

2016

SUSTAINABLE ENERGY IN AMERICA

Factbook



Energy —
— Efficiency



Natural —
— Gas



Renewable —
— Energy

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Now in its fourth year, the Sustainable Energy in America Factbook series documents the revolution transforming how the US produces, delivers, and consumes energy. The 2016 Factbook provides an update through the end of 2015, highlighting a number of key developments that occurred as the long-term transformation of US energy continues to unfold.

Two thousand fifteen will surely be remembered as a watershed year in the evolution of US energy, as the industry passed important milestones and the federal government finalized critical new policies. The already rapid de-carbonization of the US power sector accelerated with record numbers of coal plant closures and solar photovoltaic system commissionings, while natural gas production and consumption hit an all-time high. Concurrently, the US continued to enjoy greater benefits from energy efficiency efforts as economic growth outpaced the growth in electricity consumption.

The net result on the planet: US power sector CO2 emissions fell to their lowest annual level since the mid-1990s. The net impact on consumers: negligible to positive as prices for electricity and fuel remained low by historic standards and customer choices expanded. Perhaps most importantly, many of the key changes seen in 2015 are likely permanent shifts, rather than temporary adjustments due to one-time events.

On the policy front, major initiatives appear poised to keep the US on track toward de-carbonization in the coming decades. In August, the Obama administration finalized its Clean Power Plan regulation for the existing US power fleet. In December, the US joined with 194 other nations in France to adopt the “Paris Agreement” which includes pledges to rein in emissions over the coming decades. The year closed with Congressional approval of a major, five-year extension of key tax credits supporting new US wind and solar projects and a two-year extension of measures supporting energy efficiency. The Production Tax Credit (PTC) was also extended to cover geothermal, biomass, waste-to-energy, landfill gas, hydro and ocean energy projects that commence construction before 2017.

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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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 2015 wherever possible
- Employs **Bloomberg New Energy Finance data** in most cases, augmented by EIA, FERC, ACEEE, ICF International, 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 **fourth 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 2016 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.
- **2015 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 analyses of US levelized costs of electricity, corporate renewables procurement, US transmission build, small-scale CHP generation and additional energy efficiency data.

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

About the Factbook (2 of 4): Understanding terminology for this report

	FOSSIL-FIRED / NUCLEAR POWER	RENEWABLE ENERGY	DISTRIBUTED POWER, STORAGE, EFFICIENCY	TRANSPORT
SUSTAINABLE ENERGY (as defined in this report)	• Natural gas • CCS	• Solar • Wind • Geothermal • Hydro • Biomass • Biogas • Waste-to-energy	• Small-scale renewables • CHP and WHP • Fuel cells • Storage • 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

About the Factbook (3 of 4): The sub-sections within each sector

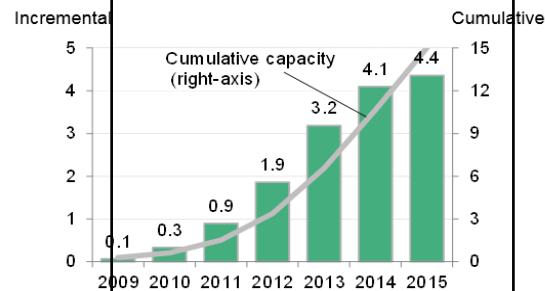
For each sector, the report shows data pertaining to three types of metrics (sometimes multiple charts for each type of metric)

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

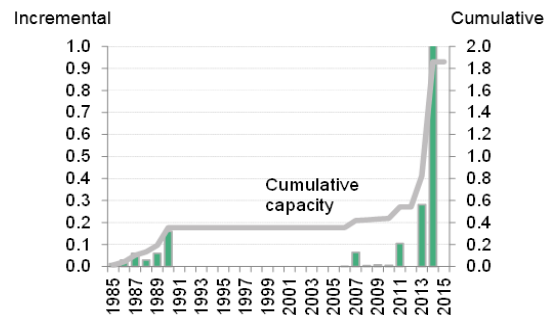
Financing: US large-scale solar investment

Deployment: US large-scale solar build

US utility-scale photovoltaic build (GW)



US concentrating solar power build (GW)

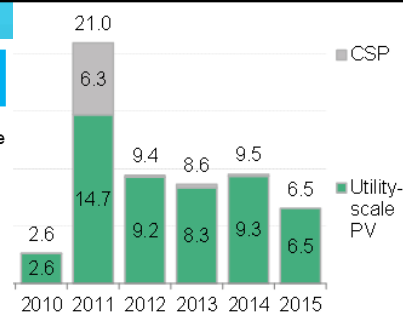


- After six years of dramatic growth, utility-scale PV build began to level off in 2015. However, we expect the segment to nearly double to its largest build year on record in 2016, as developers rush to commission projects by the end of the year prior to the scheduled step-down in the federal Investment Tax Credit (ITC) for solar.
- No concentrating solar power (solar thermal) plants were commissioned in 2015, in contrast to 2014 which saw over 1GW of major projects commissioned. Developers and financiers continue to focus their attention on PV.

Source: Bloomberg New Energy Finance
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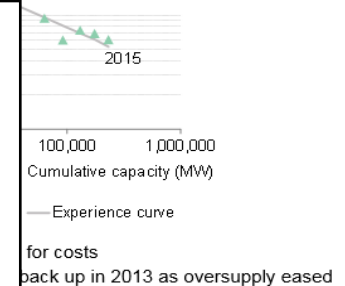
Venture capital / private equity investment in US
Asset finance for US utility-scale solar projects by technology (\$bn)

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After a quiet 2013, including funding for both early-stage projects

Absent a change in the ITC expiration date and therefore only a proxy for actual volumes.



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.



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)

2015 was a transformative year in the US energy industry. Greater energy efficiency and structural changes to the composition of the economy allowed the US to achieve higher energy productivity. The power sector continued to de-carbonize and add near-record amounts of clean energy as policy activity at the global, national and state levels set the country on track for further emissions abatement. Unprecedented levels of natural gas supply pushed down power prices, putting the country in a more internationally competitive position while also prompting coal-to-gas switching that slashed US carbon emissions. Utilities are investing more in energy efficiency measures to curb both electricity and gas demand. At the same time, the grid itself is being reshaped by greater penetration of renewables and growth in distributed resources such as solar PV and storage. The policy frameworks laid out in 2015, combined with the beginnings of structural change in the power sector and beyond, are pushing the country toward greater energy productivity and cleaner growth in the decades to come.

As in years past, the goal of the 2016 Factbook is relatively simple: to record and highlight the important developments that transpired in US energy over the prior 12 months. It also provides a look back over the past seven years, and in some case decades, to show trends. Among the most notable developments:

Investment in energy efficiency continues to pay dividends for the US economy.

- Energy productivity – the ratio of US GDP to energy consumed – continues to grow, improving by 2.3% from 2014 to 2015 following a 1.1% increase the previous year. The US economy has now grown by 10% since 2007, while primary energy consumption has fallen by 2.4%. And while the shifting composition of the US economy is no doubt a driver, estimates put forward by the American Council for an Energy Efficient Economy indicate that as much as 60% of the energy intensity improvements seen since 1980 are due to efficiency gains, with only 40% the result of structural changes in the US economy.
- Within the electricity sector specifically, this “decoupling” – a disconnection between energy consumption and economic growth – is also visible: electric load growth in 2015 clocked in at only 0.5%, compared to a projected 2.4% increase in GDP. And since 2007, electricity demand has been flat, compared to a compounded annual growth rate of 2.4% from 1990 to 2000.
- Meanwhile, final data for 2014 – the latest year for which we have estimates – show that annual investment in energy efficiency measures continues to grow. Natural gas and electric utility spending on efficiency reached \$6.7bn, up 8.1% from the \$6.2bn seen in 2013; Energy Savings Performance Contracting (ESPC) investment topped \$6.4bn. Accordingly, electricity savings continue to climb year-on-year, breaching 25GWh in 2015. Since 2007, incremental efficiency achievements have risen 17% on average annually. On a sectoral basis, efficiency investment shrank slightly in the residential sector for the first time in over a decade, but expanded in commercial, industrial and other sectors. Regionally, New England, the Pacific, Great Lakes and the Mid-Atlantic region still lead in electrical efficiency savings. The Southeast remains a largely untapped market with fewer enabling policies such as energy efficiency resource standards (EERS).

Executive summary (2 of 8)

The US is making major strides toward a de-carbonized electricity grid and set important new records in 2015. Critically, these milestones represent structural changes to the fleet, suggesting a permanent change is afoot.

- Challenging economics and the shadow of environmental regulations encouraged the accelerated retirement 14GW of coal-fired power plants, representing 5% of the installed coal capacity in the country. Since 2005, the US has disconnected over 40GW of coal-burning power plants, while adding only 19GW new coal to the grid. Several gigawatts of coal-fired capacity have also converted to natural gas or, in a few cases, biomass. Due to both these retirements and competition from low-priced natural gas, coal provided only 34% of US electricity generation in 2015, down from 39% in 2014 and from 50% at its peak in 2005.
- Renewables continue to pick up steam, with an estimated 8.5GW of wind and 7.3GW of solar photovoltaic (PV) installed in 2015. Wind build was 65% above 2014 levels, as developers rushed to complete construction ahead of the anticipated end-2016 expiration date of the Production Tax Credit. In total, 2015's tally of 16.4GW fell just shy of 2012's record 18.2GW of new renewable capacity; however, PV additions across both the distributed and utility-scale sectors set new records as 2.9GW and 4.4GW, respectively, connected to the grid. This represents a 13% bump up from 2014 build for PV. New hydro build hit 306MW (+115% from 2014) and geothermal added 61MW of new capacity (+33%). Biomass, biogas and waste-to-energy together added 224MW, up 15% from the year before.
- As natural gas prices sank to their lowest levels since 1999 and natural gas plants displaced generation previously provided by retiring coal plants, natural gas consumption in the power sector exceeded 10quads for the first time ever, surpassing 2012's high-water mark of 9.8quads. Natural gas is now within striking distance of being the largest source of US power, producing just over 32% of US generation in 2015, compared to 34% for coal.
- Importantly, surging renewables build and coal retirements have not triggered a dramatic leap in retail power prices. Average retail electricity rates across the country remain 5.8% below the recent peak (2008) in real terms, in part due to cheap generation from natural gas. Year on year, retail rates in 2015 fell 1.3% in real terms, even as real GDP grew by 2.4%. There are, however, regional price differences. New York, Texas, the Southeast and states in the central southern US reaped the greatest price reductions over the past year (over 2%) and generally have the lowest retail prices in the country. California saw the largest uptick (1.8%) and, alongside New York and New England, has some of the highest retail prices in the contiguous US.
- The continued low cost of power allows the US to potentially out-compete a number of other countries on electricity charges for businesses, with average industrial retail rates in the US (7.1¢/kWh in 2014) far below those of Germany (15.9¢/kWh), China (14.3¢/kWh) and even India (10.7¢/kWh).
- Corporate procurement of clean energy continues to grow, doubling from 2013 to 2014 and again from 2014 to 2015. In 2015 alone, corporations contracted 3.1GW of new renewable capacity. Although wind farms make up the majority of this contracted capacity, solar jumped from 0.3GW in 2014 to 1.1GW the following year, quadrupling its share of the overall pie. Large corporate buyers included Google, Amazon, Facebook and Apple; the list of key players covered the retail, technology, manufacturing, financial and insurance sectors. Additionally, corporations such as IKEA, Comcast, Hyatt, Morgan Stanley, and Johnson & Johnson announced and/or commissioned fuel cell capacity in 2015.

Executive summary (3 of 8)

The evolution of US power is rapidly reducing the country's overall carbon footprint.

- The changes that have taken place over the past decade through 2015 resulted in the lowest yearly carbon emissions produced by the US power sector since 1995. At 1985Mt, the 2015 emissions figure was 4.3% below 2014 levels and 17.8% below 2005 levels. Two thousand five is both the benchmark against which the Clean Power Plan is measured, and against which the Obama administration set the goal of 26-28% emission reduction by 2025 contained in the US' Intended Nationally Determined Contribution (INDC) for the UN climate talks in Paris.

Critical policy supports have been unveiled that, if fully implemented, will ensure the US remains on track to a lower-carbon energy sector.

- The Obama administration sought to give policy certainty to the power industry and accelerate the de-carbonization of the US grid by finalizing regulations limiting carbon emissions from power plants in August 2015. The Clean Power Plan, which will regulate the country's existing fleet of fossil-fired power plants, aims to cut emissions 32% (relative to 2005 levels) by 2030 through assigning each state a target emissions level (in tons of carbon) or emissions rate (in tons per megawatt hour). As the centerpiece of the Obama Administration's INDC, the Plan was also supported by the New Source Performance Standards (NSPS) which set limits on emissions from newly constructed plants and will effectively require new coal-fired power plants to install carbon capture and storage technology.
- The Clean Power Plan's reduction burdens (as measured by required cuts to emissions levels) vary widely across states. Those on the West Coast and in New England face smaller reduction targets that they are already on track to meet, while more coal-reliant states like Montana, the Dakotas and Kansas must cut emission levels by over 30%, even after accounting for recent and planned abatement actions such as coal retirements. To achieve these targets, states must design and carry out their own implementation programs, which will likely require a combination of coal-to-gas switching, renewables build and demand reduction measures such as energy efficiency. State proposals are due to the EPA by September 2018 and will be implemented from 2022 to 2030.
- In mid-December, 195 countries came together to sign the "Paris Agreement." The Agreement is effectively a hodgepodge of bottom-up pledges from individual countries, including the US pledge to bring emissions to 26-28% below 2005 levels by 2025. Paris marks only one small milestone on the path to halting global climate change: as they stand today, the pledges would be insufficient for hitting the "below 2°C" goal. But the agreement's framework also includes five-year "check-ins" at which countries are encouraged to re-submit and strengthen their commitments.

Executive summary (4 of 8)

Continued: Critical policy supports have been unveiled that, if fully implemented, will ensure the US remains on track to a lower-carbon energy sector.

- On December 18, Congress passed comprehensive spending and tax packages which revived critical federal supports for segments of the renewable energy and energy efficiency industries, while also lifting a 40-year-long ban on crude oil exports. The bill extended tax credits for wind and solar by five years apiece, through 2019 and 2021, respectively. Federal tax incentives for both technologies will be stepped down over the five-year periods. The Production Tax Credit for other renewable technologies (including biomass, geothermal, waste-to-energy and hydroelectricity) was only given an additional two years, through end-2016. The Investment Tax Credit for fuel cells was unchanged and will expire at the end of 2016. Energy efficiency incentives for residential, industrial and commercial investments were prolonged through December 31, 2016. Efforts are already underway to ensure these other clean energy technologies see their credits expanded further in 2016.
- Just after the close of the year, on January 25, 2016, the US Supreme Court issued a key ruling that would effectively allow "demand response" (DR) programs to continue among large end-users. The Court upheld the Federal Energy Regulatory Committee's authority to regulate DR within the wholesale energy markets. The decision brings several years of uncertainty to an end for DR players and should allow the market to flourish more broadly. Currently DR, which incentivizes industrial users to cut their consumption at times of excessively high demand, is most popular within the PJM Interconnection, a wholesale electricity market covering a number of mid-Atlantic and Northeastern states.
- In much of the country, state policy is as important as federal in advancing clean energy and the underlying infrastructure necessary to support it. For example, state and local "net energy metering" (NEM) policies and utility rate designs are essential to the economics of distributed generation. Two thousand fifteen saw two significant and differing regulatory proposals for addressing NEM. California unveiled a second-generation "NEM 2.0" program which maintains a net metering regime, with requirements that solar customers move to time-of-use rates, pay an upfront interconnection fee and pay the same non-bypassable charges as customers without a solar system. Neighboring Nevada adopted NEM program changes that alter the rates charged and credits granted to customers with rooftop solar, changing the economics for both existing and future solar customers. Similar proceedings regarding NEM and rate design policies are underway elsewhere, as states consider the implications of further growth in distributed generation and how to balance the need to advance deployment, while addressing concerns over potential rate inequities between solar-owning and non-solar-owning ratepayers, which could affect future investments in the underlying grid infrastructure.
- Another form of critical state policy is the renewable portfolio standard (RPS) – a state mandate on the share of utility-delivered power provided by clean energy. RPS are the main driver behind wind and solar build in the Northeast; they incentivize renewables generation in other states as well. In 2015, Hawaii increased its target to 100% renewables by 2045, while California and New York raised their targets to 50% by 2030. Meanwhile, West Virginia became the first state to repeal its RPS and Kansas turned its mandatory standard into a voluntary program.

Executive summary (5 of 8)

Continued: Critical policy supports have been unveiled that, if fully implemented, will ensure the US remains on track to a lower-carbon energy sector.

- Energy efficiency resource standards (EERS) have advanced in the past decade, but momentum slowed after 2010. Florida and Indiana removed their programs in 2014, Ohio froze its scheme in 2015 and federal support of energy efficiency did not receive the five-year extension that was granted to wind and solar investments. However, a handful of states including Delaware, Utah and New Hampshire are on their way toward adopting EERS. Additionally, the final Clean Power Plan has an option for states to count energy efficiency measures toward compliance.
- Nevertheless, state and local governments continue to enact other critical policies to promote energy savings, with 10 states adopting more stringent residential and commercial building codes in 2015, including Texas, California and New Jersey. Three cities, including Atlanta, enhanced building energy use policies, setting mandates for commercial buildings to report and benchmark their consumption. As of the end of 2015, 6.5bn square feet of commercial floor space, or around 7.7% of total US commercial sector floor space, was covered by such policies.

A 'new normal' of lower oil prices is being felt through the US economy and offers both opportunities and potential obstacles to the greening of US energy.

- Lower gasoline prices dented sales of alternatively-fueled vehicles in 2015. Hybrid and plug-in hybrid vehicles, which compete more directly with traditional gasoline-fueled cars, took the biggest hit: sales of these two vehicle classes were down 16% and 24%, respectively, relative to 2014. But other equally important factors were also at play, including supply constraints and delays in new model rollouts that dampened sales in the first half of 2015.
- However, sales of battery electric vehicles (BEV) proved resilient, growing 16% over the course of 2015, relative to 2014 levels. State and federal purchasing credits help to keep the lifetime costs of BEV ownership up to 25% below that of comparable midsize gasoline-fueled cars. Additionally, a significant amount of BEV purchases – notably, those of the Tesla Model S – continue to be motivated by non-economic factors.
- Overall, gasoline consumption rose 4.1% in 2015, the largest annual increase since 1988, as prices at the pump fell an additional 11% after collapsing by one third in 2014. For the first time since record-keeping began in 2008, the average fuel economy of vehicles sold for model year 2015 stayed flat relative to the previous year, at 25.3mpg. In previous years, the impact of Americans' preference for SUVs and pick-up trucks had been tempered by both higher oil prices and improving vehicle efficiency, in line with federal Corporate Average Fuel Economy (CAFE) standards. Over the past year and a half, however, the collapse of retail gasoline prices by more than 40% was enough to stall the annual gains in vehicle efficiency. But 2015 may prove to be an anomaly: the average fuel economy of vehicles sold remains 20% above that of 2008 levels, and continued hikes in CAFE requirements should ensure a return to this trend over the long term.

Executive summary (6 of 8)

Continued: A 'new normal' of lower oil prices is being felt through the US economy and offers both opportunities and potential obstacles to the greening of US energy.

- Natural gas production and storage inventories reached all-time highs in 2015. Sustained low energy prices have prompted oil and gas producers to decrease drilling activity; hence, fewer rigs are in operation, leading to more competition amongst rig operators. Service companies have slashed fees in response, allowing drilling and completion costs to fall for oil and natural gas wells alike. In addition, improved technology and experience have enabled producers to continue to produce natural gas at even lower costs, with many of them focusing on regions with the most favorable production economics. Together, these factors have buoyed supplies in a depressed price environment. In December 2015, natural gas prices fell to the lowest levels seen since 1999.
- Thus, although lower-priced crude has little direct effect on the power sector (oil is burned for less than 2% of US generation), it has indirectly impacted the electricity markets by helping to weigh down natural gas prices. Natural gas-burning power plants substantially influence power prices across the US. As gas prices have fallen, so have wholesale power prices. For power generators bidding into the wholesale electricity markets, the decrease in power prices has squeezed profit margins. The lower-priced gas environment changes the equation for all power generators operating in deregulated markets, by potentially lowering future revenue streams.
- For technologies such as solar thermal and solar PV, falling power prices can make "grid parity" that much more difficult to achieve. However, generation costs associated with renewables have also been dropping. In windy parts of the country like Texas and the Midwest, wind developers have signed long-term power purchase agreements (PPAs) in the range of \$19-35/MWh, undercutting both on-peak and off-peak power prices as well as other sources of generation. Also in Texas, utility-scale solar plants have achieved PPAs at rates close to \$50/MWh, and in regions with either high retail electricity rates or high solar PV capacity factors, distributed solar can be an economically competitive option for homeowners. These falling costs, combined with the anticipated drawdown on the federal Investment Tax Credit and the expiration of the Production Tax Credit, led to significant build in solar and wind in 2015. New build in solar (7.3GW) and wind (8.5GW) outpaced even that of natural gas (6.0GW). Wind in particular marked a 65% increase in build from the previous year. Geothermal, hydro, biomass, biogas and waste-to-energy saw 0.6GW of build. New capacity additions in 2015 for geothermal jumped one-third from the previous year, while biomass, biogas and waste-to-energy saw a 15% bump. The rate of hydro installations soared 115% during the same period.

Executive summary (7 of 8)

The US continues to extract unprecedented volumes of natural gas thanks to greater productivity from existing resources. This extraordinary resource is being put to use in a growing variety of ways.

- Low gas prices are further supported by Appalachian Basin shale production, which continues to expand despite a shrinking rig count as producers drill more selectively and technologies improve. Output from the Marcellus and Utica shales has been so abundant that domestic natural gas production through the first nine months of 2015 increased 6.8% from 2014 and 26% from 2007 levels, even as traditional "dry" gas production has declined.
- With the natural gas center of supply rapidly shifting from the Gulf Coast to the Northeast, midstream companies are playing catch-up to reverse existing pipelines and to re-plumb the network to transport gas out of the inundated Appalachian Basin. In 2015, companies installed over 11Bcfd of total pipeline capacity across the country, including 3.3Bcfd of takeaway capacity from the Marcellus and Utica shales. Many more projects were approved or filed for approval this year, but due to routine delays, the bulk of these projects are not expected to be in service until 2017 or 2018.
- Gas utility construction expenditures for distribution infrastructure rose to \$9.7 billion in 2014, compared to an average of about \$5 billion per year during the 2000s, according to data compiled by the American Gas Association. This reflects, in part, the increased prevalence of natural gas replacement and expansion programs across the US.

Investment in zero-carbon energy and enabling technologies maintained its momentum.

- Since 2007, the US has poured \$445bn into renewable energy and energy smart technologies, which enable the integration of variable sources of power generation into the grid. Annual totals range from \$36bn to \$64bn; investment in 2015 hit \$56bn, up 8% from the year before. Just over half of all new investment was directed towards solar, and 21% towards wind. The increase came as project developers rushed to get projects online ahead of the anticipated expiration of critical federal tax credits, and as falling costs made rooftop solar economically competitive in parts of the country.
- Asset financing, which includes only investment in new projects, for biomass facilities rebounded to \$349m in 2015 from none the previous year; biogas received \$285m in 2015, about seven times what it saw in 2014. The rush was again due to tax credit considerations. At the same time, flows into other renewables continue to taper, with virtually no new financing directed towards new construction in geothermal, small hydro or carbon capture and storage in 2015. Waste-to-energy has not seen asset financing since 2012. Outside of the power sector, energy smart technologies attracted \$3.1bn, with Tesla Motors leading the pack.
- Investment in key infrastructure to support the transformation of the grid remains critical and continues to lag the rapid build-out of renewable technologies in some regions of the country. Transmission constraints in high wind-build areas such as the Midwest, for example, have led to the curtailment of generation from zero-carbon sources. In 2014, investor-owned utilities invested \$98bn in upgrading the electric grid; early estimates put forward by the Edison Electric Institute suggest \$20bn was directed towards transmission. In Texas, a multi-year \$7bn investment in the Competitive Renewable Energy Zone (CREZ) has allowed the state to connect up to 18GW of wind capacity in the West and the Panhandle to load centers in the Southeast, helping to relieve transmission congestion costs and reduce curtailment. Several large projects, currently in the planning stage, hope to follow Texas' lead by building new lines connecting wind in Kansas and Iowa to demand in the Midwest and Mid-Atlantic.

Executive summary (8 of 8)

Continued: Investment in zero-carbon energy and enabling technologies maintained its momentum.

- Globally, the US held its place as the second-most attractive country for clean energy investment – but it remains far behind China, which received \$111bn worth of capital flows into the sector compared to the US' \$56bn. Other APAC countries brought in \$58bn, while investment in Europe fell off dramatically to \$59bn from \$72bn in 2014.

Renewable energy technologies represent a substantial and growing portion of the overall US power matrix.

- Renewables including large hydro now make up 20% of the US plant stack, at 221GW. Hydroelectric facilities and pumped storage represent nearly half of this at 102GW – a figure that has stayed roughly constant since 2008. Wind is the second-most prevalent renewable technology, standing at almost 75GW at the end of 2015, roughly triple its installed capacity at the end of 2008 (25GW). But solar has been the fastest growing, averaging a 60% clip annually since 2008 to bring its total capacity to 28GW.
- Geothermal, biomass, biogas, and waste-to-energy additions have grown at a slower pace, with 3.2GW added collectively since 2008. Capacity for biomass, biogas and waste-to-energy reached a total of 13.5GW in 2015, 15% above 2008. Geothermal installations have also risen 15% since 2008, to finish 2015 at 3.6GW. These technologies provide around-the-clock power at levelized costs comparable to those of other renewables, but they have not enjoyed the same policy support as the wind and solar industries. They continue to represent roughly 17GW of capacity across the country. Hydropower, for its part, is also supported differently compared to wind and solar, which has meant that installed capacity has stagnated at just over 101GW since 2008.
- Distributed generation, driven by solar PV, is playing a rapidly growing role in the renewable energy story. 2015 was yet another record year for distributed solar PV in the US, with 2.9GW of new build due to growth in both the commercial and residential sectors. As a result, cumulative distributed PV capacity in the US now exceeds 11GW. Build for combined heat and power (CHP) installations ticked up 25% over 2013 levels, clocking in at 847MW in 2014, due to greater demand from the industrial sector. Cheaper gas has also incentivized CHP generation, which soared from 304TWh in 2013 to over 360TWh in 2014 and 2015. However, not all news is good for distributed generation outside of solar. Growth in CHP is still hampered by the lack of supportive federal or state policies. Activity in other distributed, smaller scale technologies has also been muted, with only 6MW of small- and medium-scale wind built in 2014 and three small-scale biogas projects in 2015.
- Behind-the-meter storage has grown in popularity among commercial and industrial players in states such as California, Hawaii and New York, where utilities set high demand charges. Some of the storage projects are supported by subsidies such as the Self-Generation Incentive Program (SGIP) in California, which offers \$1.46/W for a storage system and has induced the installation of 119 projects, or 2.4MW of commercial storage in the state. The economics for residential distributed storage have been less favorable as net metering and lack of time-of-use tariffs limit its economic case. However, utilities such as Southern California Edison, Con Edison, and the Hawaiian Electric Company have begun to explore aggregated distributed storage (sometimes with solar). Companies including Sunverge, Stem, Green Charge Networks and Advanced Microgrid Systems have started piloting advanced storage management systems to coordinate and aggregate distributed storage (sometimes also coupled with solar or other generation sources). In 2015, aggregated storage bid successfully into California's real-time power market; the technology can also provide grid services.

The 2016 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 had seen 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%; installed renewable energy capacity (excluding hydropower) had doubled; and total energy use had fallen by 6%, driven largely by advances in energy efficiency.

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 mix, reaching 205GW 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.

This year's Factbook documents 2015, a year in which the US economy continued to add record amounts of renewables and policies from the international level down to the state level set out frameworks for greater focus on sustainable energy.

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4. Large-scale renewable electricity and CCS

4.1 Solar (PV, CSP)

4.2 Wind

4.3 Biomass, biogas, waste-to-energy

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5.6 Energy storage

6. Demand-side energy efficiency

6.1 Energy efficiency

6.2 Smart grid and demand response

7. Sustainable transportation

7.1 Electric vehicles

7.2 Natural gas vehicles

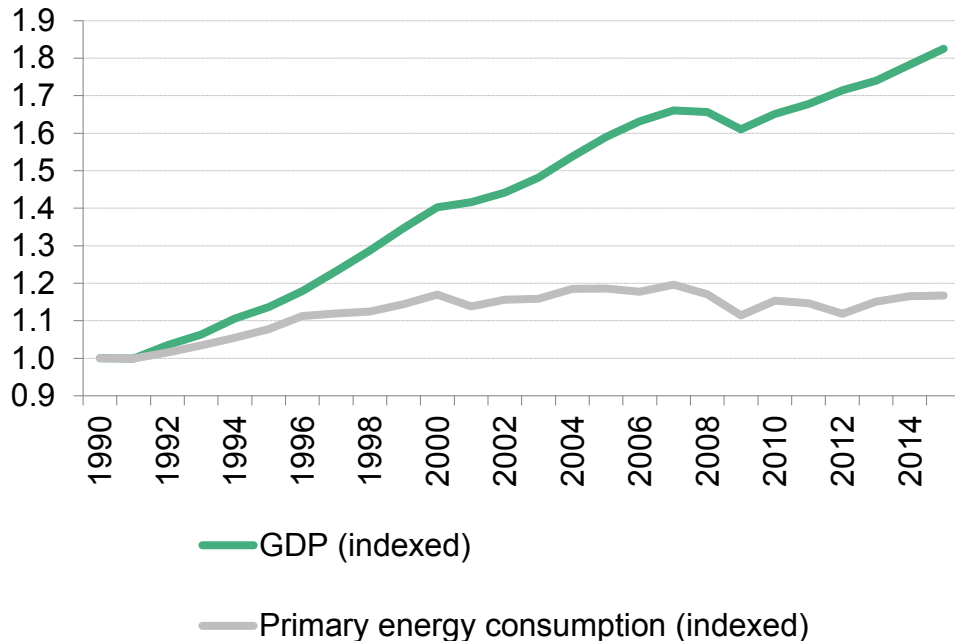
8. Themes

8.1 EPA Clean Power Plan

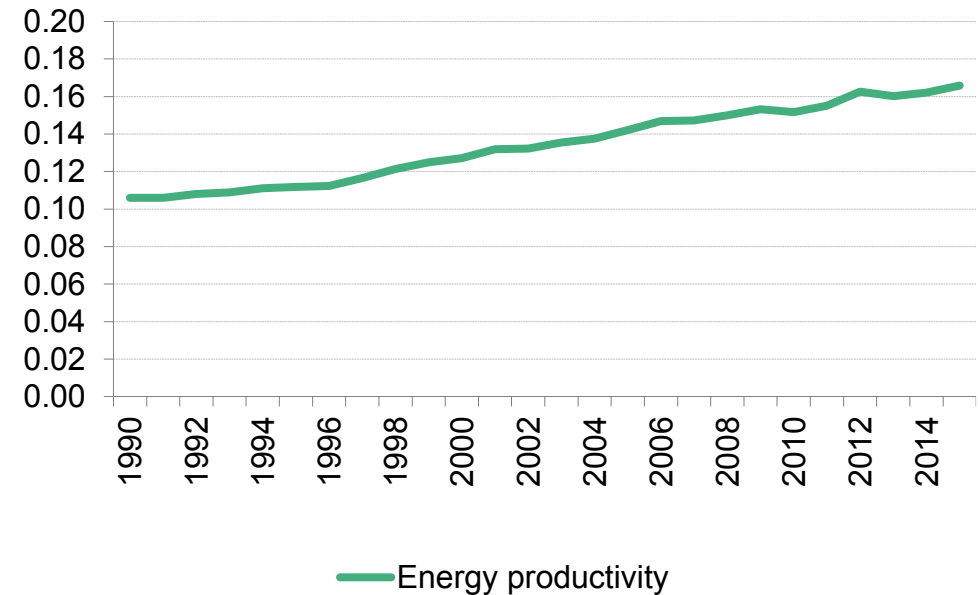
8.2 Global context

US energy overview: Economy's energy productivity

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



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



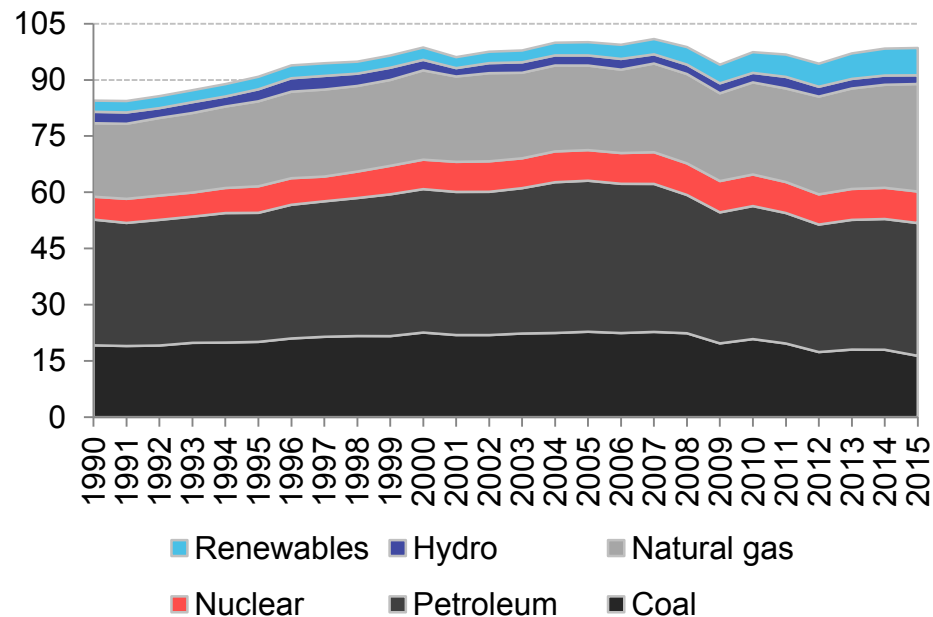
- The US economy is increasingly energy productive, resulting in a decoupling between growth in GDP and growth in energy consumption. As US GDP expanded 83% over the last 25 years, energy consumption only ticked up 17%.
- By one measure (US GDP per unit of energy consumed), productivity has improved 56% since 1990, 13% since 2007, and 2.3% between 2014 and 2015.

