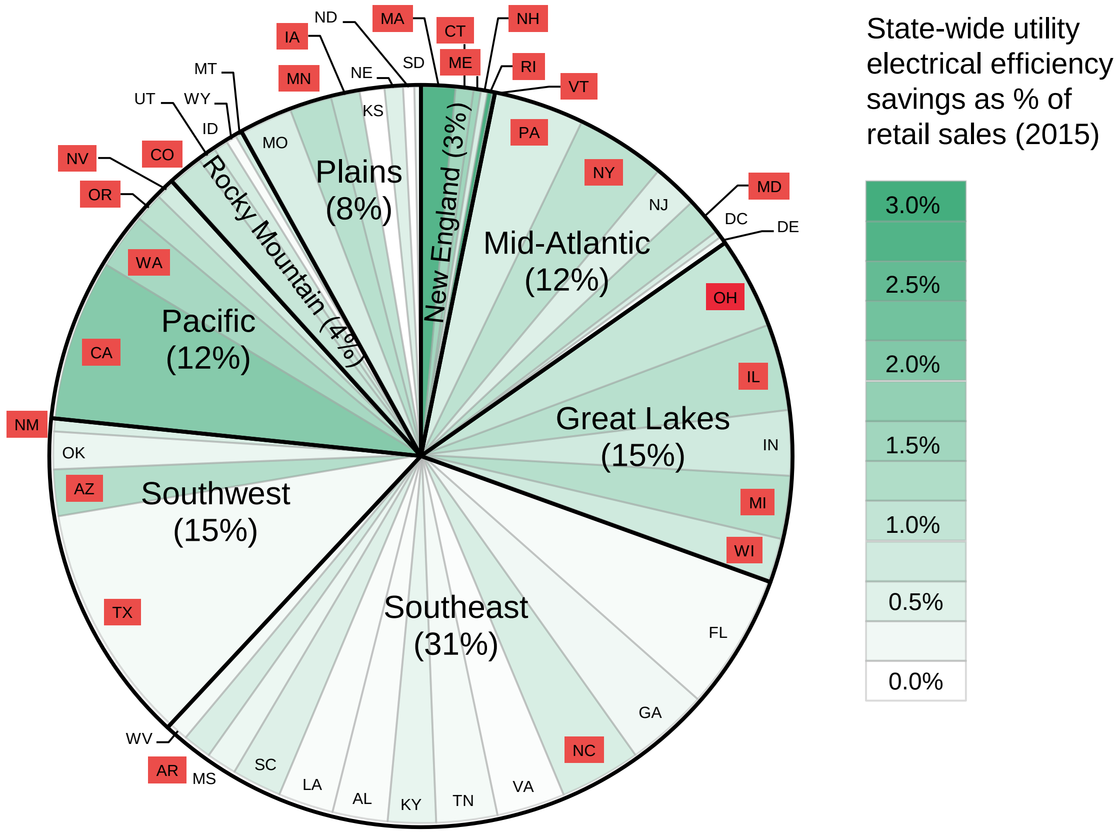

- There is some correlation between EERS policies (states highlighted in red) and energy efficiency savings. States with EERS have a higher rate of savings than their neighbors. However, regional trends dominate: a state with EERS in a region with low savings (e.g. NC, AR) tends to have a lower saving rate than states that without EERS in regions with higher savings rates.
- While EERS are a driver of energy efficiency, the levels of savings achieved depend on a multitude of factors, such as the stringency of savings targets established within the EERS, program participation rates, and complementary measures that incentivize utilities to meet targets, such as rate reform and performance incentives.

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 US state and region, and natural gas program savings by state, 2015 (%)

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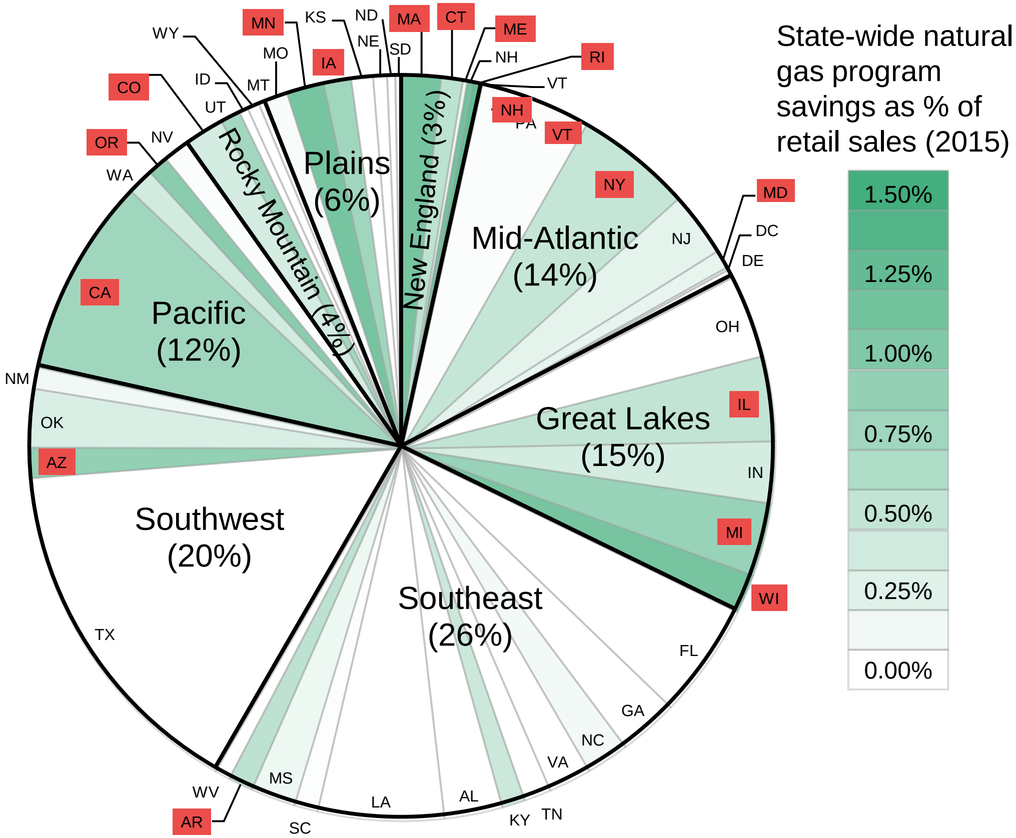
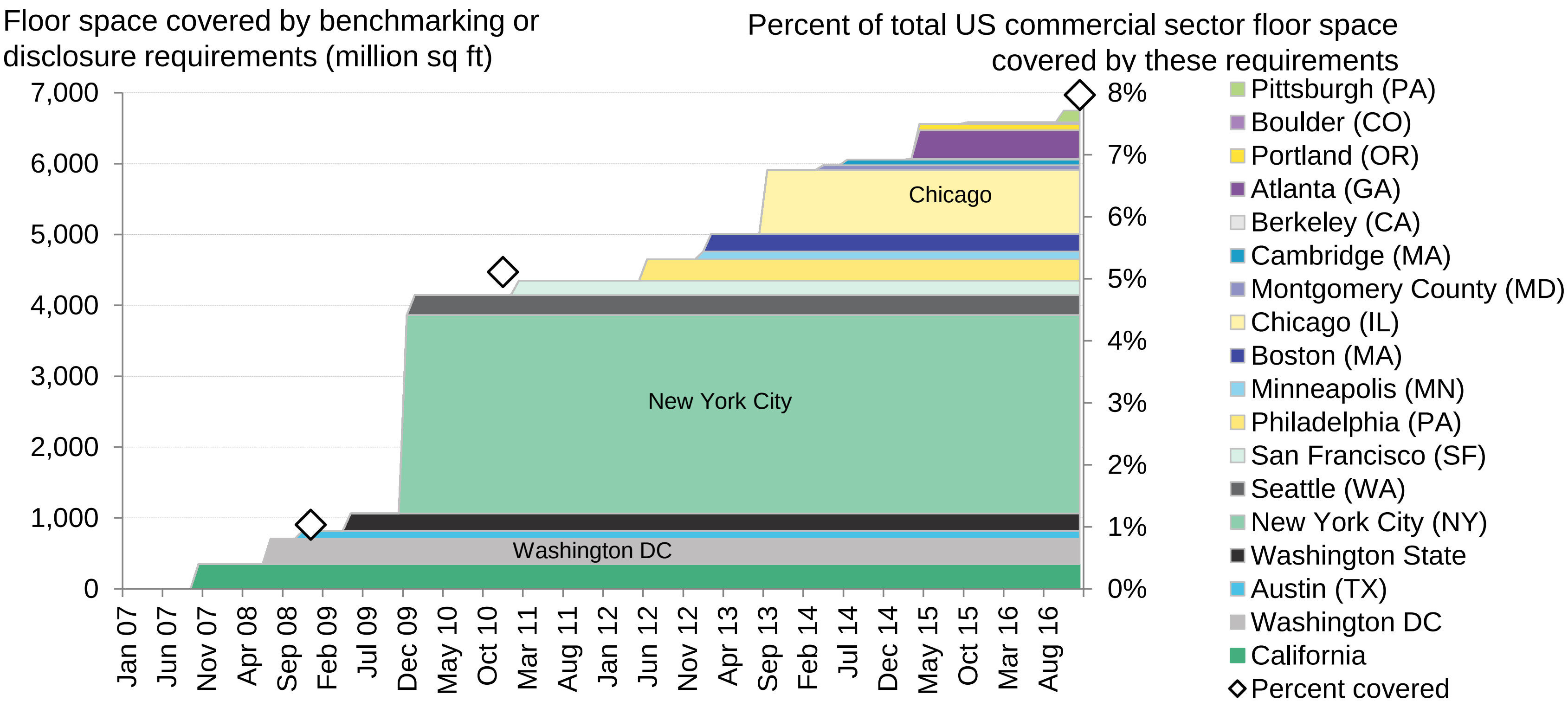


- The Southeast and Southwest, which account for 46% of US gas (end-use) consumption, have the lowest levels of savings.
- Interestingly, the regional trends identified on the previous slide for electricity are less dominant. EERS policies appear more correlated with natural gas savings—states with EERS in a region with low savings (e.g. AZ, AR, KY) stand out from their neighbors, as do states with no EERS in high-savings regions (e.g. PA, OH).
- The Great Lakes' share of total natural gas consumption shrank one percentage-point between 2015 and 2016, while the Southeast's expanded by the same amount. The opposing direction of the changes in a region where EERS is popular (Great Lakes) versus a region where it is not (Southeast) suggests that efficiency programs have a material impact.

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

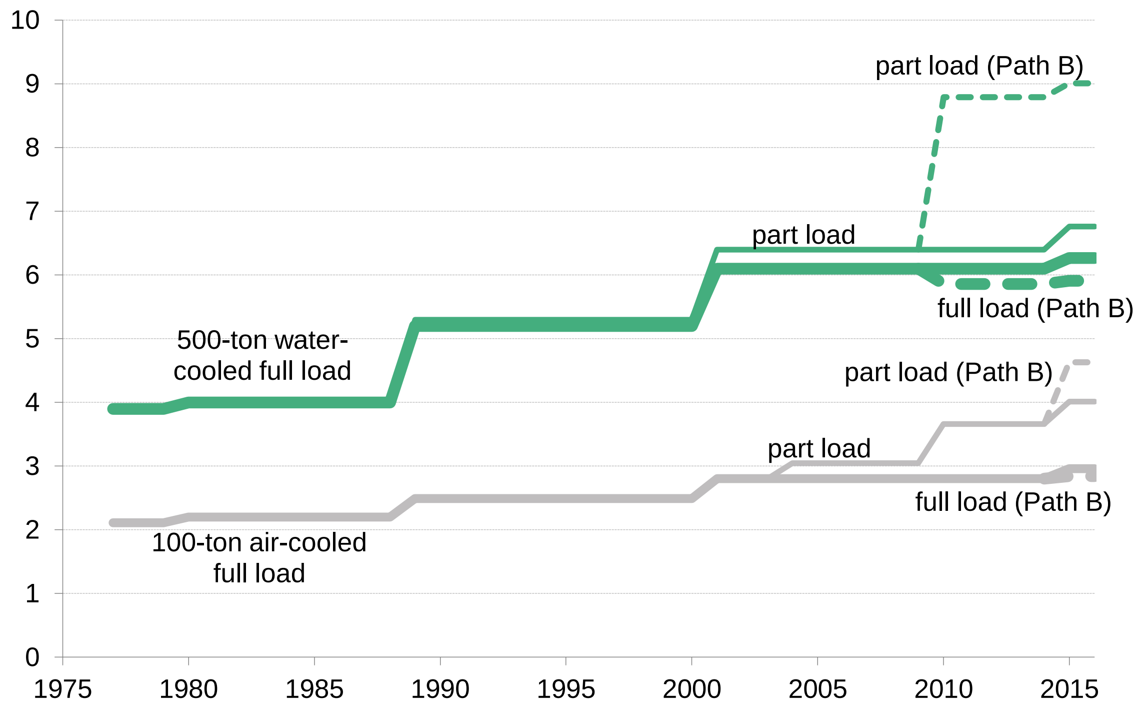
Policy: US building floor space covered under state or local building energy use benchmarking / disclosure policies



- States and cities have been creating building energy use policies, including building energy efficiency benchmarks and mandates to disclose energy consumption.
- As of the end of 2016, 6.7bn square feet of commercial floor space, or around 8% of total US commercial sector floor space, was covered by such policies. This represents an 3% uptick over the 2015 tally.
- In 2016, Pittsburgh and Portland, ME both enacted policies which will require large non-residential buildings to participate in benchmarking and transparency programs (Portland, ME not shown in graph due to lack of data). City buildings are also covered by the ordinances.

Source: Institute for Market Transformation (IMT), US DOE's Buildings Energy Data Book, Bloomberg New Energy Finance Notes: Accounts for overlap between cities and states (eg, 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 US commercial sector floor space covered. Diamonds are spaced out in irregular intervals since data for the denominator (total commercial sector floor space in the US) 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.

Policy: Performance standards for chillers, per ASHRAE Standard 90.1 requirements (y-axis measures coefficient of performance)



- Performance standards help to drive improvements in appliance efficiency. This chart shows how the standards for chillers have evolved since the late 1970s in terms of "coefficient of performance."
- The standards have not only come to require greater efficiency, but have also become more nuanced. In the early 2000s, they began to require that systems exhibit higher performance when operating at partial load, as illustrated by "Path B" on the chart above. Path B shows how systems can have a lower performance at full load, so long as their partial load performance is substantially higher – a useful requirement for systems that operate primarily at part-load.
- After 2010, a further provision was inserted to recognize the usage profiles of different systems.

Source: ASHRAE 90.1-2013 Standard

Notes: ASHRAE is the American Society of Heating, Refrigerating and Air Conditioning Engineers. The standard shown in the chart is part of Standard 90.1, which dictates minimum requirements for energy efficient designs for buildings. The standard is on "continuous maintenance," allowing it to be updated based on changes in technologies and prices. The coefficient of performance is a measure of efficiency, based on the ratio of useful energy acquired versus energy applied; the higher the coefficient, the more efficient the system. The intended use of the Integrated Part Load Value (IPLV) rating (the reference to 'part load' above) is to compare the performance of similar technologies, enabling a side-by-side relative comparison, and to provide a second certifiable rating point that can be referenced by energy codes. A single metric, such as design efficiency or IPLV, should not be used to quantify energy savings.

Policy: Thermal performance standards by building placement (R-values)

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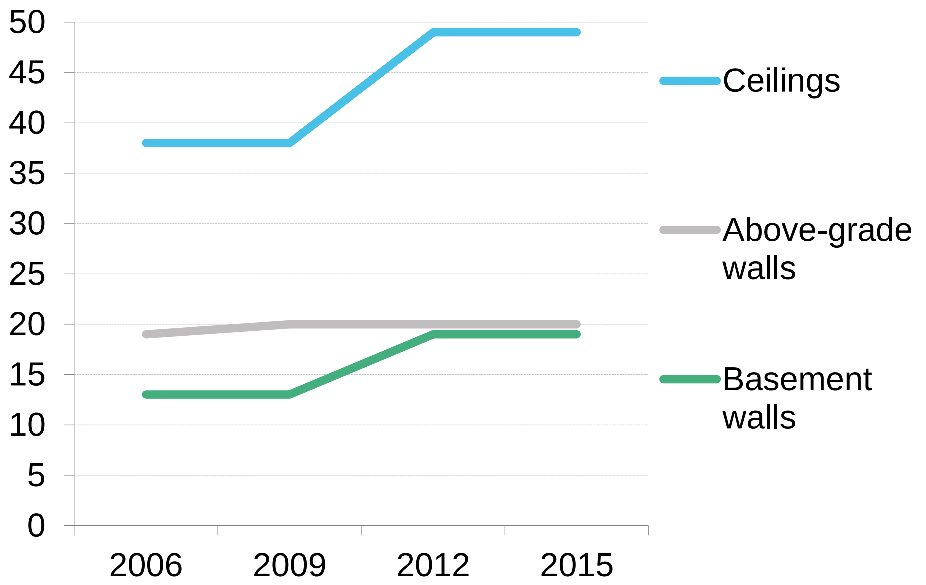
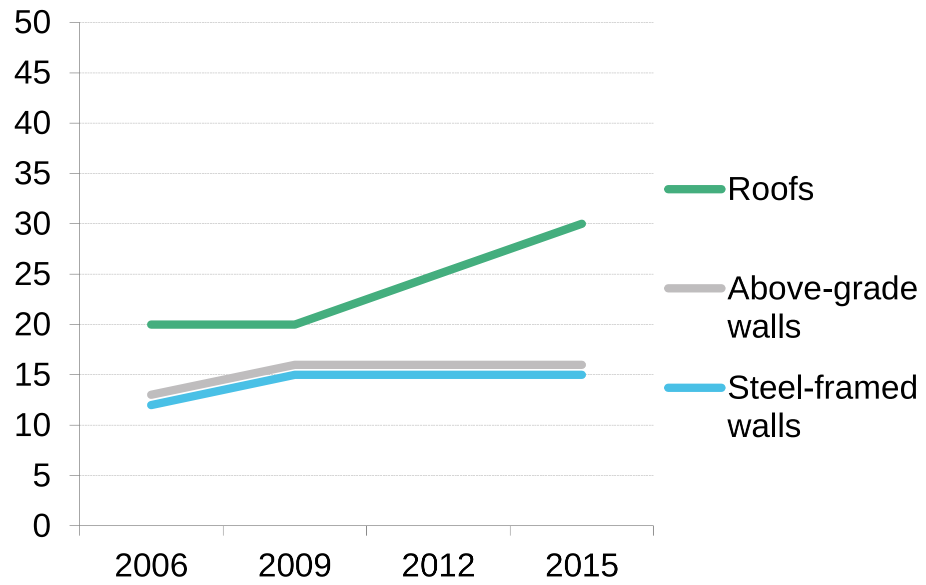
Residential buildings



Commercial buildings



- New buildings face increasingly stringent insulation requirements.
- There is also a growing effort to improve the energy efficiency of existing buildings. ICC and ASHRAE now require insulation upgrades during the replacement of existing roofs. Due to the size of the market for “re-roofing,” this new focus on existing buildings may impact building energy use more quickly than changes to new construction requirements.
- In 2016, six states adopted stricter residential and commercial building codes, including New York, Utah, Tennessee, Massachusetts, Connecticut, and Ohio.

Source: PIMA (Polyisocyanurate Insulation Manufacturers Association), NAIMA (North American Insulation Manufacturers Association), based on standards from ASHRAE and ICC

Notes: Thermal performance standards as established by ASHRAE and ICC are given in R-values, a measure of a component’s resistance to heat transfer (greater R-value means more resistance – ie, better insulation). ICC is the International Code Council. ASHRAE is the American Society of Heating, Refrigerating and Air Conditioning Engineers.