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

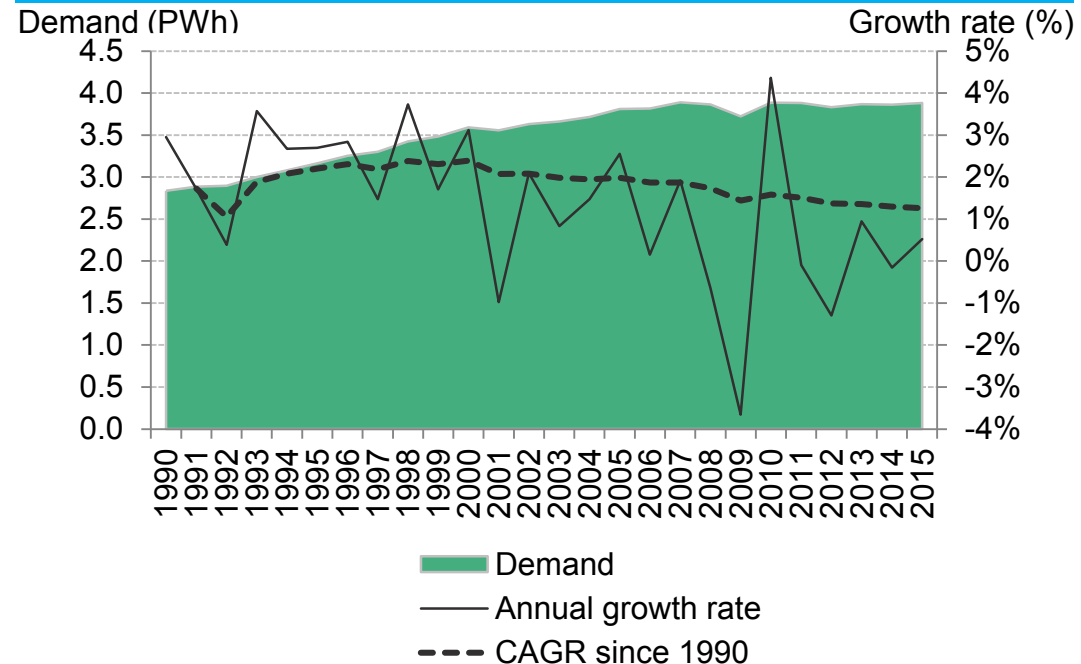
Notes: Values for 2015 energy consumption are projected, accounting for seasonality, based on latest monthly values from EIA (data available through September 2015). GDP is real and chained (2009 dollars); annual growth rate for GDP for 2015 is based on consensus of economic forecasts gathered on the Bloomberg Terminal as of January 2016.

US energy overview: Energy and electricity consumption

US primary energy consumption by fuel type (Quadrillion Btu)



US electricity demand

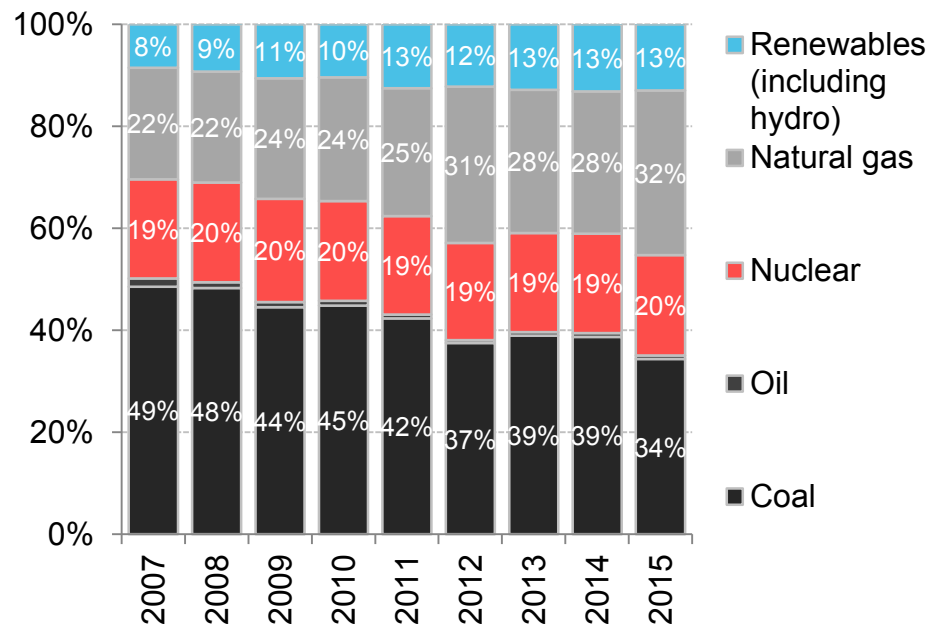


- Energy consumption flatlined from 2014 to 2015 even as GDP grew 2.4%. Since 2007, energy consumption has fallen 2.4% while GDP has grown 10%.
- Estimates from the American Council for an Energy Efficient Economy suggest as much as 60% of the energy intensity improvements since 1980 are due to efficiency gains, with structural changes to the economy responsible for the other 40%.
- The mix of energy consumption has also shifted toward lower-carbon sources since 2007:
 - Petroleum's share of total energy shrank from 39% to 36% and coal's dropped from 23% to 17%.
 - Natural gas expanded from 24% to 29% and renewables (including hydropower) climbed from 6% to 10%.
- Annualized electricity growth has been declining, from 5.9% in 1950-1990, to 1.9% in 1990-2007, to 0% since 2007.

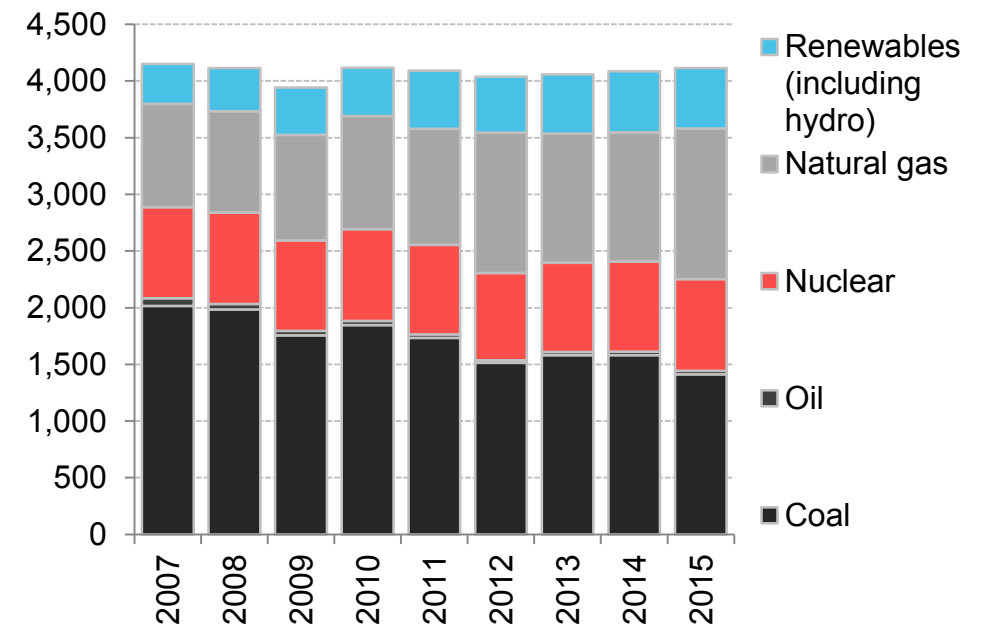
Source: EIA Notes: PWh stands for petawatt-hours (billion MWh). CAGR is compound annual growth rate. Values for 2015 are projected, accounting for seasonality, based on latest monthly values from EIA (data available through September 2015).

US energy overview: Electricity generation mix

US electricity generation by fuel type (%)



US electricity generation by fuel type (TWh)



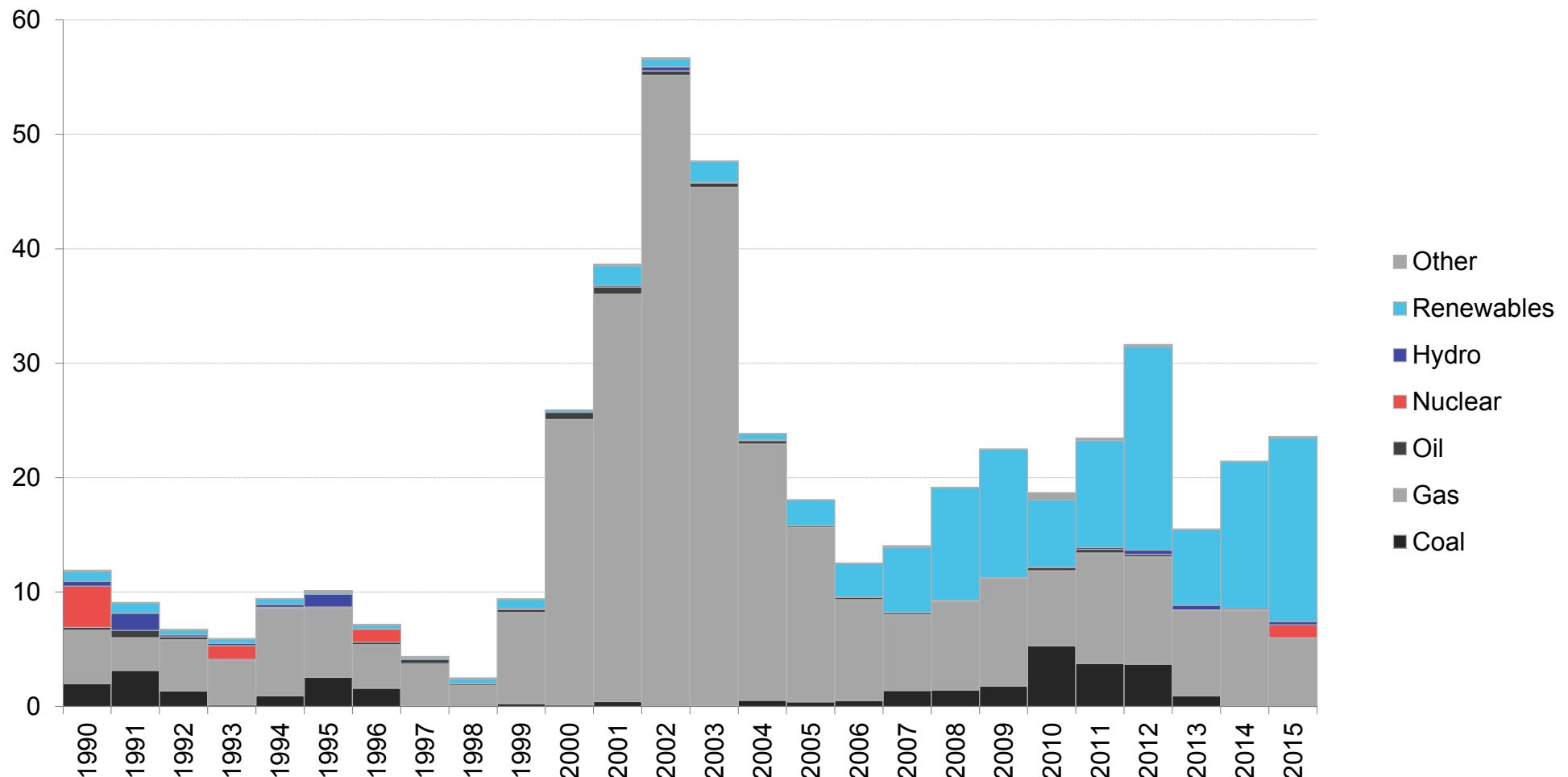
- The US electricity mix in 2015 saw a surge in natural gas-fired generation at the expense of coal, as falling fuel prices pushed down the costs of gas generation and record numbers of coal plants retired. Generation from natural gas plants increased by 17% from 2014 to 2015, while coal generation fell by 11%.
- The US power sector is gradually decarbonizing. From 2007 to 2015, natural gas increased from 22% to 32% of electricity generation, and renewables climbed from 8% to 13%. Coal's share slipped from 49% in 2007 to only 34% in 2015.

Source: EIA

Notes: Values for 2015 are projected, accounting for seasonality, based on latest monthly values from EIA (data available through October 2015). 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)

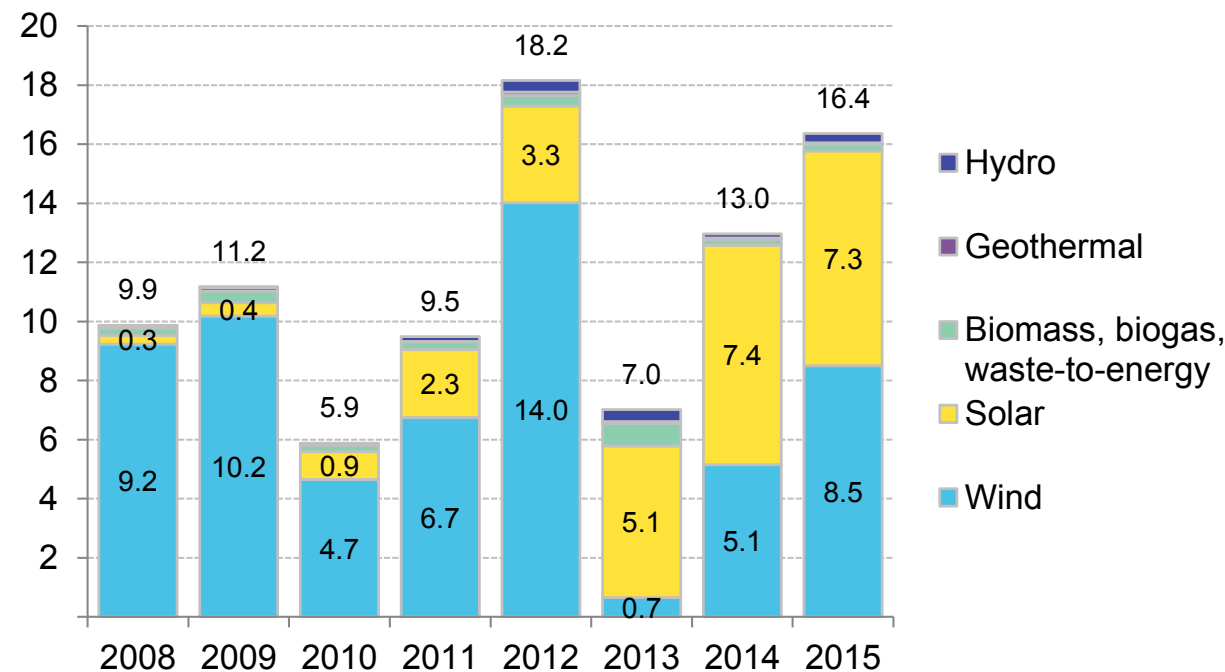


- Since 2008, renewable energy projects have made up just over 50% of new capacity additions.
- Since 2000, 94% of new power capacity built in the US has been natural gas plants or renewable energy projects.
- In 2015, non-hydro renewables were the largest contributor to build for the second year in a row, providing over 16GW or 68% of total build. Gas made up another 25%. For the first time since the 1990s, there was also nuclear build of 1.1GW.

Source: EIA, Bloomberg New Energy Finance

US energy overview:

Renewable energy capacity build by technology (GW)

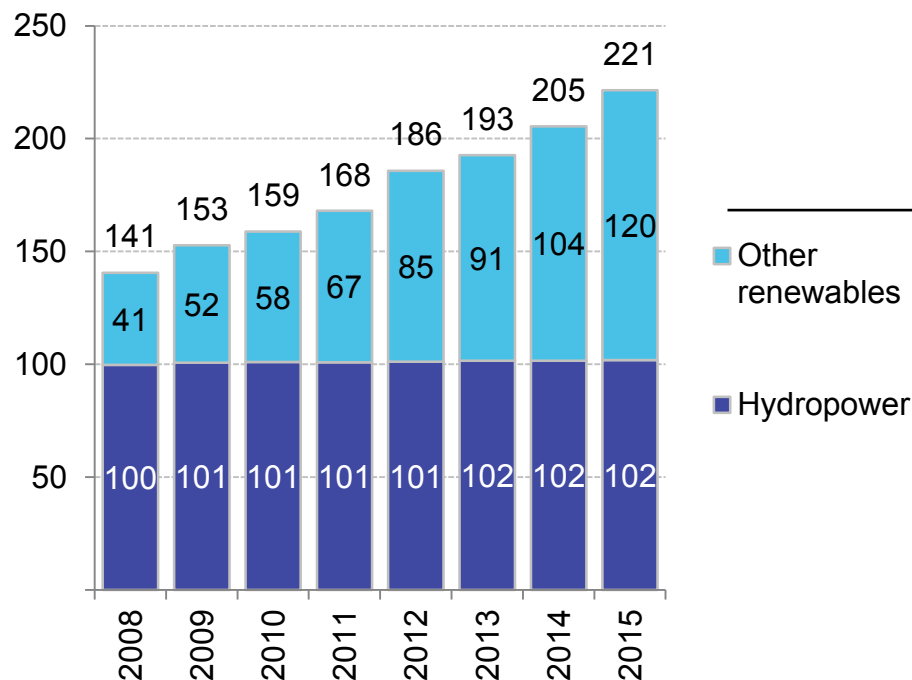


- Solar experienced another year of strong build, adding 7.3GW in 2015 – similar to what occurred in 2014.
- The building frenzy was driven by developers attempting to capture the Investment Tax Credit (ITC) before it was due to drop in value at the end of 2016. But recent Congressional approval of the ITC extension means developers will continue to receive a 30% credit so long as their projects begin construction before the end of 2019. The value of the credit will step down thereafter.
- Small-scale solar continues to grow as the economics make it a viable alternative to retail rates in many regions of the country.
- Wind build surged from 5.1GW in 2014 to 8.5GW in 2015 as developers rushed to capture the Production Tax Credit (PTC) before it was due to expire at the end of 2016. As with the ITC, the PTC was extended at the end of 2015 by five years: projects beginning by end-2019 now have until end-2021 to commence operations.
- Other sectors (biomass, biogas, waste-to-energy, geothermal, hydro) are idling without long-term policy support.

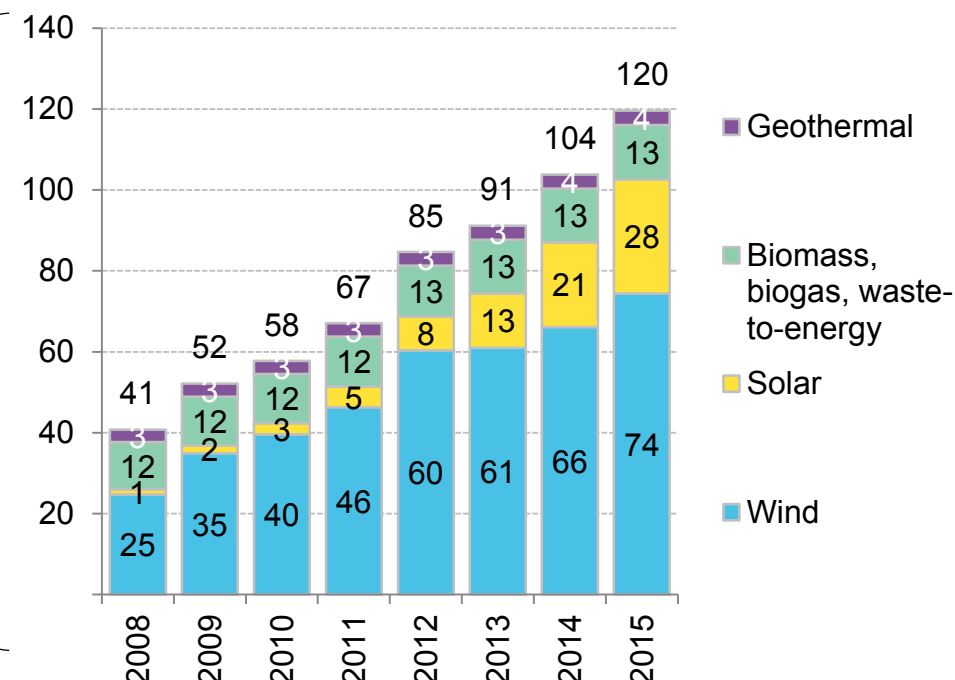
Source: Bloomberg New Energy Finance, EIA Notes: Numbers include utility-scale (>1MW) projects of all types, rooftop solar, and small- and medium-sized wind.

US energy overview: Cumulative renewable energy capacity by technology

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



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



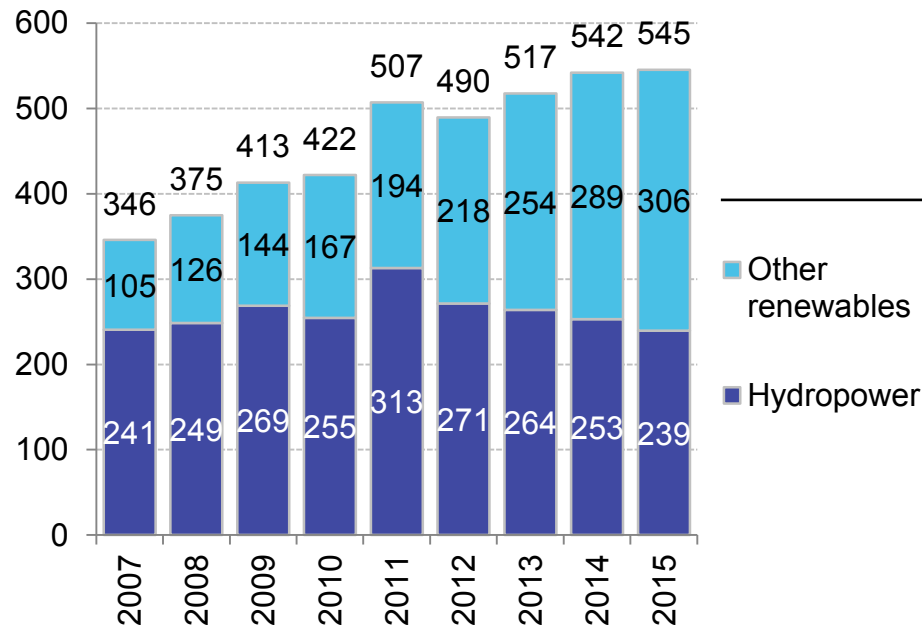
- Capacity from hydropower remained unchanged in 2015, while capacity from other renewables expanded 15% with help from supportive tax policies, renewable portfolio standards (RPS) and falling system costs.
- US non-hydropower renewable capacity has almost tripled since 2008, mostly due to new wind and solar built from 2012 onward. Wind and solar together have quadrupled since 2008.

Source: Bloomberg New Energy Finance, EIA

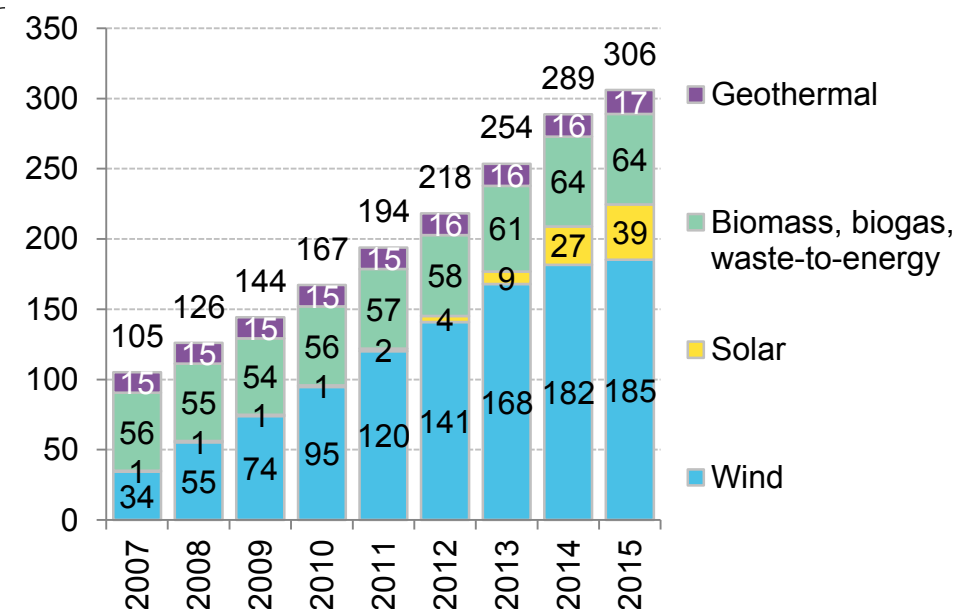
Notes: Hydropower capacity includes pumped hydropower storage facilities. Totals may not sum due to rounding.

US energy overview: Renewable energy generation by technology

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



US non-hydropower renewable generation by
technology (TWh)



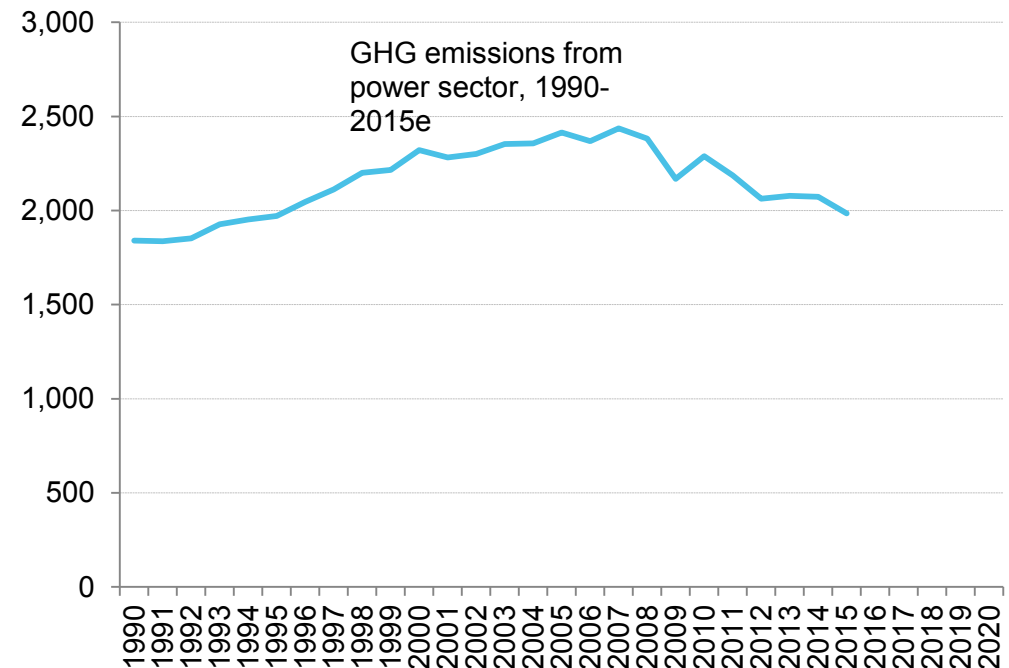
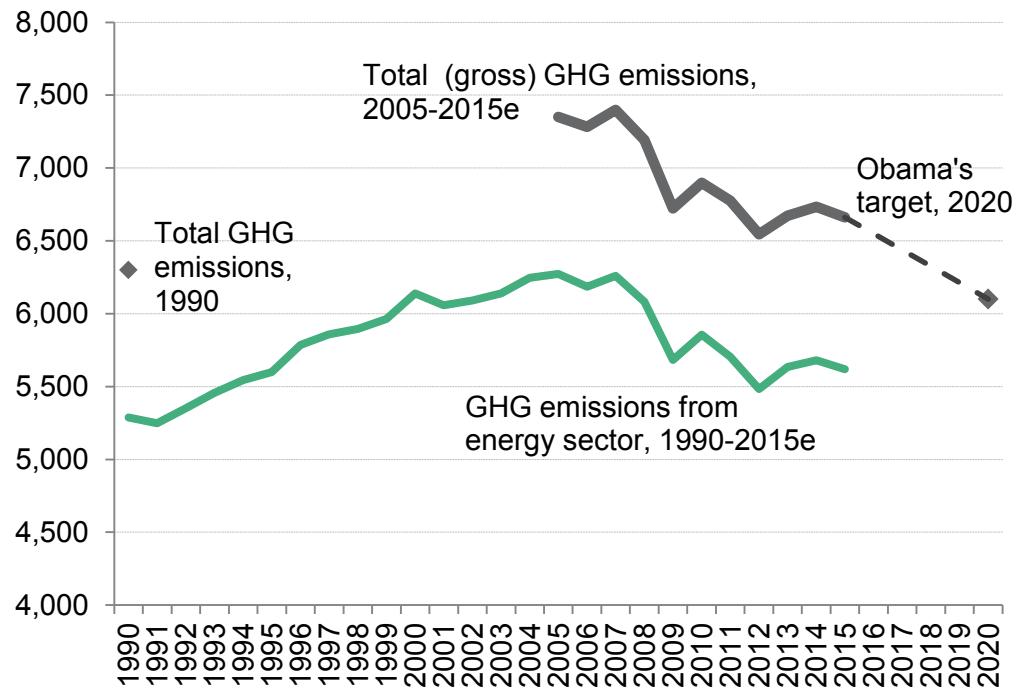
- Generation from non-hydropower renewables grew to 306TWh in 2015, up from 289TWh in 2014. Wind continues to make up the bulk of this generation (185TWh, or 61%) but the growth in 2015 came primarily from a 45% surge in generation from solar.
- Hydro generation has decreased since 2011 due to the ongoing droughts in the West Coast states.
- Non-hydropower renewables now account for 7.4% of US electricity, up from 7.0% the previous year. This figure has grown every year since 2005, when non-hydro renewables generated only 2.2% of US electricity.

Source: Bloomberg New Energy Finance, EIA

Notes: Values for 2015 are projected, accounting for seasonality, based on latest monthly values from EIA (data available through October 2015). 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 are not included.

US energy overview:

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



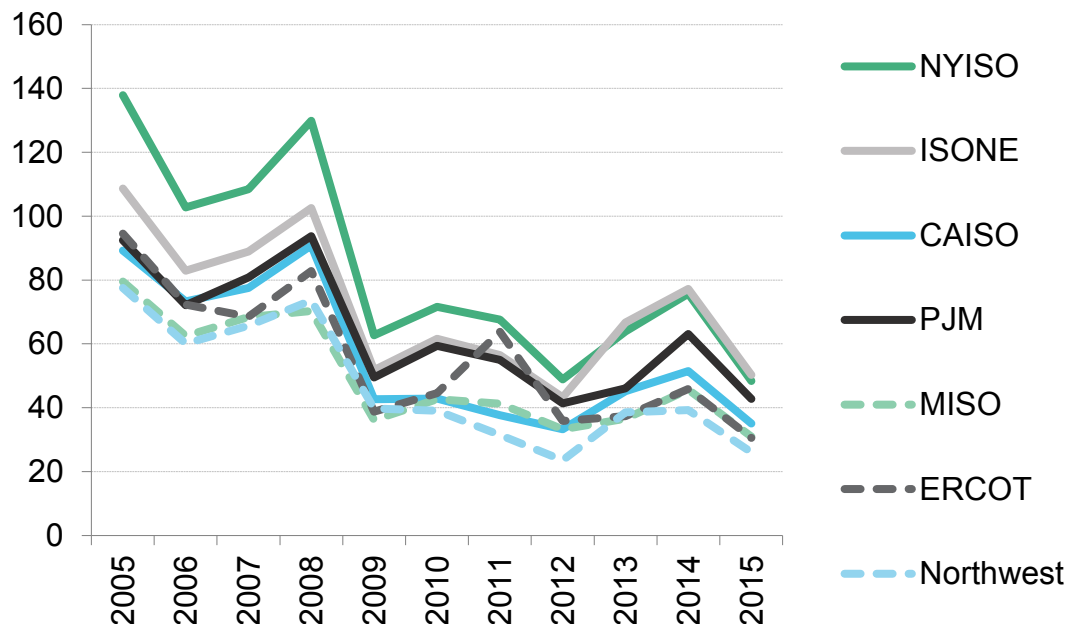
- In 2015, total GHG emissions resumed their long-term trend, falling an estimated 1.1% from 2014 levels. Total GHG emissions (excluding sinks) have now fallen 9.4% from 2005 levels, the baseline used in the White House's climate commitments.
- Within the energy sector, emissions exhibit a similar trajectory, decreasing 1.1% year-on-year. Energy sector emissions now sit at 10.4% below 2005 levels.
- Although overall energy-sector and economy-wide emissions remain above 2012 levels, power-sector emissions have sunk to their lowest levels (1,985Mt) since 1995 as cleaner-burning natural gas has displaced generation from coal-fired power plants.