Policy: ACEEE state-by-state scorecard for energy efficiency policies, 2016

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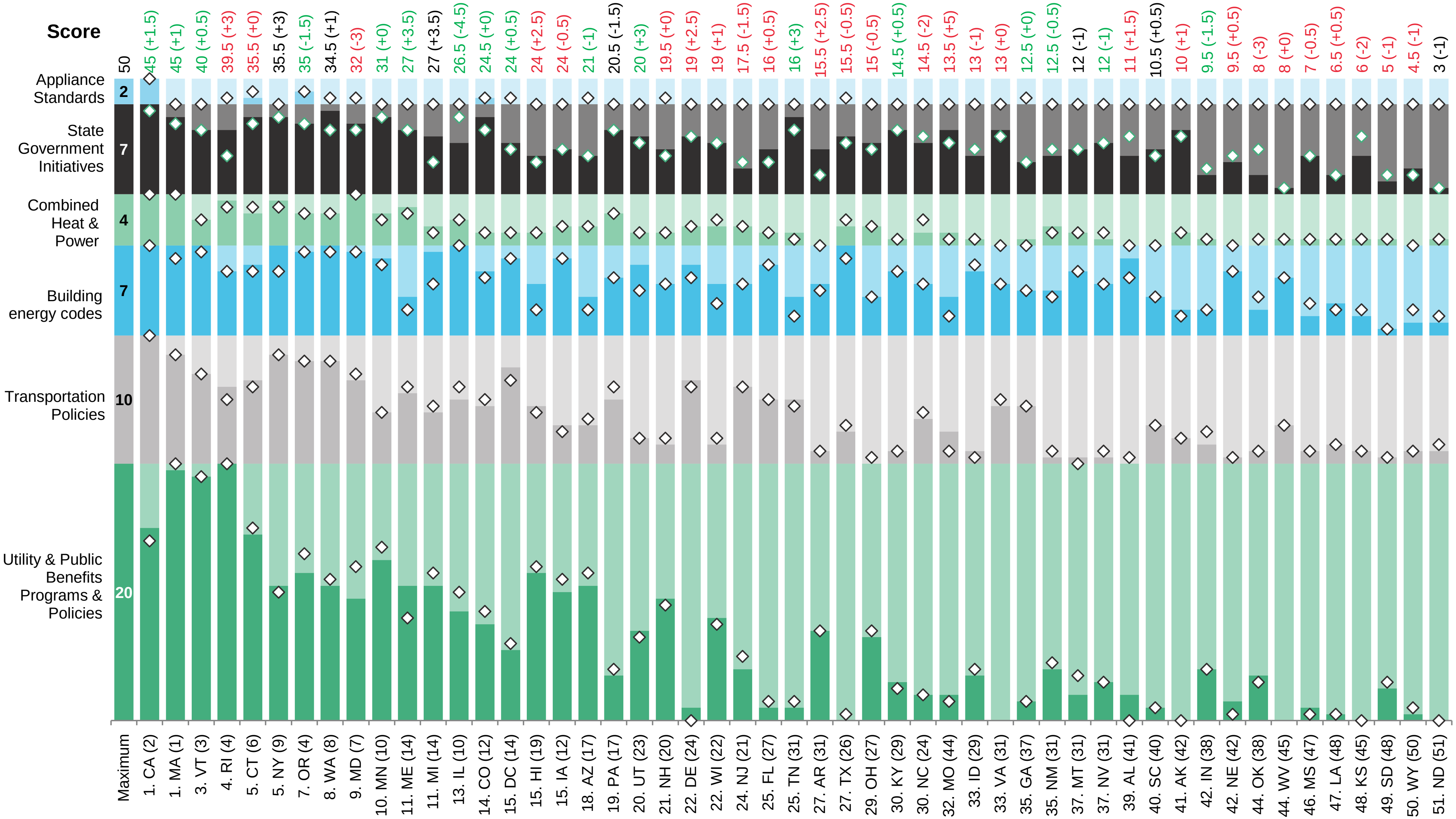
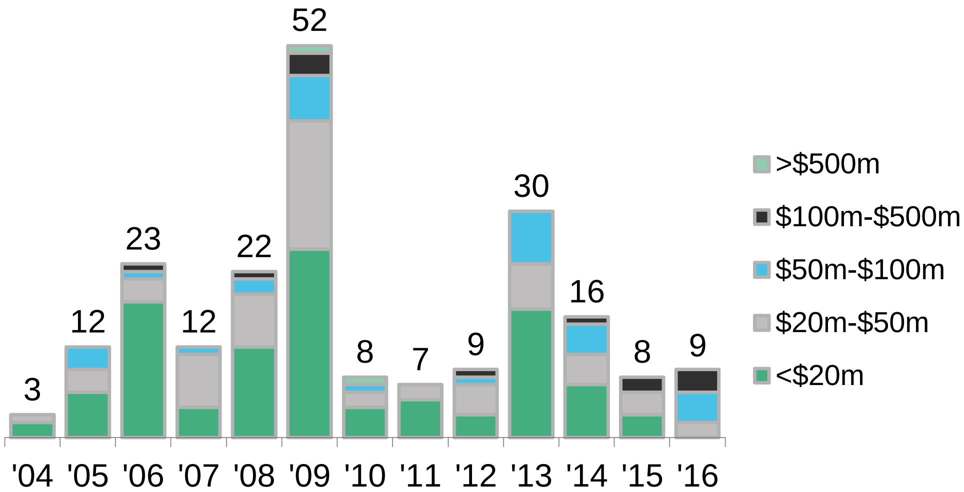


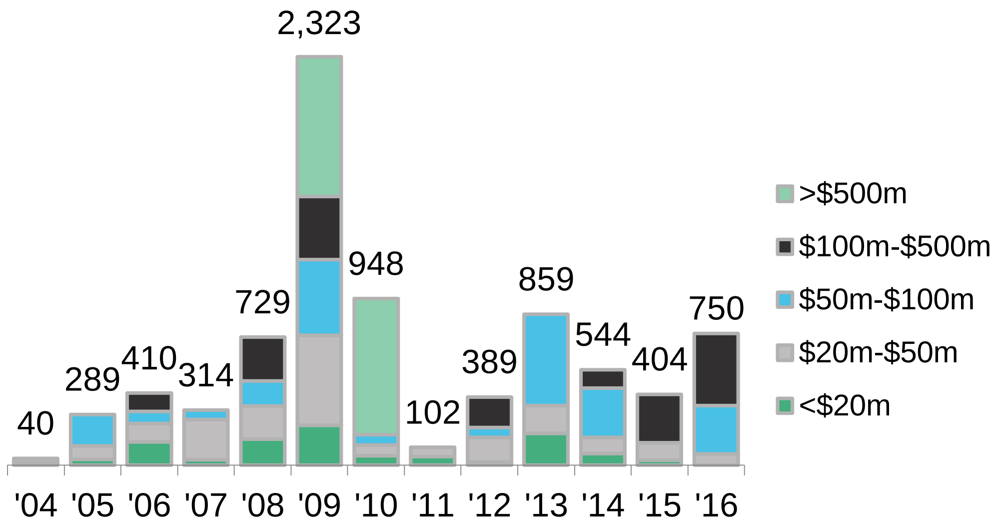
Source: ACEEE, EIA, Bloomberg New Energy Finance   Notes: Numbers in parentheses at the bottom of the chart indicate 2015 ranking. Numbers in parenthesis at the top denote the change in score from 2015 levels. Diamond symbols indicate 2015 score within each category.

Policy: US federal ESPCs executed through the DOE's umbrella agreement, by year and deal size

Number of ESPCs



Total contract value of ESPCs ($m)

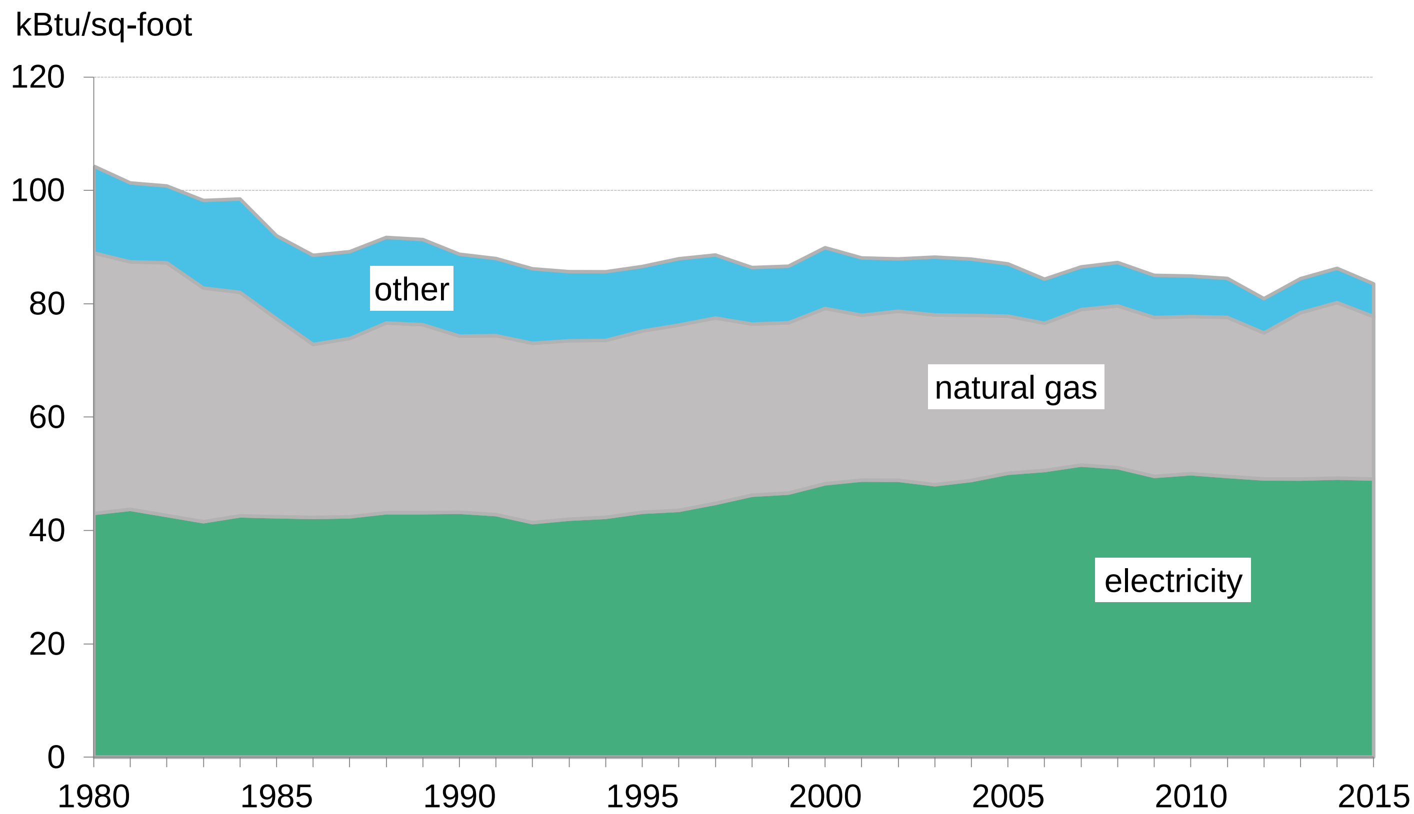


- The federal sector remains an important part of the energy-savings performance contract (ESPC) market, with long time horizons and access to finance allowing 'deep' retrofits and cutting-edge projects.
- 2016 saw an uptick in contract values, no doubt in part due to President Obama's target of completing $4bn in federal performance-based energy efficiency deals by the end of 2016.
- Another noticeable trend in 2016 was the shift to larger individual projects. Fewer had a contract value below $50m than the previous year and more were above $100m.
- Utility energy service contracts are another vehicle for federal energy efficiency, but data on their impact is limited.

Source: Federal Energy Management Program (FEMP), US Department of Energy (DOE), Bloomberg New Energy Finance

Notes: DOE's umbrella agreement refers to indefinite-delivery, indefinite-quantity (IDIQ) contracts between the DOE and energy service companies. 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. Values are in nominal dollars.

Deployment: US commercial building energy intensity (kBtu/sq-ft)

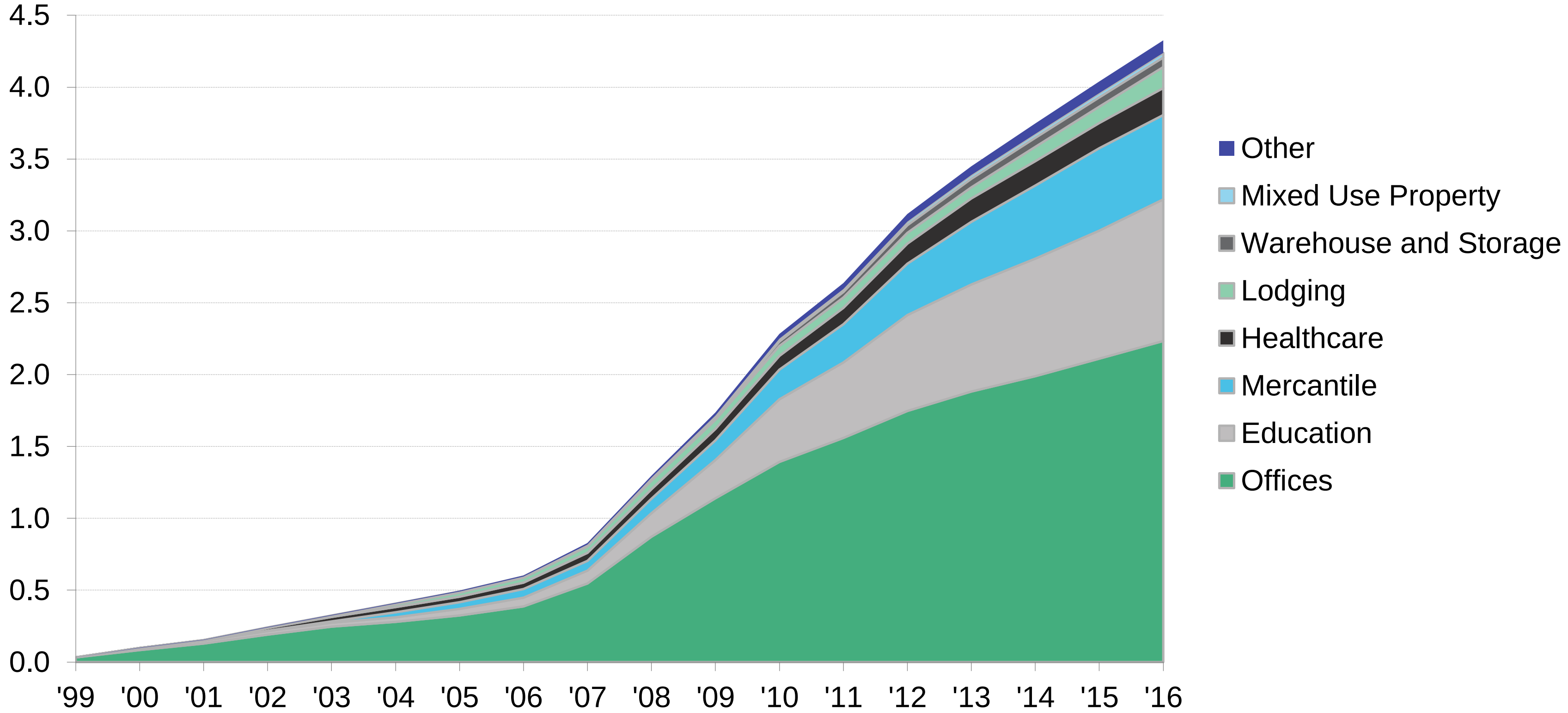


- Between 1985 and 1995, the energy intensity of US commercial buildings decreased by an average of 0.6% year on year. Between 1995 and 2005, energy intensity remained approximately constant. However, the fall in intensity picked up momentum again between 2005 and 2015, when it shrank 0.4% on average year on year.
- The figures here are based on EIA data for overall consumption of the commercial sector; the latest information on total commercial floor space; and other estimates on the consumption profile of the commercial sector based on previous editions of the Commercial Buildings Energy Consumption Survey (CBECs).

Source: EIA, Bloomberg New Energy Finance

Notes: This analysis is based on (i) EIA data on US commercial building energy consumption and floor space for the years 1979, 1983, 1986,1989, 1992, 1995, 1999, 2003, 2012 and (ii) EIA data for total US commercial sector energy consumption for every year between 1979-2013.

Deployment: Energy Star-certified floor space in US non-residential buildings by building type (bn sq-ft of floor space)



- As of 2016, 4.3bn sq-ft of US commercial building floor space was Energy Star-certified. This represents approximately 5% of total floorspace in US commercial buildings.
- Although adoption of Energy Star certification has increased rapidly, year-on-year additions peaked in 2012 and have been decreasing gradually since then. Likely reasons for this include the fact that some certified building are being re-certified, and that there are fewer 'easy wins' in the form of uncertified large office buildings.
- Offices and educational buildings account for 74% of certified buildings. They are also the segments where certification is growing most quickly, both in absolute terms (122 and 94 million sq-ft newly certified in 2016, respectively) and as a proportion of their addressable market (new 2016 certifications accounted for 0.8% of total floorspace for those segments). Certification in lodging is also picking up momentum, with 0.6% of the addressable market newly certified in 2016.

Source: EPA, Bloomberg New Energy Finance

Deployment: Energy Star-certified floor space and total floor space for US commercial buildings by sector and size, 2015

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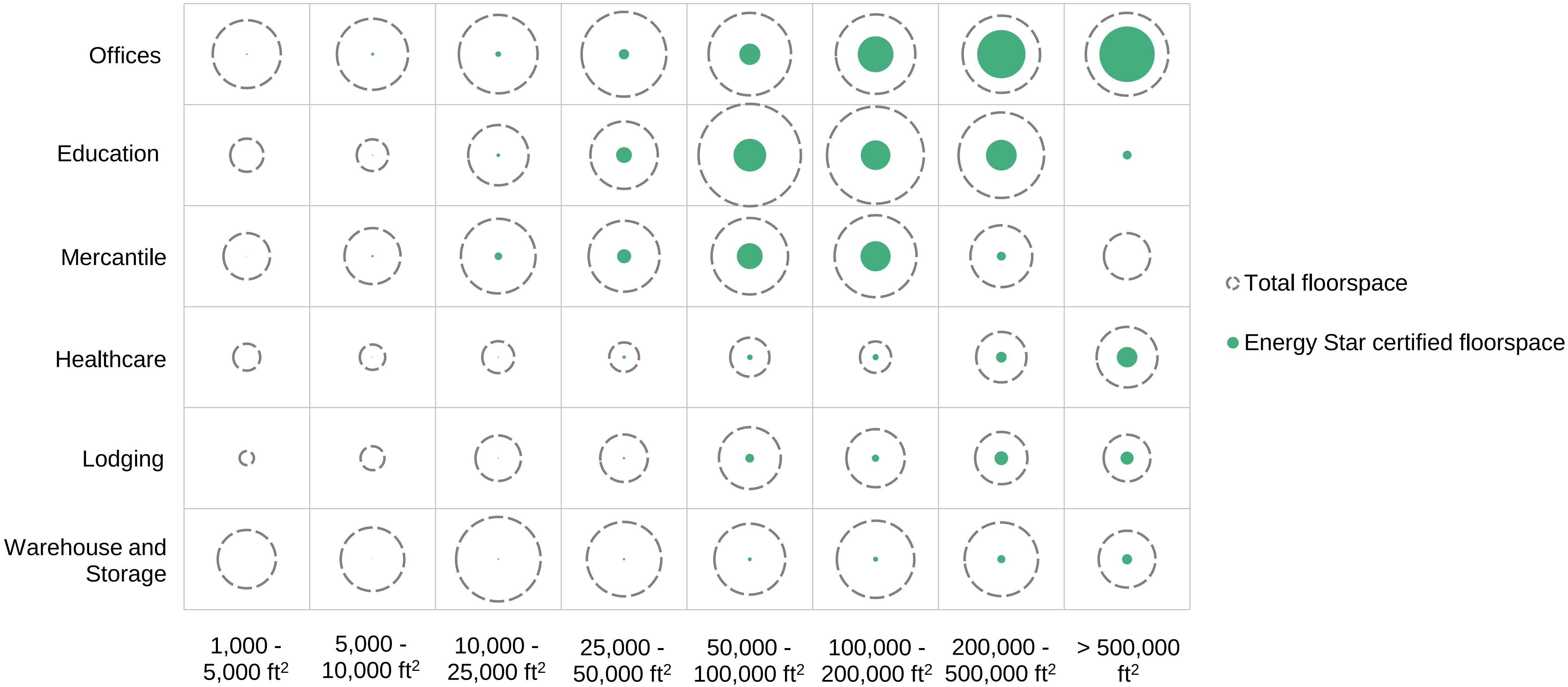

- Unsurprisingly, certification is concentrated in larger buildings. In offices, the majority of floorspace in buildings above 200,000 square feet are certified, meaning that new opportunities for certification must be found in smaller offices or other segments.
- A new trend in 2016 is the uptake of certification in lodgings. There is still a majority of large uncertified lodgings, so there is room for Energy Star penetration to expand in this segment.
- There is a relatively high rate of certification in mid-size mercantile buildings. Larger mercantile buildings represent an as-yet untapped opportunity.

Source: EPA, EIA, Bloomberg New Energy Finance

Notes: There is insufficient data for total US floor space of educational buildings in excess of 500,000ft^2.

Deployment: Percent of Energy Star-certified products sold by product type, 2015

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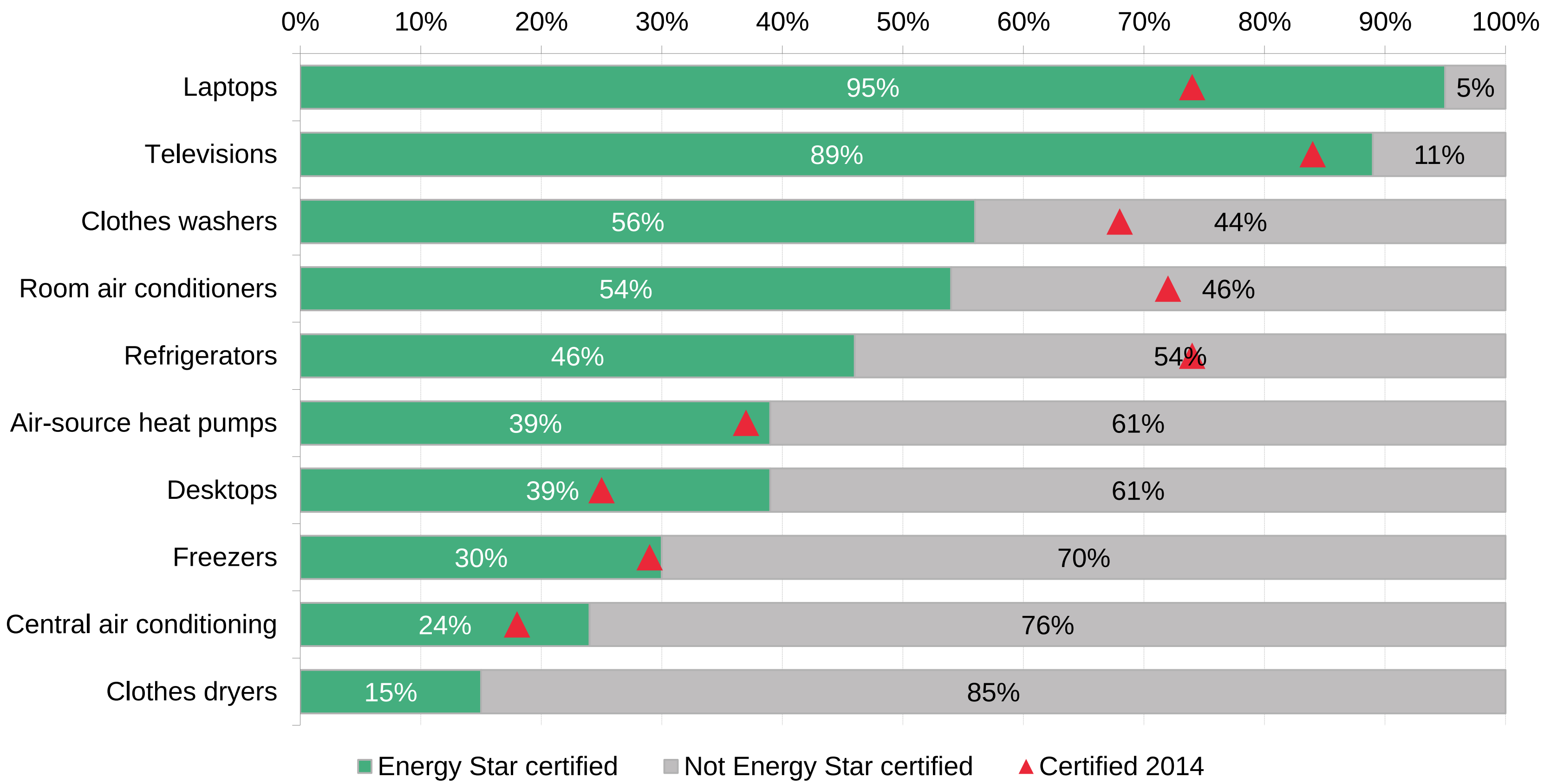

- This chart shows a selection of energy-consuming products and the percent of units sold that were Energy Star-certified.
- Of the products considered, laptop computers have the highest rates of certification, 95%. This is in contrast to desktop computers, where it is just 39%. Because energy efficiency 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.
- In most cases the uptake of certified products is increasing. However for clothes washers, room air-conditioners and refrigerators this was not the case. Possible reasons for running contrary to the broader trend could include the introduction of new, more stringent, certification standards and 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; “Lamps” refer to share of Energy-star certified lamps out of the total lamps market, including incandescent and halogen lamps. Share of household consumption takes EIA data on household consumption by end-use in 2014.

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

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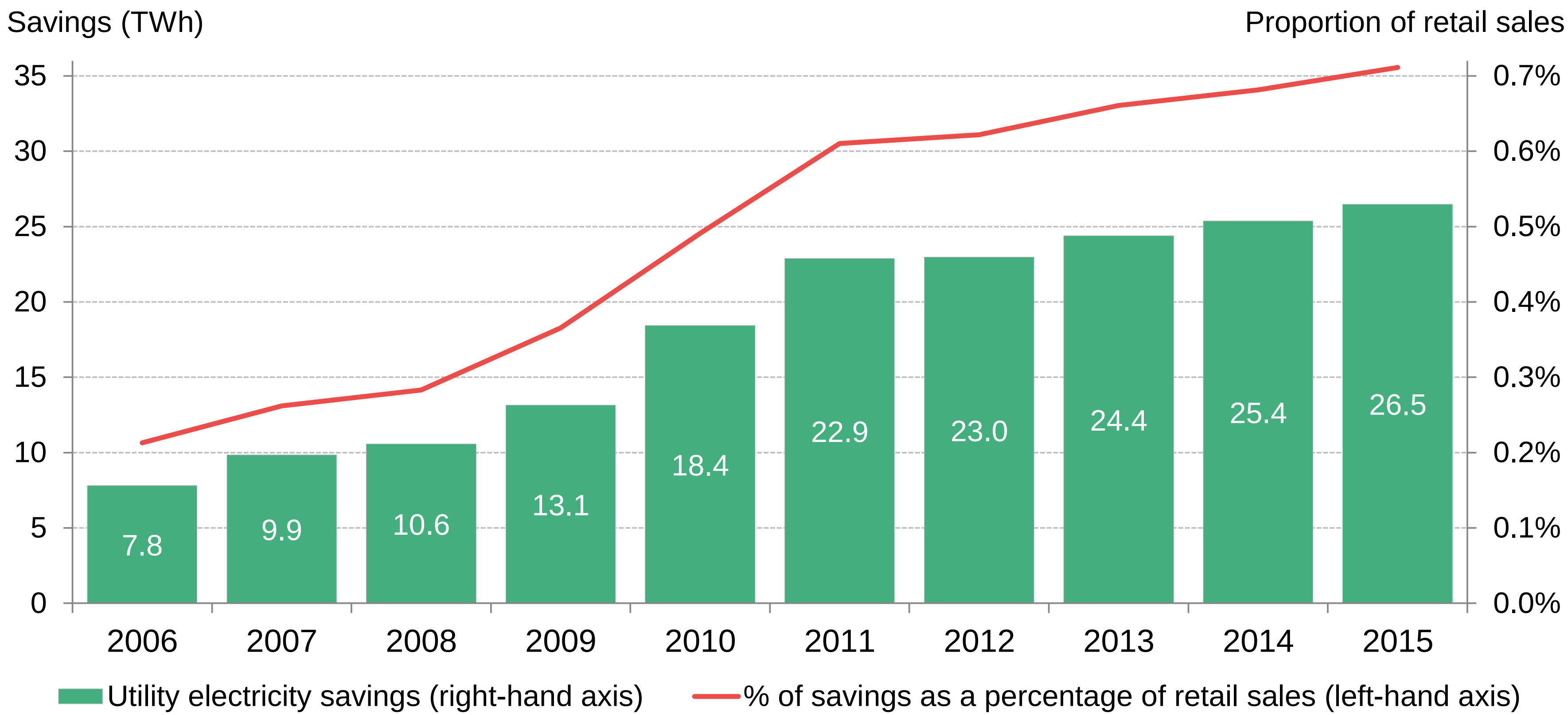
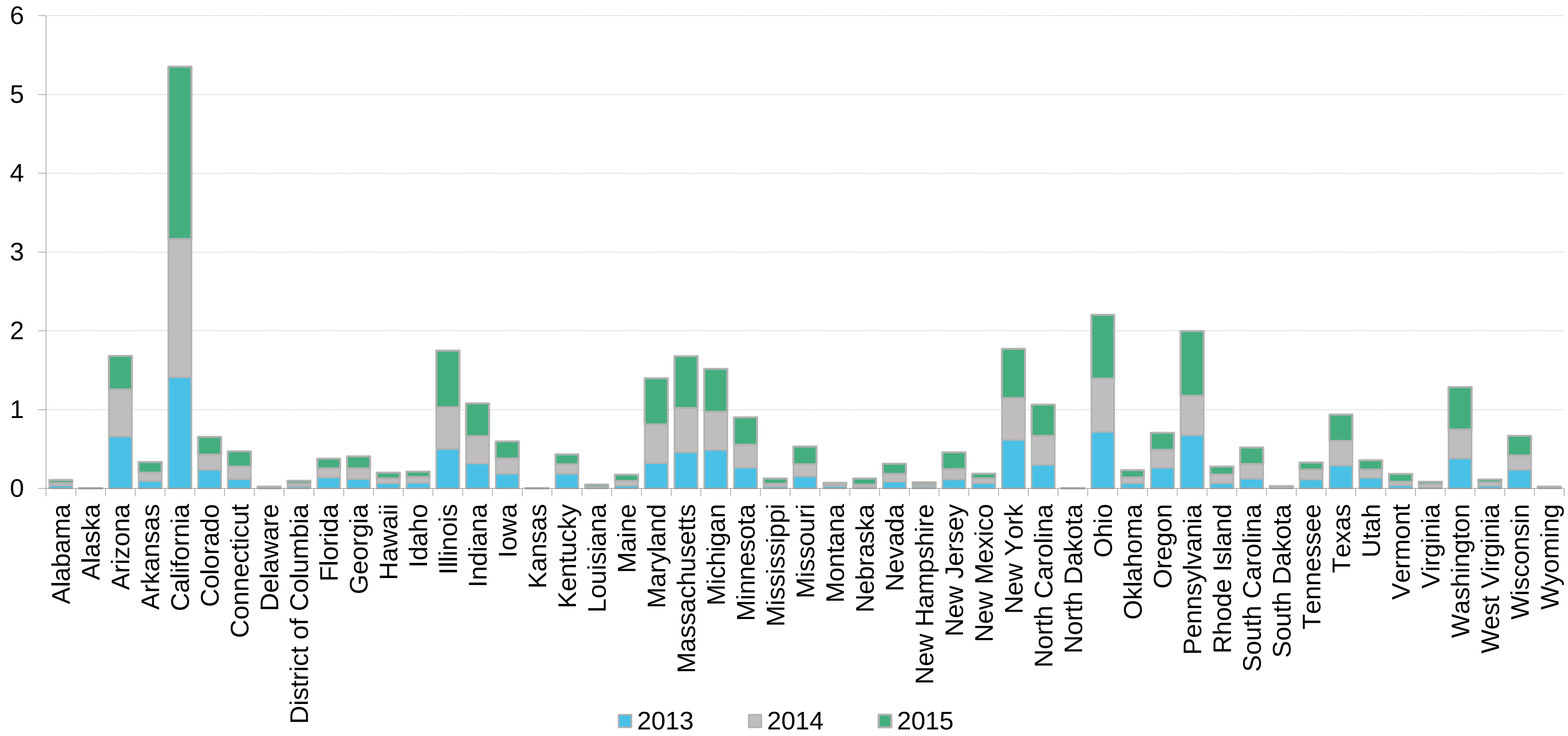


- Between 2006 and 2011, incremental annual energy efficiency savings by electric utilities grew 24% year on year. This coincides with the uptake of both energy efficiency resource standards (EERS) and decoupling legislation in many states.
- Although savings continued to increase after 2011, it was at a slower rate. In 2015, savings grew 4% on 2014 levels. This coincides with a slowdown in the number of new states adding EERS.
- States with the highest incremental savings as a percentage of total retail sales in 2015 were Rhode Island (2.9%), Massachusetts (2.7%), Vermont (2.0%) and California (2.0%).
- States with notable increases in incremental savings were Washington (+0.4% as a fraction or retail sales, 39% year-on-year growth), California (+0.4%, 23%) and Maine (+0.3%, 26%).

Source: ACEEE Note: The ACEEE Scorecard points to caveats in the energy efficiency savings data reported by states. Historically, 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. For 2016, ACEEE adjusted this to 0.817 based on the median net-to-gross ratio calculated from states that report both figures.

Deployment: GHG savings as a result of energy efficiency achievements by electric utilities to date, 2013-15 (MtCO2e)



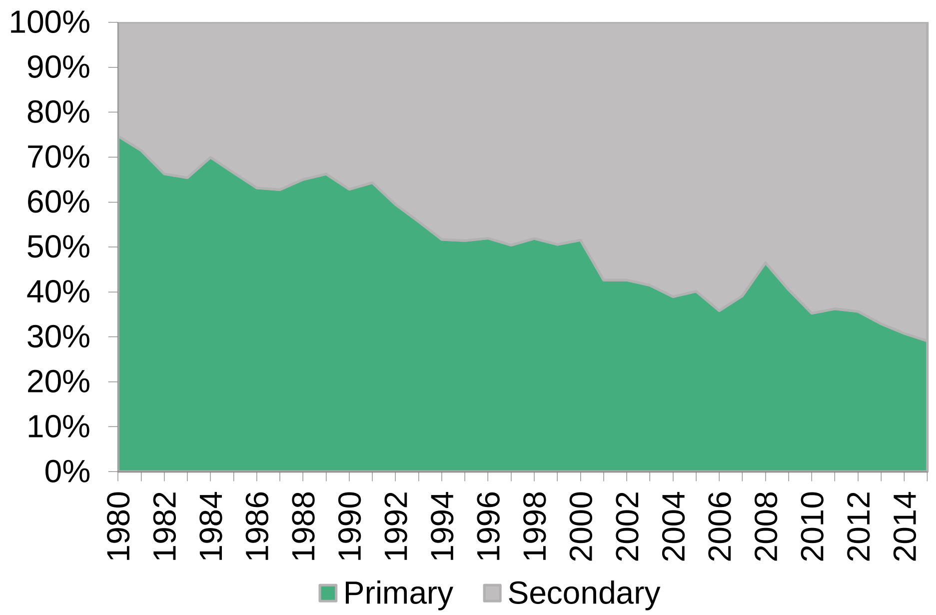
- Electric utility energy efficiency programs saved a total of 34.2MtCO2e in greenhouse gas emissions from 2013 to 2015. Nearly 16% of the savings were due to efforts made in California.
- Pennsylvania, Ohio and Illinois are the next largest savers, respectively, followed by Massachusetts and New York.

Source: Bloomberg New Energy Finance, ACEEE

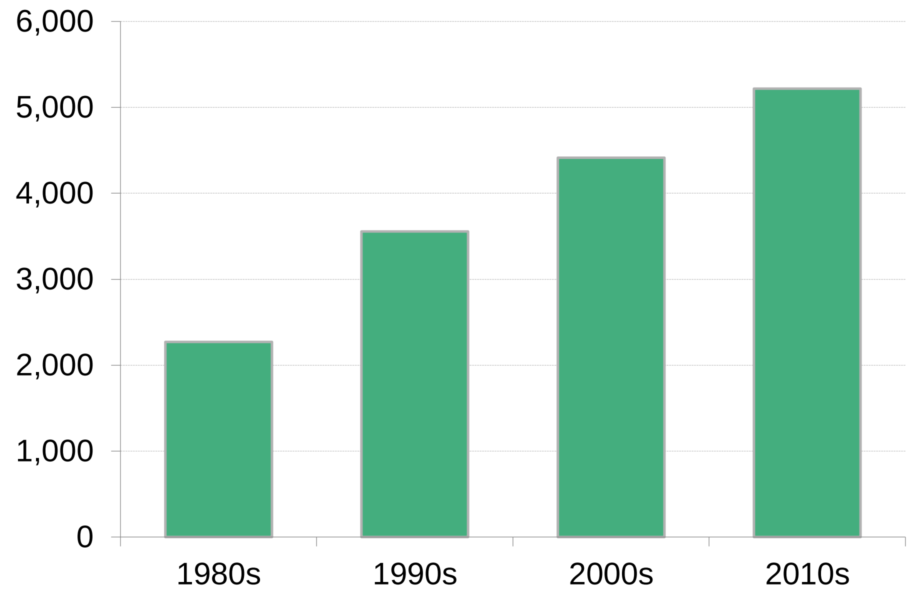
Note: Uses ACEEE data on electric efficiency program savings and Bloomberg Terminal data on historical emissions factors. Emissions factors are calculated assuming that the displaced consumption would have been generated by the marginal natural gas combined-cycle unit; data on historical power and natural gas prices are used to calculate an implied heat rate for the marginal unit.

Deployment: US aluminum recycling trends

US production of primary vs. secondary aluminum



Average annual aluminum scrap recovery by decade (billions of pounds)



- Because producing aluminum from secondary sources (ie, recycled post-consumer and industrial scrap) consumes significantly less energy than making new aluminum, the industry provides insights into industrial sector adoption of energy efficiency.
- The share of aluminum pulled from secondary sources exceeded 70% for the first time in 2015, up from 48% in 2000 and only 25% in 1980.
- Scrap recycling rose 18% from the previous to the current decade, partly due to the addition of imported cans into the US recycling stream.

Source: The Aluminum Association, US Geological Survey, US Department of Interior, US Department of Commerce

Notes: Not shown here is the considerable share of aluminum imports consumed in the US, which have historically met around 45% of US demand.