Source: Bloomberg New Energy Finance, EIA, EPA

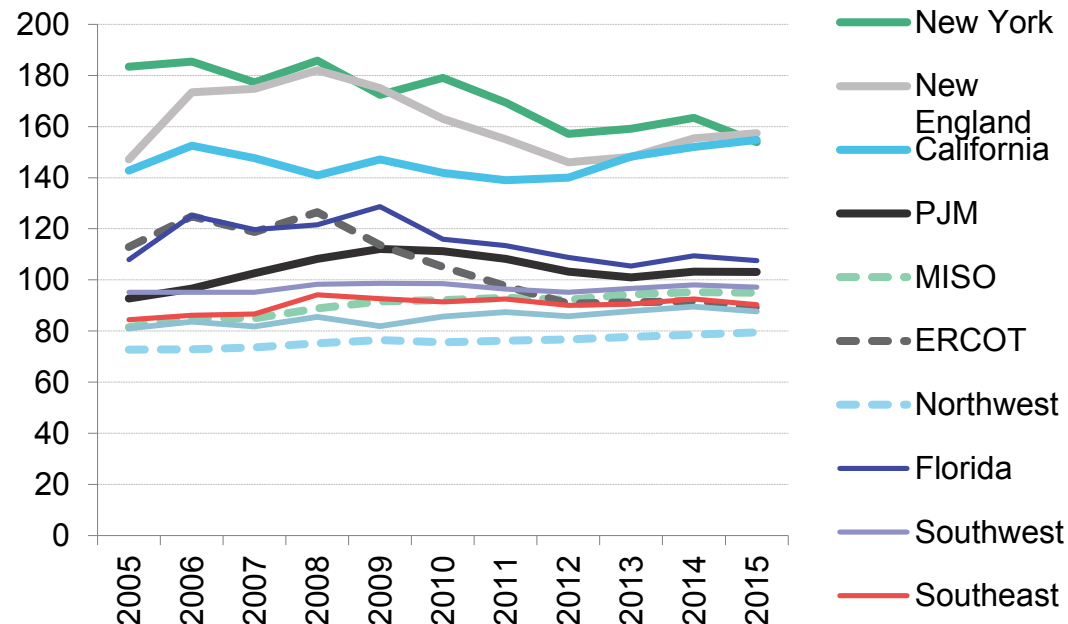
Notes: Values for 2015 are projected, accounting for seasonality, based on latest monthly values from EIA (data available through September 2015). 'Obama's target' refers to a pledge made in Copenhagen climate talks in 2009. The target shown here assumes 17% reduction by 2020 on 2005 levels of total 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 (1990-2013), published April 2015. Data for CO₂ emissions from the energy sector comes from the EIA's Monthly Energy Review.

US energy overview: Retail and wholesale power prices

Wholesale power prices (\$/MWh)



Average retail power prices (\$/MWh)



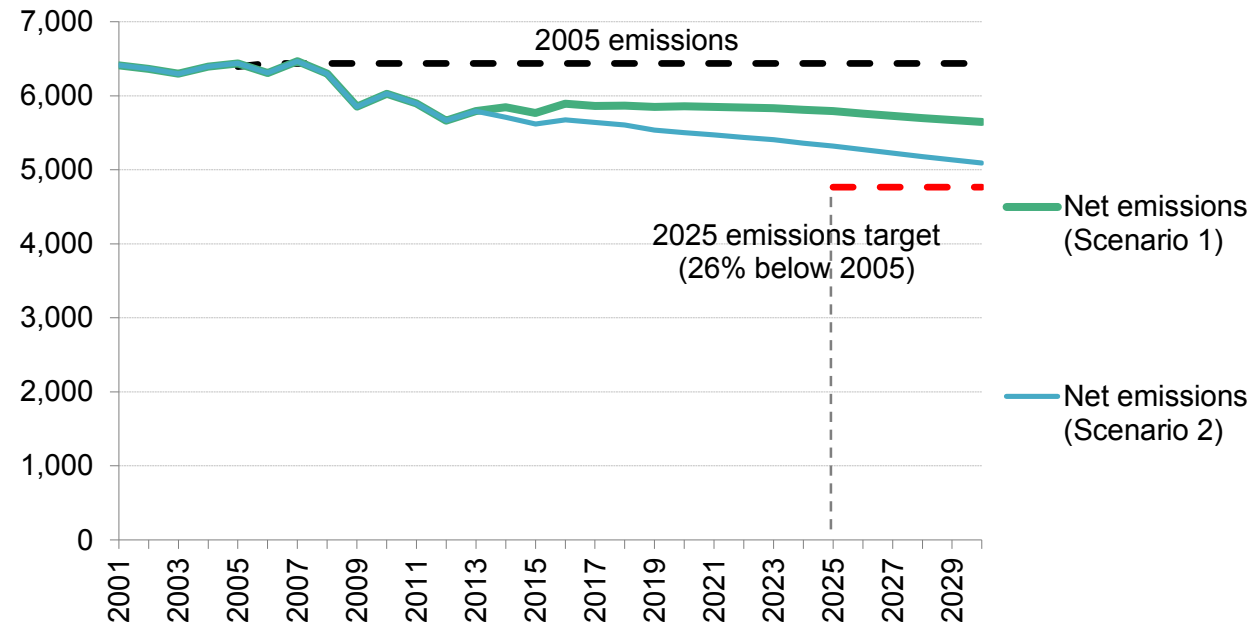
- Wholesale prices fell in the past decade across the country in part due to cheaper natural gas generation, and 2015 was no exception. Over the course of the year, wholesale power prices fell by about a third in each of the regions in the graph above. The largest percentage decline occurred in NYISO (36%), while CAISO experienced a slightly smaller decline of 32%.
- Across most regions of the US, retail power prices have risen since 2005. MISO experienced the largest increase (17%) in the continental US. However, prices fell significantly in both New York (-16%) and ERCOT (-21%).
- Prices in most regions remain well below the peak prices seen in 2008-09. 2015 also saw declines in retail electricity rates as average retail prices in the US fell 1.3%. The greatest decrease again occurred in New York (-5.8%) and ERCOT (-2.7%), while California and New England saw upticks (1.8% and 1.3%, respectively). New York, New England and California continue to have the highest average retail power prices in the country.

Source: Bloomberg New Energy Finance, EIA, Bloomberg Terminal Notes: Data through end-November 2015. Wholesale prices taken from proxy power hubs in each ISO. Prices are in real 2014 dollars.

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Policy – key sustainable energy policy developments in 2015 (1 of 5): US emissions pledge

US net GHG emissions, historical and forecast under two scenarios, relative to 2025 target outlined in the US INDC



- On March 31, 2015, the US released its official pledge for US emissions cuts as part of the United Nations climate negotiations. The US “Intended Nationally Determined Contribution” (INDC) formalized a target agreed to in a pact with China in November 2014: to reduce emissions to 26-28% below 2005 levels by 2030. An earlier target proposed by President Obama set a 2020 goal of 17% below 2005 levels.
- In 2013, the last year with complete data, net emissions (ie, including sinks) stood 10% below 2005 levels.
- The new pledge builds off existing and coming programs (eg, CAFE standards, EPA Clean Power Plan), but more policy may be needed to achieve the targets.

Source: Bloomberg New Energy Finance, EIA, EPA, US Department of State. Notes: Net GHG emissions include total emissions less sequestration. Full data only available through 2013. Scenarios 1 and 2 show two trajectories for US emissions growth, based on a combination of Bloomberg New Energy Finance (BNEF) forecasts and EPA, EIA and US Department of State analyses. Both scenarios use BNEF’s forecast for US power-sector emissions, assuming full compliance with the EPA Clean Power Plan. Both scenarios assume transportation growth as per the EIA’s AEO2015 reference case and assuming existing CAFE standards. Scenario 1 assumes residential, commercial and industrial sectors’ energy growth as per the EIA AEO2015 reference case; and agricultural, waste and forestry and land use sectors’ growth as per the 2014 US Climate Action report. Scenario 2 assumes the historical decline rate for the residential and commercial sectors; assumes the industrial, agricultural and waste sectors’ emissions level remain constant from 2013; and assumes forestry and land use emissions follow the “high sequestration case” in the 2014 US Climate Action report.

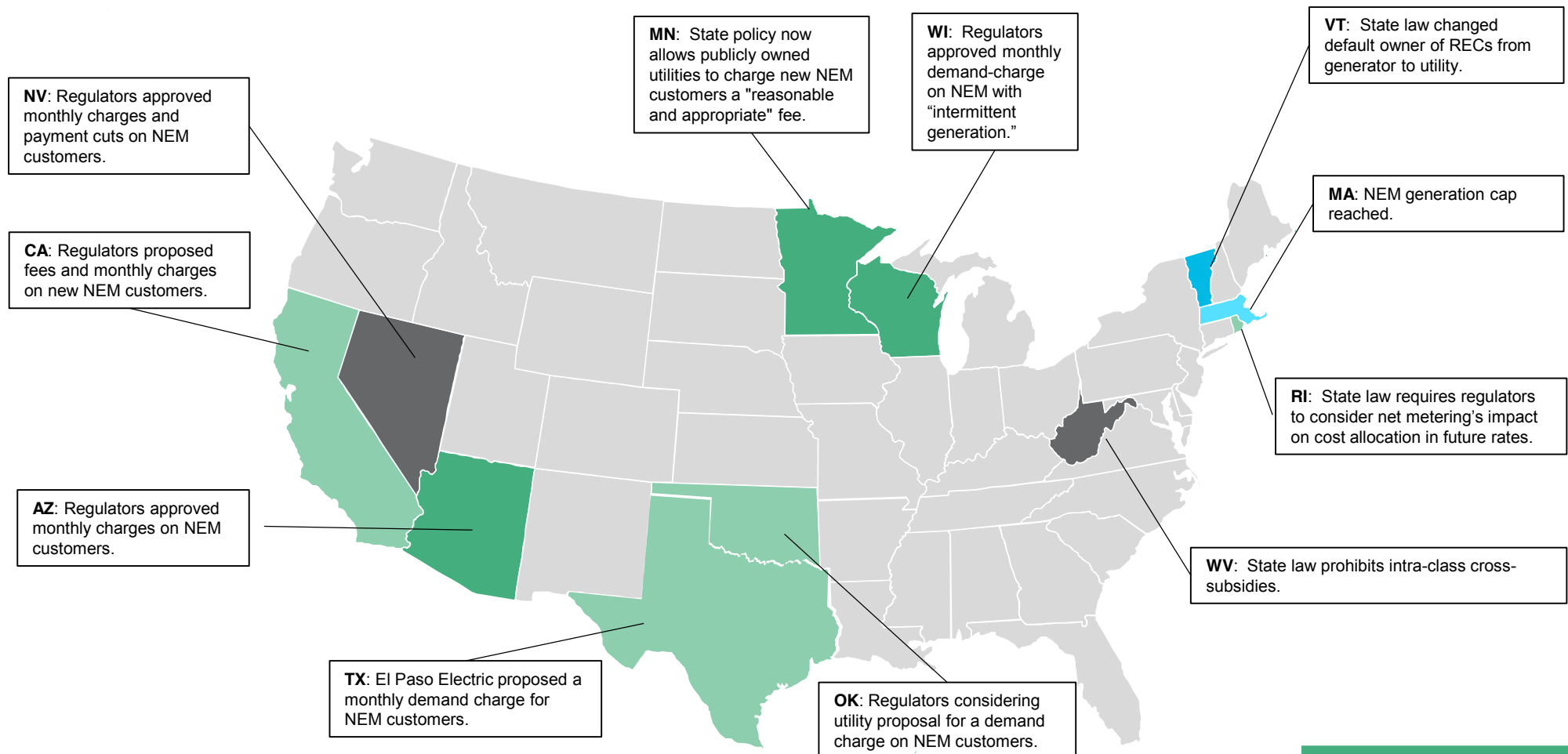
Policy – key sustainable energy policy developments in 2015 (2 of 5): Federal legislative action

- At the end of 2015, Congress enacted major subsidy extensions for clean energy projects.
- Eligibility for wind projects to claim the Production Tax Credit (PTC) was extended through the end of 2019 and retroactively applied through January 1, 2015. The credit is \$23/MWh for projects beginning construction in 2015 and 2016, then steps down through 2019. The credit will not be available to projects breaking ground after 2019.
- The Investment Tax Credit (ITC) for solar projects was extended and “commence construction” language was added to the legislation. The ITC now applies to projects beginning construction before 2022 and placed in service before 2024. The credit begins at 30% for projects breaking ground before 2020, then steps down. Commercial projects placed in service after 2023 will still be eligible to receive a reduced credit of 10%. Residential projects did not receive “commence construction” language and therefore must be in service to qualify for the ITC. Residential initiatives may receive the 30% credit if put in service before 2020; the credit level then steps down and is eliminated altogether after 2021.
- Extensions were also granted for the production of second-generation biofuels and energy from geothermal, biomass and landfill gas, hydroelectric projects and ocean energy; however, the majority of these technologies received extensions of only two years, compared to five year for wind and solar.
- Deductions and credits were extended for energy efficiency building improvements and the construction of efficient homes.

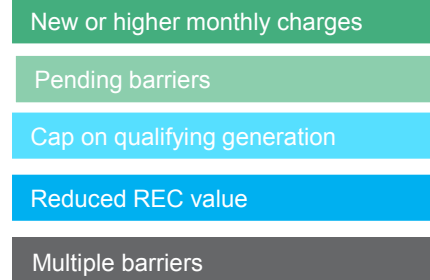
Source: Bloomberg New Energy Finance

Notes: For more on the PTC and ITC (their history, how they work, which technologies are applicable), see Sections 2.2 and 4.1 of the 2014 edition of the Factbook.

Policy – key sustainable energy policy developments in 2015 (3 of 5): State policy barriers to net energy metering erected in 2015

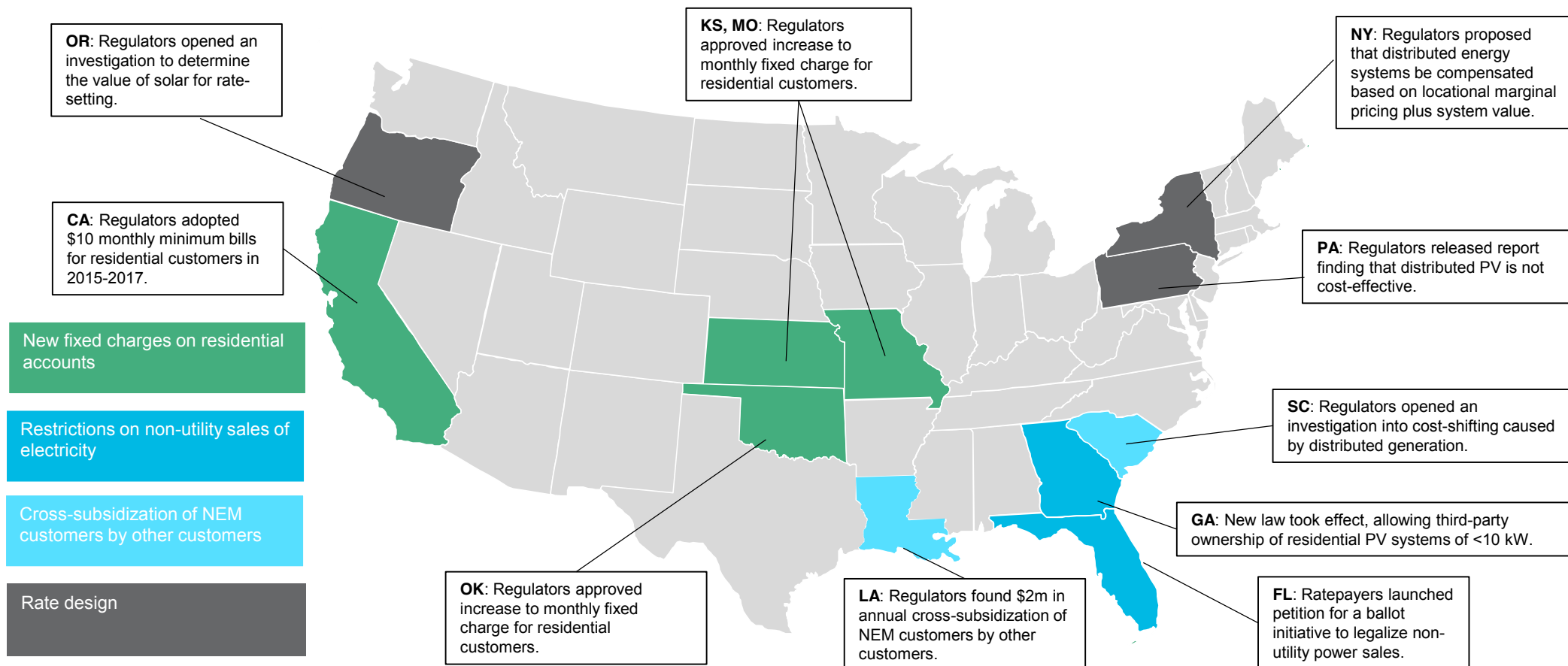


- States across the country imposed policies against net energy metering (NEM), a practice key to the economics of distributed generation.
- For example, Nevada regulators approved higher fixed charges and lower compensation for surplus generation from NEM customers. In response, SolarCity and Sunrun announced plans to leave the state. State regulators are now considering grandfathering in existing NEM customers so that they are not subject to the new rule.



Source: Bloomberg New Energy Finance

Policy – key sustainable energy policy developments in 2015 (4 of 5): State policy actions on distributed solar (excluding NEM) in 2015



- Outside of NEM, states also influence the economic viability of distributed solar by policies such as fixed charges in utility rate designs. This was a topic of contention in 2015 as states dealt with further growth in distributed generation.
- California, Oklahoma, Kansas and Missouri set or increased monthly fixed charges for residential customers in 2015.
- Regulators have also been investigating the cost-shifting impact of distributed solar and new ways of compensating generation from rooftop PV systems.

Source: Bloomberg New Energy Finance

Policy – key sustainable energy policy developments in 2014 (5 of 5): EPA Clean Power Plan

- For analysis on the EPA Clean Power Plan, see Section 8.1 of this report.

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



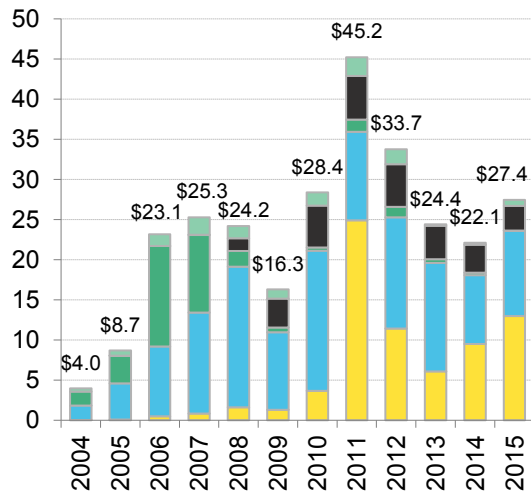
- The US funneled \$56bn toward clean energy investments in 2015, up \$3.9bn from the previous year. Clean energy investment has held steady since 2012, but has not approached the peak seen in 2011. Investment in 2011 was boosted by spending under the American Recovery and Reinvestment Act and a rush to build wind projects in advance of what had been the expiration of the Production Tax Credit in 2012.
- As with 2014, the vast majority of new investment flowed into the solar sector – \$30.2bn, or 54% of all new clean energy investment in 2015.
- The next largest category for investment continues to be wind (\$11.6bn, or 21%). This technology saw a boom ahead of what had been the effective end of the PTC before the tax credit was extended in December.
- Energy smart technologies (EST) came in just behind wind with \$11.1bn, down 22% from its 2014 high of \$14.1bn.

Source: Bloomberg New Energy Finance

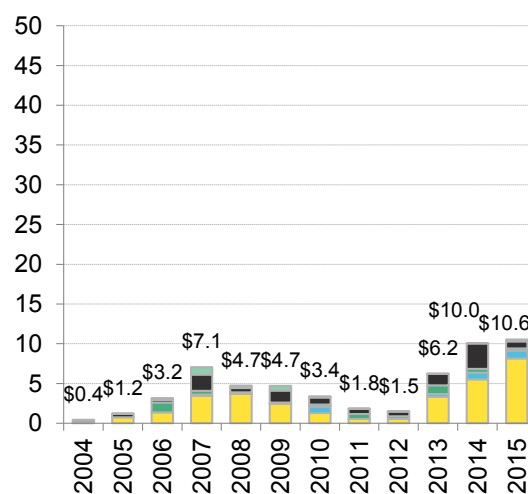
Notes: Chart displays total clean energy investment in the US across all asset classes (asset finance, public markets, venture capital / private equity, corporate and government R&D, and small distributed capacity (rooftop solar)). The definition of 'clean energy' used here is renewable energy, energy 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 in both charts 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)

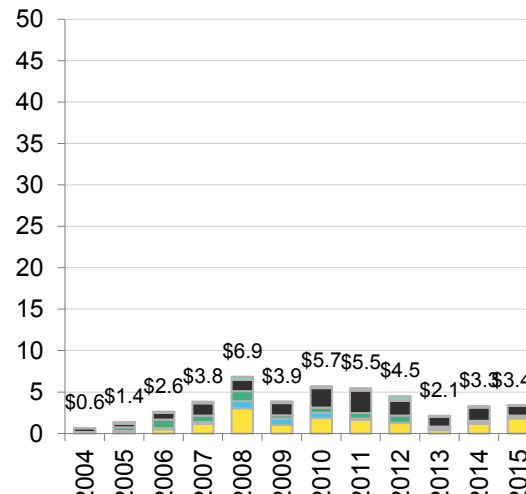
Asset finance



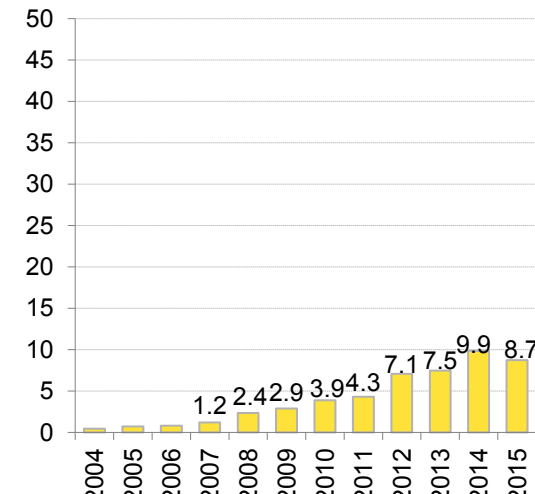
Public markets



Venture capital / private equity



Small distributed capacity (ie, rooftop solar)



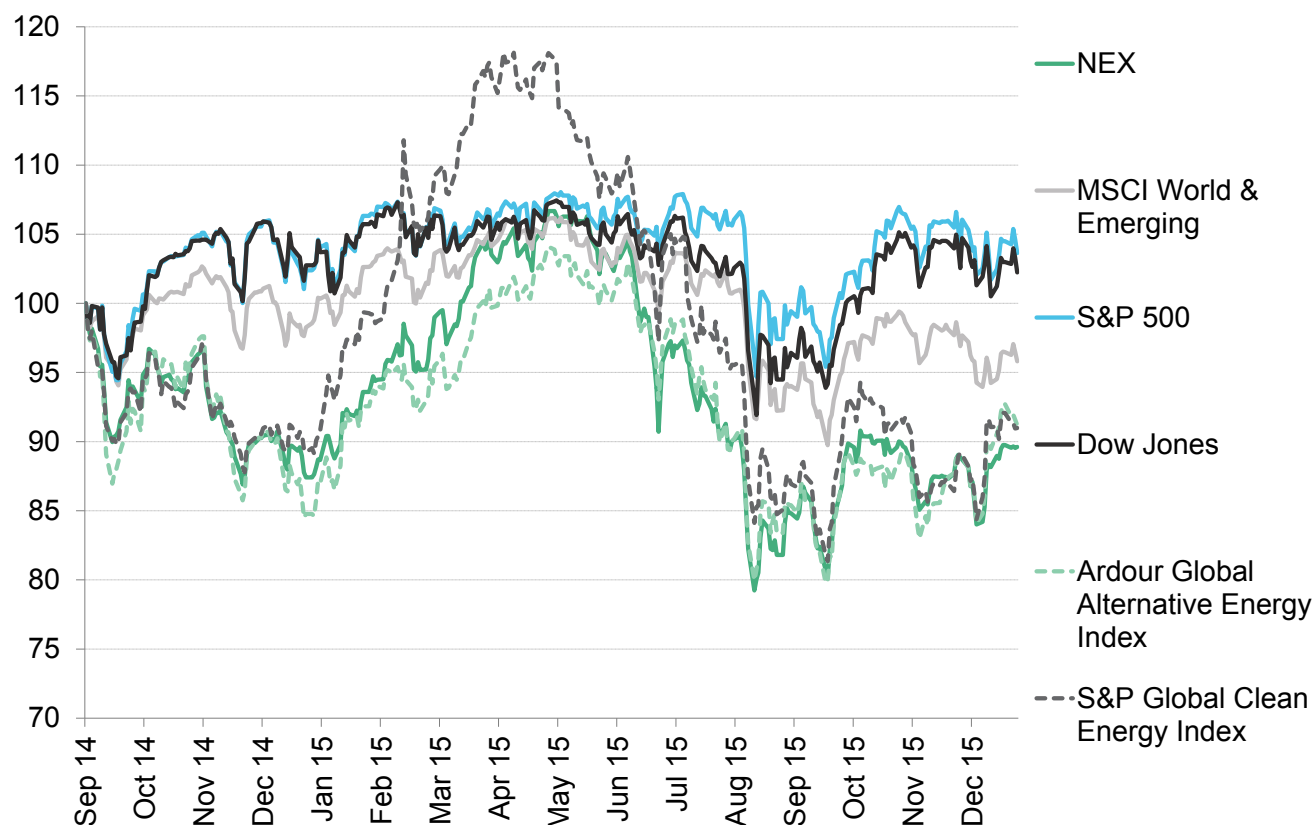
Other Energy smart technologies Biofuels Wind Solar

- The majority of asset finance in 2015 continued to go to utility-scale solar and wind, ahead of what had been the expected 2016 expiration of the ITC and PTC.
- Major public market transactions focused on solar, with SunEdison alone raising \$460m in equity in Q1, \$900m in Q2, and \$650m in Q3. TerraForm Global's IPO in Q3 raised \$675m.
- Funds raised by companies in energy smart technologies (EST) through public markets continued to focus on electrified transport, including \$750m raised by Tesla Motors in a secondary stock offering in Q3.
- Venture capital and private equity investment was level with 2014, with most funds directed towards solar and EST.
- Investment in rooftop solar came in at \$8.7bn, slightly below the 2014 total.

Source: Bloomberg New Energy Finance

Notes: See previous slide for definition of 'clean energy'. Values are in nominal dollars. Values for VC/PE include estimates for undisclosed deals.

Finance: Returns of global clean energy indices relative to benchmarks

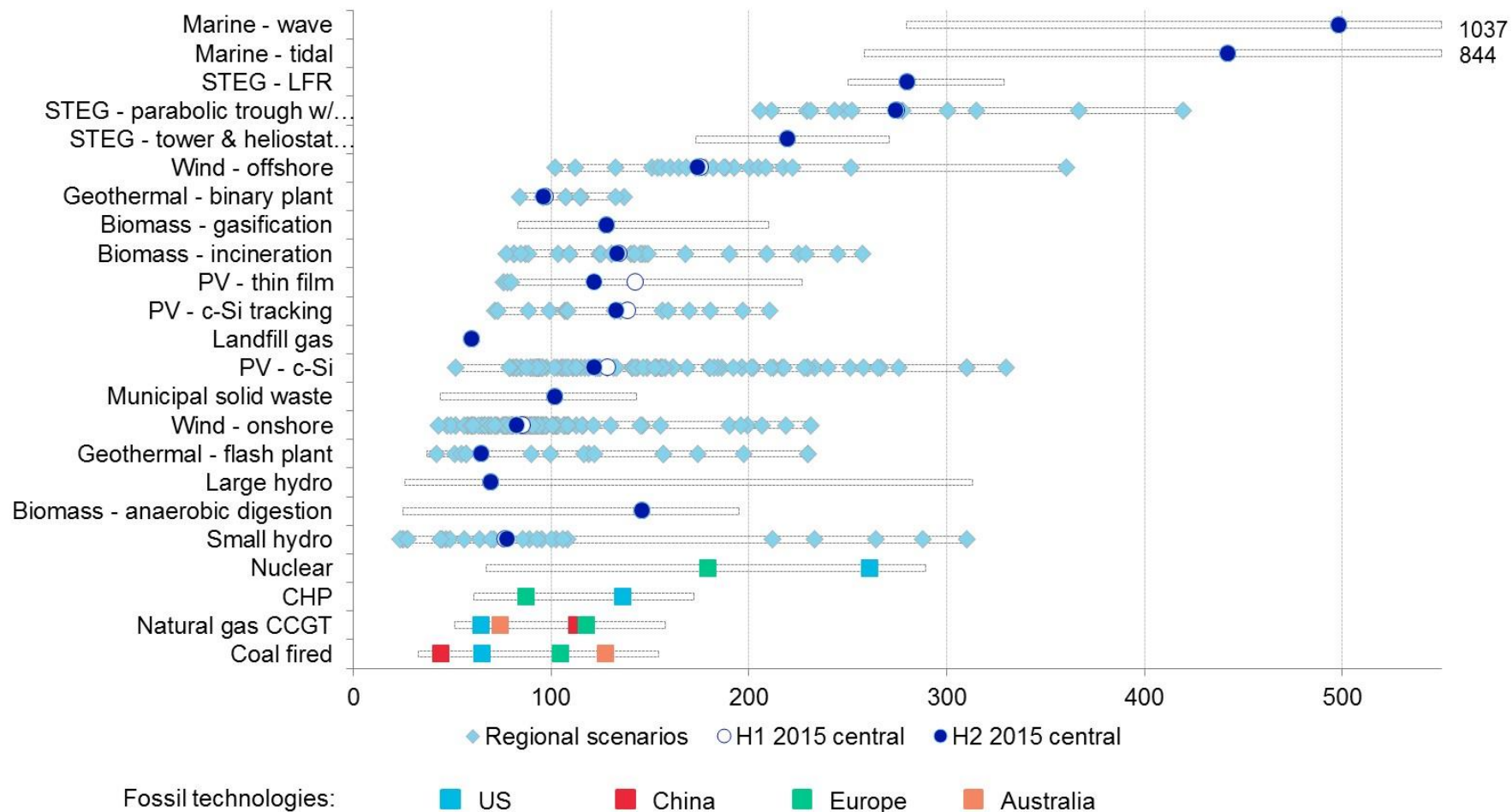


- Global stock markets fell in Q3 2015 in the wake of a stock market crash in China, which spurred global investor uncertainty. Most markets stabilized in the final quarter of 2015.
- Clean energy indices (represented here using the NEX, S&P Global Clean Energy, and Ardour Global Alternative Energy Index) underperformed the broader market (benchmarked here by the S&P 500, Dow Jones and MSCI World & Emerging).
- The NEX, a global index of publicly traded companies active in renewables and low-carbon energy, ended the year down 20%, as a result of the Chinese stock market crash and falling global oil and gas prices.

Source: Bloomberg New Energy Finance, Bloomberg Terminal

Notes: Indices normalized to 100 on September 2014.