Source: The Aluminum Association, Can Manufacturers Institute, Institute of Scrap Recycling Industries

Financing: US *estimated* investment in energy efficiency through formal frameworks ($bn nominal)

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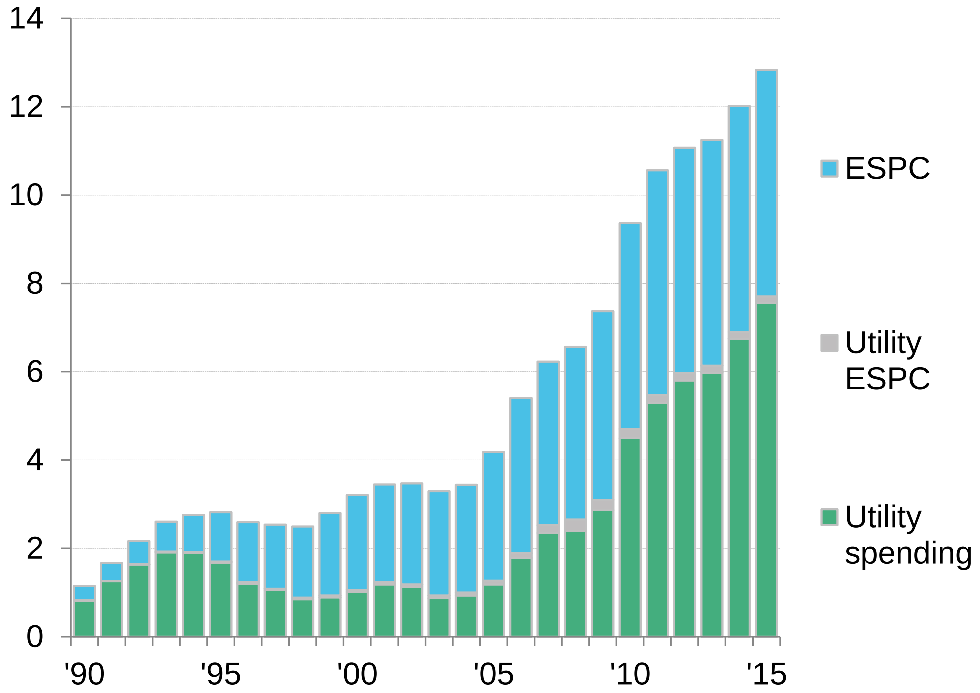
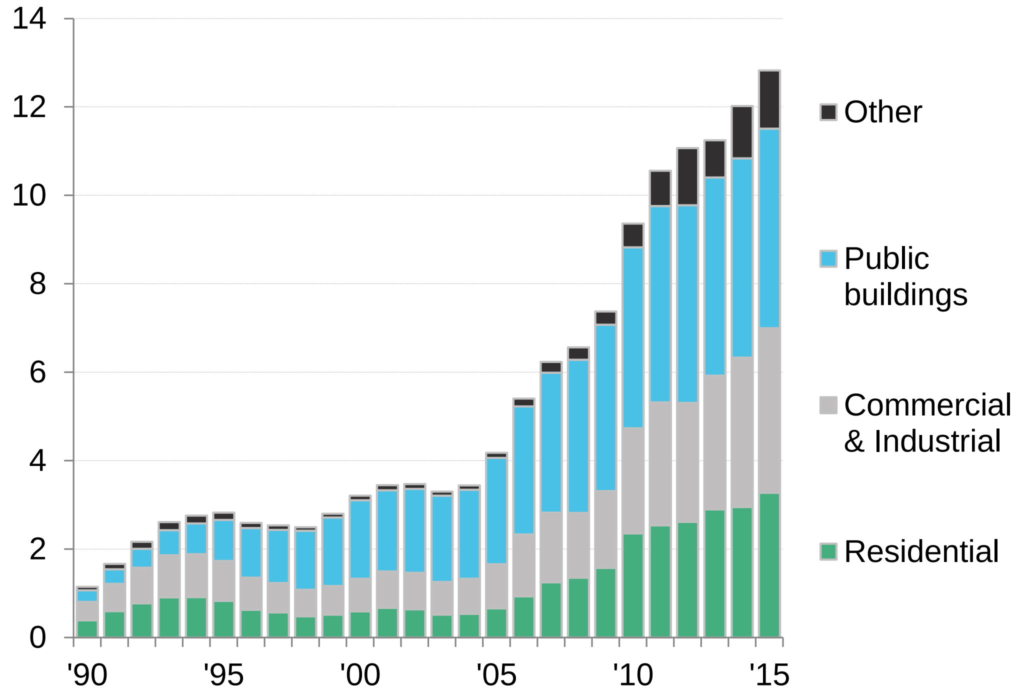
By framework



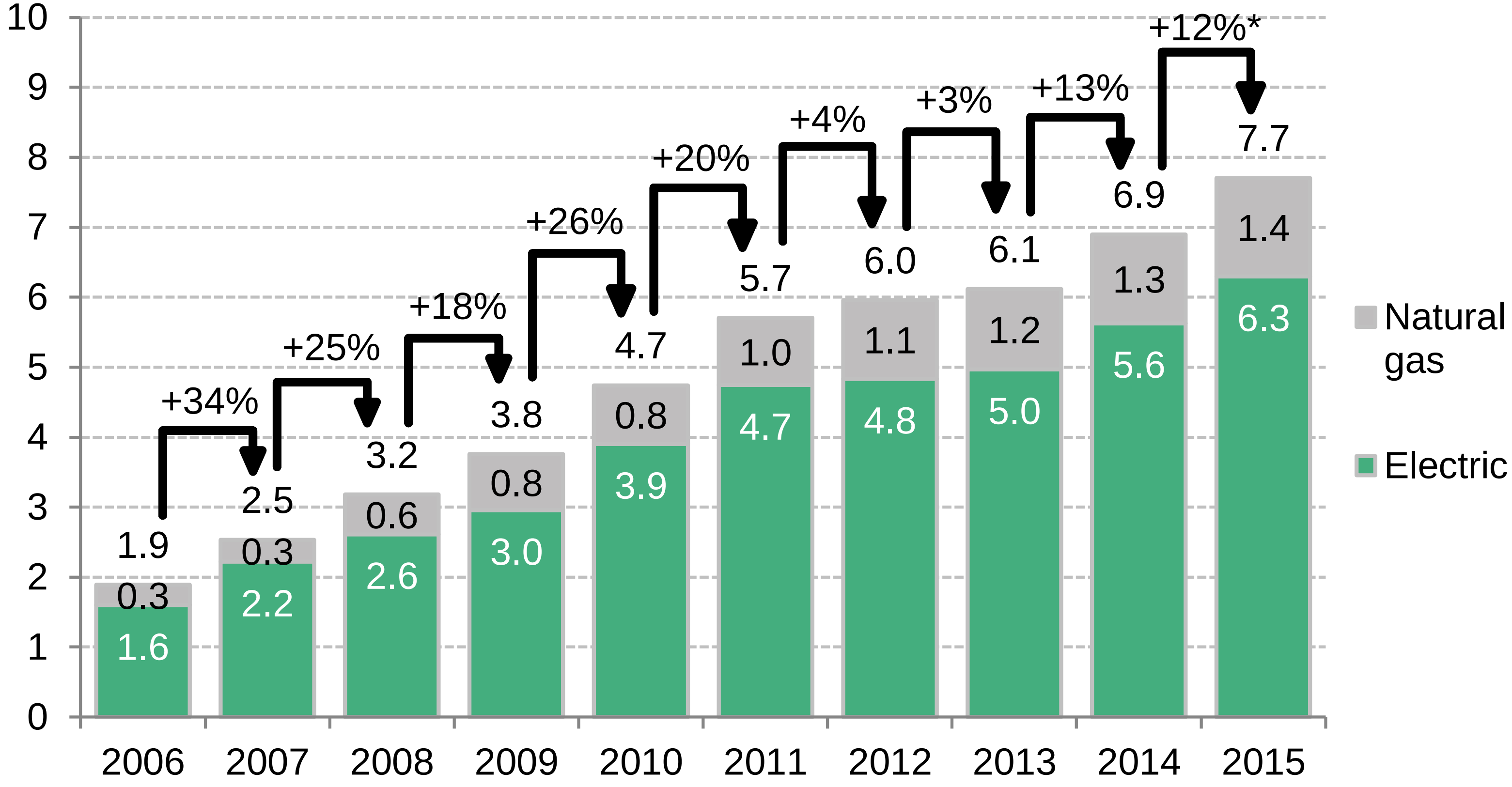
By sector



- Utility spending on energy efficiency remains the largest and fastest growing source of spending in this segment, accounting for 59% of investment in energy efficiency through formal frameworks.
- Energy-savings performance contracts (ESPC) are predominantly focused on public buildings. In 2015, ESPC spending for all measured sectors hit $5.3bn, bringing the five-year total to $26bn. Data from the Lawrence-Berkeley National Laboratory (LBNL) suggest that the ESPC market also averaged an estimated $5.3bn per year from 2011 to 2015. Anecdotal evidence collected by LBNL reveals that this figure may be incomplete, in part due to increased competition from smaller, non-traditional energy service companies (ESCOs), which do not meet LBNL's criteria for inclusion in the dataset graphed above.

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

Financing: US utility energy efficiency spending ($bn)



- In line with the trend of EERS-driven utility efficiency programs, utility efficiency spending grew rapidly between 2006 and 2011. Growth continued after 2011, but at a slower rate.
- Growth appears to have picked up again in 2014 and 2015. It should be noted, however, that 2014 and 2015 data came from different sources, since CEE data is currently not available for 2015. The 12% jump in 2015 is likely an exaggeration; the ACEEE estimates a more modest 4% growth in 2015.
- Expenditure in California grew from $1,580m in 2013 to $1,715m in 2014, the largest upswing of any state.

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

Economics: US federal ESPC activity executed through the DOE's umbrella agreement, grouped by cost of saved energy (x-axis), 1998-2015

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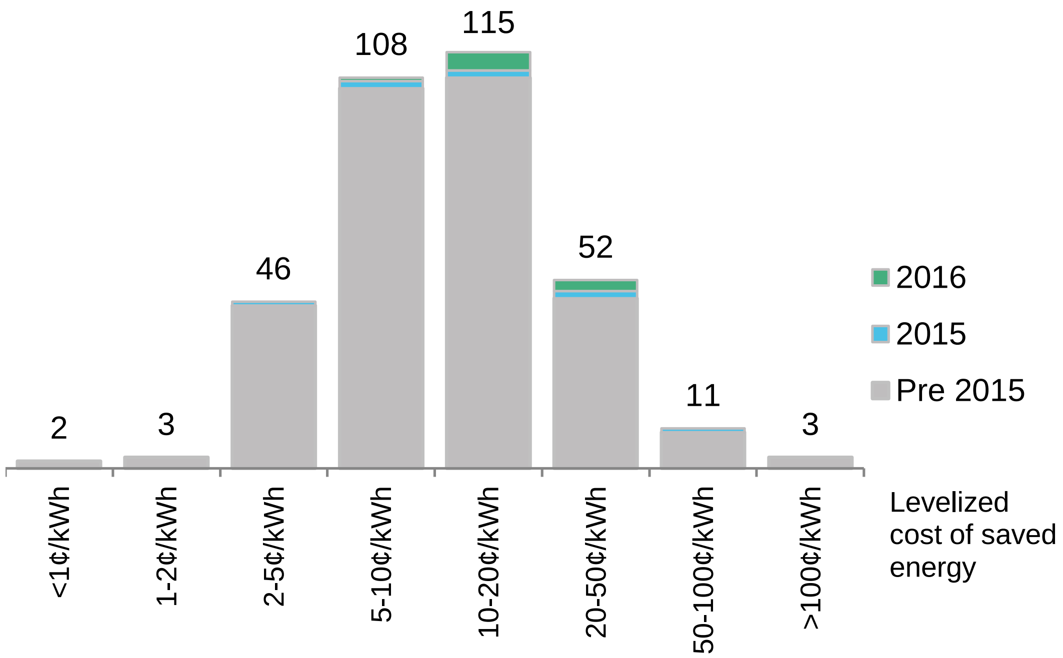
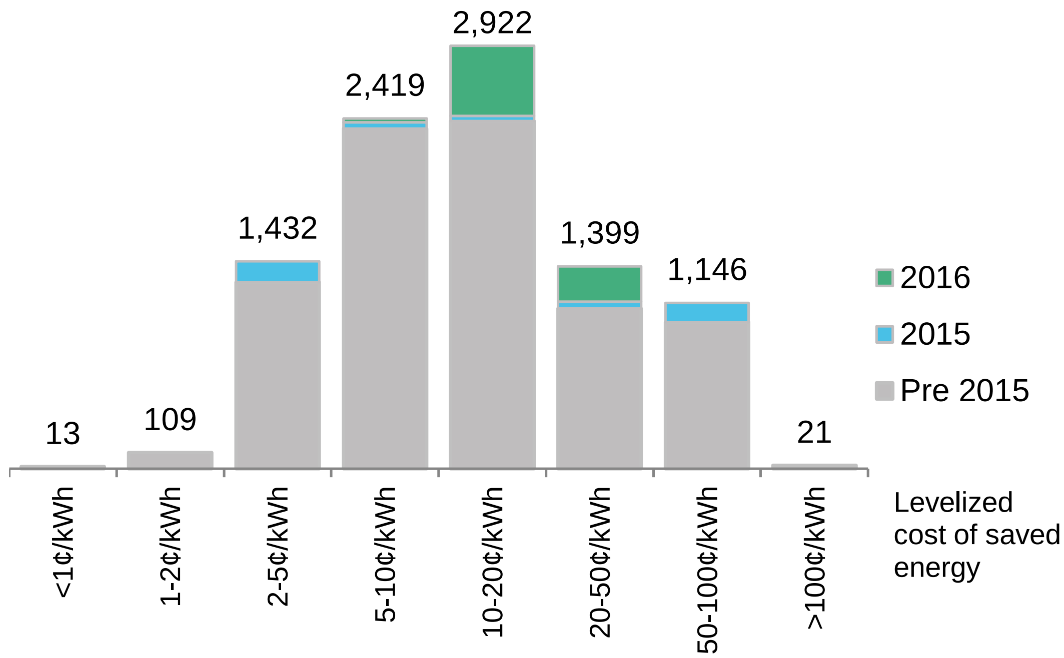
Cost of energy savings under ESPCs



Total contract value of the ESPCs ($m)



- The cost of energy saved under energy savings performance contracts (ESPCs) ranges widely, due to a number of factors such as differences in the type of energy saved, differences in the price of energy saved and the fact that other necessary infrastructure upgrades are sometimes added on top of energy savings projects, in a way that drives up cost.
- Having said this, it appears that in the past two years, the range for federal ESPCs has somewhat narrowed, with the majority of projects and investment implicitly valuing saved energy in the range 10-20¢/kWh. This is roughly in line with the cost of electricity, suggesting that more projects are being approved on the basis of energy-saving economics than in the past.

Source: Federal Energy Management Program (FEMP), US Department of Energy (DOE), Bloomberg New Energy Finance

Notes: DOE's umbrella agreement refers to indefinite-delivery, indefinite-quantity (IDIQ) contracts between the DOE and energy service companies. LCOE is calculated using 5% discount rate.

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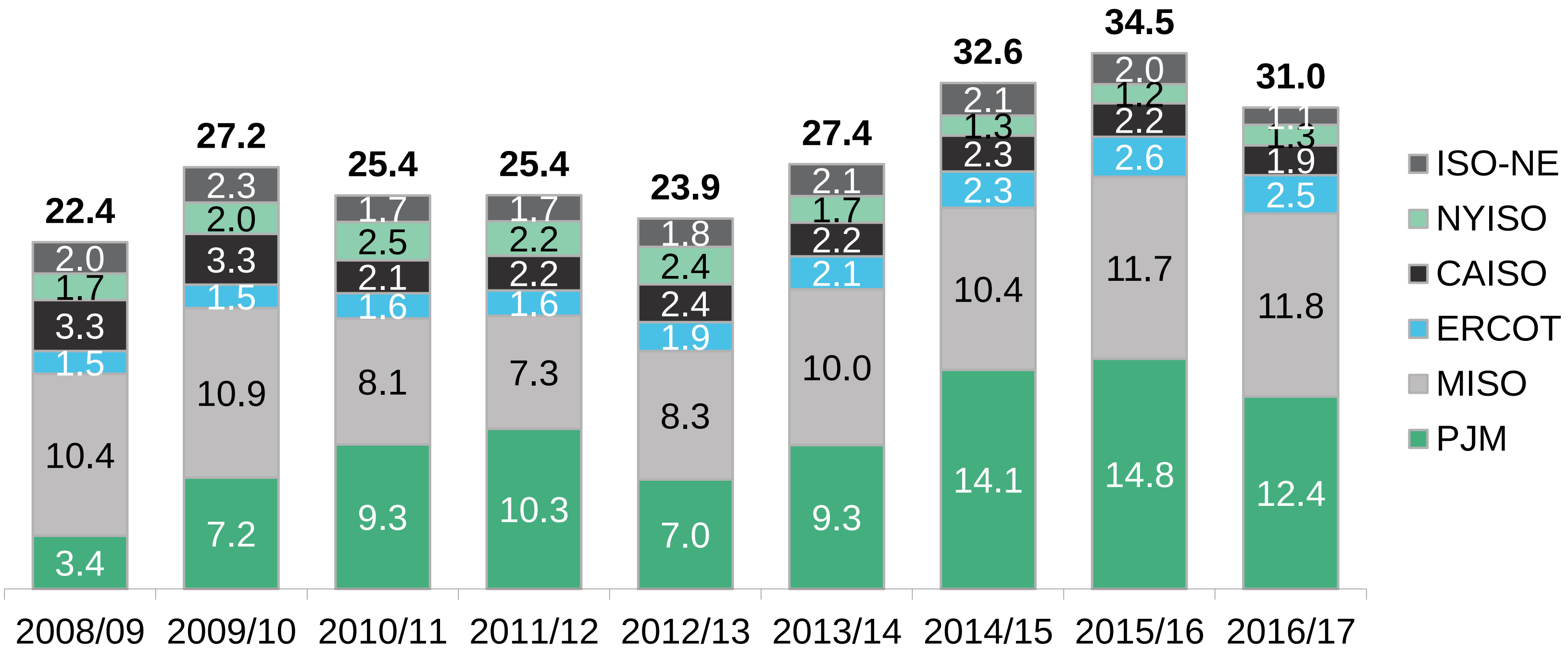
Deployment: Incentive-based demand response capacity by US ISO/RTO (GW), 2008/09–15/16



- Over 40% of US wholesale demand response (DR) is within the PJM capacity market – the largest opportunity for DR worldwide. 2015/16 represents a peak year as new rules introduced by PJM have limited the role of DR within the market. Volumes have subsequently declined in the three-year ahead auction; in the May 2016 auction, DR secured only 10.3GW.
- The bulk of MISO's DR capacity is emergency resources that are not directly dispatchable but operated through utility programs. CAISO's capacity is also administered by utilities but includes a large share of real-time and day-ahead dispatchable capacity.
- The resolution of FERC 745 has brought a measure of stability to the DR industry. Across the US, ISO/RTOs are exploring reforms and mechanisms that will increase the penetration of DR and aggregated distributed energy resources within their markets.

Source: Bloomberg New Energy Finance; ISO/RTOs

Notes: Capacity shown by delivery years which run June through May.

Deployment: US electric smart meter deployments

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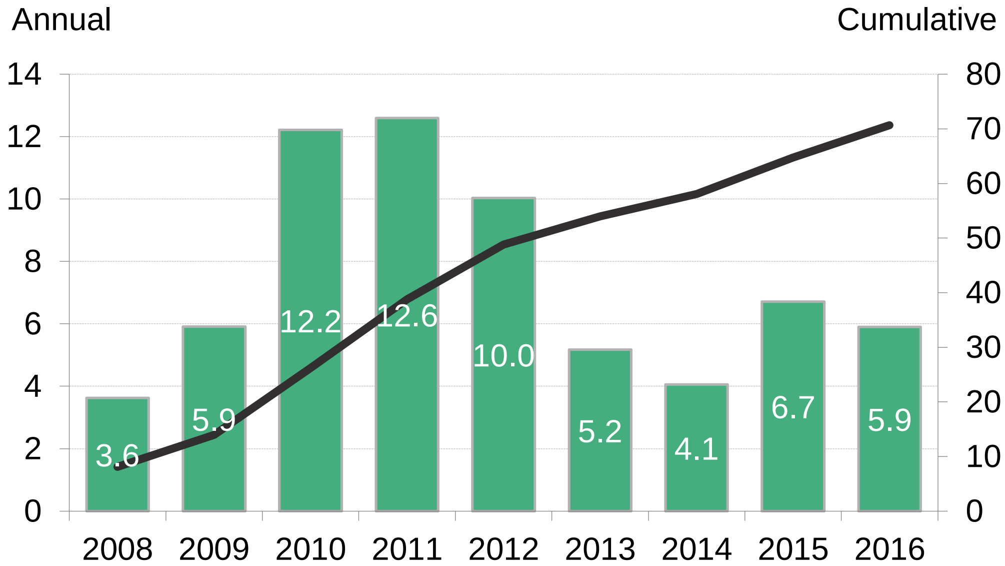
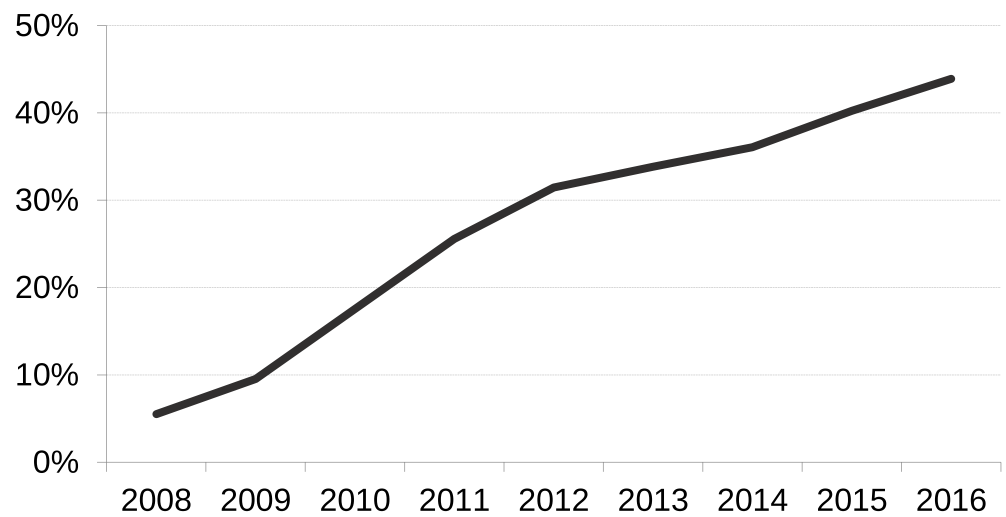
US smart meter deployments (million units)