Economics: Global levelized costs of electricity (unsubsidized across power generation technologies, H2 2015 (\$/MWh)

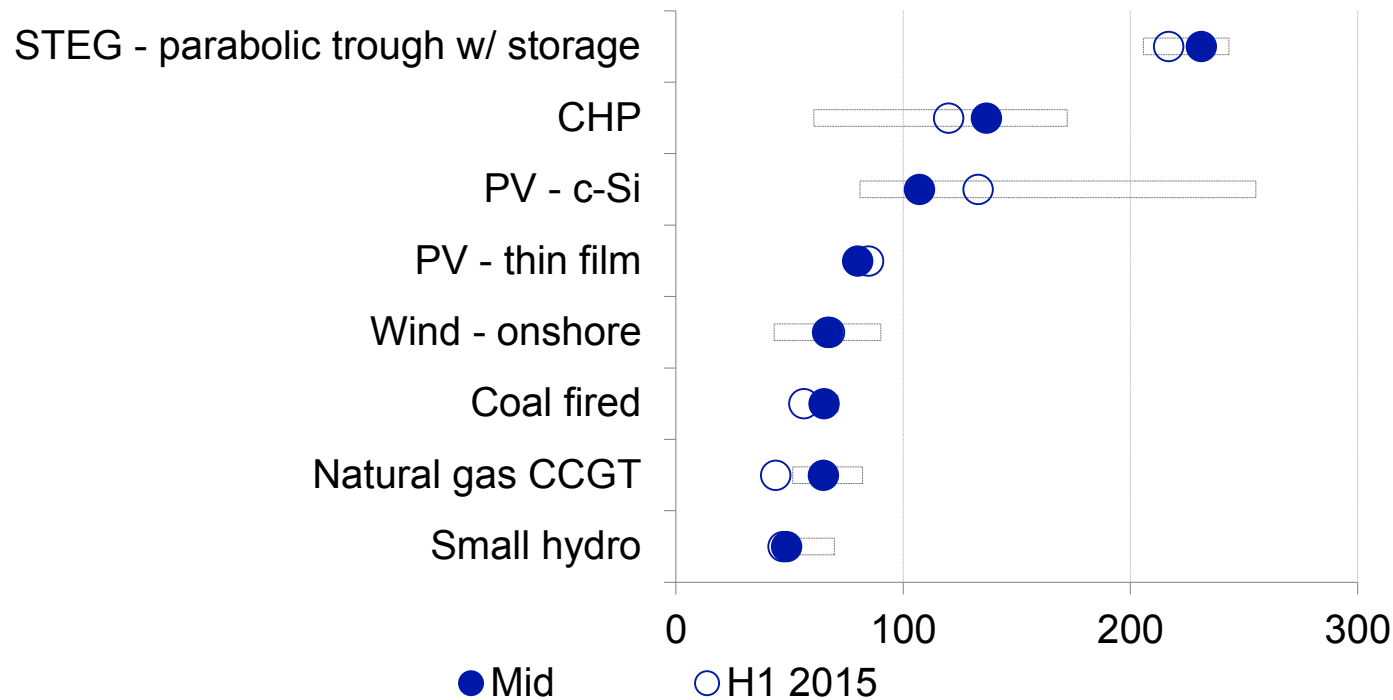


- A number of renewable energies have comparable and, at times, cheaper LCOEs than “conventional” power sources.

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; 'CCGT' stands for combined cycle gas turbine; 'c-Si' stands for crystalline silicon; 'CSP' stands for concentrated solar power; 'LFR' stands for linear Fresnel reflector. EIA is source for capex ranges for nuclear and conventional plants.

Economics: US levelized cost of electricity (unsubsidized across power generation technologies, H2 2015 (\$/MWh)

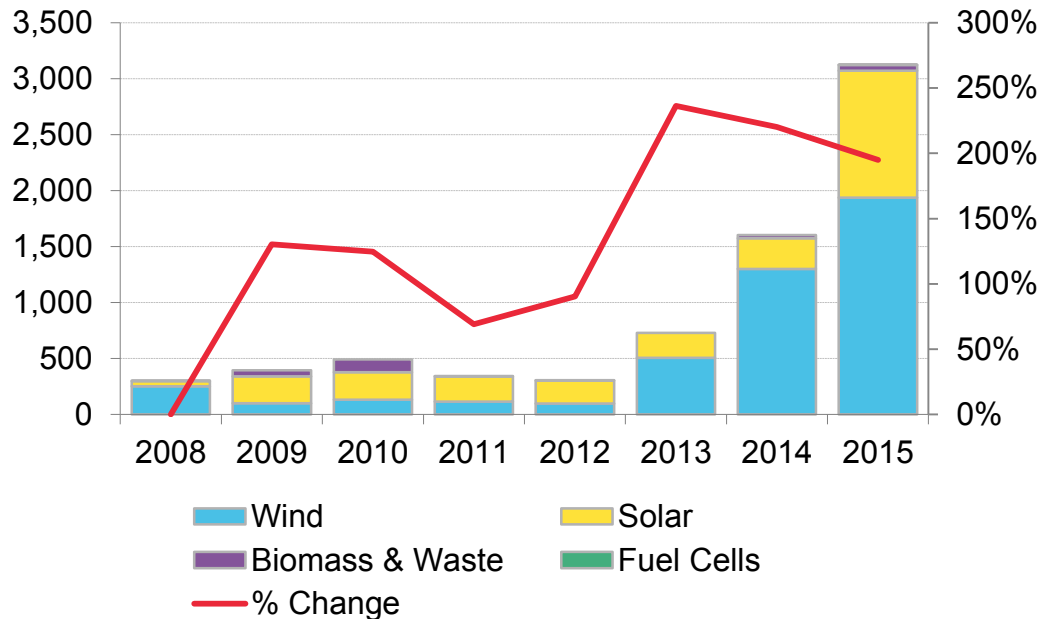


- Utilization rates of natural gas plants in the US have fallen, causing the US CCGT LCOE to increase from \$48/MWh in H1 2015 to \$65/MWh in H2 2015. This has improved the cost competitiveness of unsubsidized wind which is as low as \$43/MWh in Texas.
- The US wind sector in general has seen improvements in equipment and turbines which has improved capacity factors to an average of 37% in H2 2015, from 35% in H1 2015. This has resulted in a 1% decrease in the mid- point LCOE.
- Solar PV (crystalline silicon) LCOEs have fallen 6% since H1 2015 and unsubsidized projects are now as low as \$81/MWh in Arizona. REC markets and tax credits continue to encourage the development of the solar industry in much of the country.
- Small hydro still remains one of the cheapest energy sources due to high capacity factors. However, as droughts persist, especially in California, LCOEs will likely increase.
- Solar capacity factors are best in the Southwest (17-20% c-Si, 22-23% thin-film with tracking) and worst in the Northeast, such as states in New England (13-16%). Wind capacity factors are best in the center of the country (around 45%) and worst in Southeast states (around 27%).

Source: Bloomberg New Energy Finance, EIA

Notes: see note on slide 34, "Economics: Levelized cost of electricity (unsubsidized across power generation technologies, H2 2015 (\$/MWh))"

Renewable capacity contracted by corporations, by technology, 2008-15 (MW)



Key players in corporate procurement



- Corporate procurement of clean energy has taken off since 2012. The amount of clean energy procured roughly doubled from 2013 to 2014, and nearly did so again in 2015.
- Wind and solar are the energy technologies of choice. When procurement levels were low between 2008 and 2012, solar generally made up the majority of MW. After corporate procurement took off in 2013, however, wind made up the dominant portion of procurement. 2015 saw solar more than quadruple in MW terms and expand its share of total procurement.
- Google has been the largest player to date, procuring 71MW of solar and 1.2GW of wind. Amazon is second, with 80MW of solar and 458MW of wind contracted in 2015 alone. Large individual projects include Facebook's 202MW purchasing power agreement (PPA) with Shannon Wind Farm in Texas, and Apple's 153MW PPA with First Solar.

Source: Bloomberg New Energy Finance, company announcements

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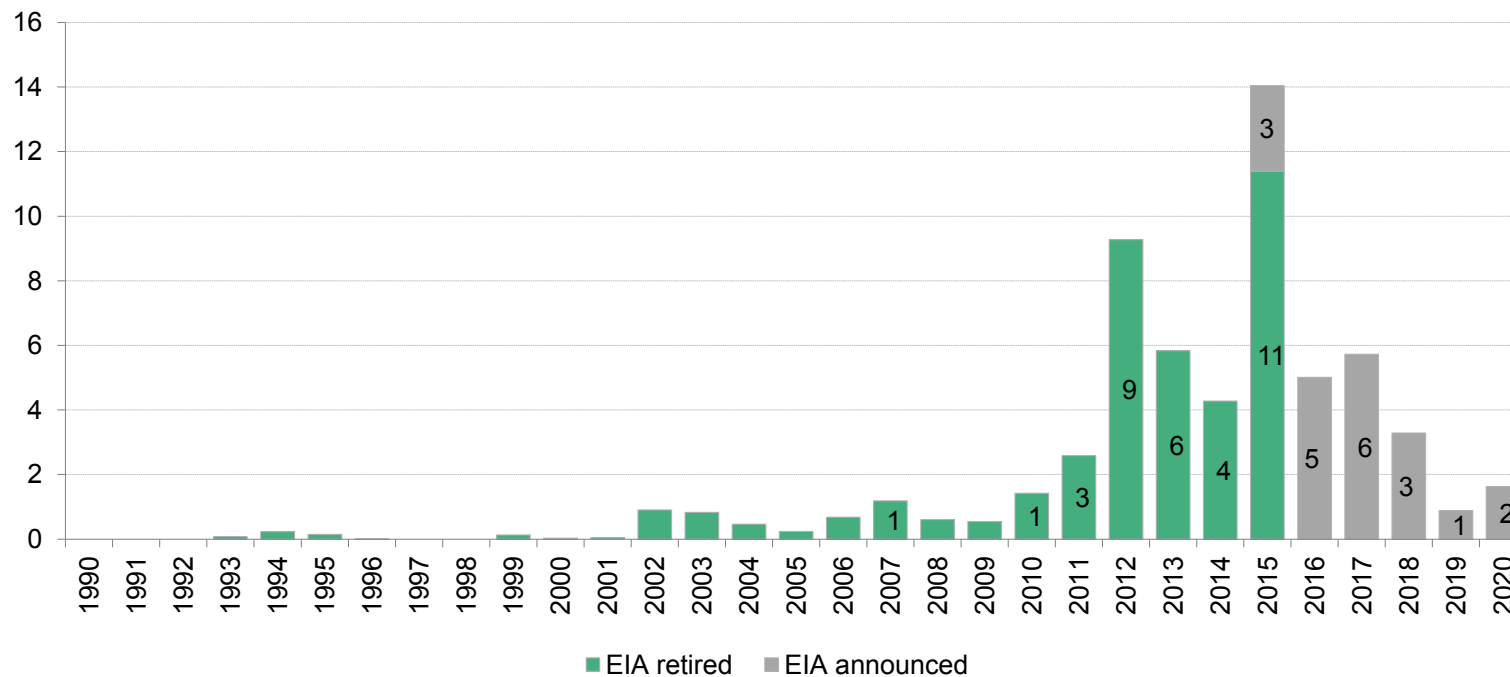
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Policy: US coal power plant retirements completed and announced by year (GW)

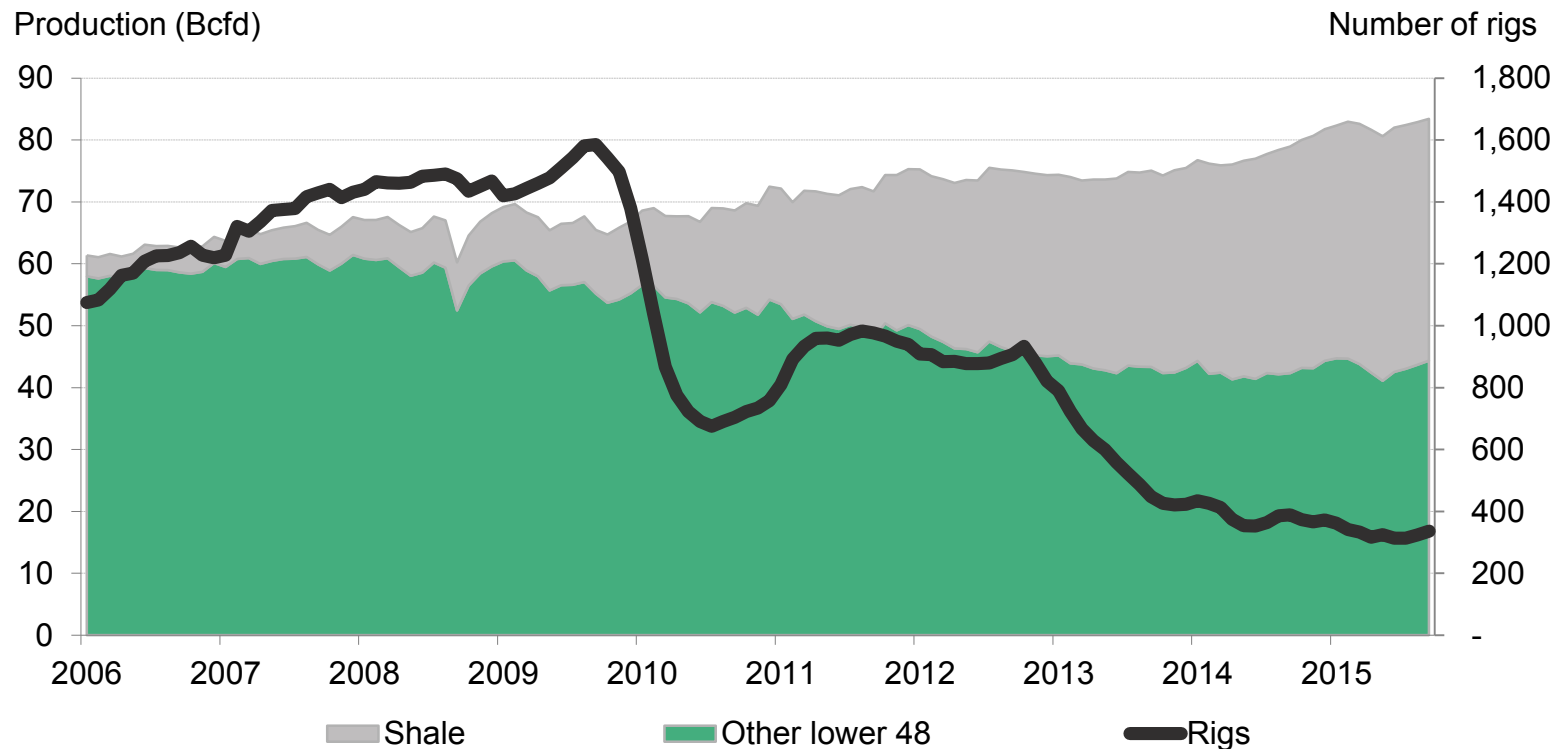


- 2015 saw the largest wave of coal retirements ever, with 11GW going offline through October 2015 and another 3GW of retirements announced. An additional, undetermined number of plants (likely less than 5GW in total) also converted from coal to burn natural gas and, in a few cases, biomass. Much of the action was driven by utilities responding to the Mercury and Air Toxics Standard (MATS) which was due to take effect in April 2015.
- Record low gas prices, old age, and increasing 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.
- MATS was put into limbo after it was remanded by the US Supreme Court in summer 2015. But remaining regulations, coupled with the Clean Power Plan and New Source Performance Standards for new coal and gas build, continue to drive up costs for existing coal plants and effectively preclude new build of coal plants without carbon capture and storage.

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-October 2015.

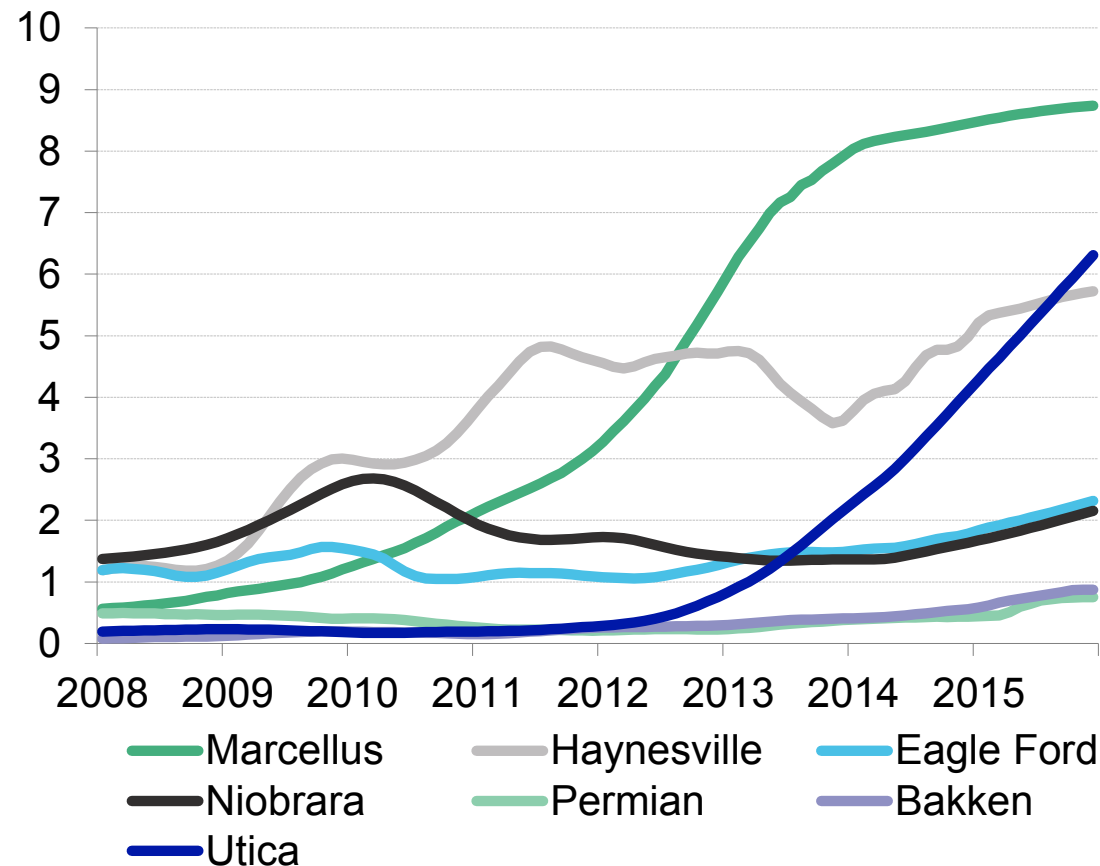
Deployment: US natural gas production and gas-directed rig count (Bcfd, rigs)



- Rig counts have dropped even lower than last year, as producers struggle to cope with the low-price environment.
- However, total US natural gas production still continues to grow. This is due to a few reasons:
 - Producers are selectively drilling in productive “sweet spots.”
 - Technological improvements in efficiencies (like pad drilling and longer laterals) are effective in shrinking well completion time, making it easier to speed up production and expand capacity for each well.
 - Further pipeline build, including new infrastructure brought online in November and December, will expand takeaway capacity, reducing supply gluts and pushing up prices. In the latter part of last year, producers were bringing back shut-in wells in response to potentially higher cash prices.

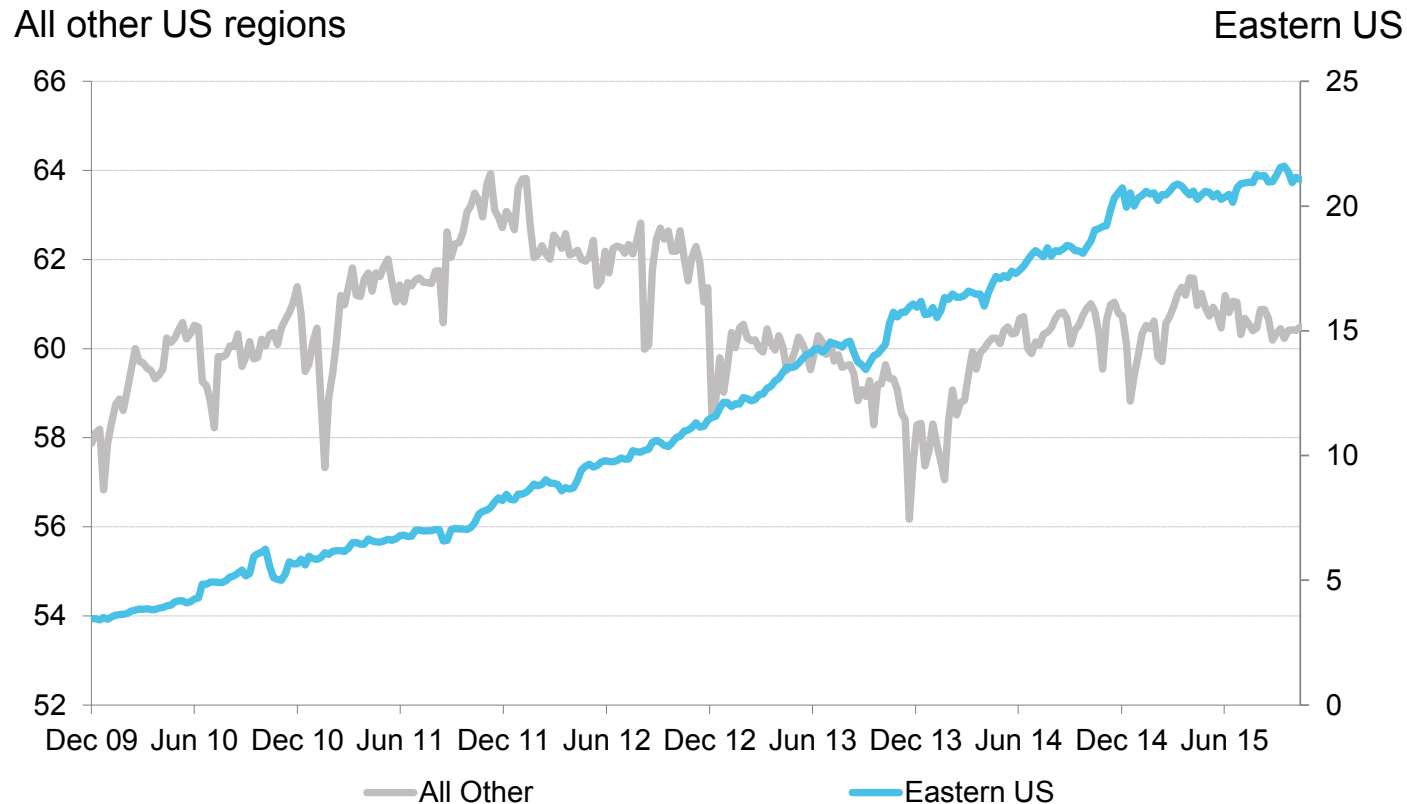
Source: Bloomberg New Energy Finance, EIA, Baker Hughes. Data up through the latest comprehensive numbers available (September 2015).

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



- The Marcellus is the most productive gas play in the US and by itself offsets declining dry gas production in other parts of the country. The most economical dry and wet gas regions are located here, and the area experienced the greatest rig productivity improvement.
- Utica productivity has also been exceptional in the past few years, having just exceeded the Haynesville during this past year.

Deployment: Gas production in the continental US (Bcfd)



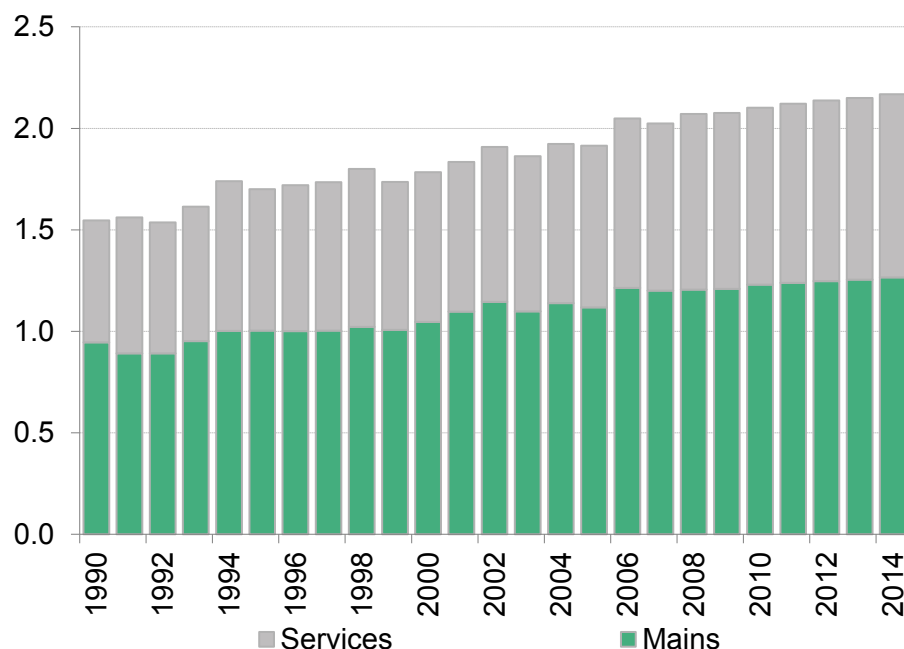
- Eastern US natural gas production continues to grow, even as producers shut wells to ride out unfavorable economics caused by the lack of takeaway capacity.
- Production in other plays was fairly stagnant in 2015 because the current low oil and gas price environment renders many plays uneconomical, and the Northeast has become a net supplier, in light of all the new pipeline projects and reversals emerging out of the region.

Source: Bloomberg New Energy Finance, LCI Energy

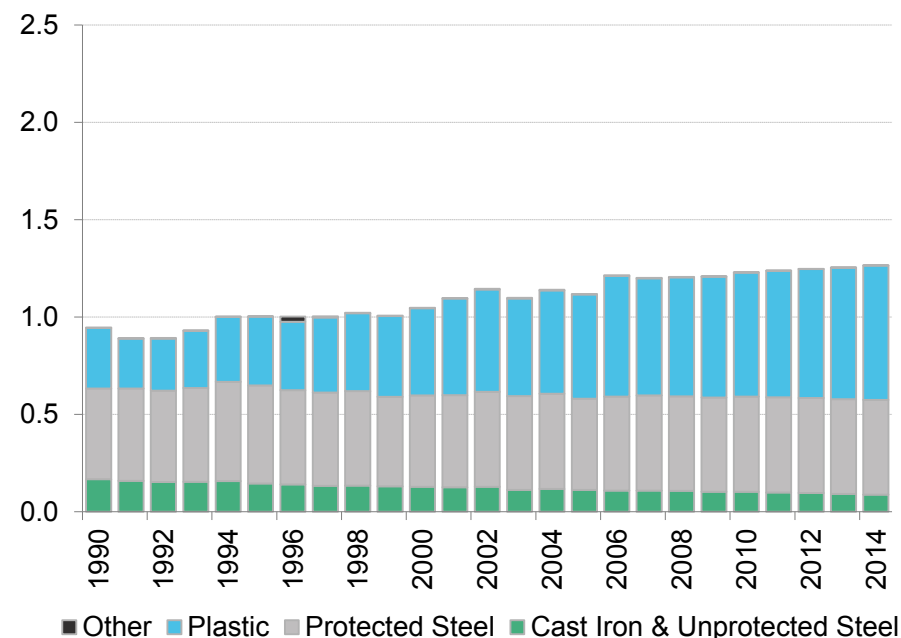
Notes: Eastern US production is mostly comprised of output from the Marcellus and Utica shales.

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

US existing natural gas distribution pipeline



US natural gas distribution mainline material

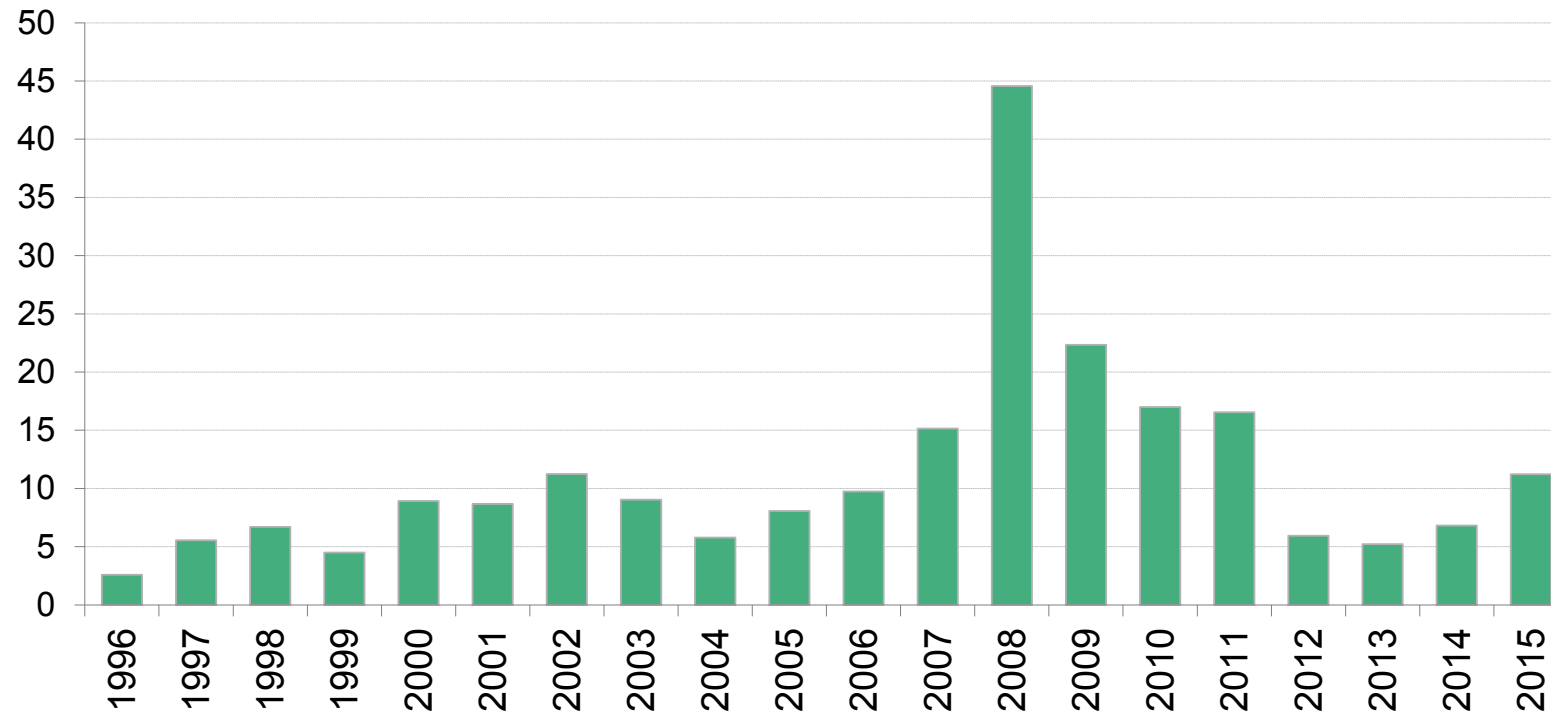


- Service and distribution pipelines – which bring gas from transmission lines to end-users – continue to grow steadily.
- Replacement and expansion efforts are upgrading US pipelines with more modern materials and expanding to underserved and unserved customers. Companies are removing older networks 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 added to connect new customers.

Source: Bloomberg New Energy Finance, US Department of Transportation, American Gas Association

Notes: 'Mains' refers 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. Numbers are not yet available for 2015.

Deployment: US transmission pipeline capacity additions (Bcfd)

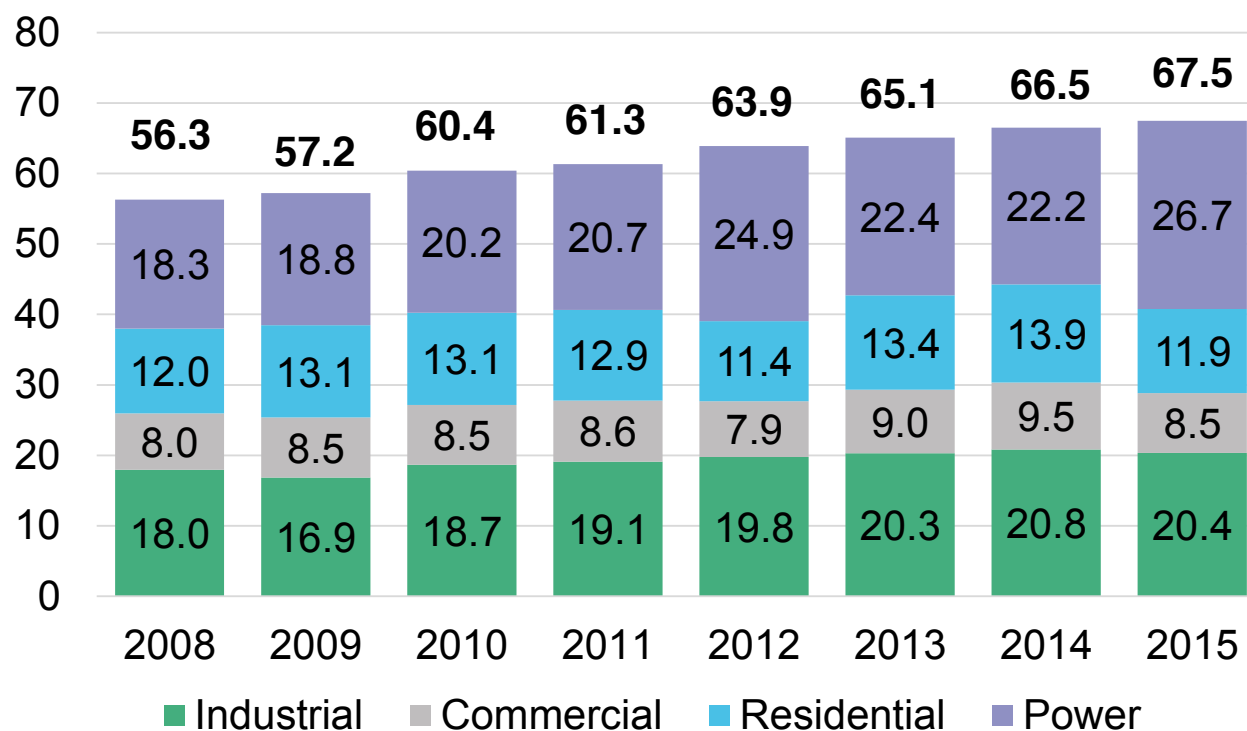


- In 2015, pipeline companies installed over 11Bcfd of total pipeline capacity, of which 3.3Bcfd provided first-mile takeaway capacity from Marcellus and Utica shales. Directionally, these first-mile pipelines will transport around 1.6Bcfd to Midwest markets, 1.1Bcfd towards the Gulf Coast, and around 0.5Bcfd to the Southeast.
- Despite routine delays on pipeline projects (over almost all phases of the implementation process), many substantial projects were approved or filed for approval this year. The bulk of these projects will commence service in 2017 and 2018.
- US-Mexico border capacity in 2015 grew to just over 7Bcfd. Moving forward, capacity will be growing at unprecedented rates, with proposed capacity in 2019 reaching over 13Bcfd.