Smart meters deployed as a percentage of US electricity customers

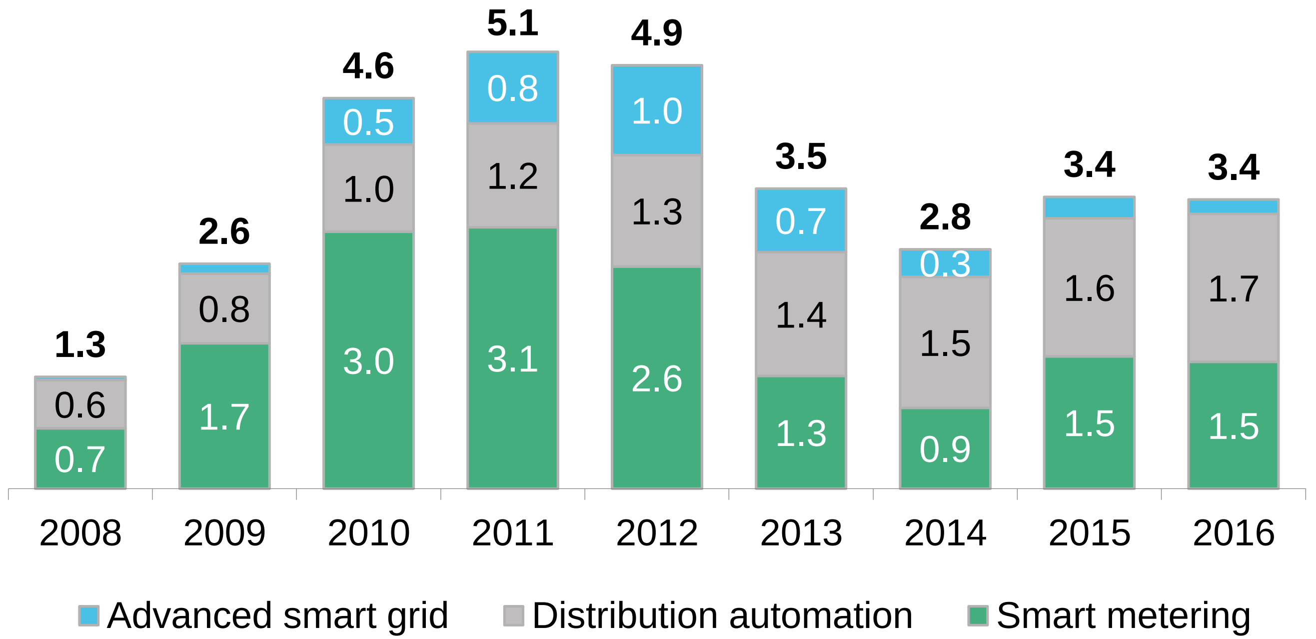


- Smart meter installations hit a peak in 2010 and 2011, supported by stimulus funding awarded in 2009. Most of the largest US utilities took advantage of the Smart Grid Investment Grant to roll out smart meters across their territories. As grant funding dried up, deployments slowed, hitting a trough in 2014. Smart metering activity has since increased as smaller utilities receive regulatory approval to move forward with the technology.
- The greatest cost saving for utilities from smart metering is replacing the need for manual meter reads. Today, 44% of US electricity customers now have a smart meter, while a further 29% have less advanced, automated meters. However, growing penetration of distributed energy and a regulatory push for dynamic retail tariffs is creating additional need for the technology.
- For example, in New York, where smart meters have largely been ignored to date, utilities are now planning widespread installations in order to achieve the goals of the *Reforming the Energy Vision* process. Smart meters will enable dynamic tariffs, improve customer data and potentially support other residential energy technologies.

Source: Bloomberg New Energy Finance, EIA

Notes: Includes data for smart electricity meters, excludes automated meters. Smart meters are defined as those capable of two-way communication over a fixed network.

Financing: US smart grid spending by segment ($bn)

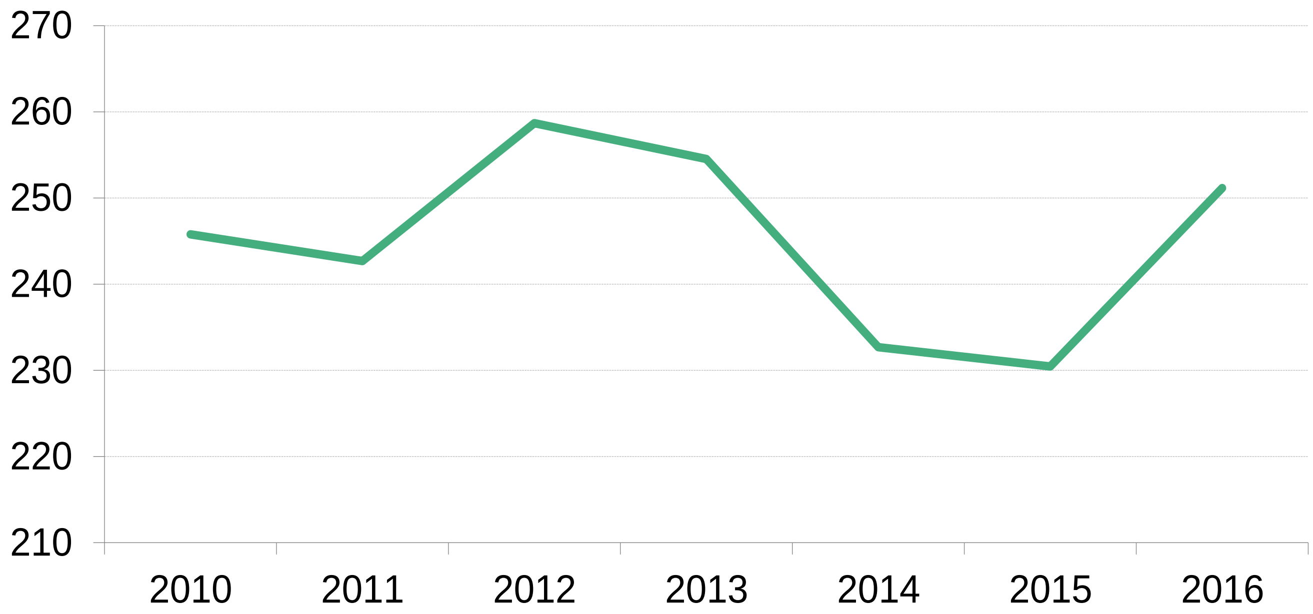


- Installation of smart meters accounted for over half of US smart grid investment until 2013, when it dropped off significantly. Expenditure on smart meters has rebounded from its low in 2014, but remains less than half its 2011 peak.
- Distribution automation spending has steadily increased each year. These investments represent utility projects within the distribution system to reduce outage frequency and durations and to more efficiently manage electricity flow within the grid. As the penetration of distributed energy resources increases, some utilities are ramping up investment in automation to manage the growing complexity of the distribution grid.
- Advanced smart grid projects account for a diminishing share of overall investment. Much of this expenditure went into pilot projects funded by the Smart Grid Investment Grant, which provided $4.5bn to modernize the US electricity grid. As these projects wind down, utilities are exploring opportunities to deploy successful technologies where appropriate.

Source: Bloomberg New Energy Finance

Notes: The 'advanced smart grid' category includes cross-cutting pilot projects, such as those involving load control, home energy management and EV charging.

Economics: US average smart meter cost ($ per meter installed)



- So far this decade, metering costs have remained between $230 and $260 per meter, despite the installed base of meters more than doubling during the same time frame.
- Unlike Europe, where extensive competition from Asian metering vendors has placed downwards pressure on prices, US utilities have benefited from higher quality devices but at fairly level prices.
- Many meter vendors are using in-house development and acquisitions to offer new products and services such as data analytics and asset management. These are billed on a subscription basis, so while the up-front cost of smart metering has remained constant, ongoing utility expenditure on the technology is increasing.

Source: Bloomberg New Energy Finance

Notes: Cost per meter includes meters, communication infrastructure, associated IT spending and installation costs. Data based on total annual smart meter investment market size and total smart meters installed in a given year; results may vary as many deployments are based on a fixed cost per meter, but the meters are deployed over several years. Values are in nominal dollars.

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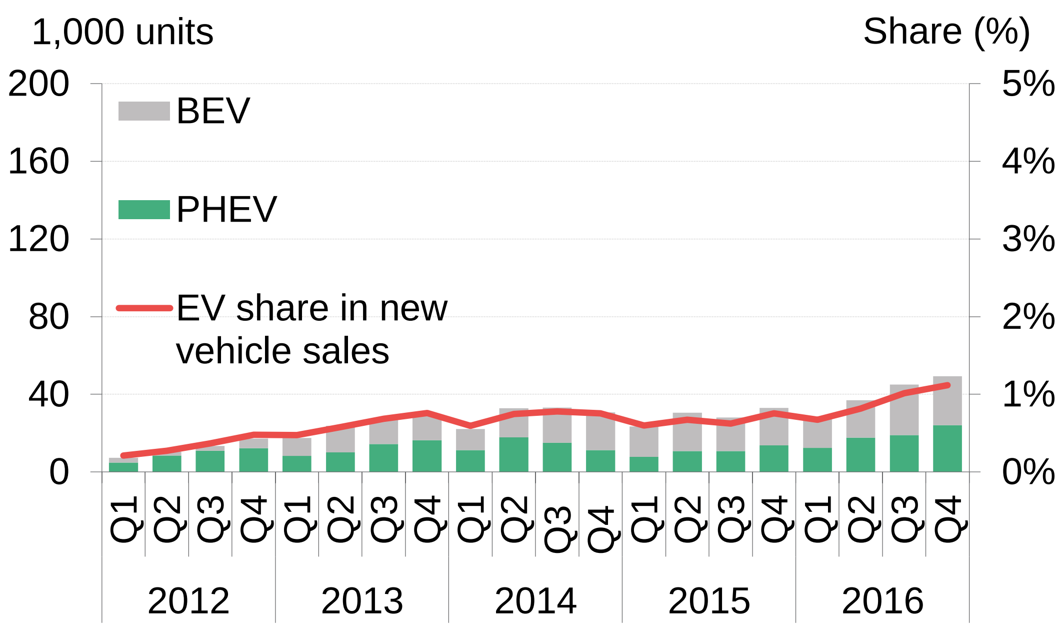
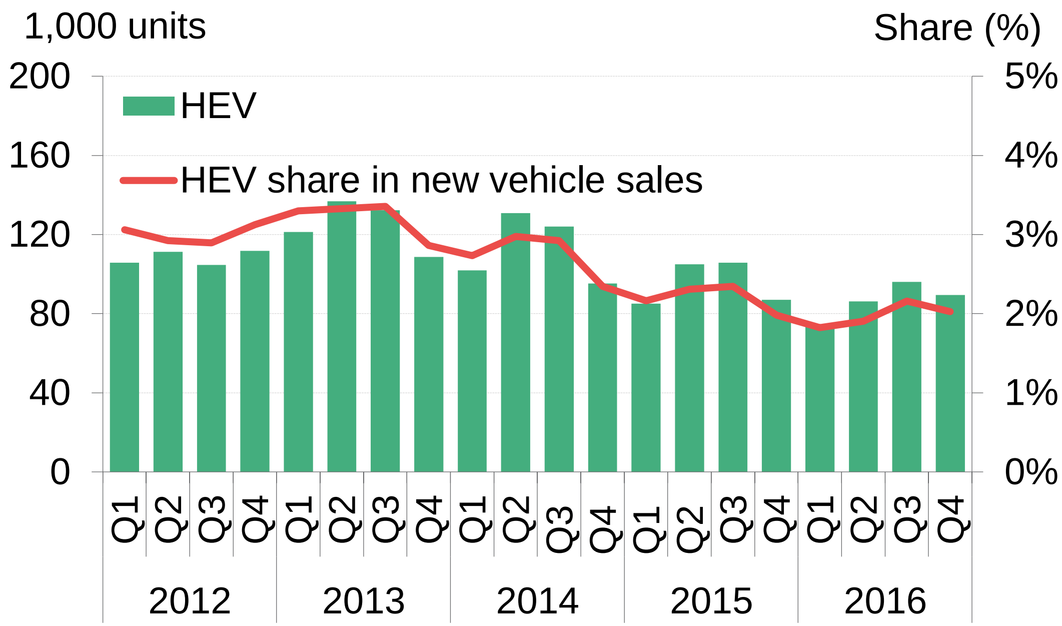
Deployment: US electric vehicle and hybrid electric vehicle sales

US EV sales



US HEV sales



- Sales of electric vehicles – a category that includes battery electric vehicles (BEV) and plug-in hybrid electric vehicles (PHEV) – jumped 38% from just short of 115,000 units in 2015 to over 158,200 units in 2016.
- New SUV model additions – the BMW X5 or the Tesla Model X – together with widespread availability of the revamped Chevrolet Volt contributed to the uptick in overall US EV sales.
- PHEV sales increased the most and were up 70% year-on-year, driven by renewed consumer interest in the upgraded Chevrolet Volt and new PHEV model introductions like the BMW X5 xDrive. BEVs saw an 18% jump in sales and were able to sustain their advantage over PHEVs by almost 12,400 units in 2016.
- Sales of hybrid electric vehicles (HEV) totalled short of 345,960 units in 2016 – a 10% decrease compared to 2015. The market continues to suffer from low gasoline prices, which make the more expensive HEVs less attractive.

Source: Bloomberg New Energy Finance

Deployment: EV model availability in North America, 2008-2016 (number of models)

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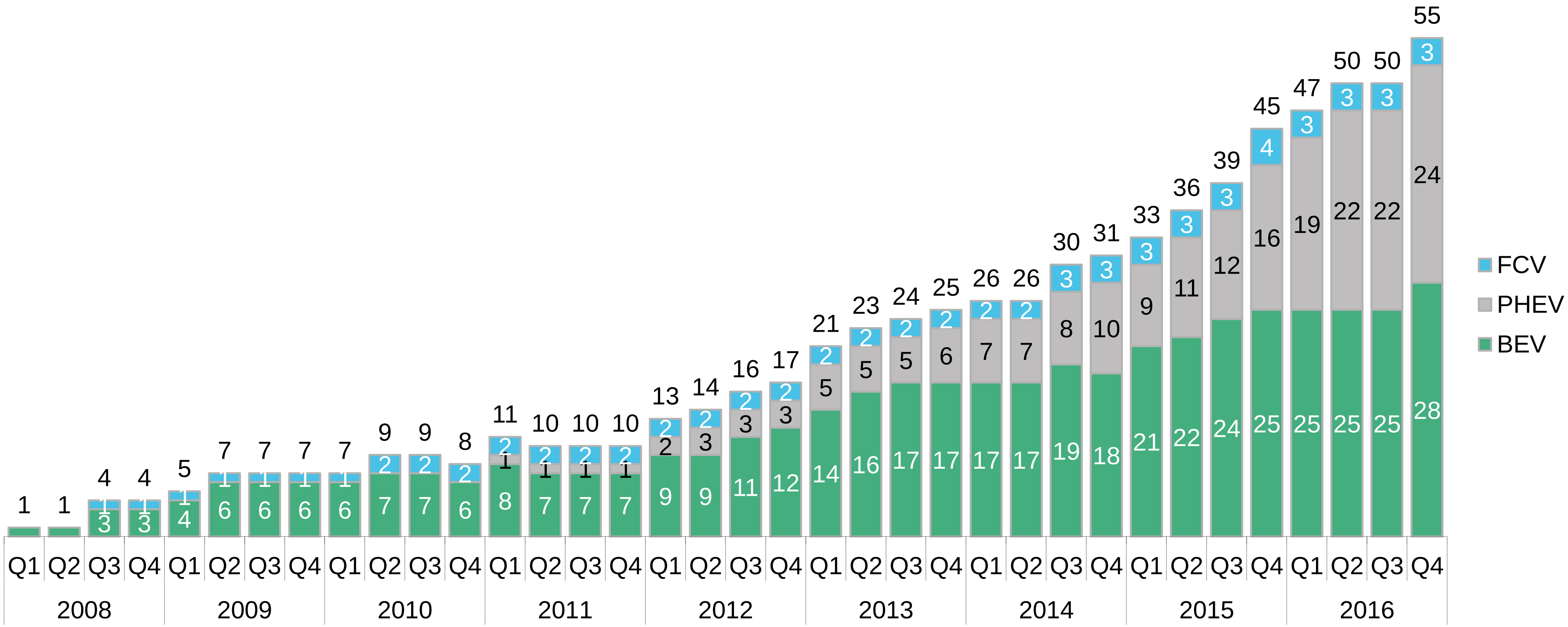

- By Q4 2016, 55 EV models were available to North American consumers, including three FCVs, 24 PHEVs and 28 BEVs.
- The growing number of PHEV models available in 2016 – making up 43% of total EV models in Q4 compared to 36% during the same time in 2015 – reflects a global shift towards partial electrification as automakers face stringent fuel efficiency requirements in their core markets (EU, China and US).
  - German automakers – mainly BMW, Daimler and VW – dominated PHEV offerings in North America in Q4 2016, offering 14 of the 24 available models. These vehicles are compliant with EU CO2 emission mandates and the US National Program (CAFE and GHG emissions).
- Three new BEV models were launched in 2016: VW's Passat GTE BEV, GM's Chevrolet Bolt and Bolloré's Bluecar (for carsharing schemes). The Chevrolet Bolt launched in 2016 with availability only in California and Oregon, where BEVs are in high demand as a result of those states' pledges to the Zero Emission Vehicle (ZEV) program. A step-by-step rollout to the rest of the US is scheduled for 2017.

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

Deployment: Share of US vehicles sold with start-stop technologies, 2012-2016

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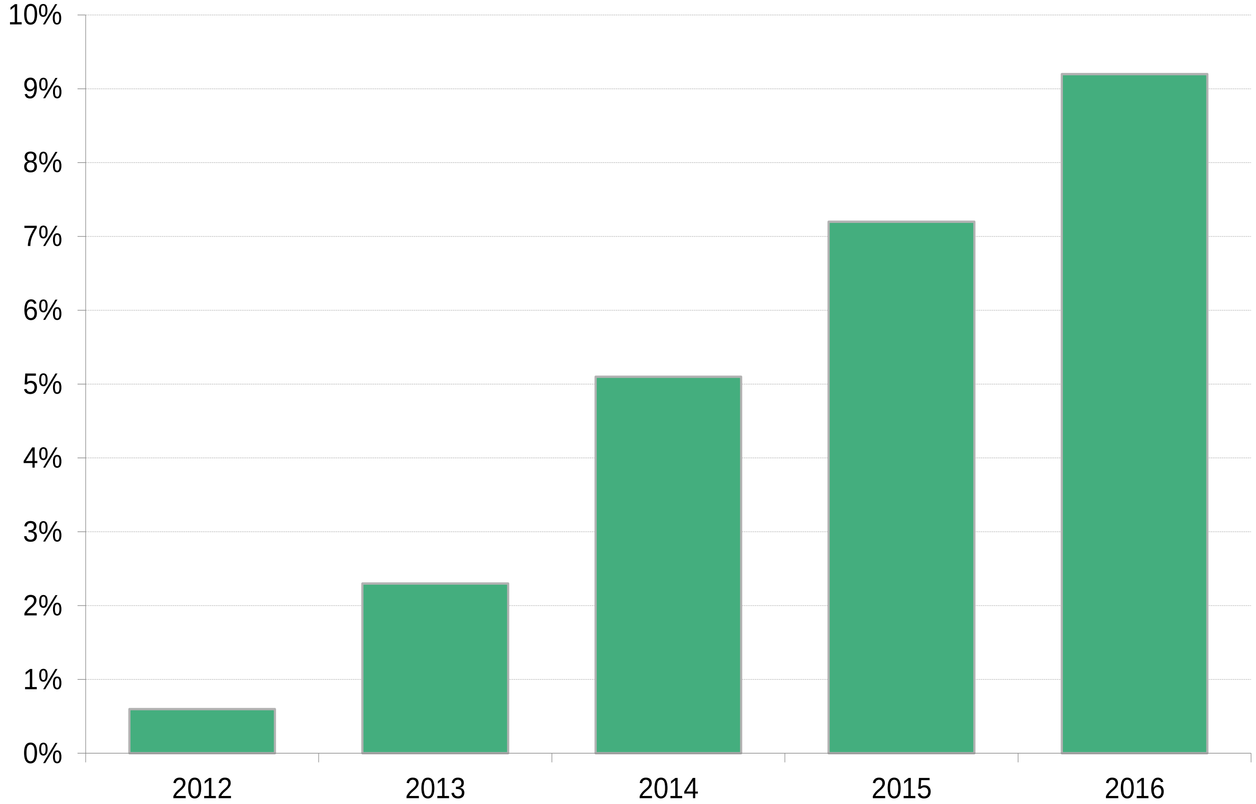

- Start-stop systems automatically shut off the engine when the vehicle is stopped, thereby cutting fuel use and reducing idle emissions. A battery continues to power lights and accessories while the engine is off. The engine automatically restarts when the driver releases the brake pedal.
- Start-stop systems deliver up to 5% fuel savings for conventional internal combustion engine vehicles, depending on driving conditions.
- In Europe, vehicles with start-stop systems made up 80% of new vehicles sales in 2016. Europe got a head start on adopting start-stop technology a decade ago, in response to carbon reduction regulations.
- In the US there were at least 90 vehicle models with start-stop available in 2016, including the Ford Fusion and F-150, Chevy Malibu and Impala, Jeep Cherokee, Chrysler 200, Kia Sol and Rio, Dodge Ram and others.