Source: Bloomberg New Energy Finance, EIA

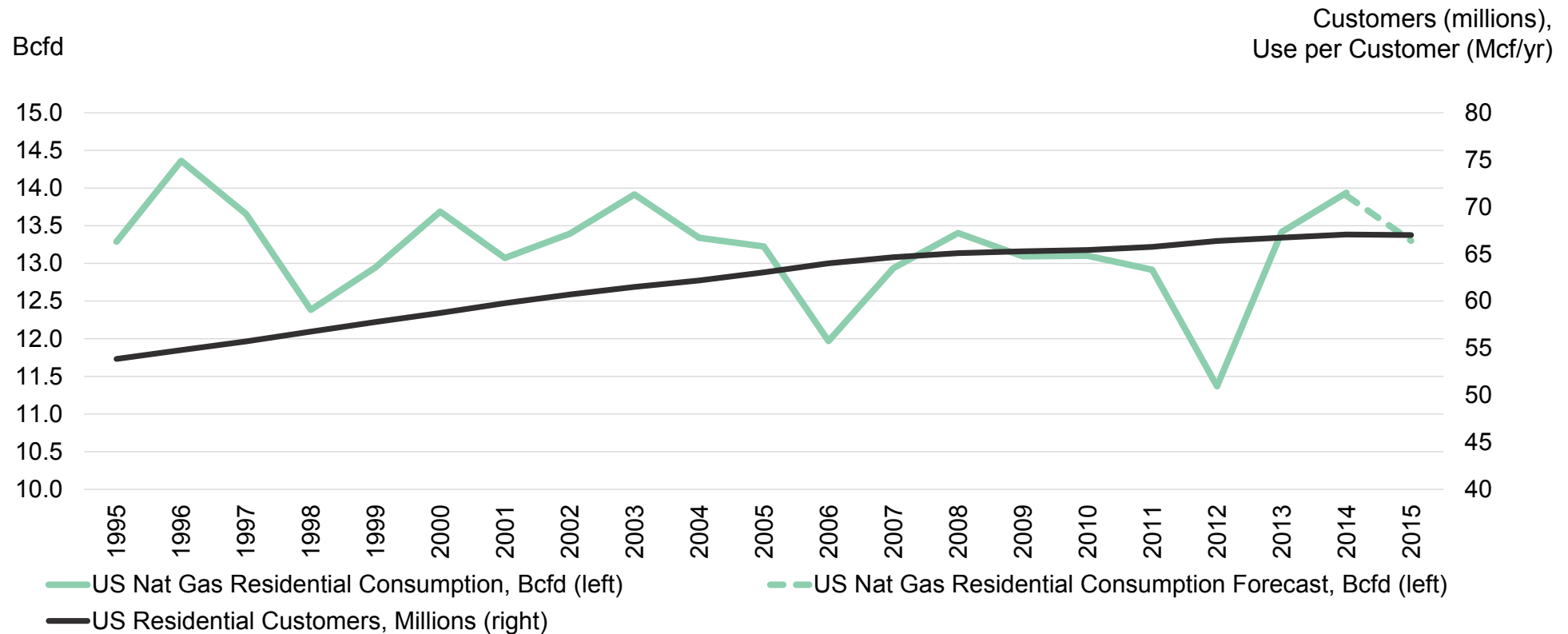
Note: EIA data used here includes both first-mile takeaway capacity and other pipeline additions that do not impact takeaway capacity.

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



- Total US annual gas demand has grown steadily: 2015's level represents a 15.4% increase since 2008, and an estimated 1.5% increase since 2014.
- Over the last year, power generation demand has seen the greatest increase (>20%) by far. We attribute this to structural reasons:
 - Natural gas has entered a prolonged low-price era, supported by high production volumes which are stranded behind constrained pipeline takeaway capacity.
 - Aggressive coal-to-gas conversions and coal retirements.
- Beginning 2016, LNG exports will become a large part of new demand.

Deployment: US natural gas residential customers vs. residential consumption

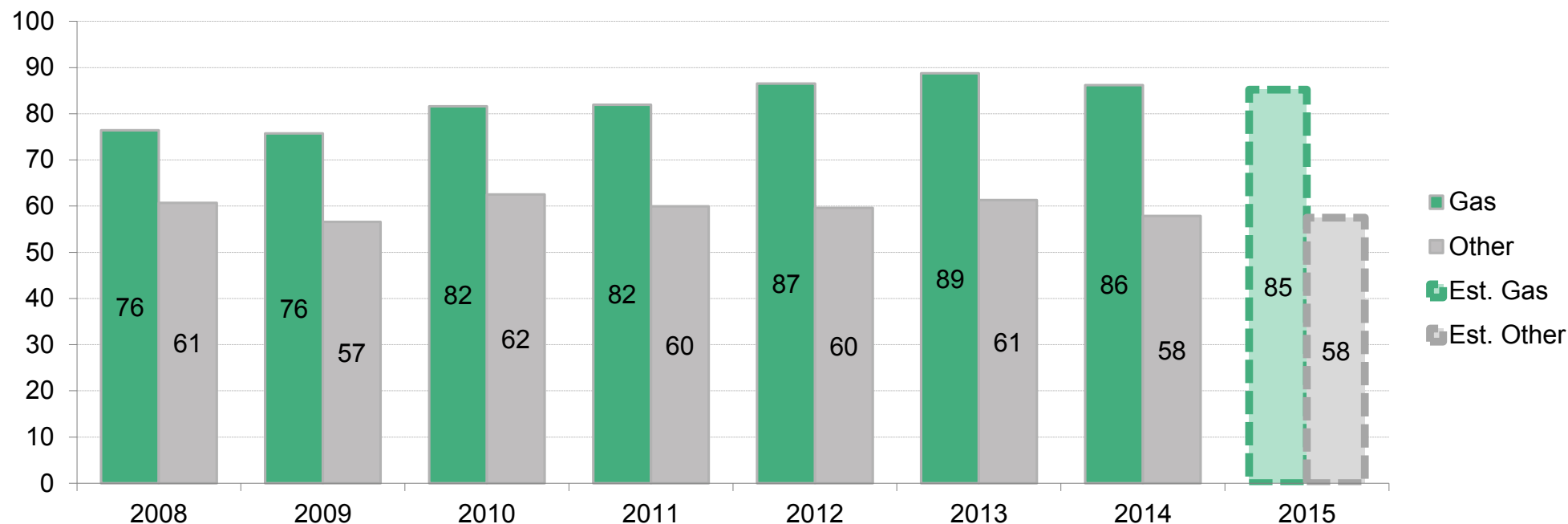


- Due to energy efficiency efforts, residential consumption has fallen even as more customers join the gas network. Per capita consumption has fallen steadily since the mid-1990s.
- Consumption dropped during the abnormally mild winter of 2011-12, but a return to more normal winter temperatures and increased heating demand during the polar vortices increased consumption in 2013 and 2014.
- Estimated residential consumption in 2015 was lower than in 2014 because of milder winter temperatures.

Source: Bloomberg New Energy Finance, EIA

Notes: Values for 2015 are projected, accounting for seasonality, based on latest monthly values from EIA (data available through September 2015).

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

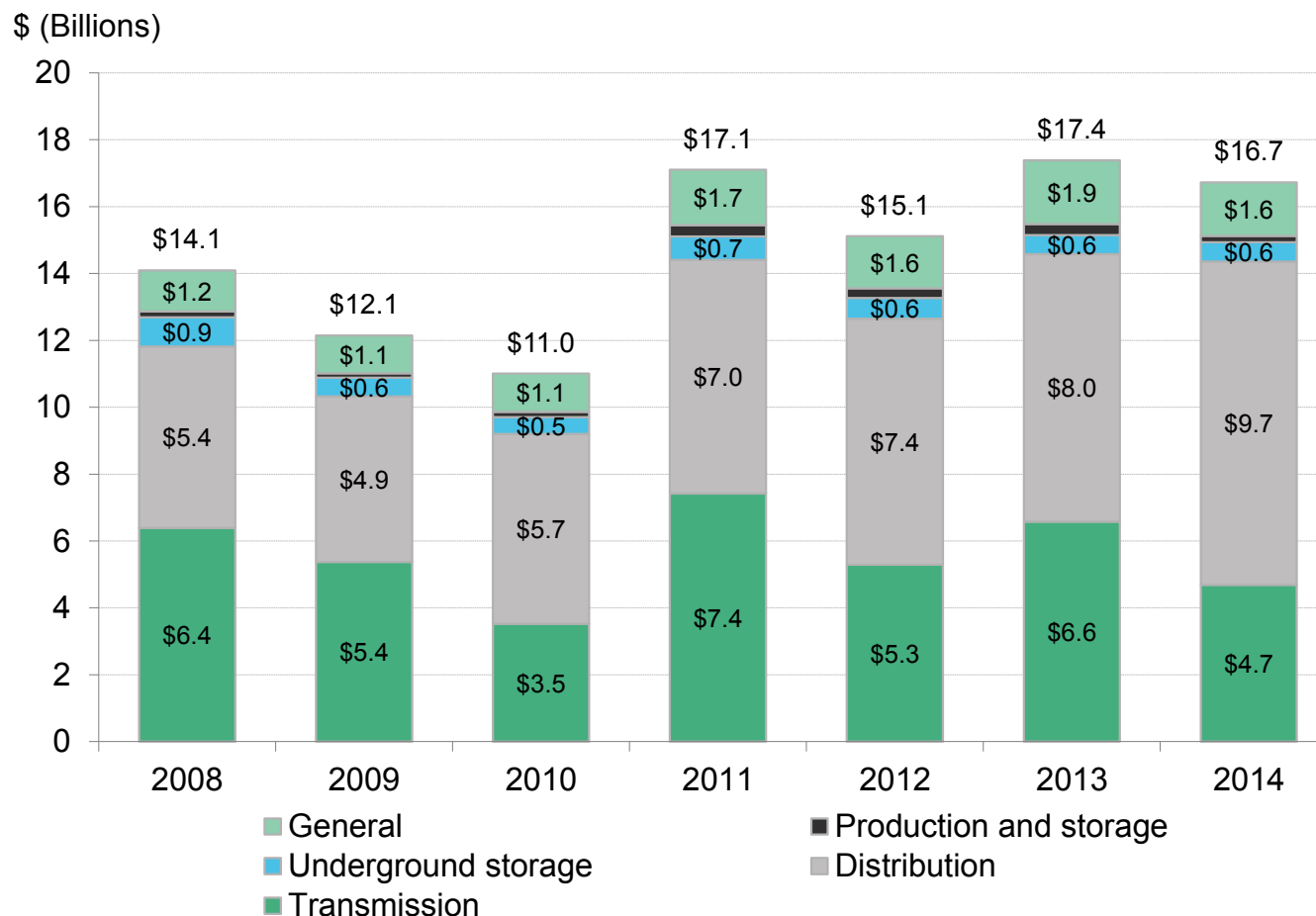


- Rising industrial sector on-site generation has boosted electric sector gas consumption since 2008.
- However, across all fuels, growth in industrial sector on-site generation has lost some momentum over the last few years.
- In 2014, the industrial sector saw a noticeable drop in on-site generation from gas. This recent blip is expected to reverse in the next few years, as new facilities—especially new chemical and fertilizer plants—come online.
- In 2015, natural gas was responsible for approximately 85TWh worth of on-site generation, with 58TWh provided by other sources.

Source: Bloomberg New Energy Finance, EIA

Notes: Values for 2015 are projected, accounting for seasonality, based on latest monthly values from EIA (data available through September 2015).

Financing: US midstream gas construction expenditures (\$bn)

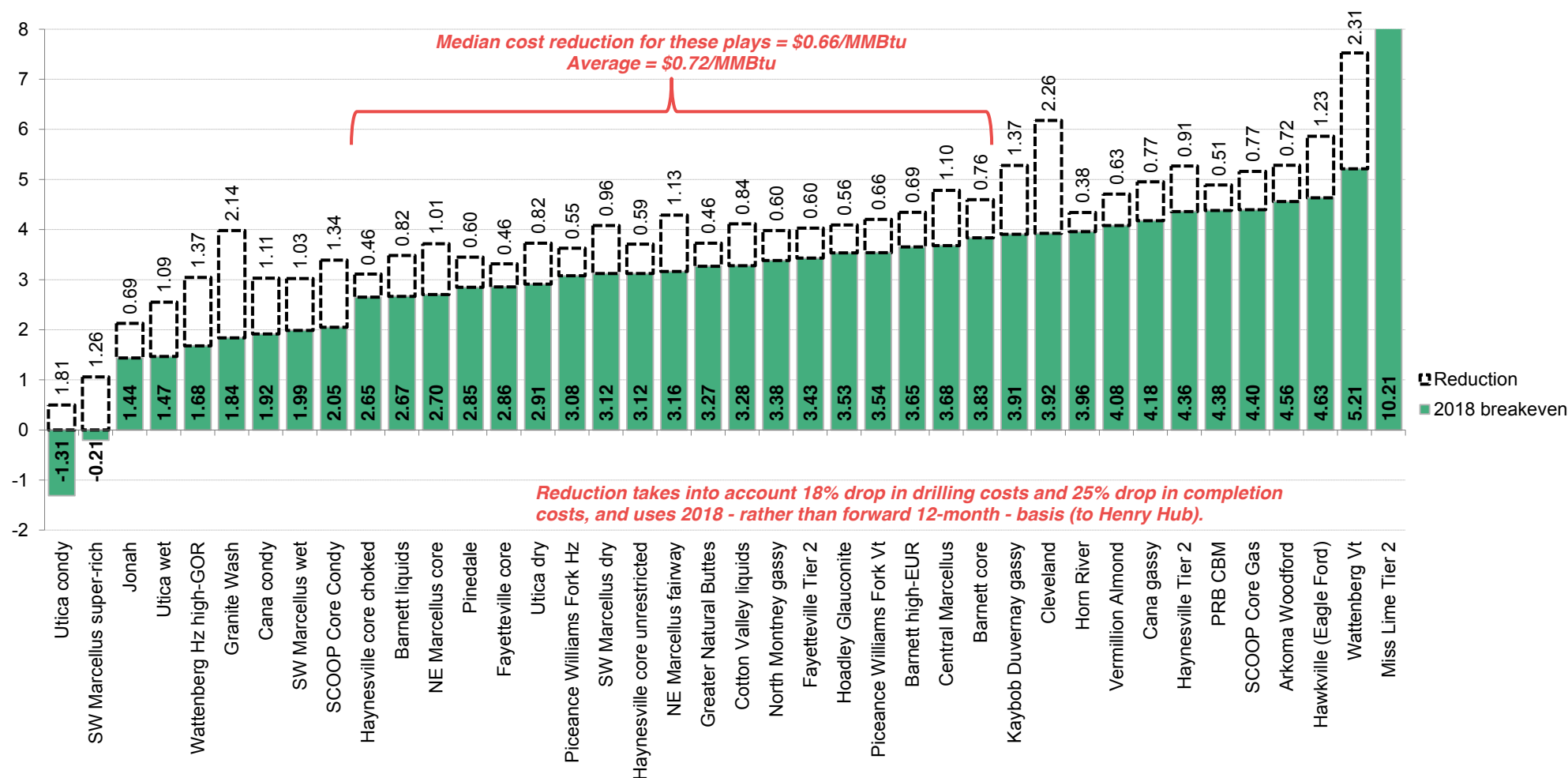


- While total midstream expenditures decreased in 2014, investments into pipeline distribution rose over 20%.
- This suggests that midstream companies and local distribution companies (LDCs) anticipate additional natural gas hookups for new and existing customers from new and expanding interstate pipelines.

Source: Bloomberg New Energy Finance, American Gas Association

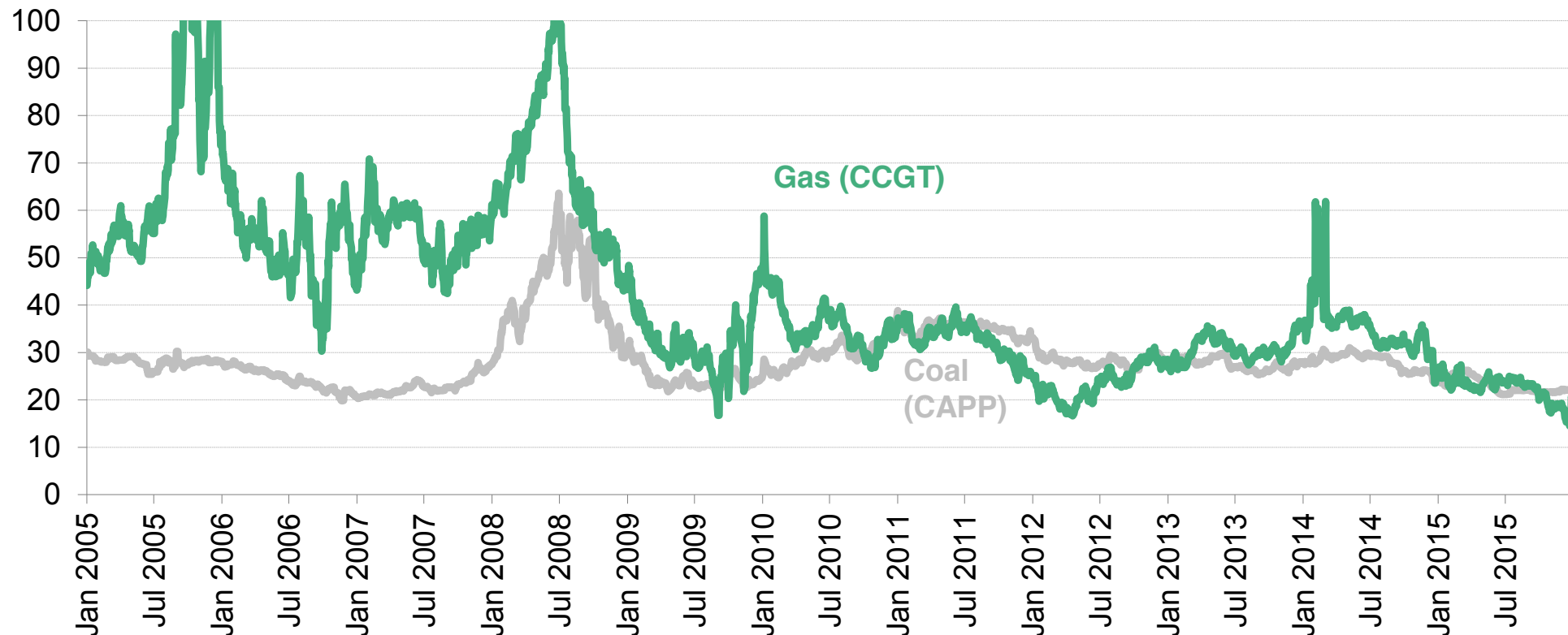
Notes: Values reflect expenditures reported to the AGA by different types of companies across the supply chain, including transmission companies, investor-owned local distribution companies, and municipal gas utilities. 'General' includes miscellaneous expenditures such as construction of administrative buildings. Totals may not sum due to rounding.

Economics: Gas breakevens before and after the oil rout (\$/MMBtu)



- Reduction in drilling and completion (D&C) activity since the oil price collapse has resulted in falling service costs.
- Anecdotally, drilling costs have fallen by ~18% since Q4 2014 and that completion costs have fallen by ~25%.
- Given that D&C costs represent the vast majority of total well costs (both upfront and ongoing), reduction in D&C costs mean reductions in the price needed for a producer to “break even.”

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

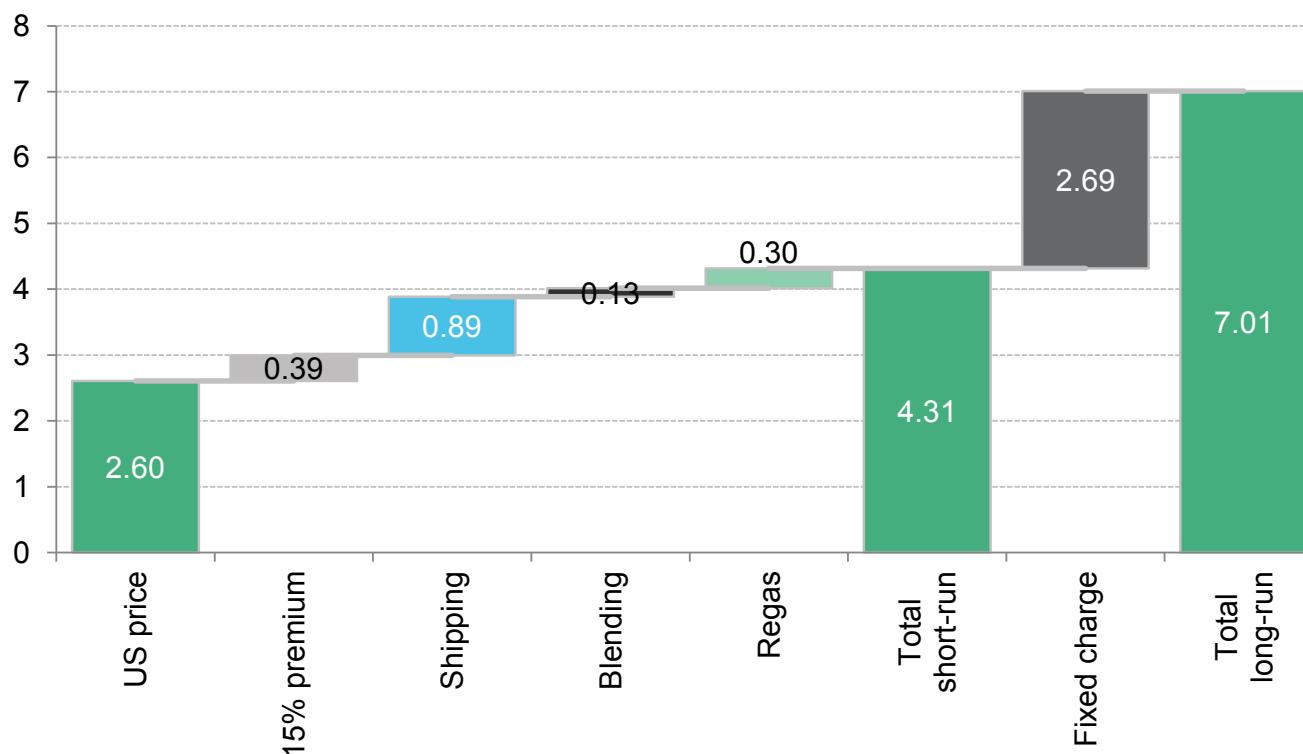


- Power has served as the swing demand source for natural gas: when the price of gas falls below the price of coal, gas burn rises until the differential (in \$/MWh) between the two fuels closes.
- As gas becomes consistently cheaper than coal, it creates a strong impetus for coal-to-gas switching.
- Power burn in PJM and the Southeast has the greatest sensitivity to gas prices. The coal-to-gas switch potential is, therefore, the strongest in these regions.

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: LNG cost build, US Gulf Coast to Europe (\$/MMBtu)



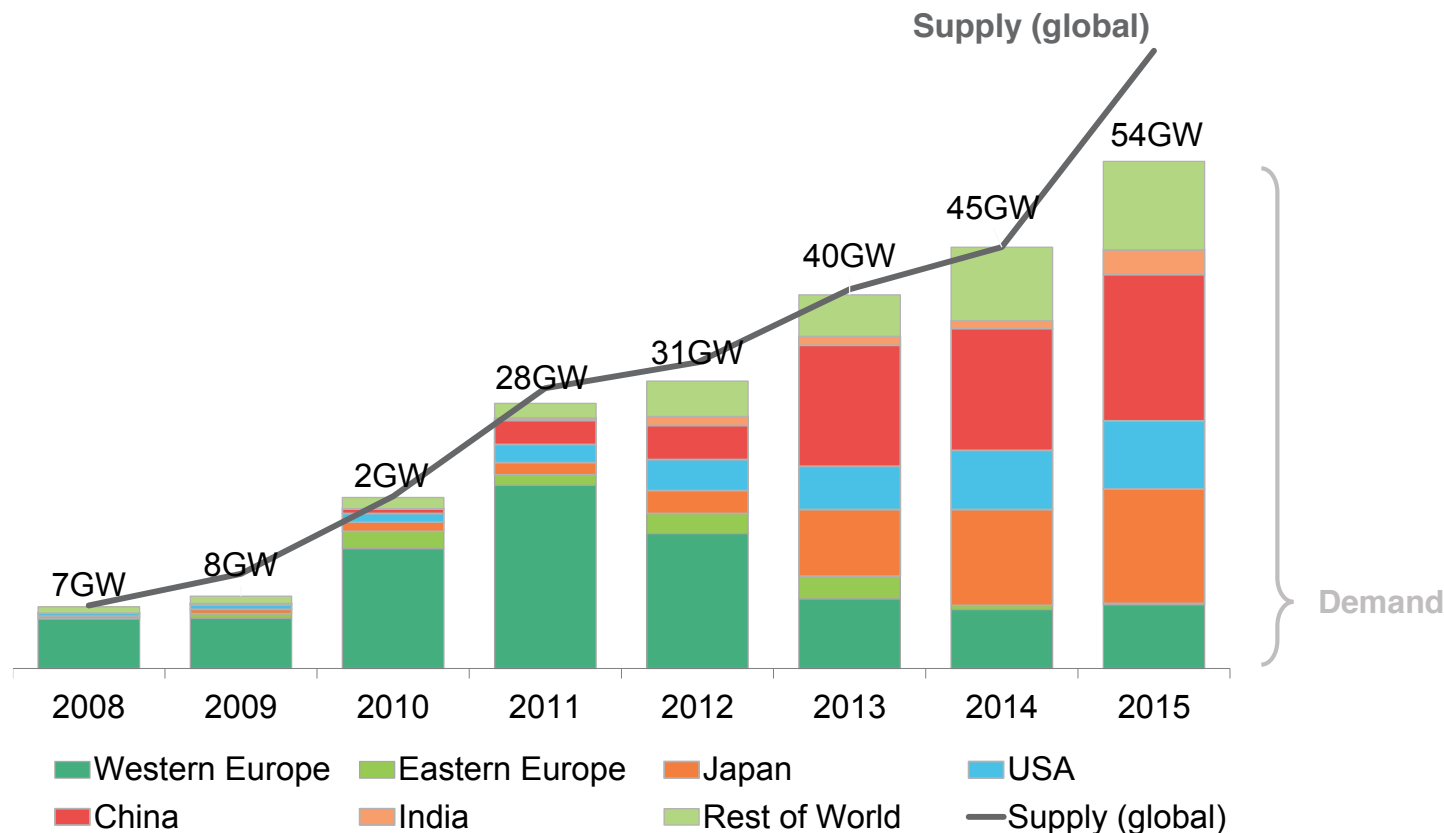
- US LNG exports are expected to be priced competitively with current global LNG spot prices.
- US exports will be sold at a 15% premium from Henry Hub; this mark-up captures O&M costs. In addition, there is a fixed charge averaging about \$2.69/MMBtu to help terminal operators recuperate sunk costs.
- Five US LNG export terminals are currently under construction (Sabine, Cameron, Cove Point, Corpus Christi, Freeport), the first of which (Sabine Pass) is anticipated to commence service in Q1 2016.
- Together, these facilities could bring over 70MMtpa of LNG export capacity to the US by end-2019.

Source: Bloomberg New Energy Finance

Notes: 'Regas' is regasification, or the process in which imported LNG is expanded and reconverted into gas that can be injected into the pipeline distribution network. 'Fixed charge' is the cost associated with recouping upfront costs (the other costs shown here are short-run marginal costs).

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Deployment: Global PV supply (grey line) and demand (bars, by country) (GW)



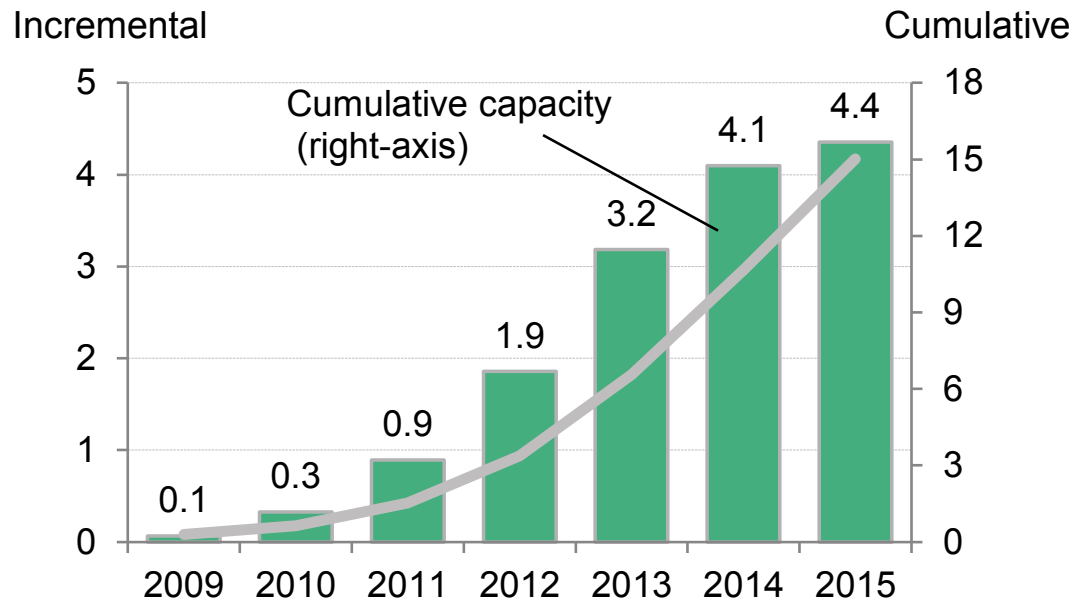
- Driven by record high volumes and record low prices, the global photovoltaic (PV) market saw another year of expansion in 2015. China, Japan and the US were particularly bright spots and will remain so in 2016.
- Trade disputes continued in the US, as the government maintained tariffs on Chinese and 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.

Source: Bloomberg New Energy Finance

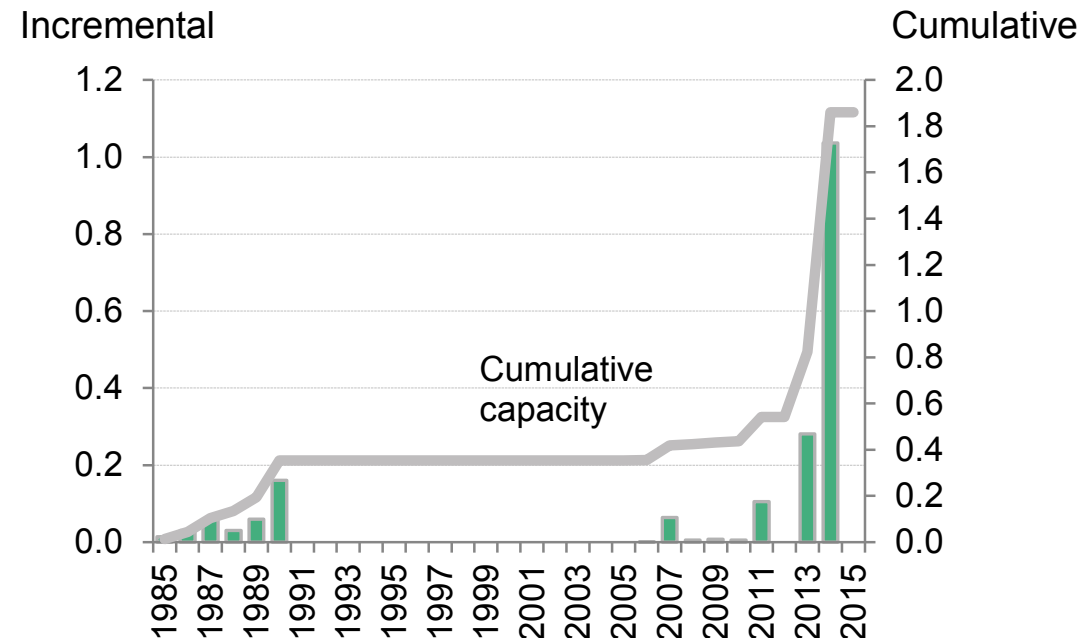
Notes: In chart at right, 2015 values represent an average of optimistic and conservative analyst estimates.

Deployment: US large-scale solar build

US utility-scale photovoltaic build (GW)

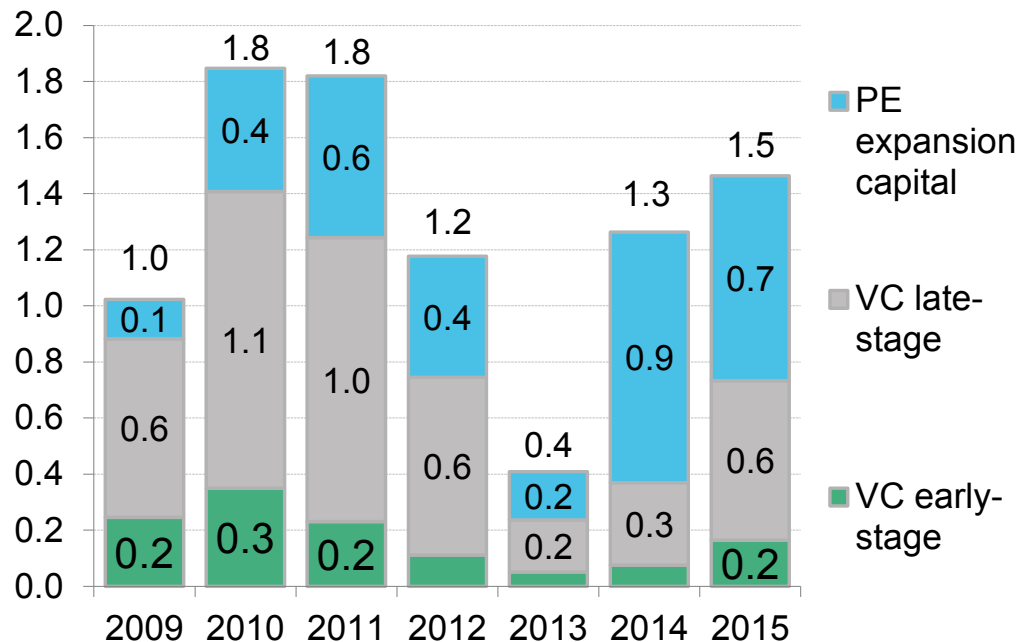


US concentrating solar power build (GW)

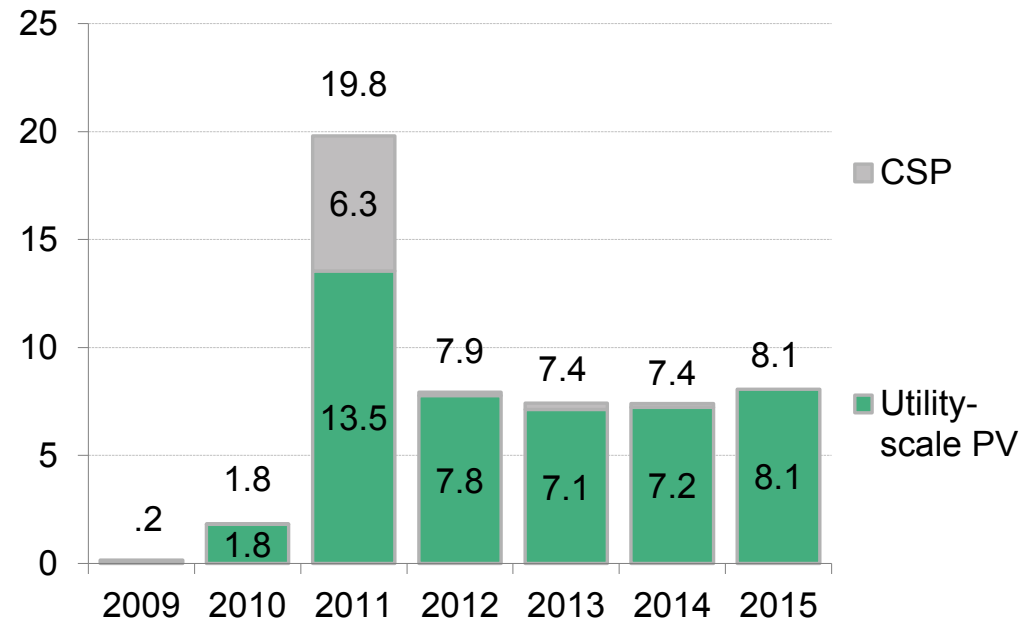


- After six years of dramatic growth, utility-scale PV build began to level off in 2015, although installations still increased 6% over the previous year.
- The ITC was extended for five years at the end of 2015, and 'commence construction' language added.
- No concentrating solar power (solar thermal) plants were commissioned in 2015, in contrast to 2014 which saw over 1GW of major projects commissioned. Developers and financiers continue to focus their attention on PV.

Venture capital / private equity investment in US solar by type of investment (\$bn)

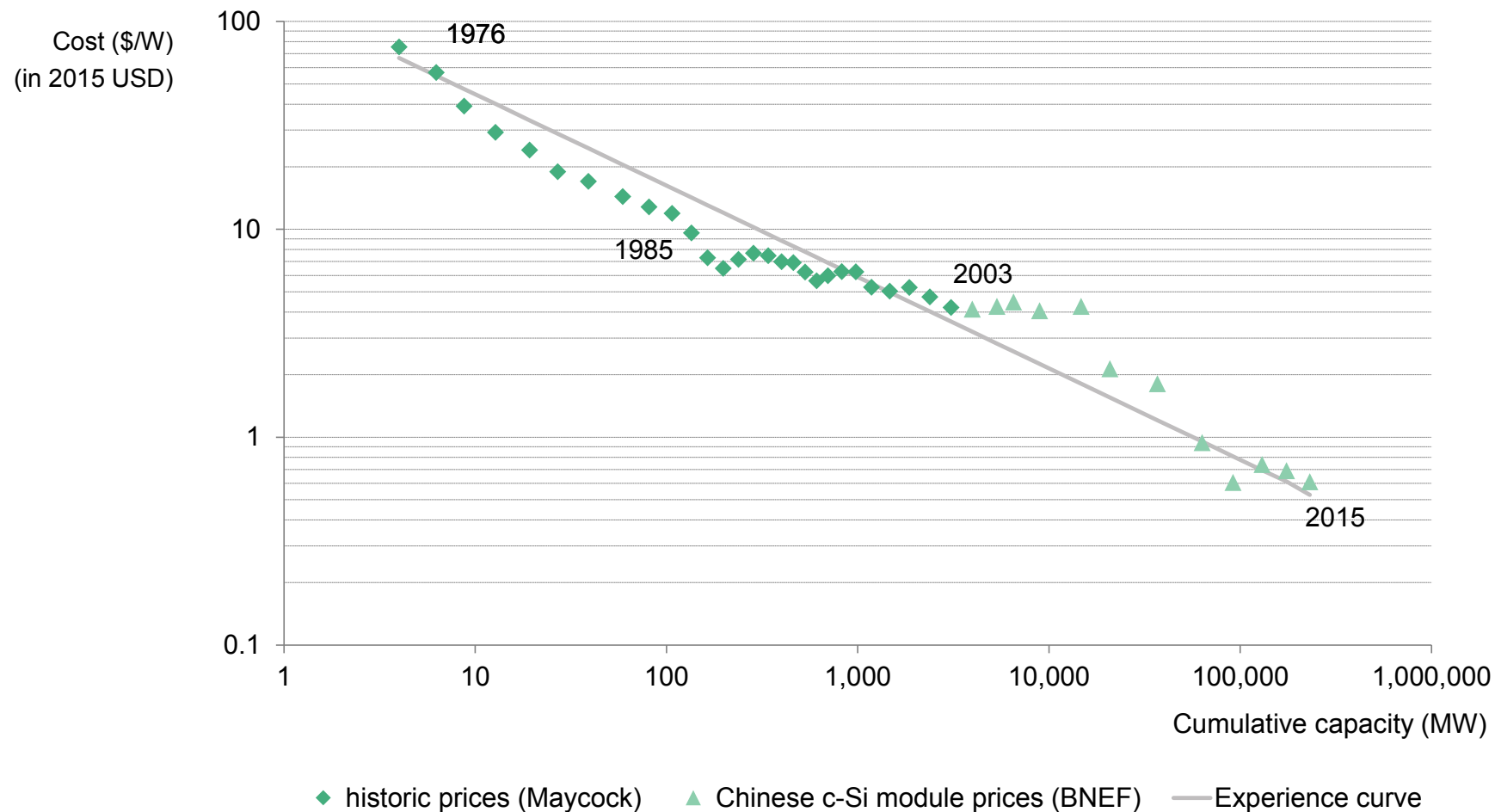


Asset finance for US utility-scale solar projects by technology (\$bn)



- 2015 was a bounce-back year for venture capital after only \$0.2bn of investment in 2013 and \$0.4bn in 2014. Private equity capital remained relatively robust, with \$0.7bn in investment in 2015.
- Asset finance deals for utility-scale PV finished 2015 at approximately \$8.1bn, including funding for both early-stage project development and later-stage project operations.
- Note that the investment figures here are based on **disclosed deals** only and therefore only a proxy for actual volumes.

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

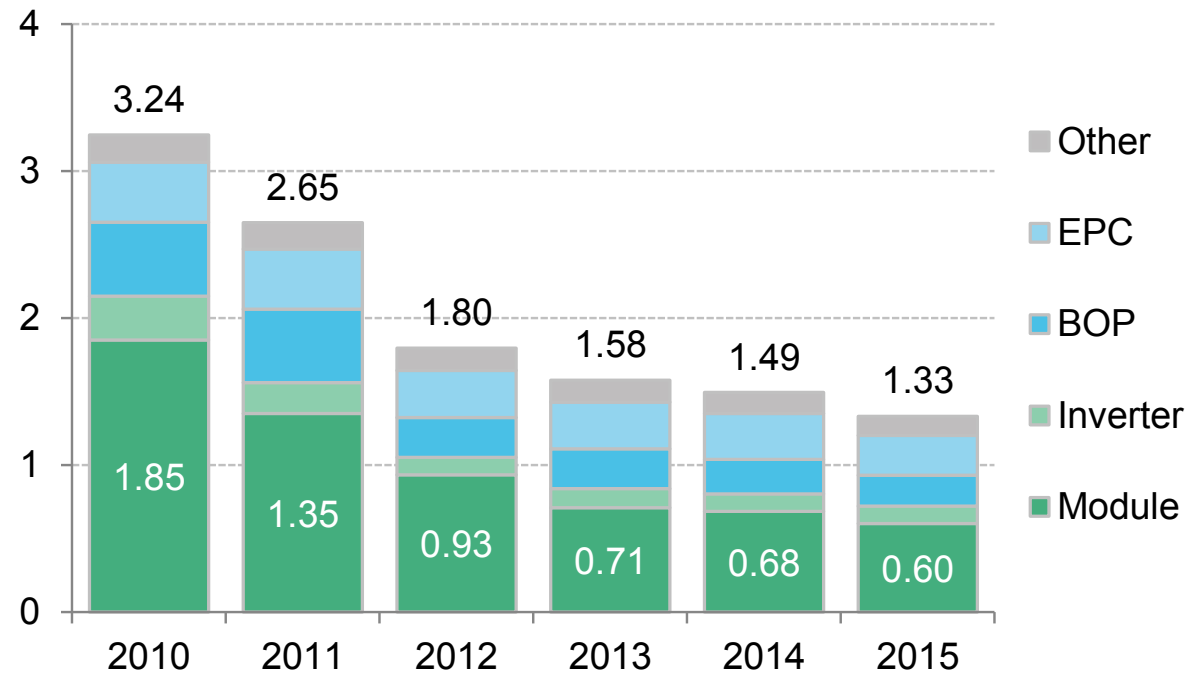


- For the past few decades, module pricing has generally followed the experience curve for costs.
- Prices tumbled in 2012 due to a buildup of manufacturing overcapacity, before ticking back up in 2013 as oversupply eased.
- In 2015, prices continued to slide, hitting their lowest level yet. .

Source: Bloomberg New Energy Finance, Paul Maycock

Notes: Prices in 2015 USD.

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

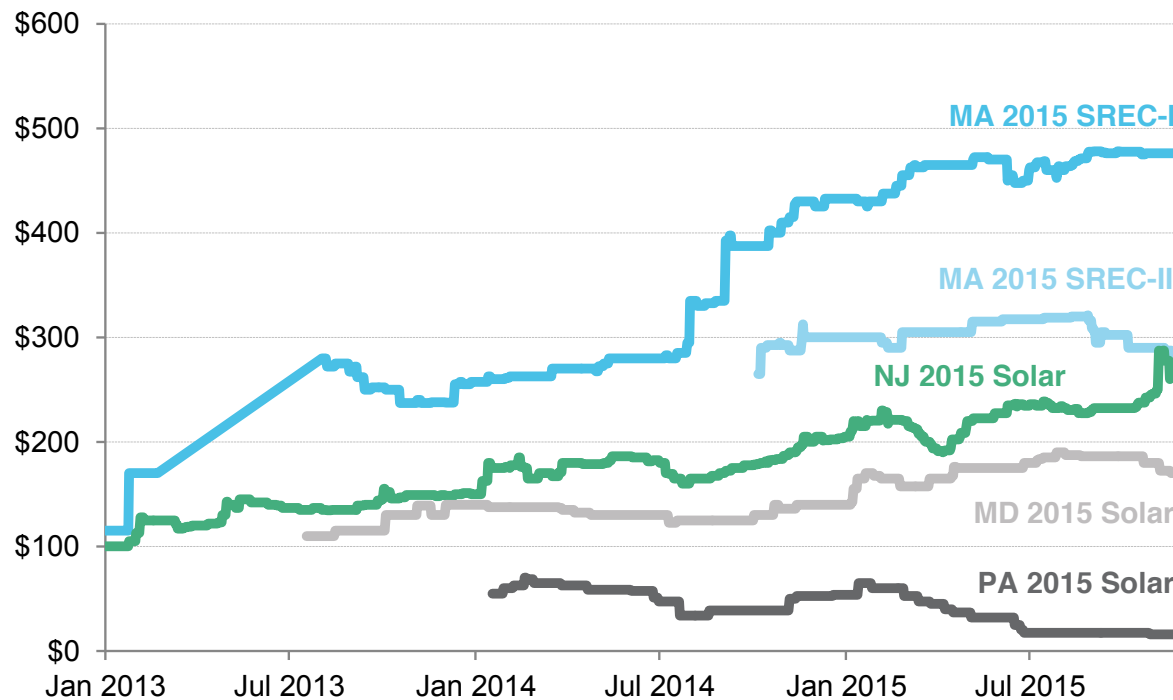


- The cost of building a utility-scale PV facility declined dramatically from 2010 to 2012 (based on the global benchmark for mature markets) before leveling off to more modest annual cost reductions from 2012 to 2015.
- Germany, a mature market, sets the best-in-class capex. The US faces higher costs for best-in-class utility-scale PV.
- Lower capex translates into lower levelized costs: utility-scale solar plants in Texas and Nevada have recently secured PPAs to sell power at long-term rates below \$50/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.'

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

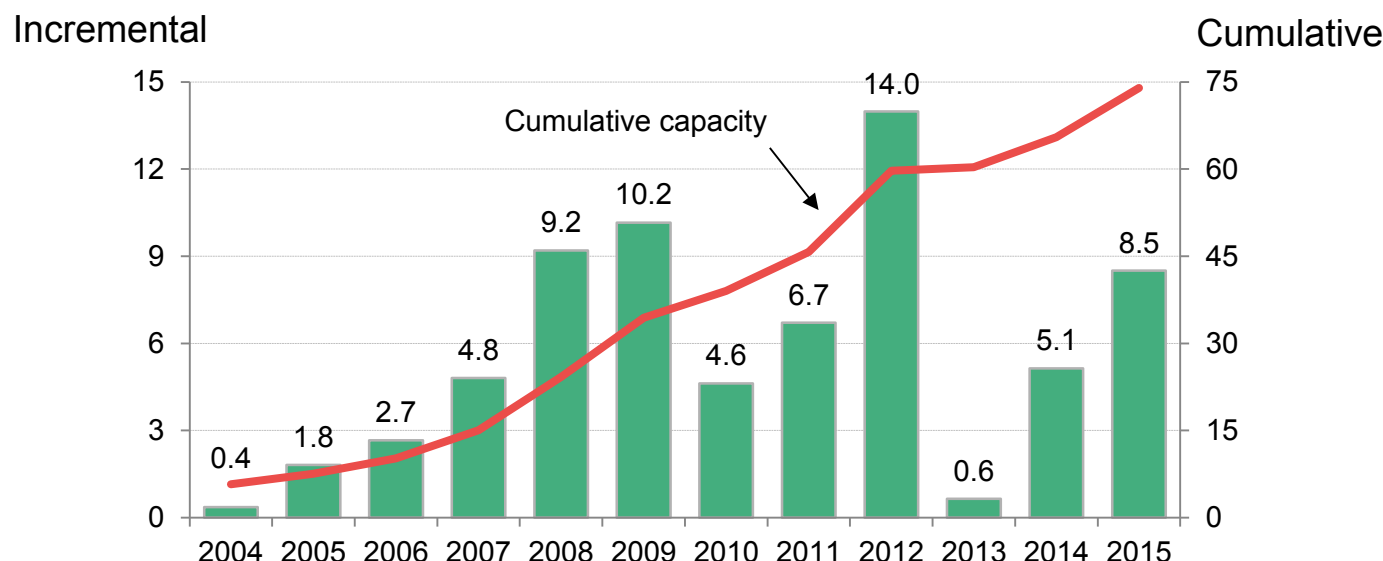


- In some states, solar projects generate revenue by selling solar renewable energy credits (SRECs) to utilities that need to comply with solar carve-outs within state renewable portfolio standard (RPS) programs.
- Spot market prices today range from as high as \$475/MWh for a solar REC in Massachusetts to as low as \$16/MWh in Pennsylvania. Prices in Massachusetts are among the most stable and lucrative in the nation due to the unique design of its incentive program.
- New Jersey SRECs have moved steadily higher as build rates for behind-the-meter commercial systems have been weaker than expected.
- PA SRECs dropped in 2015 due to oversupply in the PA solar market.

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)



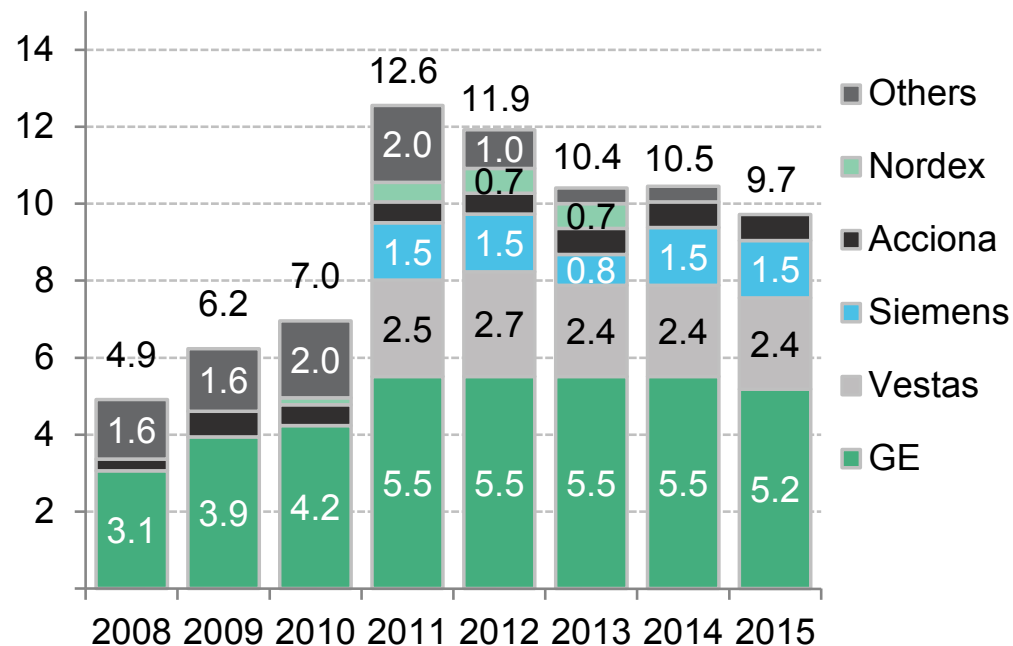
- New build in 2015 increased 65% from 2014 levels, from 5.1GW to 8.5GW.
- The increase was driven by the extension of the Production Tax Credit (PTC) in 2013 and 2014, the key federal incentive for wind in the US. The PTC expired at the end of December 2012, was renewed January 2013, expired December 2013 (but wind projects qualified for the incentive by starting construction in 2013), was 'retroactively' renewed in December 2014 and expired again two weeks later, at the end of 2014. The current pipeline suggests healthy build through to 2016.
- The PTC was again extended to apply to projects commencing construction through 2019, with a phase-out for projects beginning after 2016.
- A majority of the build is occurring in Texas. The state completed a \$7bn transmission build-out in 2013 to connect windy regions in the Panhandle and West Texas to demand centers. Wind in Texas is among the cheapest in the country, with an unsubsidized levelized cost of electricity of around \$50/MWh, due to high capacity factors (>50%) and low cost to build. In addition to power purchase agreements with utilities, corporations signed close to 1.5GW of contracts with wind farms in Texas. A large amount of wind capacity was also made possible through long-term power hedges with financial institutions.

Source: Bloomberg New Energy Finance

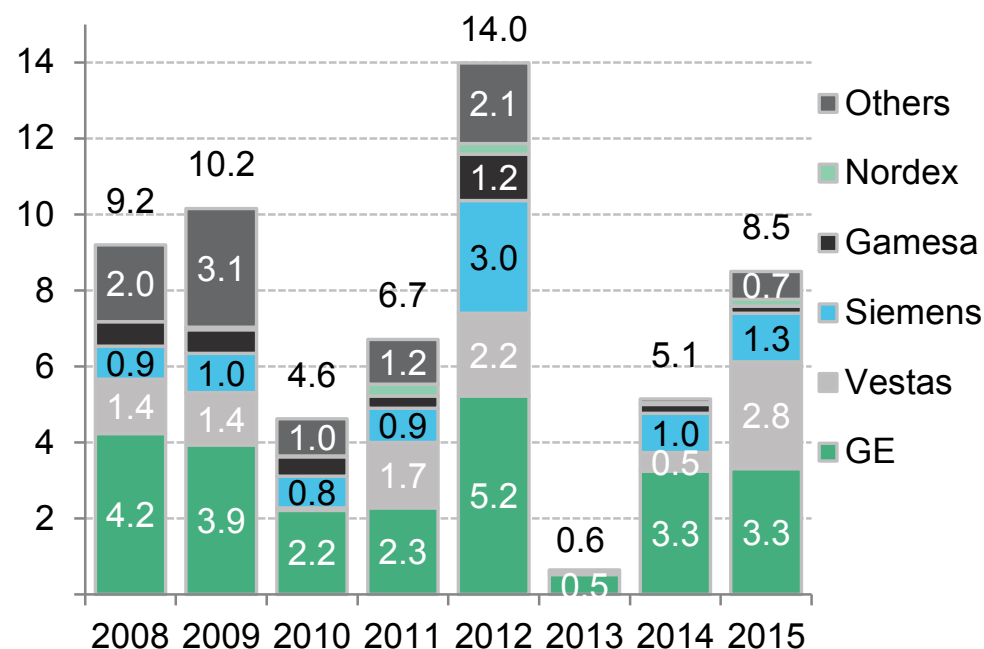
Notes: Includes all utility-scale wind development, excluding partially commissioned projects, including distributed turbines that are above 1MW (Bloomberg New Energy Finance threshold for utility-scale).

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)

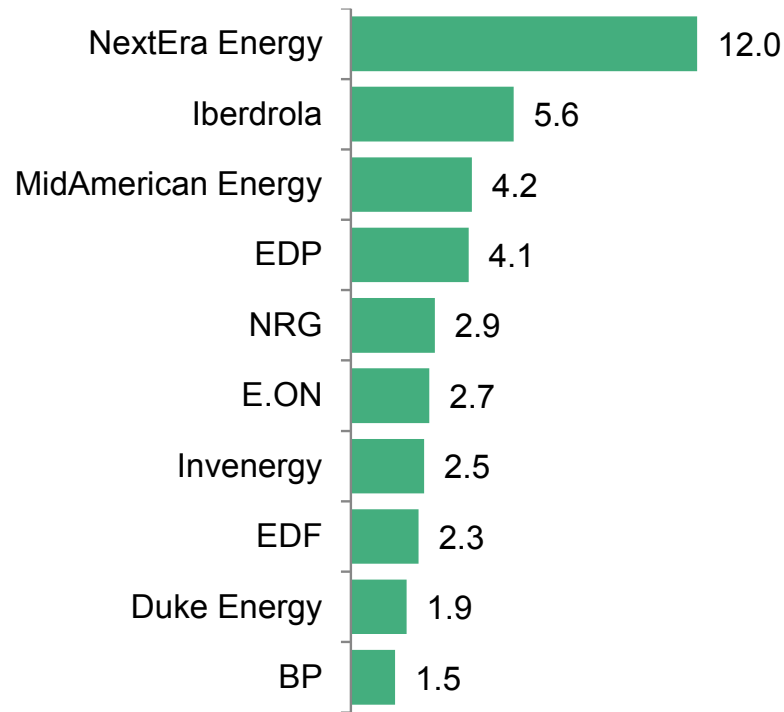


- Several manufacturers have closed nacelle assembly facilities in the US since 2012, including Clipper, Nordex, and Mitsubishi. Several others laid off workers in 2012 and rehired them in 2013 after the PTC was extended. More recently, Gamesa has shuttered its US production and Alstom and GE have been combined with the close of GE's acquisition in October 2015. The recent PTC extension will provide some business-planning certainty for wind developers and manufacturers, allowing them to avoid expensive cycles of layoffs and rehiring.
- 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 in the market.

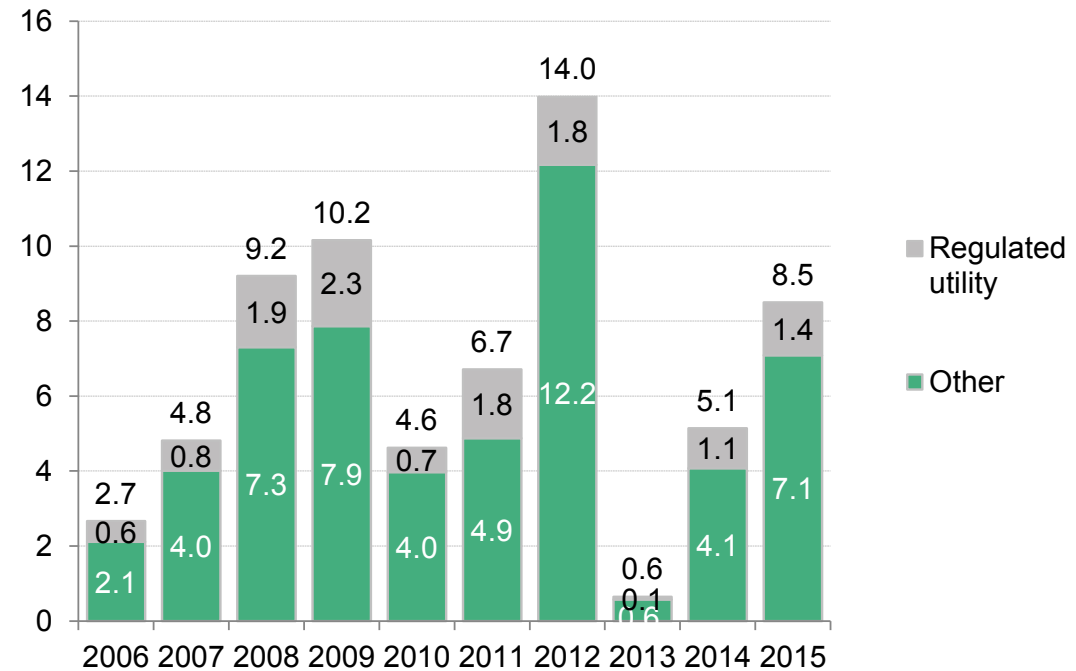
Source: Bloomberg New Energy Finance

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

Top 10 US wind owners, as of end-2015* (MW)



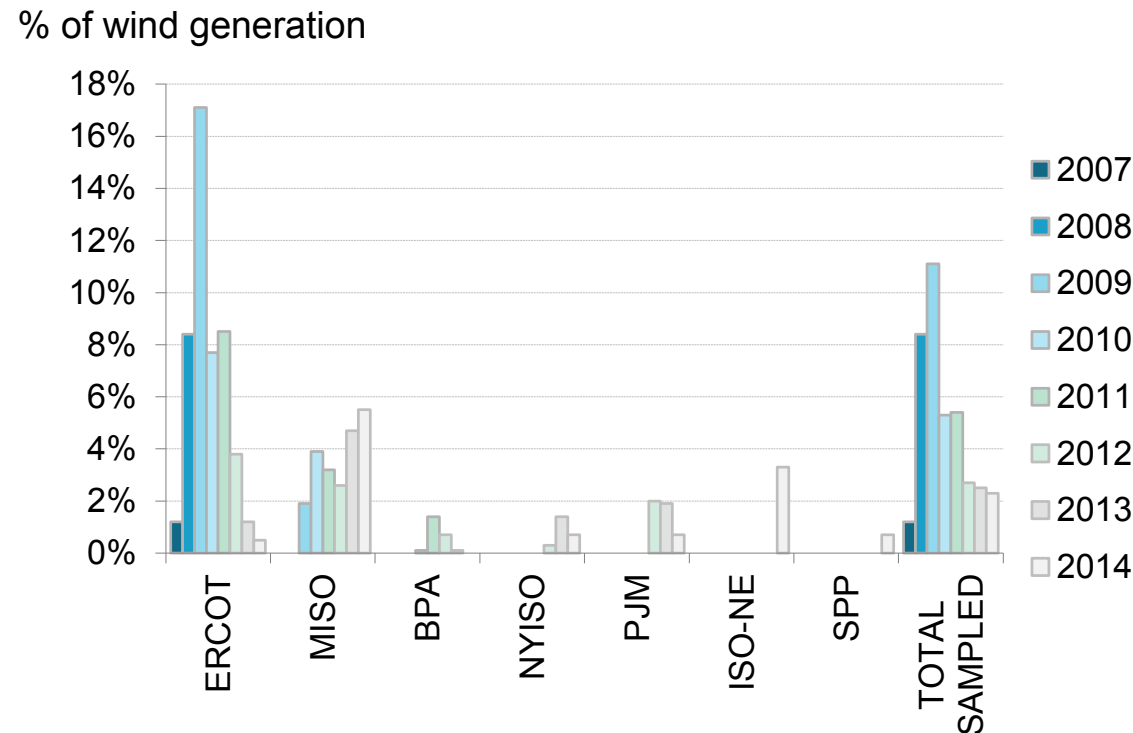
US wind capacity commissioned by type of developer (MW)



- NextEra Energy remains the dominant wind developer in the US market. Next in line are Iberdrola (Spanish utility) and MidAmerican / Berkshire Hathaway Energy (the holding company owned by Warren Buffett's Berkshire Hathaway that includes both PacifiCorp and MidAmerican).
- Regulated utilities are responsible for building only a small share of wind assets in the US; most prefer to sign power purchase agreements with independent generators rather than build and own projects.

Source: Bloomberg New Energy Finance

Notes: *In chart at left, estimates are given to reflect changes in ownership in 2015. Ownership is based on 'net ownership' as opposed to 'gross ownership', to account for co-ownership. Values are based primarily on data directly from company websites. 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.

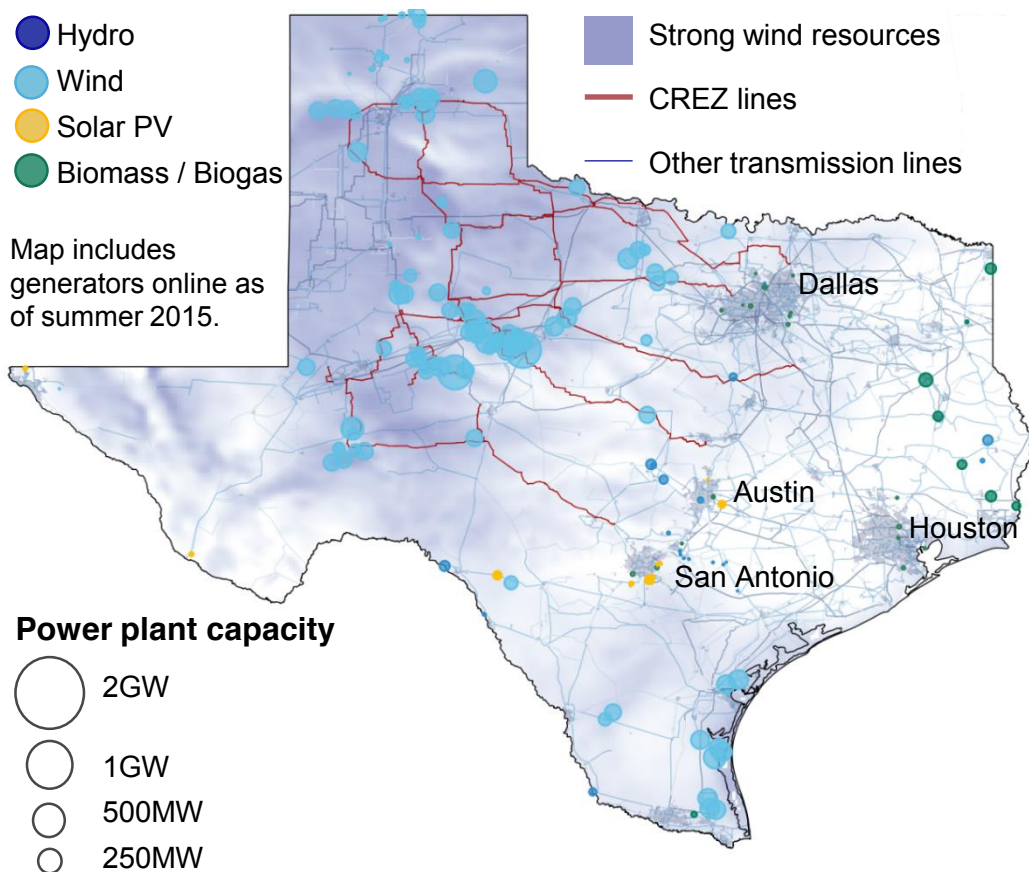


- Wind curtailment can be due to transmission constraints, inflexibilities in the grid and environmental or generation restrictions.
- This was a significant problem in ERCOT (Texas) from 2008-2013, but Competitive Renewable Energy Zone transmission line build-outs and upgrades, and increased efficiency in ERCOT's wholesale electricity market have addressed the problem. Curtailment fell from a peak of 17% in 2009 to 0.5% in 2014.
- MISO and New England have also experienced higher curtailment than other regions. Like ERCOT, MISO's transmission investment has not kept pace with the rapid build-out of wind projects, and annual curtailment numbers continue to rise. New England's curtailment levels in 2014, the only year with data, were roughly double those of BPA and NYISO.
- In aggregate, curtailment has fallen since 2009, but still resulted in roughly 980MW of lost wind output in 2014.