Source: EPA, Bloomberg New Energy Finance, IHS

Deployment: Demand for lithium-ion batteries for passenger EVs by battery supplier

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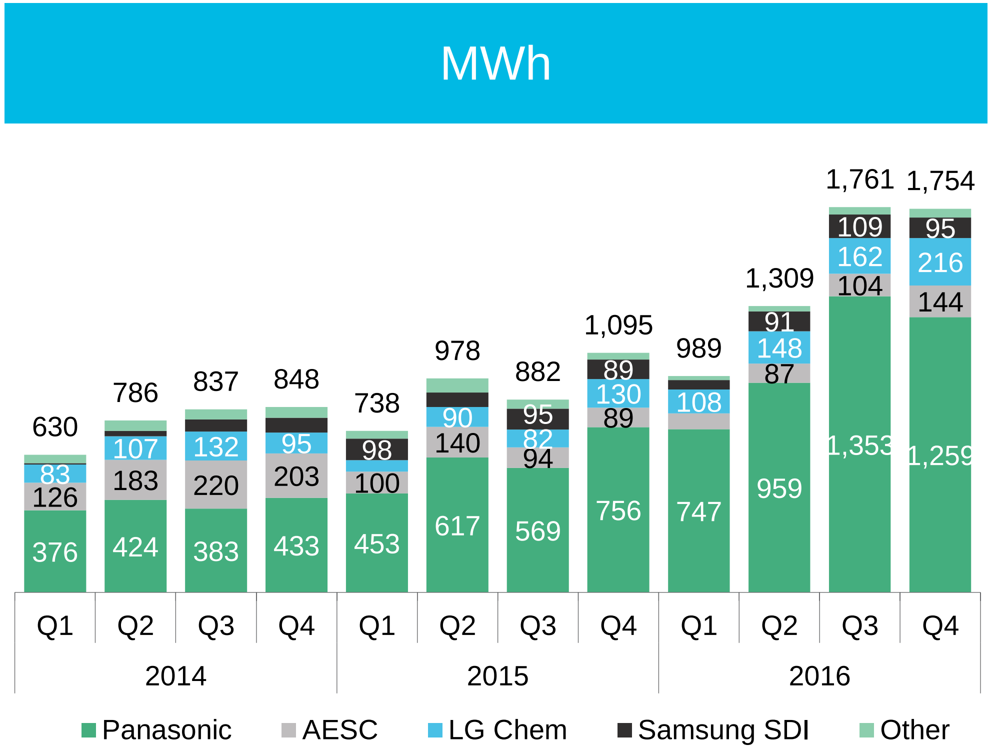
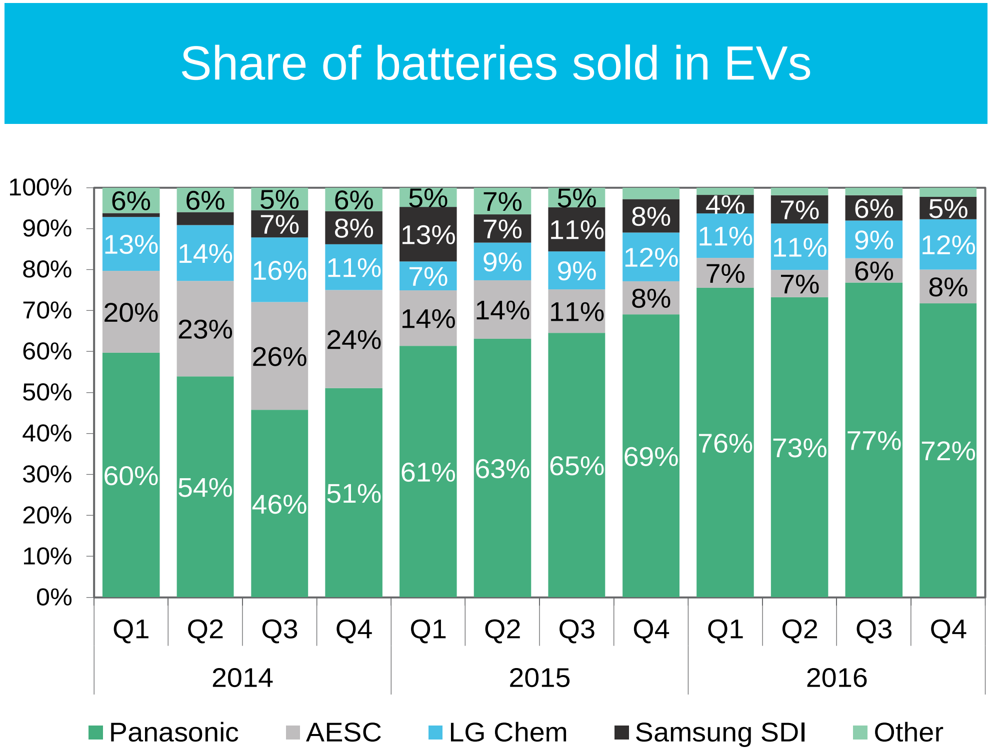
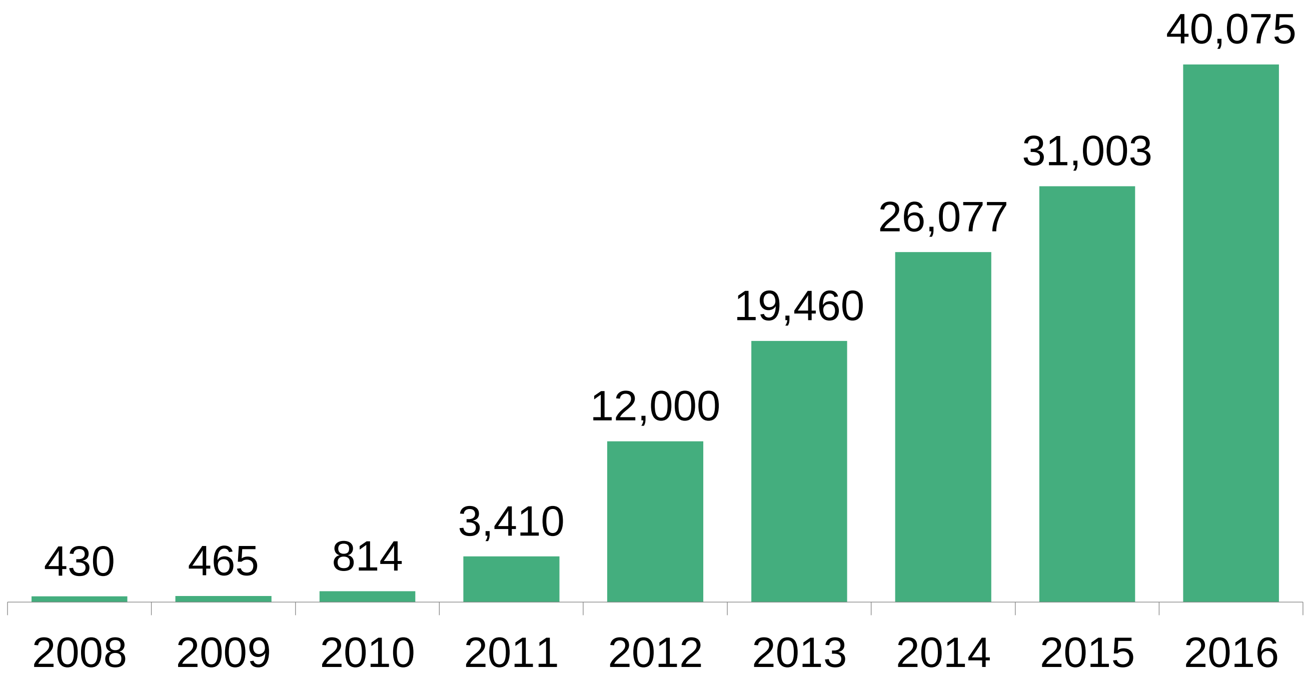




- Demand for lithium-ion batteries from EVs in the US has nearly doubled since 2014, reaching 5,813MWh in 2016.
- Panasonic dominates the supply due to its close relationship with Tesla - it provides batteries to both the Tesla Model S and the Model X. Strong sales of the two Tesla models in the US meant that Panasonic produced 74% of batteries sold in EVs in the US in 2016.

Source: Bloomberg New Energy Finance

Deployment: US public electric vehicle charging outlets (number of outlets)



- The number of public EV charging outlets has climbed steeply since 2008. In 2016 alone, the number of publicly available EV charging outlets increased 29% compared to the previous year.
- Some 80% of public charging outlets in the US are Level 2 – ie, delivering 3.3kW to 7.2kW. Around 13% are almost equally split between different rapid charging standards – CHAdeMO, CCS and Tesla Supercharger. Level 1 make up the remaining 7% of public charging outlets.
- Since most charging takes place at home, public EV chargers face low utilization rates that result in poor returns on investment for those who own and operate them. However, early investments by regulated utilities, auto OEMs, EV charging network solutions providers and governments are building out the infrastructure to support a larger EV fleet.

Source: Alternative Fuels Data Center, Bloomberg New Energy Finance

Notes: Does not include residential electric charging infrastructure.

Financing: Investment in US electric vehicle companies ($m)

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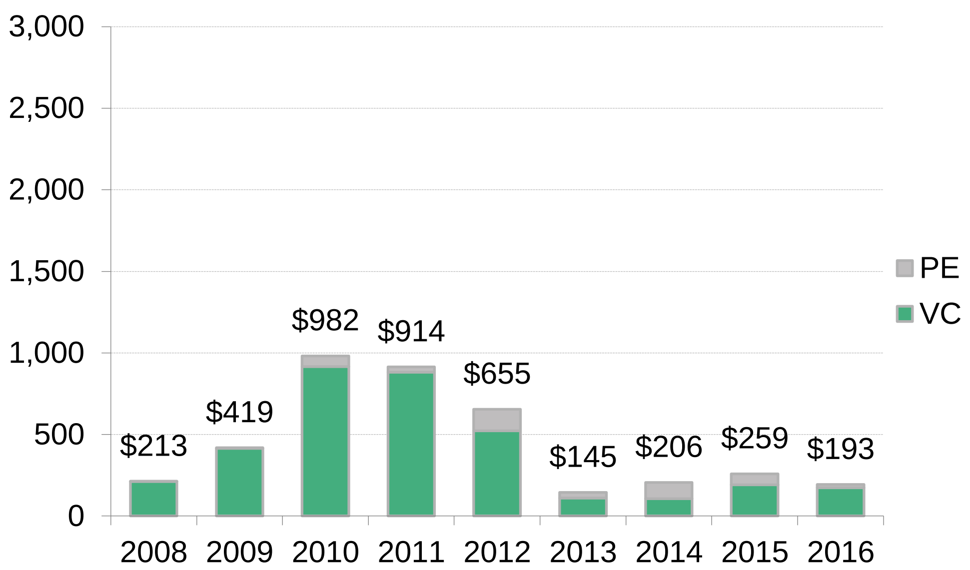
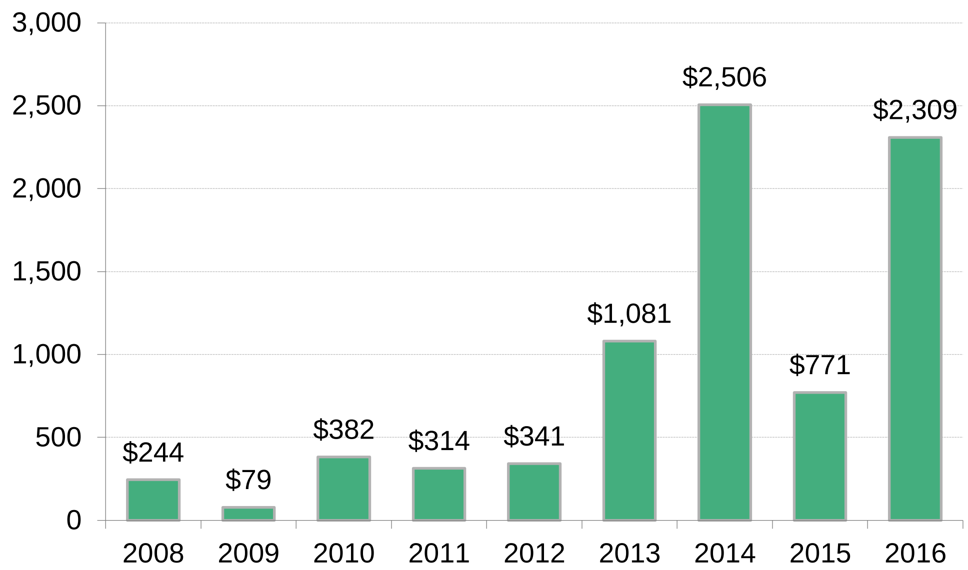
Venture capital / private equity



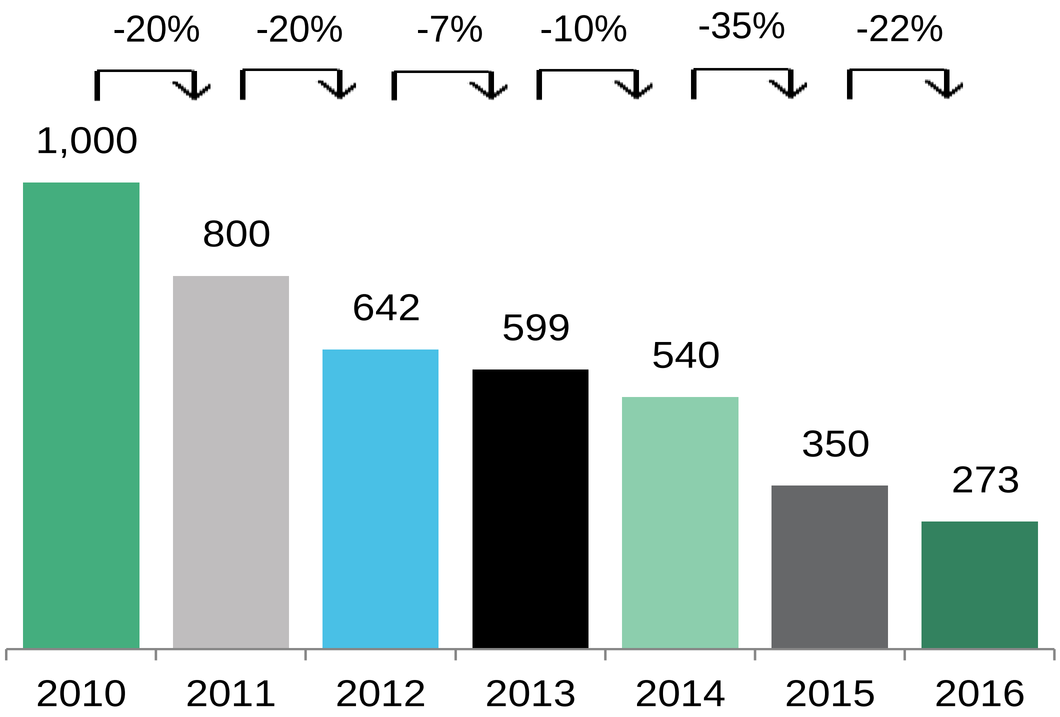
Public markets



- Venture capital and private equity firms have invested just short of $4.0bn of private capital in the US electrified transport sector since 2008. Public markets investment stands at $8.0bn over the same period.
- Notable deals in 2016 included the following:
  - Tesla raised $2.3bn via a secondary share placement to help pay for the expansion of production necessary to accommodate the demand for the Model 3.
  - ChargePoint raised $50m in a series F funding round. The lead investor, Linse Capital, was joined by Constellation Technology Ventures, Draemar Energy Ventures, Statoil Energy Ventures, Envision Ventures and three private investors. The proceeds were earmarked for the next phase of expansion outside North America.

Source: Bloomberg New Energy Finance

Economics: Lithium-ion battery pack prices, 2010-2016 ($/kWh)



- Lithium-ion battery prices have fallen 73% since 2010. For the last two years, the change was propelled mostly by technology improvements (largely in energy density) and factory overcapacity, which resulted in growing competition between major battery manufacturers.
- The diminishing cost of lithium-ion battery packs is the driving factor behind the falling cost of BEVs.
- Stationary storage systems use similar cells, but the price of a fully installed stationary system can be twice the price illustrated here due to the cost of inverters, engineering and installation.
- 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.

Source: Bloomberg New Energy Finance

Economics: BEVs are as cheap or cheaper than many gasoline vehicles in the US, when using purchasing credit incentives

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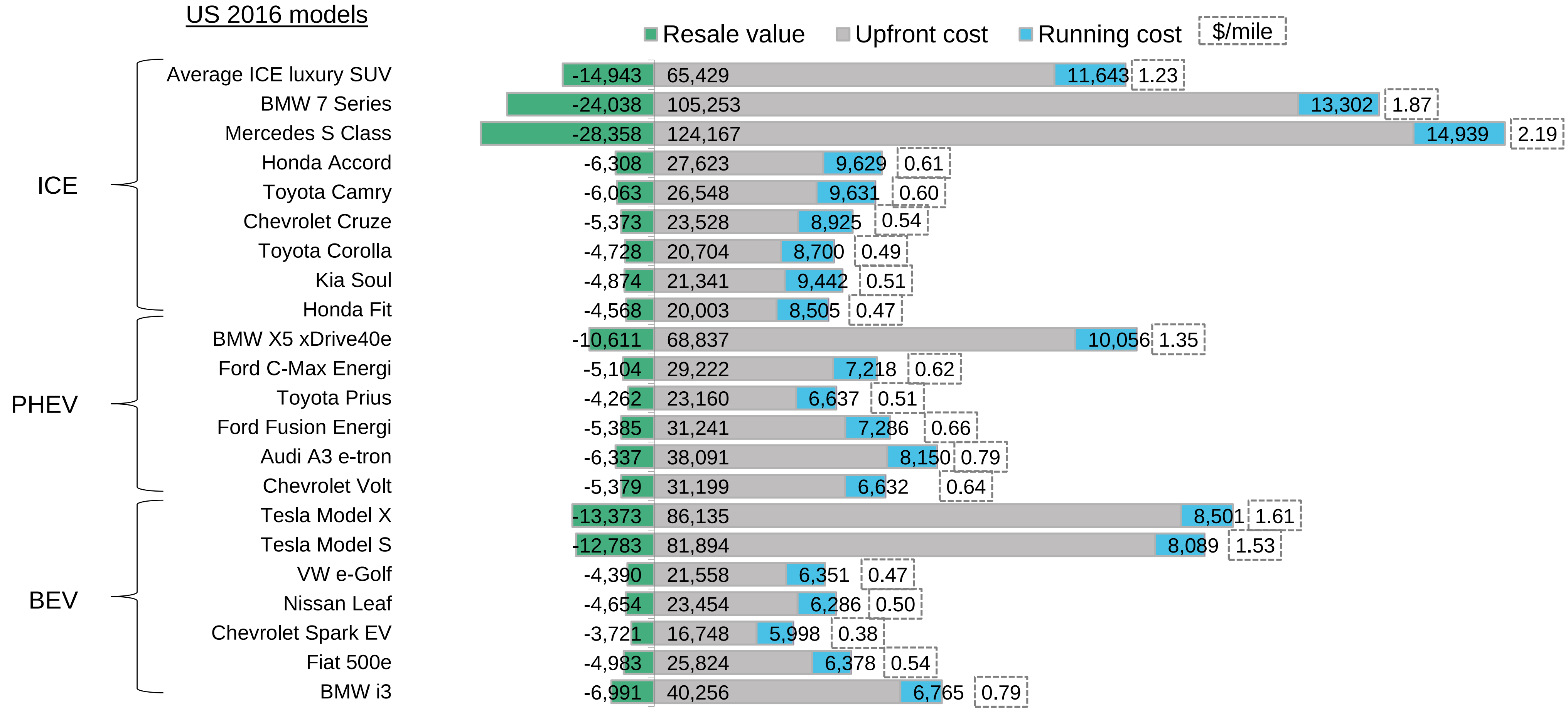

- With subsidies, battery electric vehicles cost up to 15% less than owning equivalent gasoline cars for all segments – small, medium and large.
  - Capital costs are up to 14% lower for battery electric vehicles, when including state and federal purchasing incentives of up to $10,000.
  - Fuel and running costs are up to 40% lower for a BEV.
- Plug-in hybrids cost more than midsize gasoline cars.
  - Prices for PHEV 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.