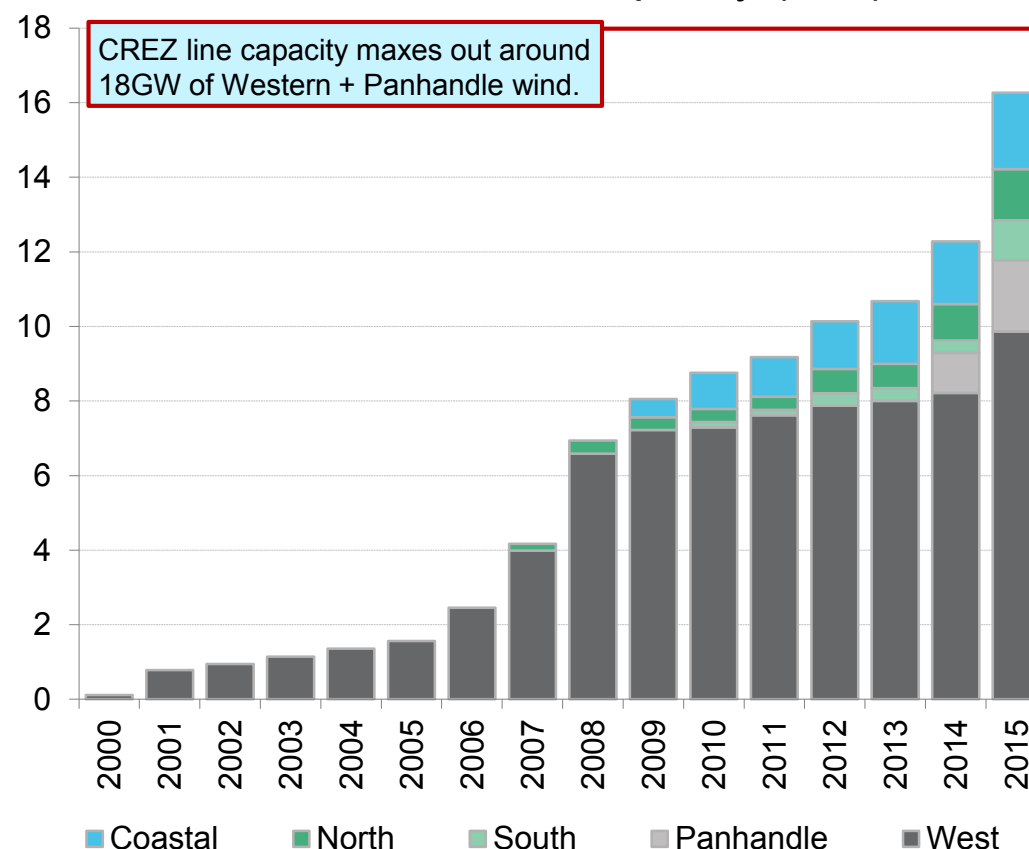
Source: Bloomberg New Energy Finance, Lawrence Berkeley National Laboratory

Notes: Except for BPA, data represents forced and economic curtailment. BPA's 2014 estimate was 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)

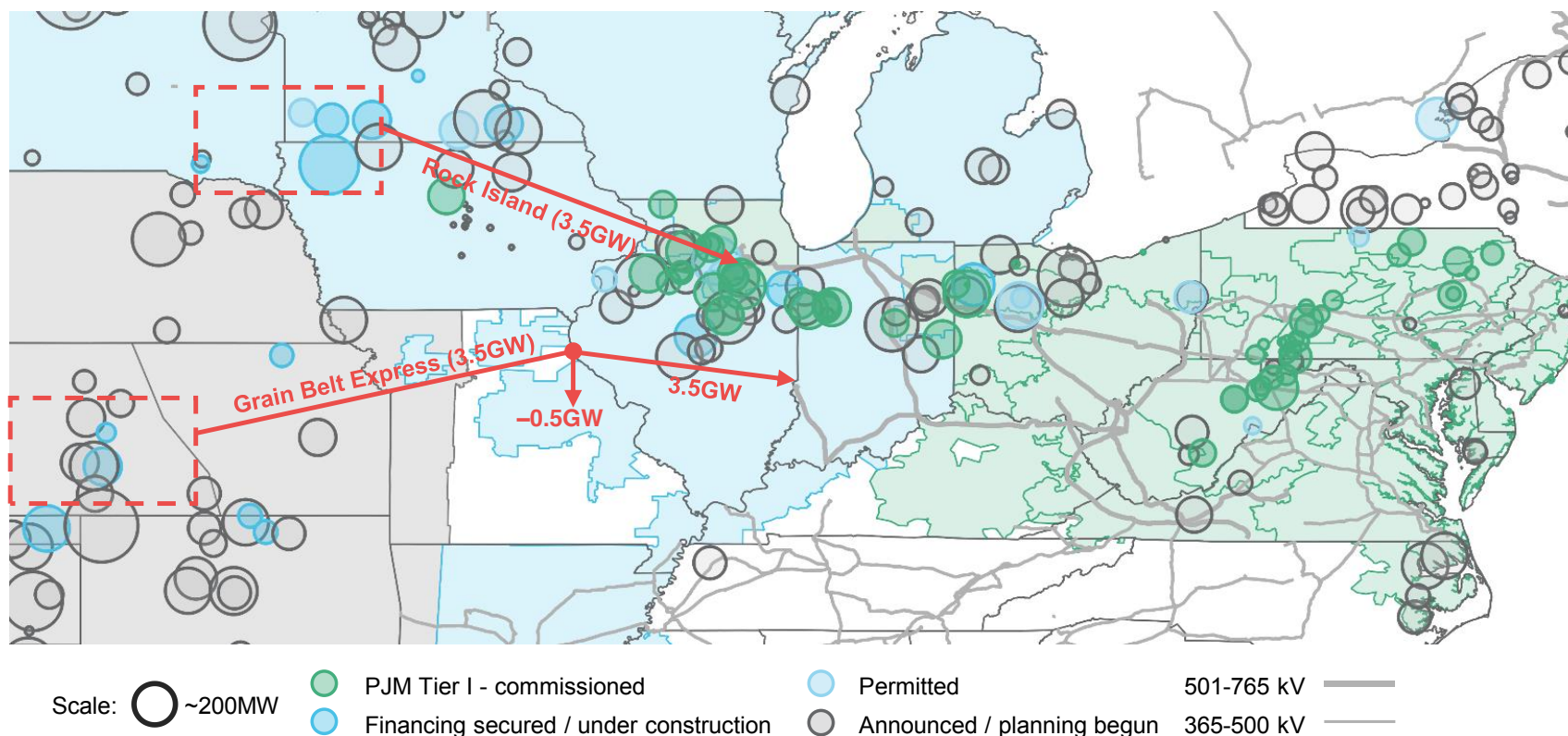


Cumulative wind capacity (GW)



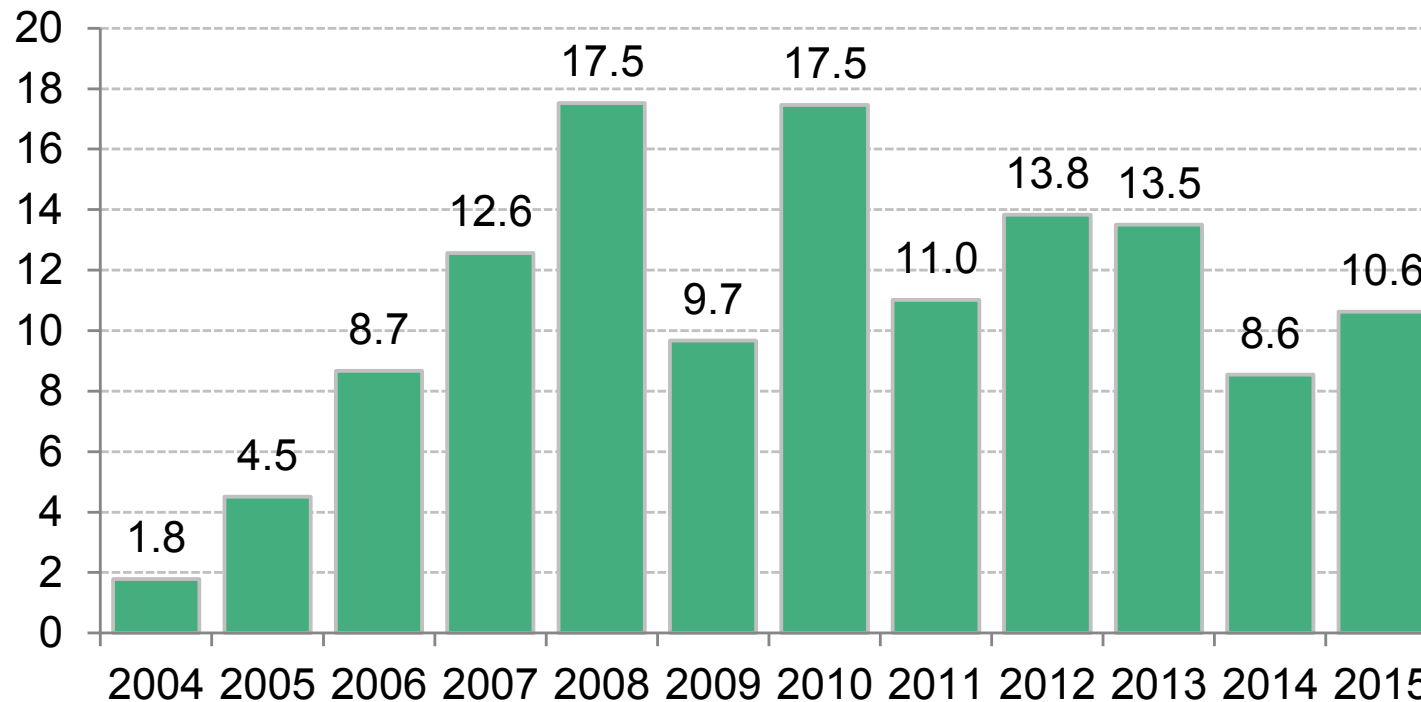
- Texas is home to one quarter of America's installed wind capacity (16 of 69GW installed as of September 2015).
- Most of it was enabled by a \$7bn investment in the Competitive Renewable Energy Zone (CREZ) transmission lines, which bring West Zone and Panhandle wind to load centers in the East.
- The CREZ lines can accommodate roughly 18GW of West + Panhandle wind before significant curtailment (and congestion pricing) comes back into play. Cumulative wind capacity in 2015 puts ERCOT within 2 GW of CREZ's maximum capacity.

Deployment: Transmission build-out in MISO and SPP and development stage wind farms



- Two high-voltage merchant transmission lines being developed by Clean Line Energy Partners could bring a swath of much-needed wind to PJM to meet RPS demand. Clean Line proposes to link wind farms in Kansas to PJM (via a substation in western Indiana; Grain Belt Express project) by 2019 and to send wind from northwest Iowa into PJM (via a substation in Illinois; Rock Island project) by 2021. These lines could unlock as much as 7GW of capacity.
- But challenges remain:
 - Permitting*: in January 2015, Clean Line announced it was beginning a competitive solicitation process to allocate capacity for the Grain Belt Express; however, the project still awaits a key approval in Missouri, where it has run into opposition from landowners and the PSC.
 - Offtake*: project developers hoping to interconnect via Clean Line generally need to secure long-term (>3-year) offtake agreements (for power, RECs or both) in order to obtain debt finance. However, the current market for long-term offtake opportunities in PJM is slim at best – not just for RECs but for power as well. In fact, there are *at least* three permitted wind farms in PJM currently marketing to utilities where PPA availability is the only construction bottleneck.

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

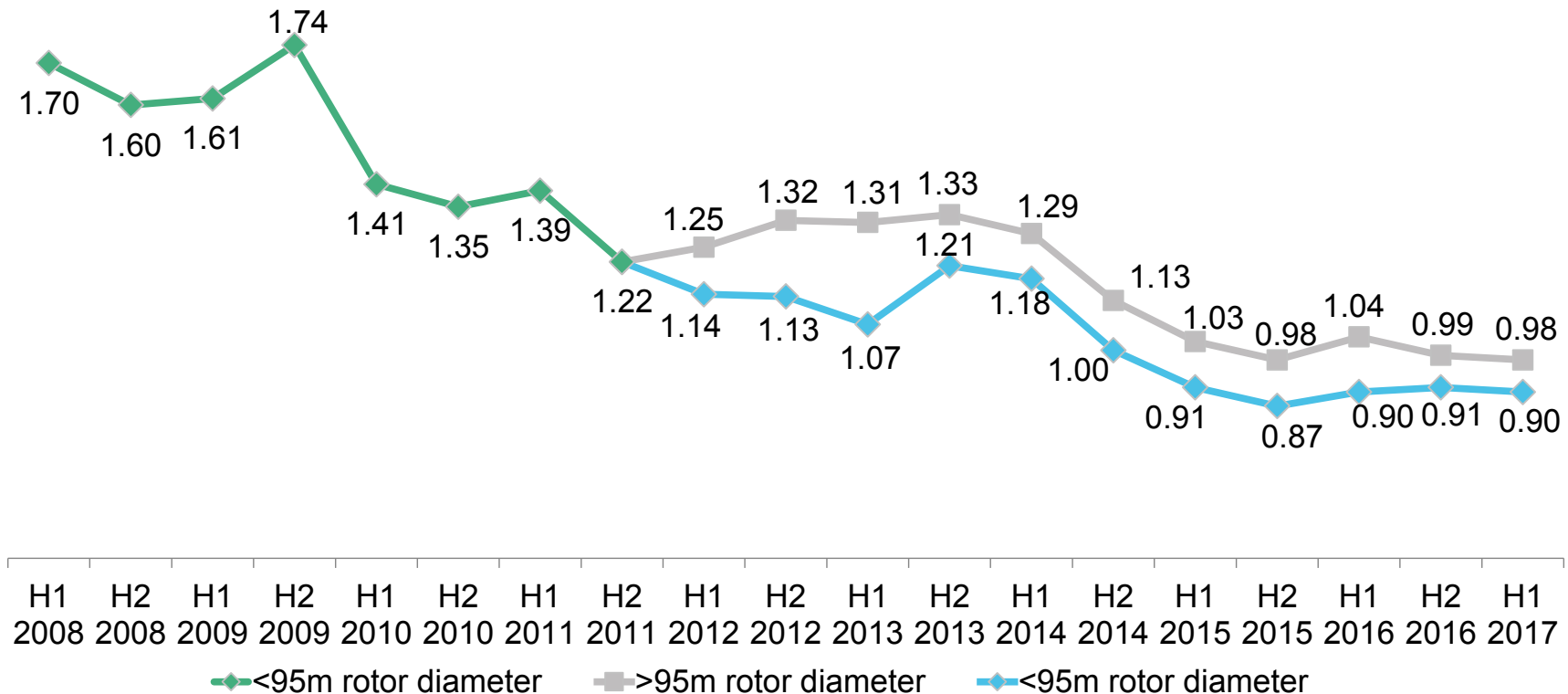


- The 2015-16 wind pipeline is very healthy: a large portion of the financing secured in 2013-15 is for wind projects to be commissioned in 2015-16.
- Asset financing has tracked closely with the status of the production tax credit (PTC), which has expired and been retroactively extended multiple times 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).

Source: Bloomberg New Energy Finance

Notes: Values include estimates for undisclosed deals.

Economics: Wind turbine price index by turbine type and delivery date (\$m/MW)

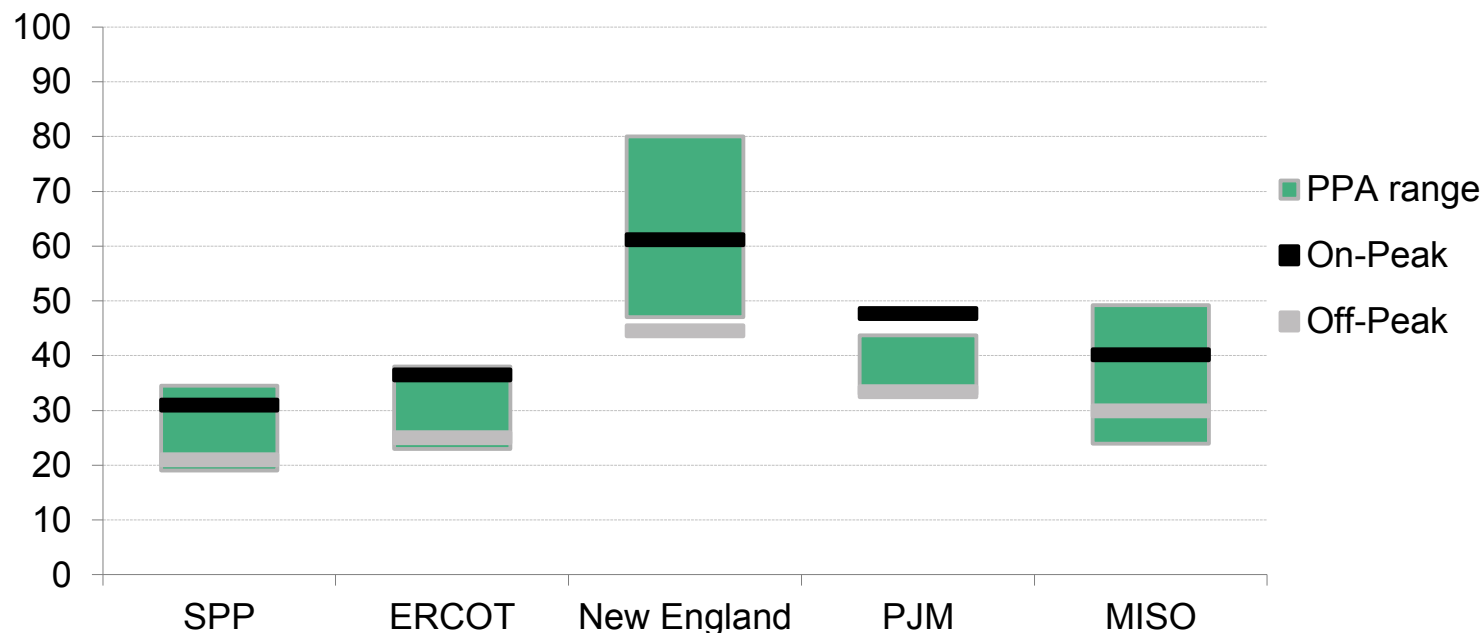


- Global wind turbine prices increased from 2011 to 2013 as rotor diameters and hub heights increased - larger machines resulted in higher costs and higher prices per MW. Furthermore, gains in the Euro against the US dollar in 2013 amplified the price recovery in the Index (most European contracts in the Index are denominated in Euros). However, increasing rotor diameters improved turbine capacity factors, causing prices on a per MWh basis to decline steadily since 2010.
- Turbines with larger rotor diameters (>95m), which tend to be the newer models, are priced higher than those with smaller rotor diameters (<95m), which tend to be the older models.

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 by the average EUR/USD rate for the half year of turbine delivery.

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

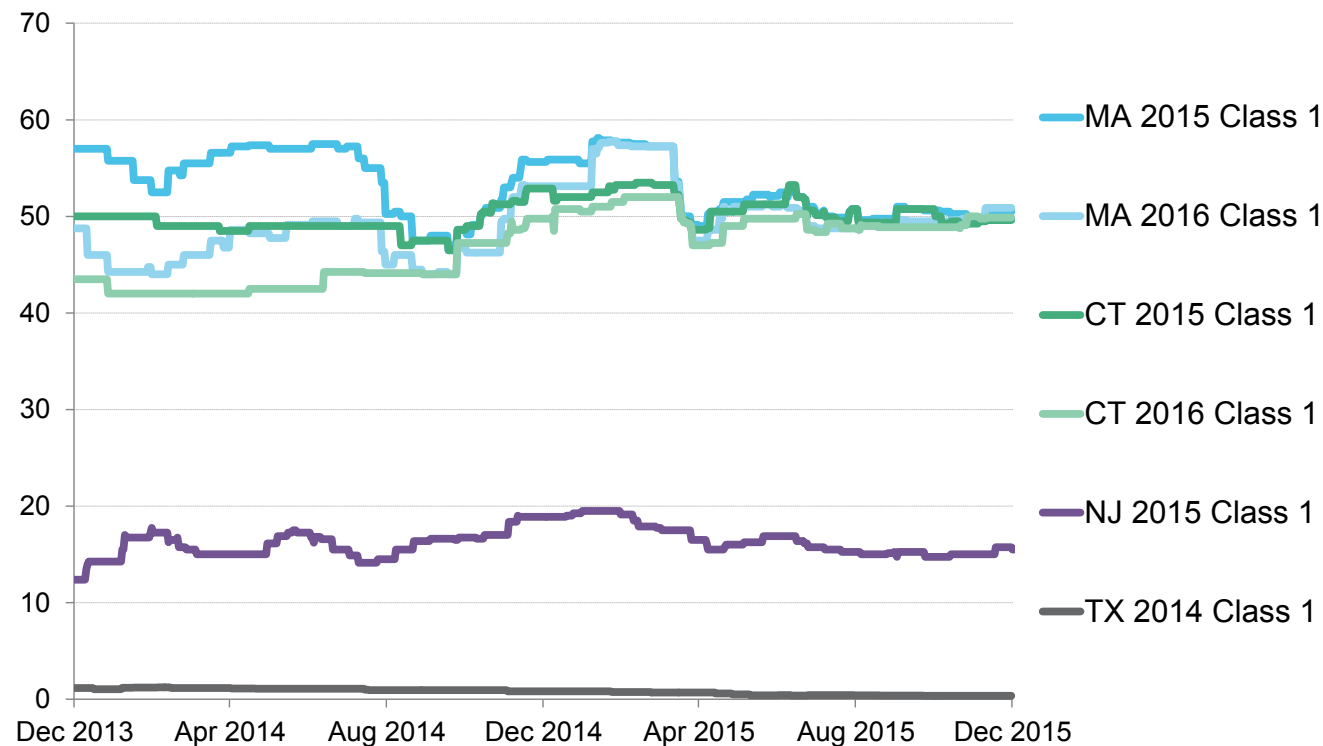


- For projects commissioned in 2015, the top regions for utility PPAs are high-wind speed regions with the lowest-cost electricity for onshore wind like SPP, MISO and ERCOT. The cheapest PPAs were signed in Oklahoma, Kansas, Nebraska and Texas. At \$19-35/MWh, average PPA prices in these regions are consistently below on-peak wholesale power prices, and in many cases, below off-peak prices too. PPA escalators averaged 2-5%, although some escalators were as high as 7-8% in some operational years.
- Prices for PPAs signed in New England ranged from \$50-80/MWh. Higher pricing in this region is a result of higher power prices and wind LCOEs. Developing projects in New England can be costly and time consuming, and average project capacity factors are amongst the lowest in the country.
- Around 19% (1.7GW) of all projects commissioned in 2015 had a non-utility PPA contracted. Furthermore, over 1.2GW of additional non-utility wind PPAs were signed in 2015, typically for projects expected to begin operation in 2016.

Source: Bloomberg New Energy Finance, Federal Energy Regulatory Commission, SEC filings, analyst estimates

Notes: 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 2015 for selected nodes within the region.

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



- New England Class 1 REC prices converged in 2015, while remaining high due to the difficulty of siting wind in the region. With high electricity prices, and high REC prices, wind economics could work without the PTC.
- Texas, the state with the highest amount of wind capacity in the country, has the lowest REC prices due to substantial oversupply of the credits.
- REC demand within PJM remains oversupplied with prices hovering according to value of use during potential future shortages.

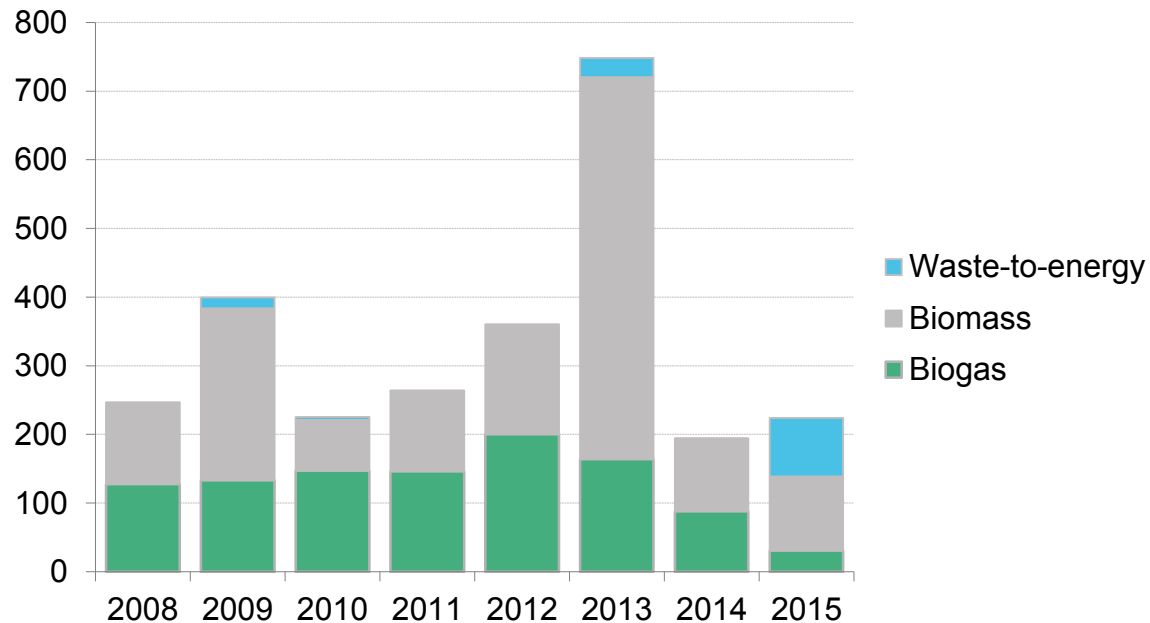
Source: Bloomberg New Energy Finance, ICAP, Evolution, Spectron Group

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.

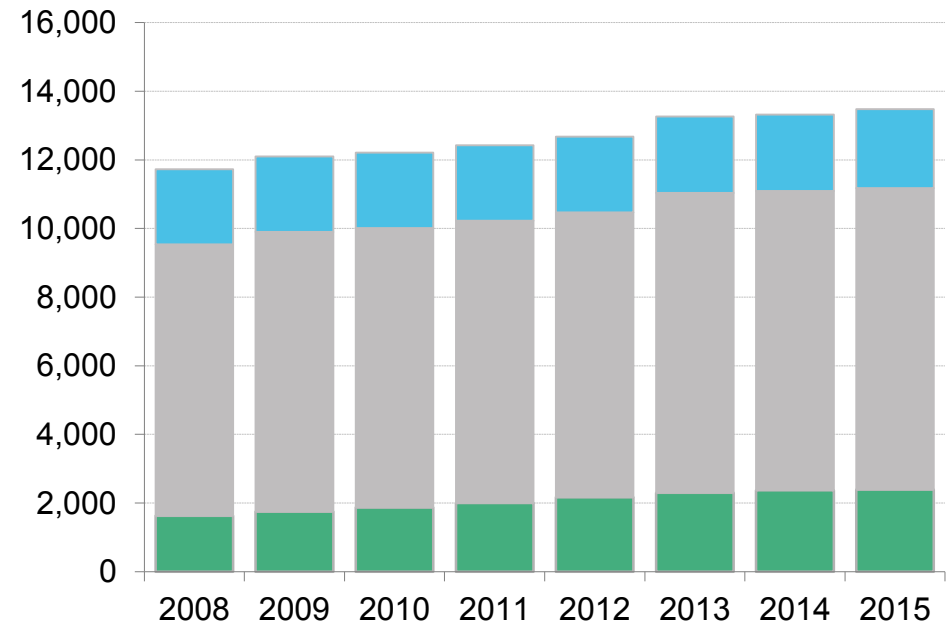
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Deployment: US bioenergy build and cumulative capacity

Annual build (MW)



Cumulative capacity (MW)



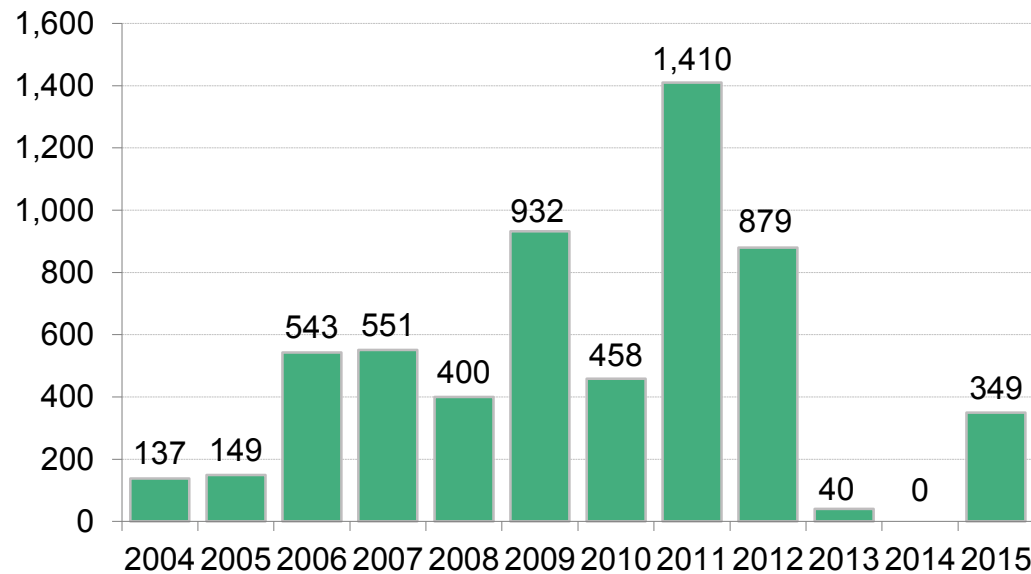
- Policy support measures (the Production and Investment Tax Credits) led to a spike in biomass installations in 2013 to 556MW. This fell sharply to 106MW in 2014 and 140MW in 2015.
- The PTC extension passed by Congress at the end of 2015 extends eligibility to biomass, landfill gas and waste-to-energy projects beginning construction before 2017 with no phase-out. These projects may also claim the extended ITC instead.
- New biogas capacity has been declining since 2012, partially because of low natural gas prices.
- The US built one municipal solid waste plant in 2015: the 85MW Palm Beach Renewable Energy Facility Unit 2.
- 11 small biomass and biogas units (totaling 42MW) retired in 2015.

Source: Bloomberg New Energy Finance, EIA

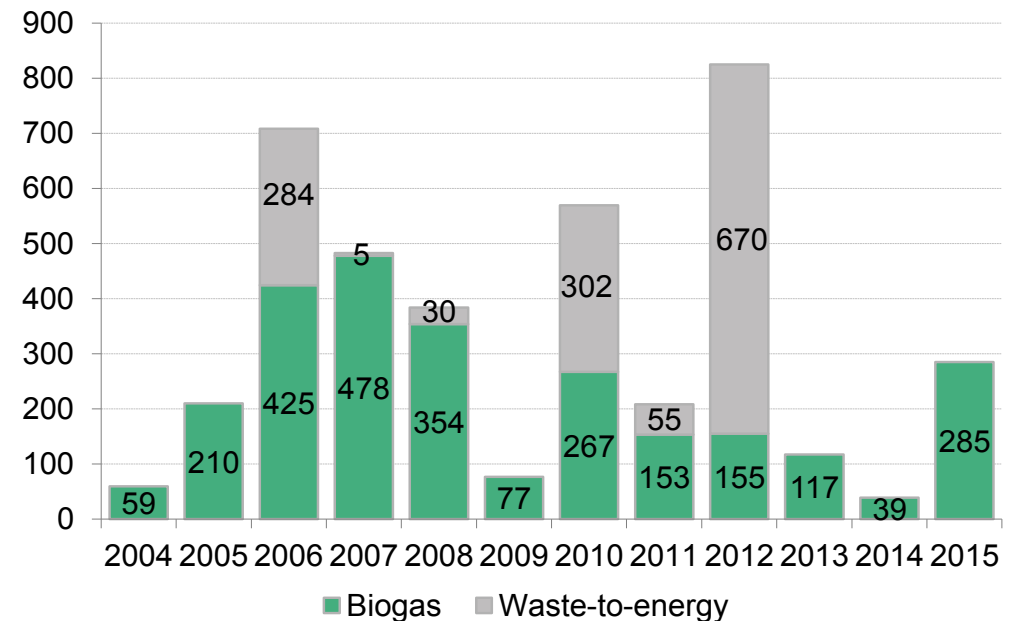
Notes: Biomass Includes black liquor. Biogas category includes anaerobic digestion (projects 1MW and above except wastewater treatment facilities) and landfill gas power. 2015 results include historical installs through September, planned build thereafter.