Economics: But BEVs are more expensive without purchasing credit incentives

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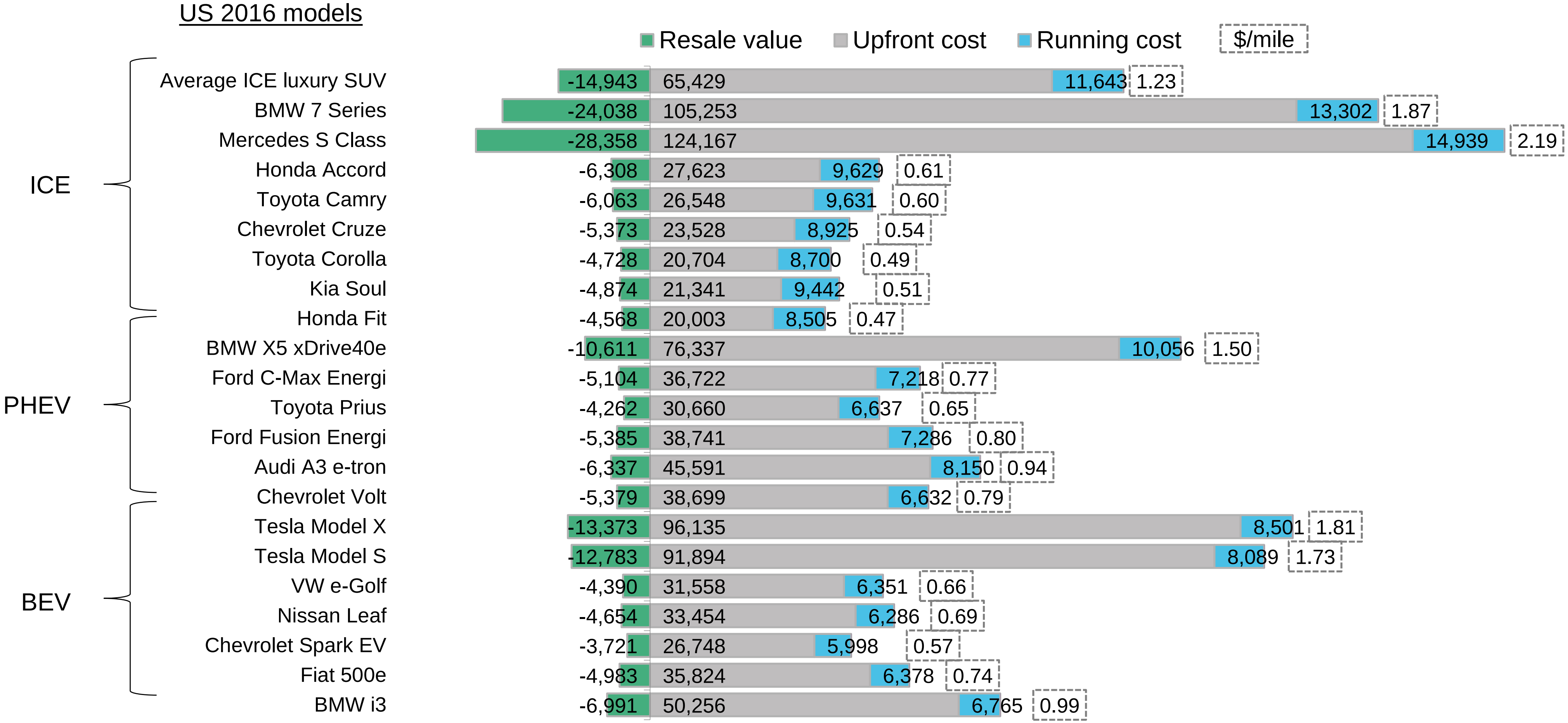

- Without price subsidies:
  - Current BEV models are up to a third more expensive than small and midsize gasoline cars, but cost the same to own and operate as large gasoline cars and SUVs.
  - Plug-in hybrids are ~40% more expensive than midsize cars due to their high purchase prices, but can be up to 15% cheaper than large gasoline cars and SUVs.

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.

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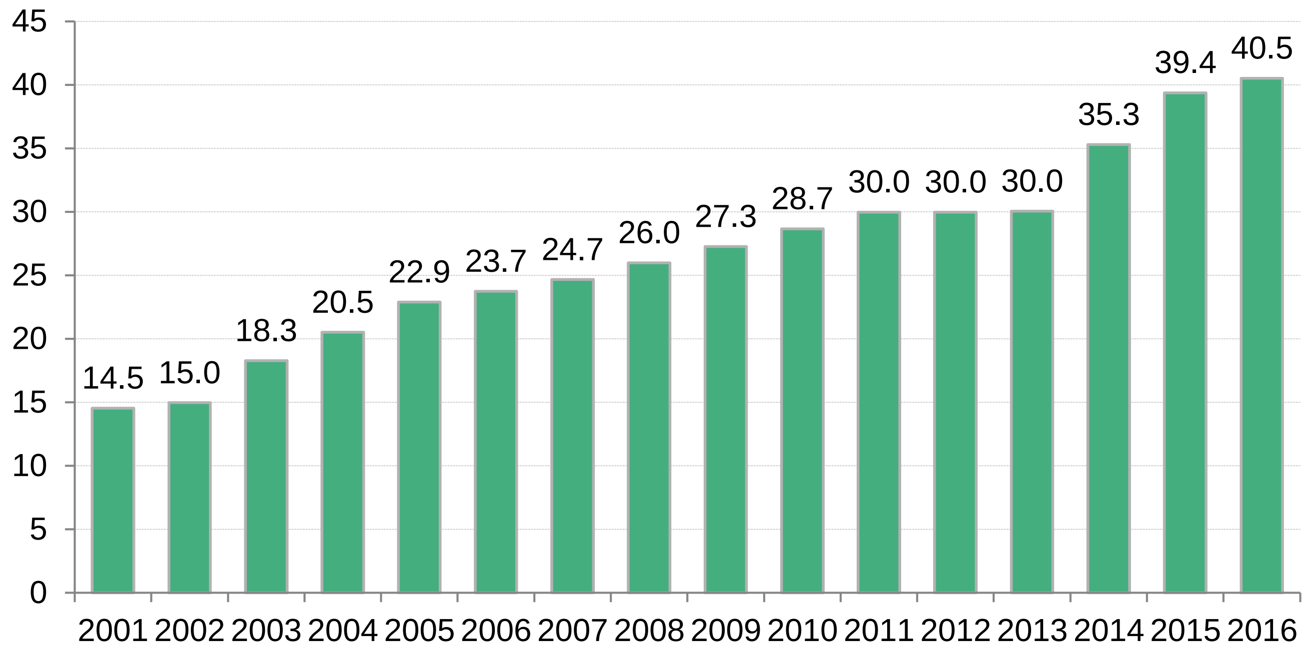
Deployment: US natural gas demand from natural gas vehicles (Bcf)

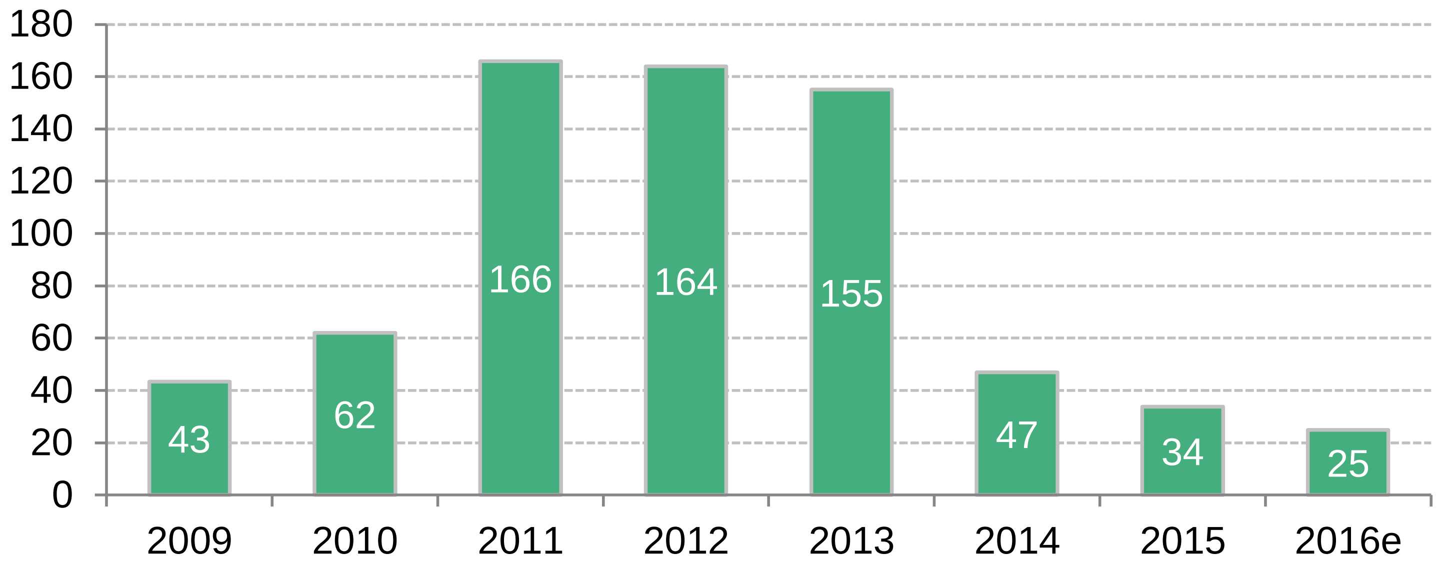


- Natural gas use in vehicles ticked up slightly in 2016, passing 40Bcf for the first time. Revised government data for 2015 showed higher consumption than previously reported, at 39.4Bcf – a 12% increase over 2014 levels.
- Compressed natural gas (CNG) remains more widely used than liquefied natural gas (LNG).
- The number of new public and private CNG and LNG stations continues to climb:
  - There were 130 new CNG stations installed in 2016, bringing the total in service to 1,728. An additional 112 stations are planned or under construction.
  - 30 LNG stations were placed in service, increasing the number of available public and private stations by 27%. Another 46 stations have been planned.

Source: EIA, Alternative Fuels Data Center

Notes: Values for natural gas demand in 2016 are projected, accounting for seasonality, based on the latest monthly values from EIA (data available through October 2016). Data excludes gas consumed in the operation of pipelines.

Financing: Capex investments by US-based Clean Energy Fuels Corp., mostly for new natural gas fuelling stations ($m)

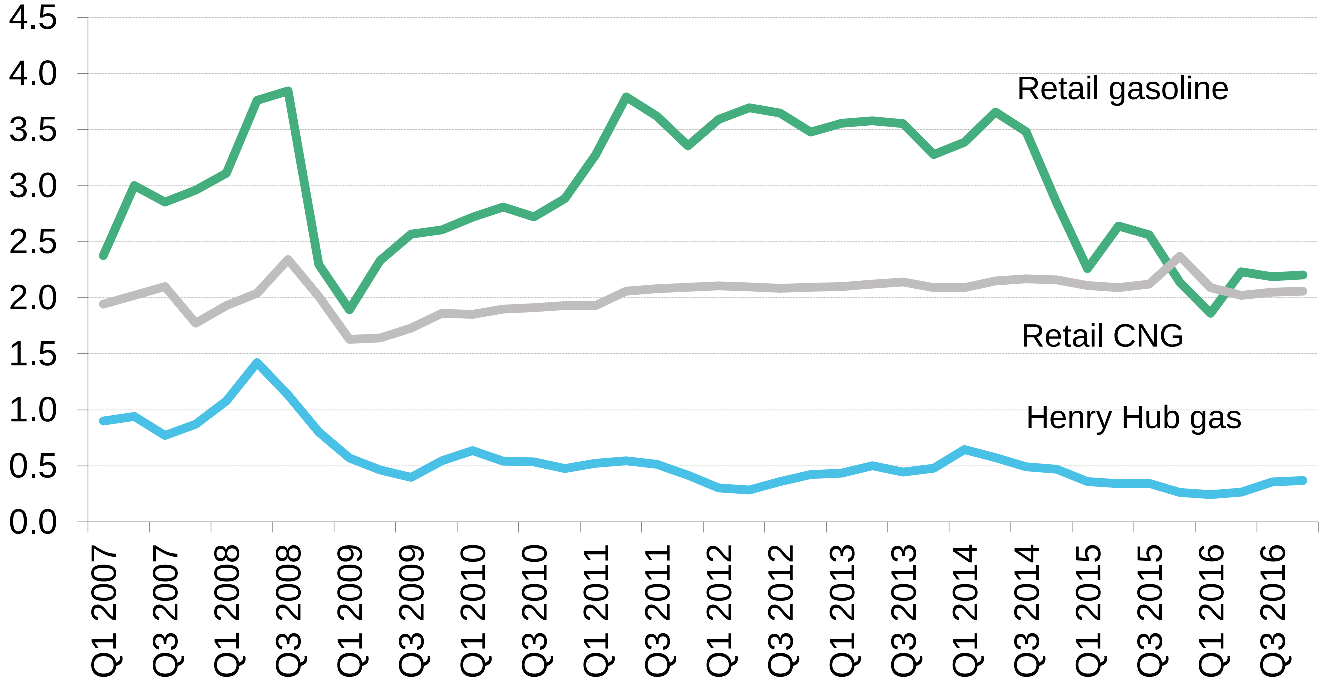


- Clean Energy Fuels is a leading natural gas fuel supplier, owning, operating or supplying 31% of US retail and private CNG and LNG fuelling stations as of the beginning of 2016. The company's spending plans are used here as a proxy for financing flows into the natural gas vehicle sector.
- The company directs most of its asset financing toward fuelling infrastructure. Spending plummeted in 2014 to $47m, less than one-third of what it initially anticipated. Similarly, 2015 spending fell to only $34bn, less than the planned capex investments of $58m, as the company sought to improve its cash position. In its 2015 Annual Report, Clean Energy Fuels budgeted $25m in capex for 2016.
- Heavy-duty trucks provide the major market for LNG, but this has been slow to expand. As of the start of 2015, there was only one major natural gas engine manufacturer for the medium- and heavy-truck market (Cummins Westport). Natural gas engines cost more than comparable gasoline or diesel engines, and its fuel price advantage has been eroded by consistently low oil prices.

Source: Clean Energy Fuels annual reports

Notes: Figures from 2009-15 reflect 'net cash used in investing activities' as per the company's cash flow statement. The amount for 2016 is based on company plans announced in its 2015 annual report ("Our capital expenditure budget for 2016 is approximately $25 million").

Economics: Average US gasoline, CNG and Henry Hub natural gas prices ($/GGE)



- Natural gas engines function almost identically to gasoline/diesel engines, but require new fuelling systems. A fuel price discount is therefore needed to incentivize consumers to convert.
- CNG previously enjoyed a substantial fuel price discount to gasoline, in the range of $1.40-$1.70/GGE from 2011-14. But the collapse of global crude oil prices erased this advantage, as gasoline prices at the pump dropped below the cost of retail CNG in Q4 2015 – Q1 2016. However, an oil price rebound allowed CNG to regain a small advantage in late 2016.
- Retail CNG prices are much less volatile than that of retail gasoline.

Source: Bloomberg New Energy Finance, Alternative Fuels Data Center

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

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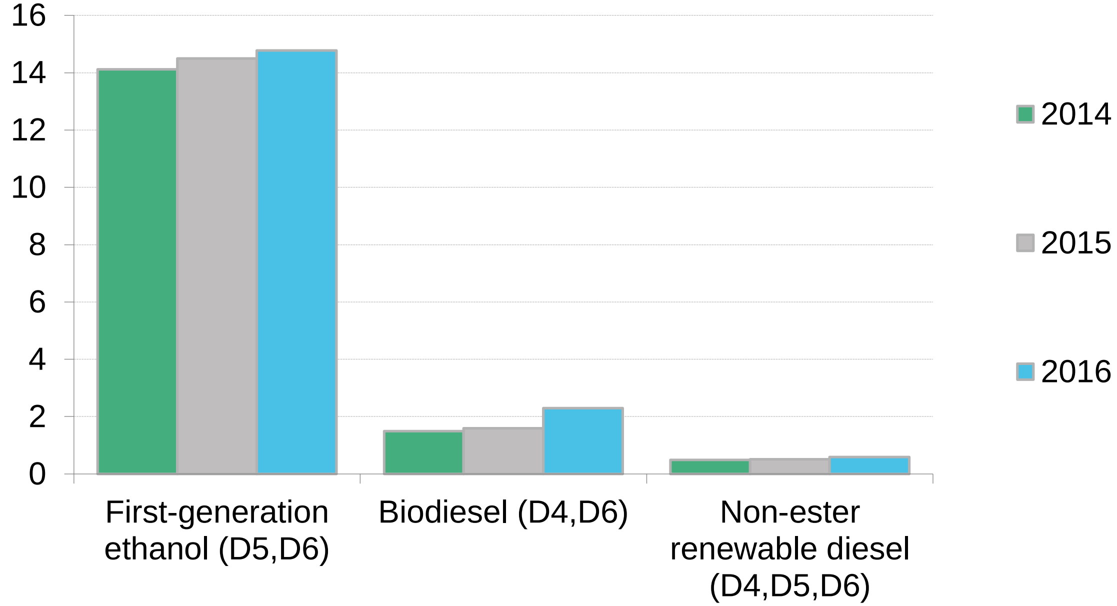
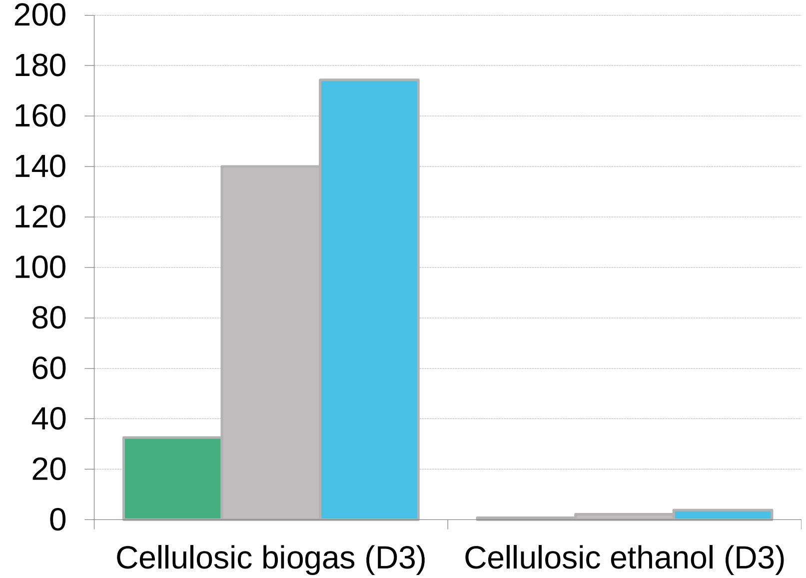
First-generation biofuels (billions of gallons)



Next-generation biofuels (millions of gallons)



- The US's Renewable Fuel Standard 2 mandates biofuel blending into gasoline and diesel 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. The most valuable RINs are the cellulosic RINs (D3s), which fetched $2.35/gallon at the end of 2016.
- The biofuel blending targets for 2016 were 24bn gallons (of which 230m was the cellulosic target). For 2017 the mandate is 26bn gallons (of which 312m gallons is cellulosic). First-generation ethanol and cellulosic biogas are the primary fuels used to meet these targets.

Source: Bloomberg New Energy Finance, EPA, Progressive Fuels Limited Notes: Fuels under the RFS2 are categorized by D codes, which indicate 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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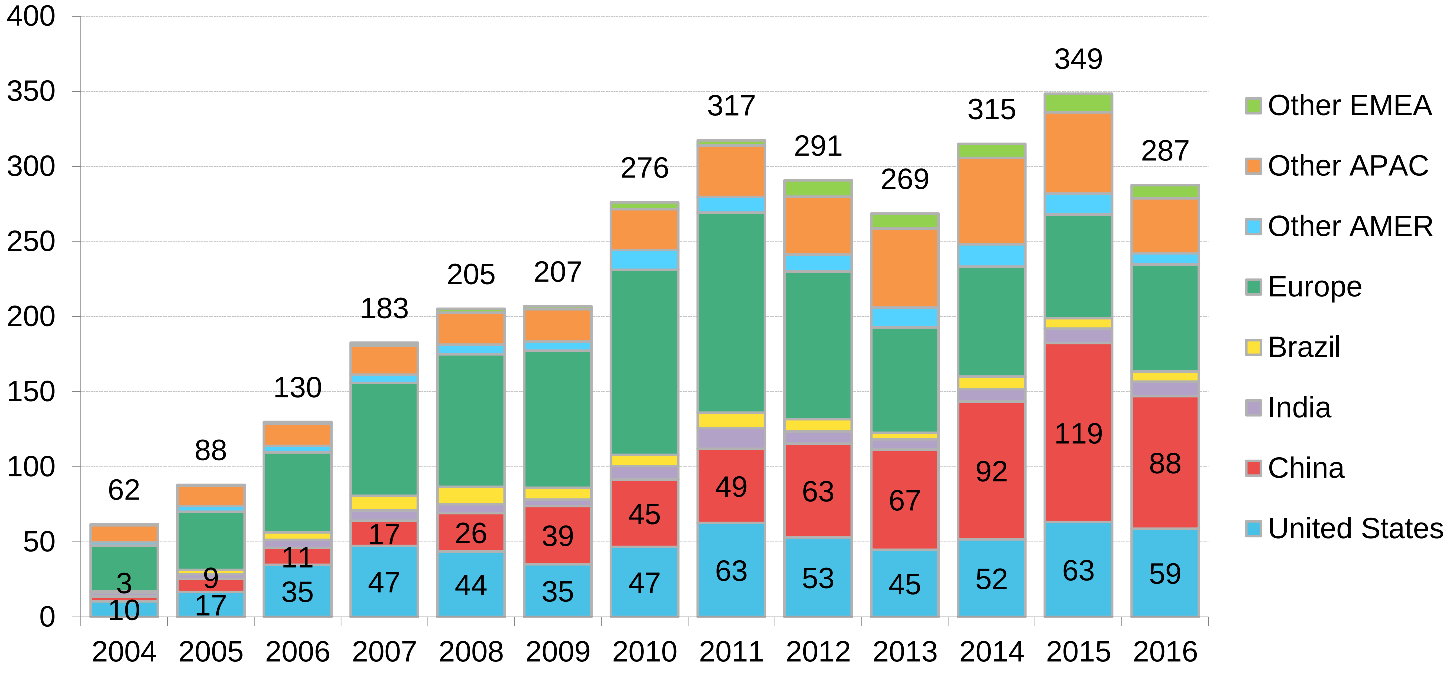
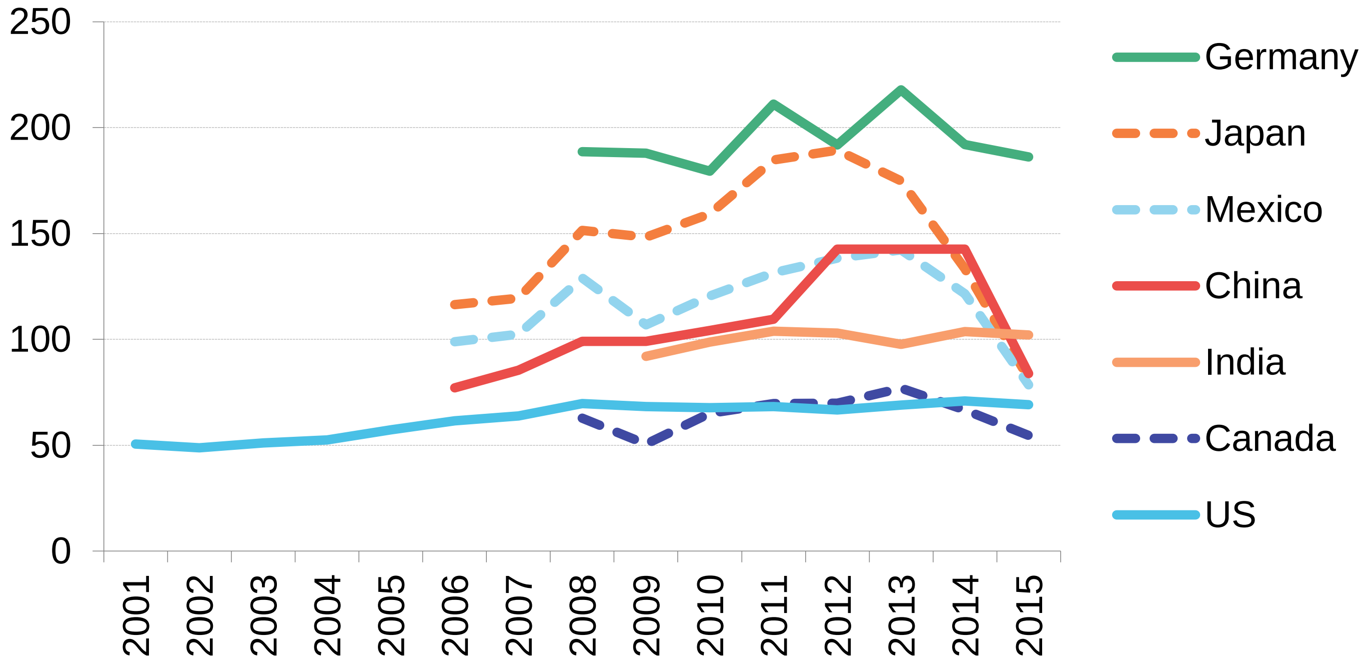
Global context: Total new investment in clean energy by country or region ($bn)



- Total global new investment in clean energy ebbed 18% in 2016 to $287.5bn, after hitting a record high of $348.5bn in 2015. The dropoff partly reflects steep declines in equipment prices, especially for solar PV.
- The most significant retreat in absolute terms occurred in China, where investment shrank $31bn (-26%) from 2015 levels. China is stepping back from building new utility-scale renewables and instead taking time to integrate existing renewable capacity. Investment stayed roughly the same in India while falling $17bn (32%) in the rest of APAC.
- In the US, investment fell 7% to $59bn, after an exceptional 2015. For details, please see section 2.2.
- European clean energy investments climbed by $2.4bn (+3%) in 2016.

Source: Bloomberg New Energy Finance Notes: For definition of clean energy, see slide in Section 2.2 of this report titled “Finance: US clean energy investment (1 of 2) – total new investment, all asset classes ($bn)” . AMER is Americas; APAC is Asia-Pacific; EMEA is Europe, Middle East, and Africa. Investment figures are nominal.

Global context: Energy prices – average electricity rates for the industrial sector by country ($/MWh)

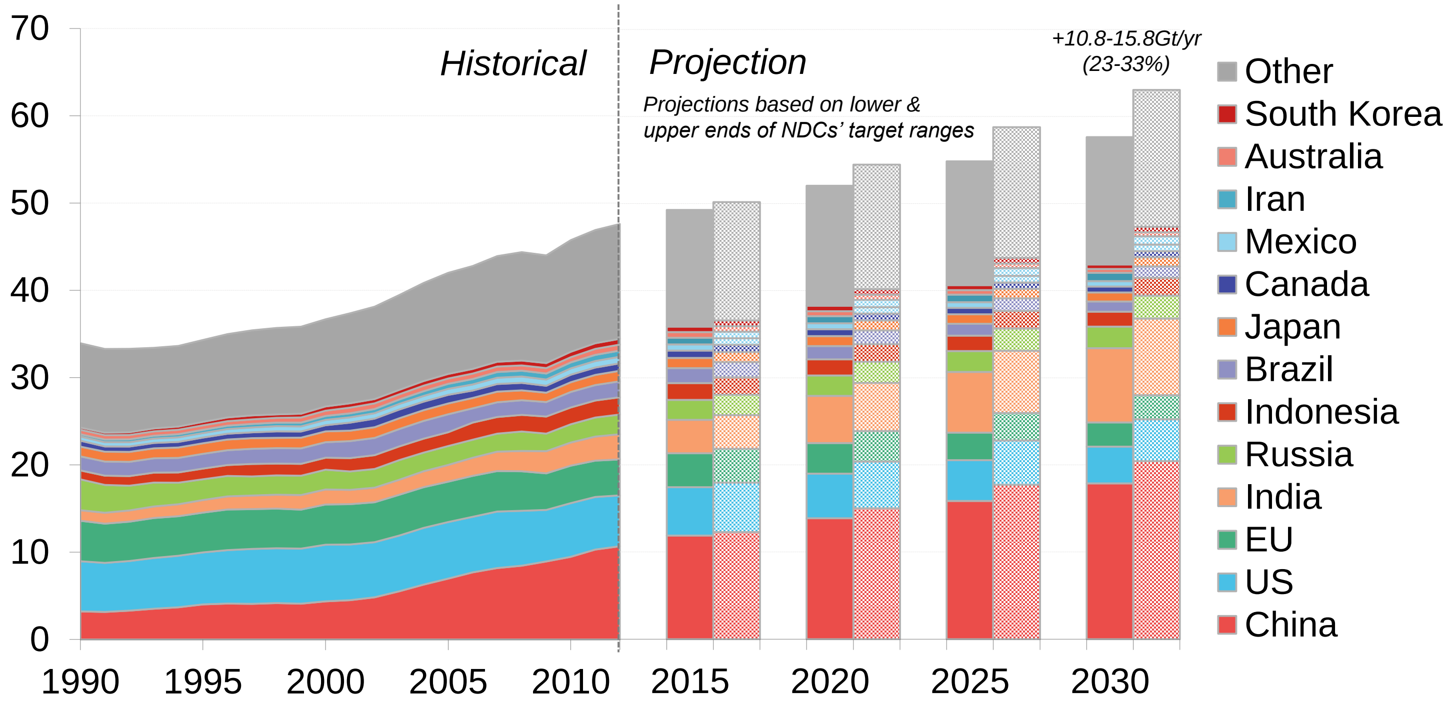


- The US – and North America in general – has among the lowest costs of electricity in the world for industrial customers (6.91¢/kWh for the US industrial sector in 2015, according to the EIA).
- Regions in the US with the lowest costs of power include the Midwest, Southwest and Northwest.
- The steep power price declines in Japan, Mexico and China in 2015 are to a large extent due to the depreciation of their currencies against the US 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).

Source: Bloomberg New Energy Finance, government sources (EIA for the US)

Notes: Prices are averages (and in most cases, weighted averages) across all regions within the country.

Projected global emissions under Nationally Determined Contributions (NDCs)

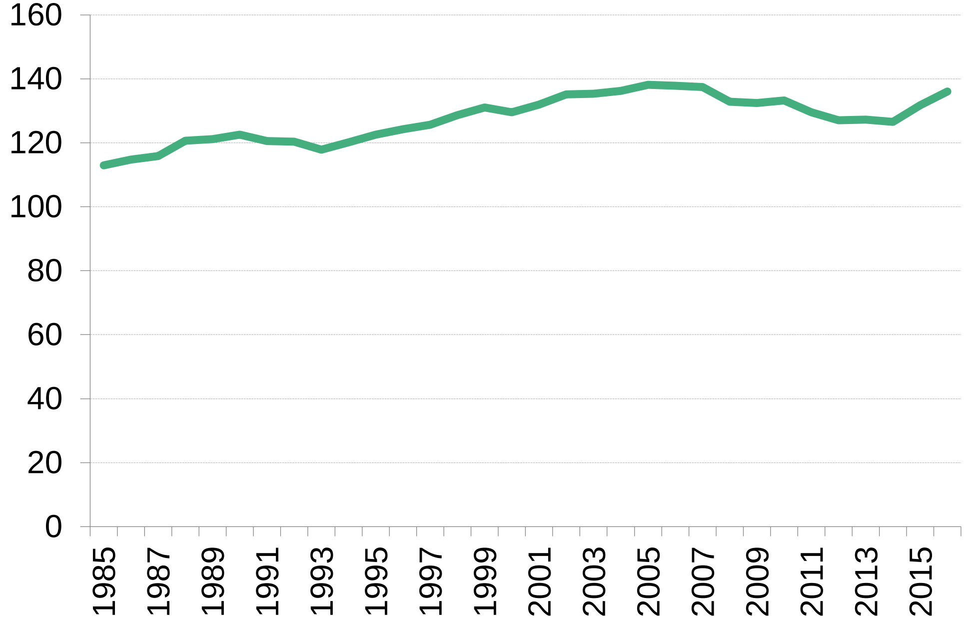


- The Paris Agreement entered into force on 4 November 2016, one month after sign-offs by 74 countries including the US, China, India, Brazil, Canada, Mexico and the EU took it over the ratification threshold.
- The Nationally Determined Contributions (NDCs) submitted by participating parties, which reflect their emission reduction goals, would put global emissions on track to rise 20-30% by 2030. This is not enough to meet the agreement's binding target of limiting global temperature increases to 2ºC. But the COP21 framework lays out a path forward for ramping up abatement goals by requiring five-year reviews of NDCs starting in 2020 and five-year global 'stocktakes' starting in 2023.
- Further, the deal includes a binding commitment to achieve "a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of the century," which is not strong enough to assure a 2ºC outcome.
- COP22, which took place November 7-18, 2016 in Marrakesh, set a timetable for the next two years of negotiations.

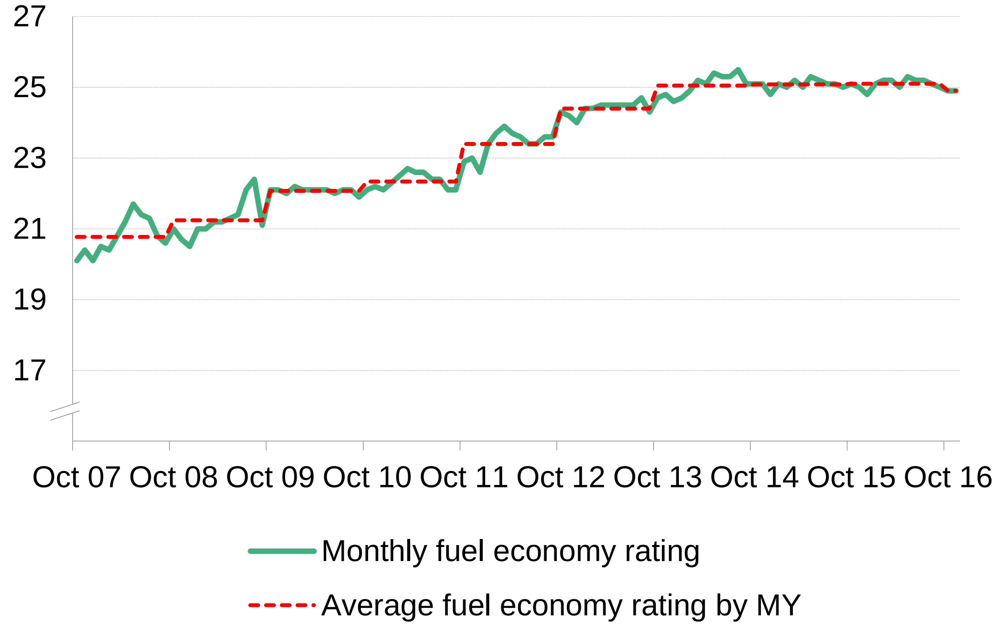
Source: Bloomberg New Energy Finance, UNFCCC, WRI.

Global context: US-related causes and implications of falling oil prices (1 of 2) – demand

US gasoline consumption (bn gallons per year)



US average fuel-economy rating (weighted by sales) of purchased new vehicles (MPG)



- Gasoline consumption rose for the second consecutive year, jumping 3.3% from 2015 levels to 136bn gallons. With the increase, consumption is now only 1.5% below the all-time peak reached in 2005; it is 7.1% above the recent trough of 127bn gallons seen in 2012.
- Average US vehicle fuel economy held steady for the third consecutive year at just over 25mpg. Continued improvements in federal corporate average fuel economy regulations have been offset by consumer buying choices, as Americans have purchased less fuel-efficient vehicles in light of falling prices at the pump.

Source: EIA

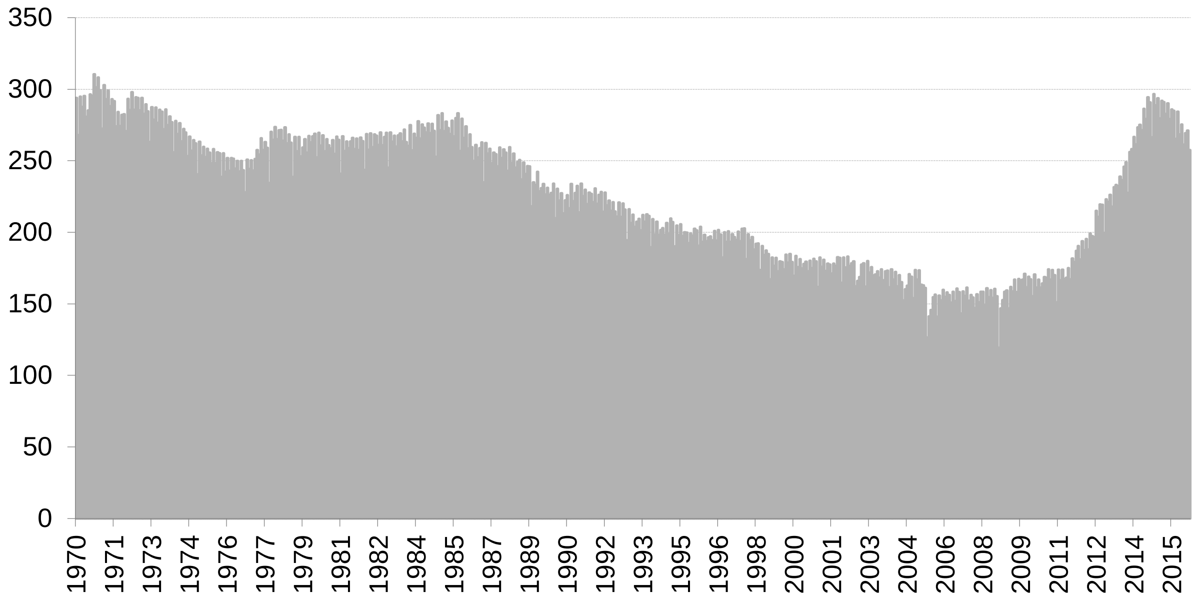
Notes: Analysis is based on daily averages of 'total gasoline all sales / deliveries by prime supplier'. Values for 2016 are projected, accounting for seasonality, based on latest monthly values from EIA (data available through November 2016).

Source: UMTRI, Bloomberg New Energy Finance

Notes: Relies on combined city/highway EPA fuel economy ratings.

Global context: US-related causes and implications of falling oil prices (2 of 2) – supply

US monthly crude oil production (million barrels per month)



- US crude oil production declined but remains well above the levels produced in the 1990s and 2000s. For the first eleven months of 2016, production averaged 8.9m barrels per day (bpd), down from the 9.4mbpd seen in 2015 but still above levels seen since 1985. Output in October 2015 had marked an 85% upsurge from the low of 5.1mbpd reached in October 2007.
- As production tightened, oil prices recovered to $54/barrel by December 2016. This followed the extended freefall in 2015, which stretched into the first quarter of 2016 and brought prices to a trough of $26/barrel in February 2016.
- Oil prices do not directly impact the majority of sustainable energy technologies in the US. Most of those technologies operate in the power sector, while oil in the US is used mainly for transportation and only rarely for power. However, more affordable gasoline at the pump has stalled gains in the average US vehicle fuel economy as consumers opted for less fuel-efficient vehicles.

Source: EIA

Notes: Data through November 2016.

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