Financing: US bioenergy asset finance

Asset finance for US biomass (\$m)



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

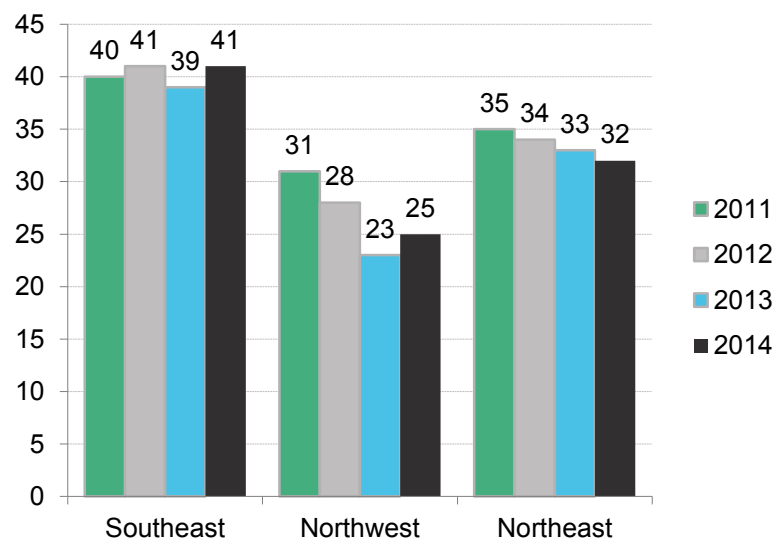


- Asset finance for new-build biomass and biogas rebounded in 2015 as project developers rushed to cash in on the Production Tax Credit (PTC) before its expected expiration. (See previous slide regarding the PTC extension.)
- There have been no waste-to-energy (WTE) deals since 2012, when \$669m financing was secured for one large deal – the Palm Beach Biomass Plant Facility Unit 2. The total asset financing secured by the sector in 2006-2011 was also composed of only four deals, including the \$302m dedicated to the HPower Honolulu plant expansion and \$178m for the Lee County plant.
- Low levels of investment in 2013 and 2014 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.

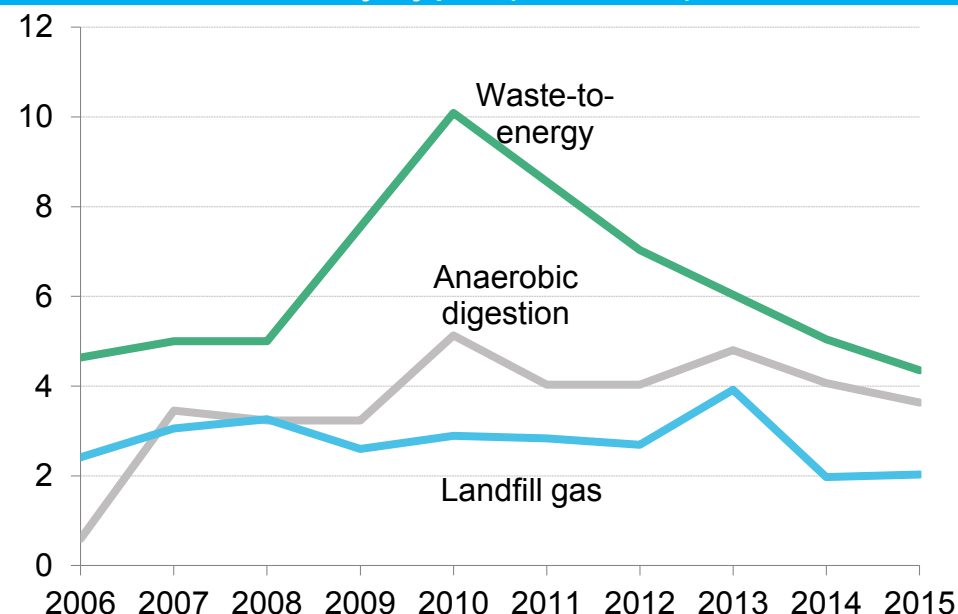
Source: Bloomberg New Energy Finance, EIA Notes: Biomass category includes black liquor. Biogas category includes anaerobic digestion (projects 1MW and above except wastewater treatment facilities) and landfill gas power. Waste-to-energy includes municipal/industrial waste.

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

Biomass feedstock prices in selected US markets, 2011–14 (\$/dry tonne)



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



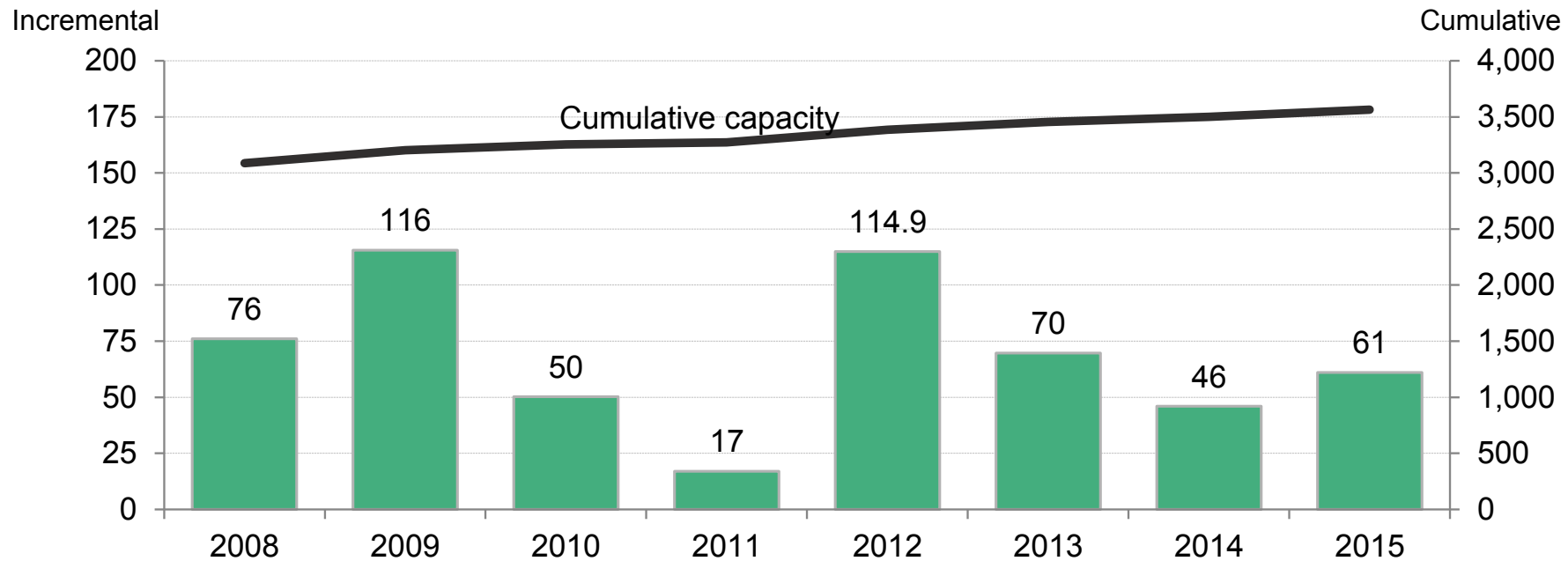
- Biomass feedstock prices in 2014 stayed roughly even with 2013 levels. Greater timber harvests in the US and Canada over the past four years have increased supply. Lumber demand has been increasing steadily as well, but is below 2008 levels.
- Capex for waste-to-energy and anaerobic digestion decreased 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

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

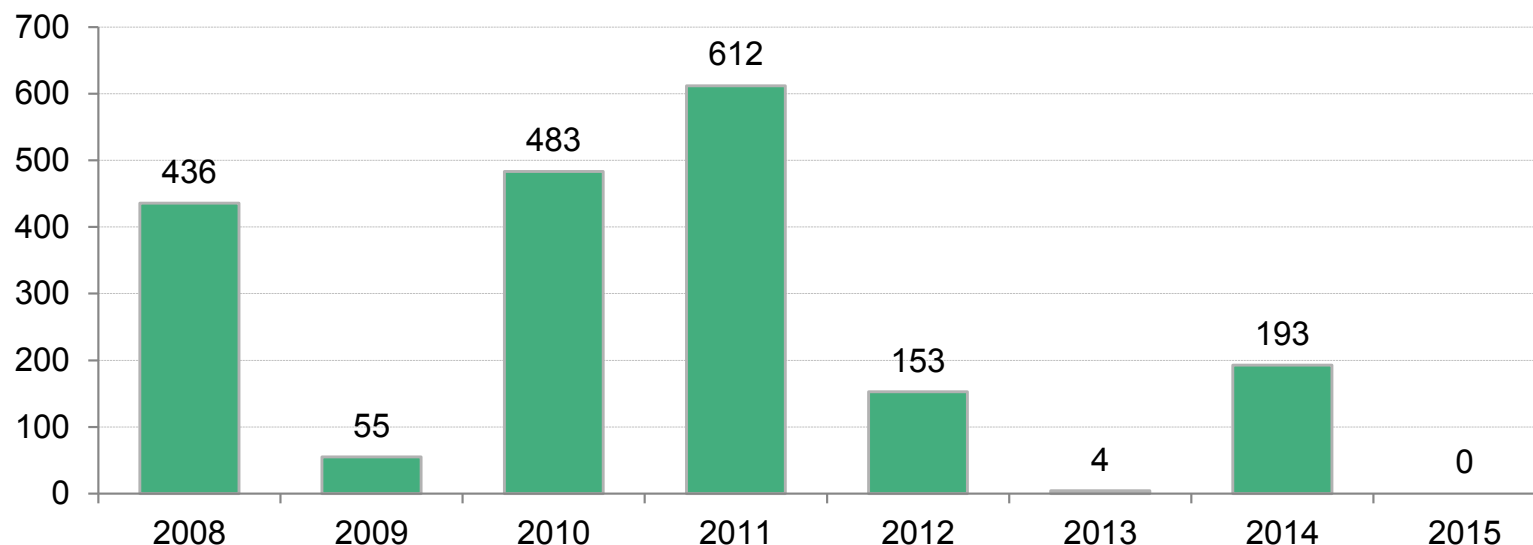
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Deployment: US geothermal build (MW)



- New US geothermal build lags behind other renewables due to long project completion periods (4-7 years), high costs of development, and lack of policy support.
- New capacity in 2015 consisted of expansions and improvements at existed sites.
 - Two projects were commissioned in 2015, totaling 61MW of incremental capacity. Both projects – McGinness Hill II (42MW) and Don A. Campbell II (19MW) – were expansions to existing projects in Nevada.
 - The Bottle Rock Power geothermal plant in California was acquired by AltaRock Energy in November 2015 from the former owners Riverstone Holdings and US Renewables Group. AltaRock is a specialist in enhanced geothermal systems (EGS), an emerging practice for geothermal power which utilizes hydraulic fracturing and stimulation (common in shale gas and oil production) to improve geothermal wells. Bottle Rock Power will likely be the next test site for the company's EGS efforts.
- The PTC was extended for geothermal to cover projects beginning construction before 2017, with no phase out. Projects also have the option to claim the 30% ITC instead.

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

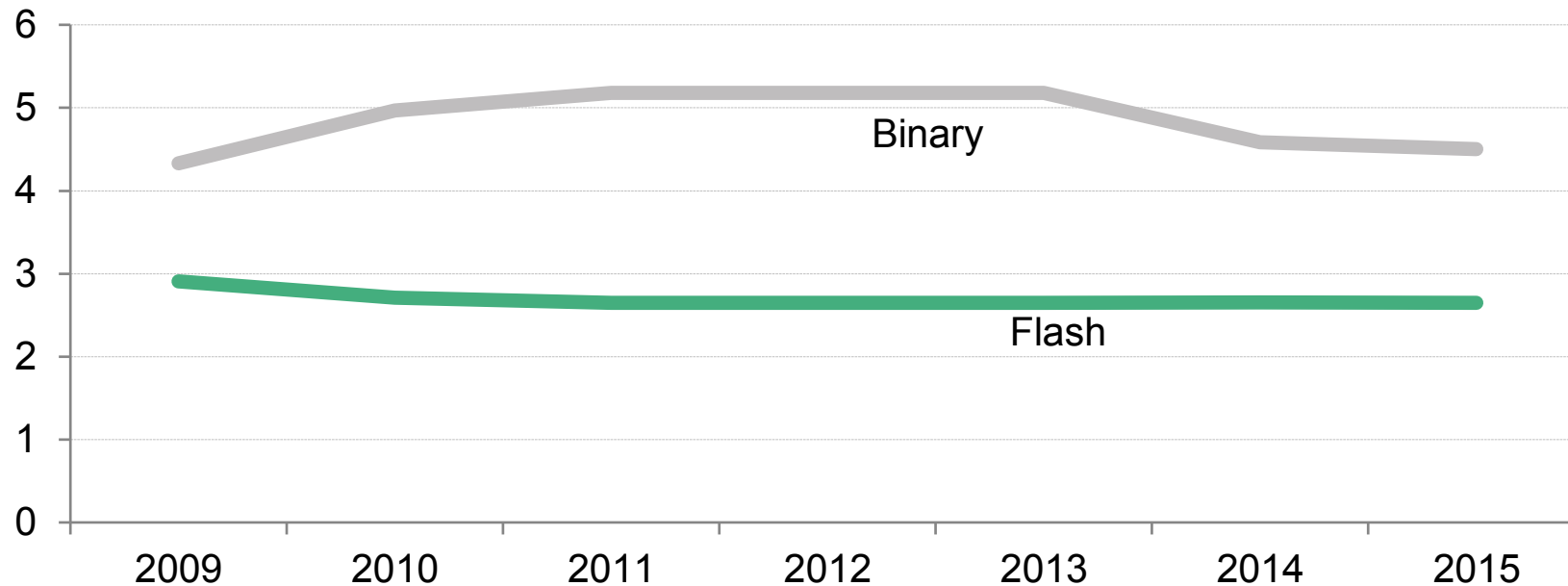


- US geothermal received no new asset financing in 2015, due to a lack of power purchase agreements (PPAs) for geothermal and to the fact that most activity was pursued on balance sheet.
- Few policies have been available to support geothermal projects. State-level policies in California and Nevada, which are home to the majority of US geothermal capacity, also offer little support to the sector:
 - An extended renewable portfolio standard (RPS) was passed in California during 2015, calling for 50% renewable energy by 2050. It is not certain that geothermal is well positioned to fulfill the RPS requirements in the state, however, as growing water concerns pose a barrier to new project development.
 - Nevada regulators approved the Integrated Resource Plan for NV Energy, the state's only electric utility, in late December. The resource plan sees NV Energy building more gas, at the expense of renewables like geothermal.

Source: Bloomberg New Energy Finance

Notes: Values include estimates for undisclosed deals.

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

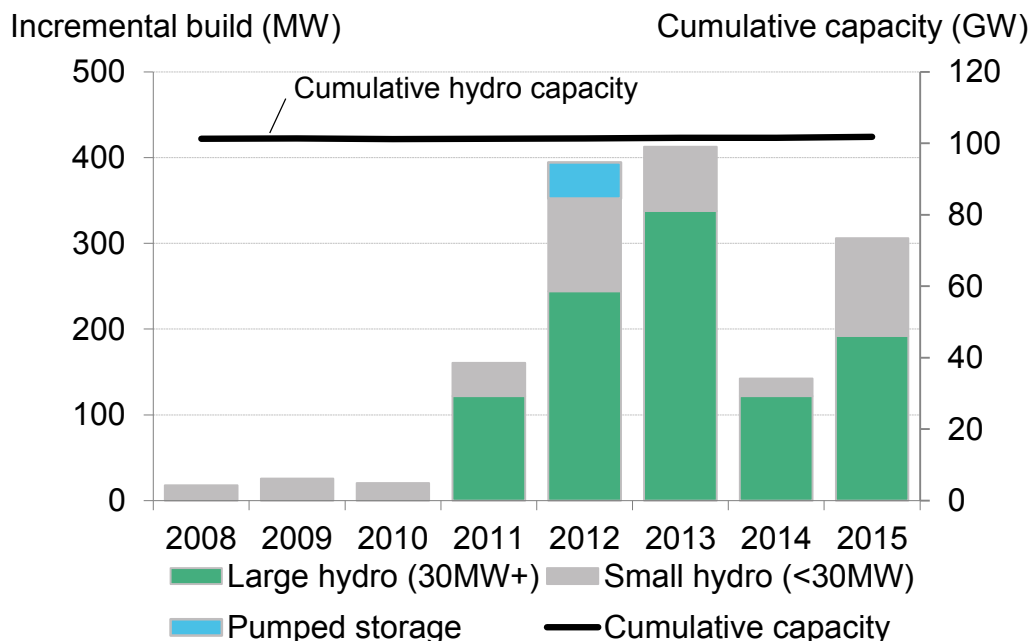


- Flash (ie, steam turbines) continues to be the primary turbine choice for geothermal plants worldwide. However, both of the US projects newly commissioned in 2015 use binary technology, with an average capex of \$4-5m/MW. Binary turbines are able to produce electricity from relatively low temperature steam.
- Comparatively cheaper debt has led to a drop in the cost of binary technology relative to 2013. As binary continues to account for a growing share of new geothermal activity in the US and abroad, learning curves and growing competition suggest that the fall in binary costs will persist.

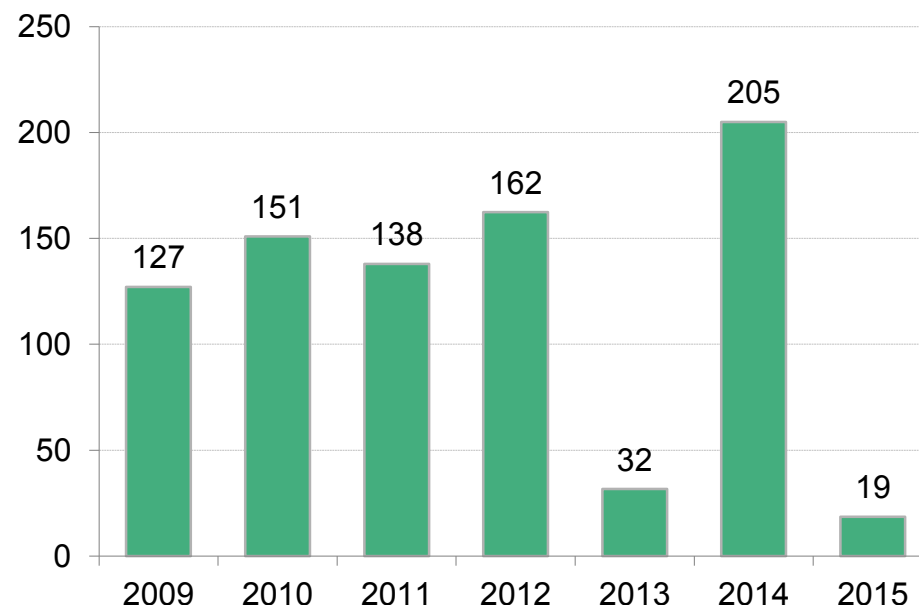
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Deployment: US hydropower build and licensed capacity

US hydropower



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



- New commissioned capacity in hydropower rebounded in 2015 after a 2014 lull. But the largest new hydroelectric generator installed in 2015 (the 120MW Wanapum unit in Washington) was tied to a dam repair effort, not a greenfield project.
- Kentucky installed more hydropower in 2015 than any other state.
- Most new development is focused on existing infrastructure; the industry hopes to unlock the potential in existing non-powered dams. According to the Department of Energy, the largest 100 such dams could offer as much as 8GW.
- PTC eligibility was extended to hydro projects beginning construction before 2017, with no phase out. Hydro projects may also elect to claim the 30% ITC instead.

Source: Bloomberg New Energy Finance, EIA

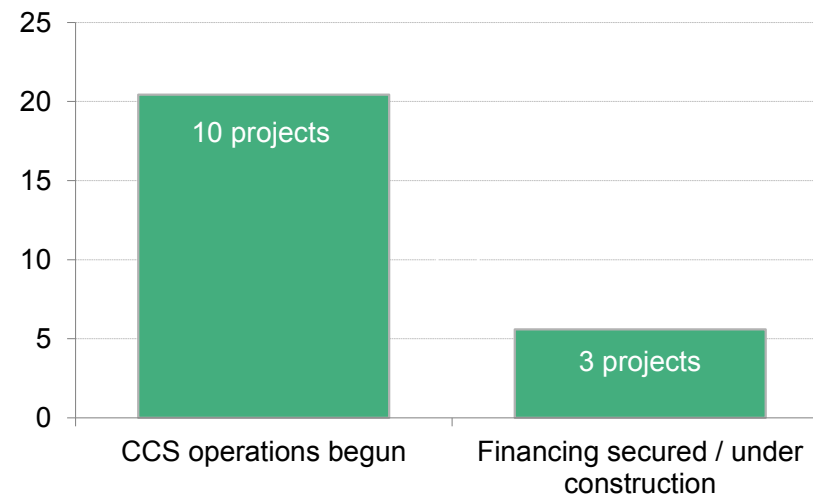
Notes: 2014 results are as of end-October 2015. Excludes pumped storage.

Source: Bloomberg New Energy Finance, FERC

Notes: The licensing figures exclude 152MW of pumped storage licensed in 2012 and 1,736MW of pumped storage licensed in 2014. 2015 results are as of end-October 2015.

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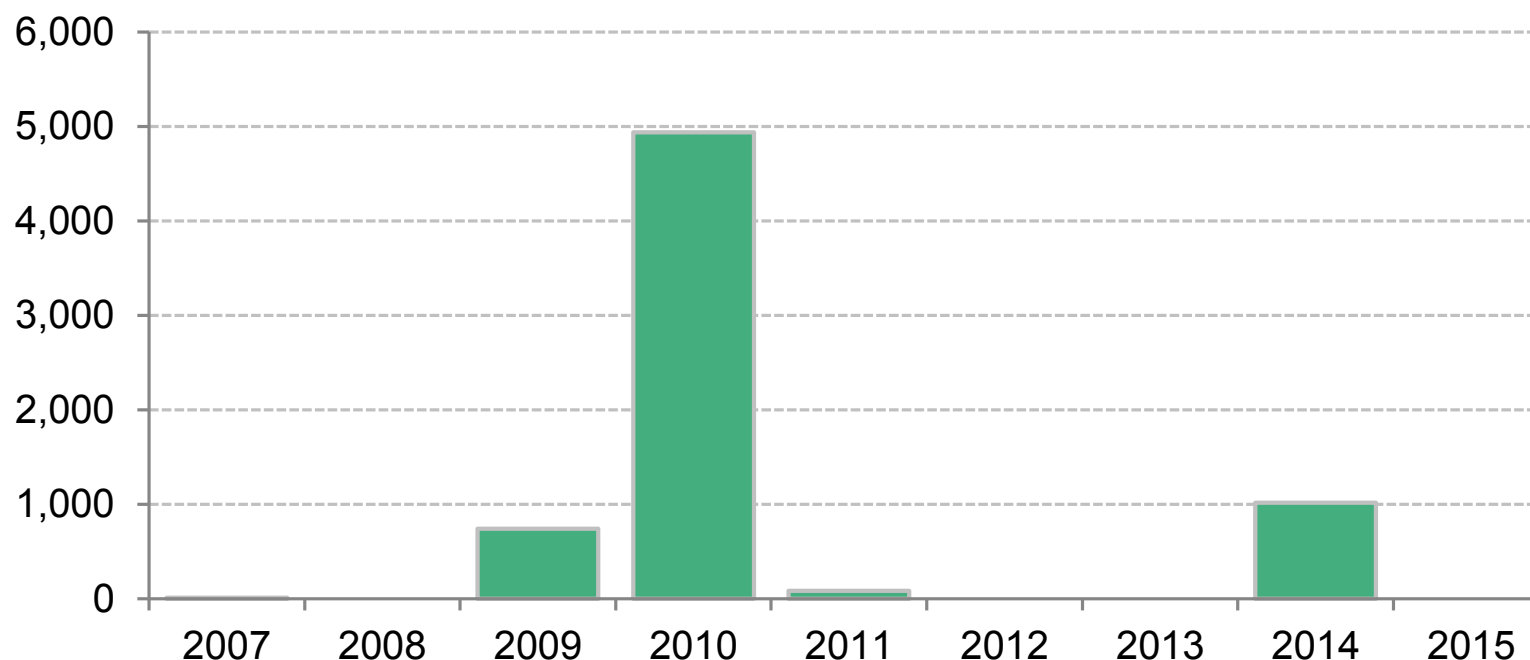
Deployment: Total CO₂ injection rate by current status of US CCS projects (MtCO₂/year)



- There are an estimated 15 large-scale (at least 100MW capacity or at least 0.5MtCO₂/yr injection rate) projects operating globally, 10 of which are in the US.
- Most operational US CCS projects are at natural gas processing facilities.
- Two projects that have passed final investment decision, or that are under construction, are at power plants. This is one fewer than last year. In February 2015, the Department of Energy withdrew funding for FutureGen, once a flagship demonstration project, because of concerns that the project developers could not meet a September 2015 deadline for Recovery Act funding. Construction at the project is now suspended.
- The first CCS power project larger than 100MW, the SaskPower Boundary Dam, was commissioned in Canada in 2014. Mississippi Power's 563MW Kemper project in the US should be the next to commission. The utility has faced problems with cost overruns and delays through construction—costs were first estimated at under \$2bn for the plant and CO₂ capture, but this has since risen to \$5.1bn. The developers initially expected to commission the plant in 2015; they now predict commissioning in Q2 2016. The problems have to do with the complexity of building a large project, rather than with CCS-specific concerns, but Kemper's challenges may make it harder to finance similar projects in the future.
- The most positive development in 2015 was Shell commissioning its Quest project, a CCS project at an oil sands upgrader, in Canada. Following the cancellation of the Keystone XL pipeline, there is greater pressure to lower greenhouse gas emissions from oil sands in Canada – Shell's project is an example of how this could be achieved. Still, this has yet to produce any tangible policy change that might support CCS.
- Prospects for CCS look extremely limited at this time. The funding gap to pay for the additional cost of CCS 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/tCO₂ level.

Source: Bloomberg New Energy Finance

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

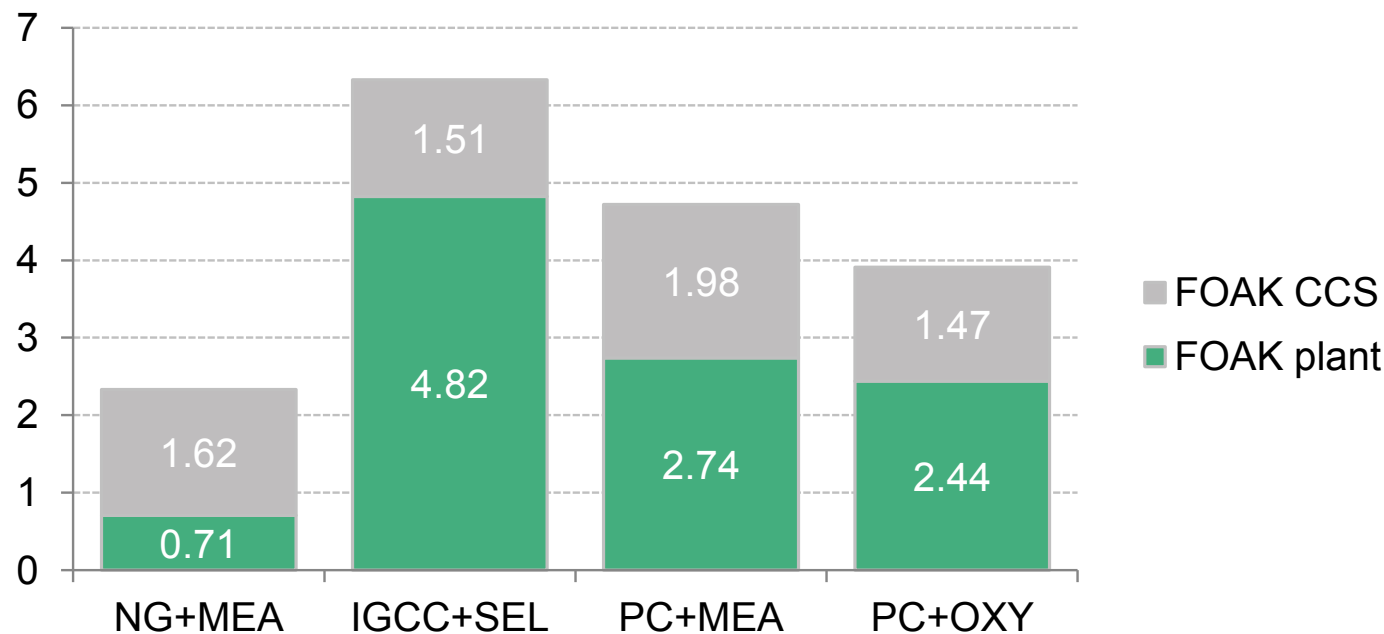


- There was no new investment for large US projects in 2015. Asset financing for CCS projects that have passed final investment decision peaked in 2010.
- CCS projects have high costs and only a small number of projects have been financed, although minimal levels of research and development continue (\$0.2bn in 2015)
- Investment levels picked up again in 2014 due to the financial close of NRG's 1.6MtCO₂/yr Parish power project.
- From 2007- 2015, 56% 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.

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



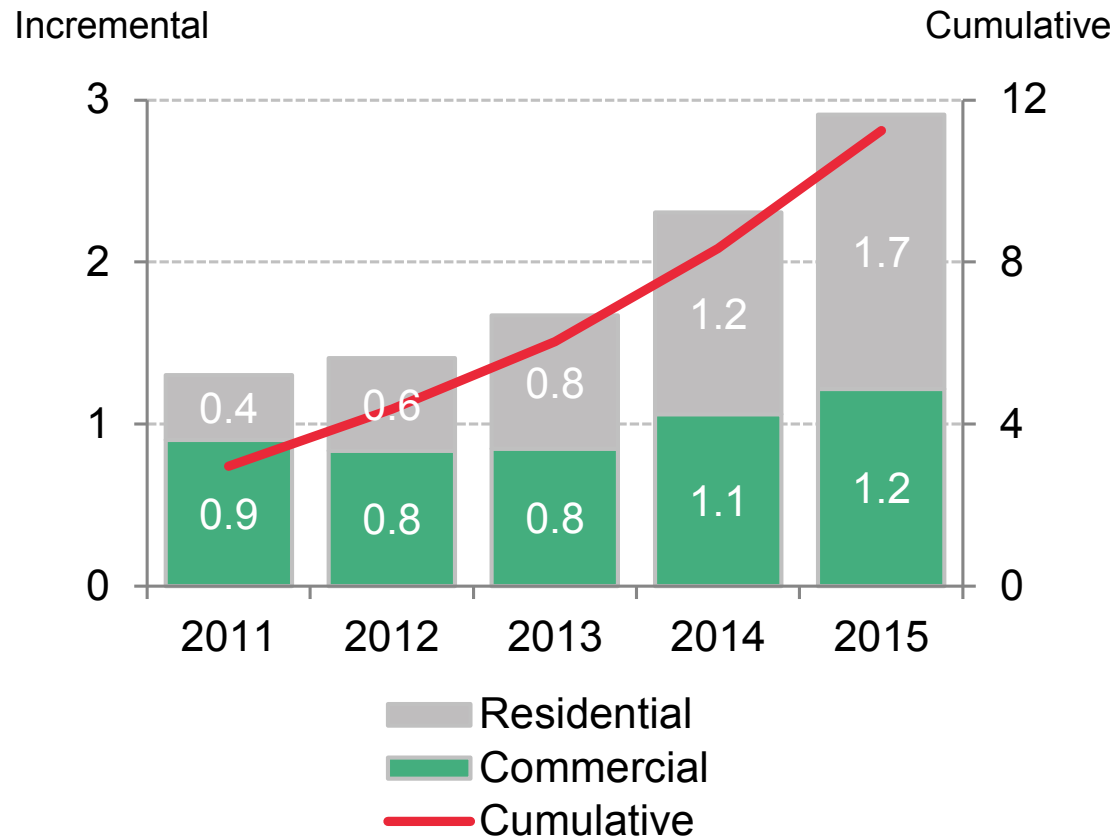
- First-of-a-kind (FOAK) costs are much higher than 'mature' costs.
- Deployment in the tens of GWs may be needed to bring down technology costs, so estimates of 'mature' costs based on FOAKs can be off.
- One large-scale project came online in Q4 2014 with government support (SaskPower's 110MW post-combustion Boundary Dam power unit in Saskatchewan, Canada). The developer expects 20-30% lower costs on its next project due to engineering efficiencies.

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 is natural gas combined-cycle plant with post-combustion (amine) capture, IGCC+SEL is 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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Deployment: US small-scale solar build by type (GW)

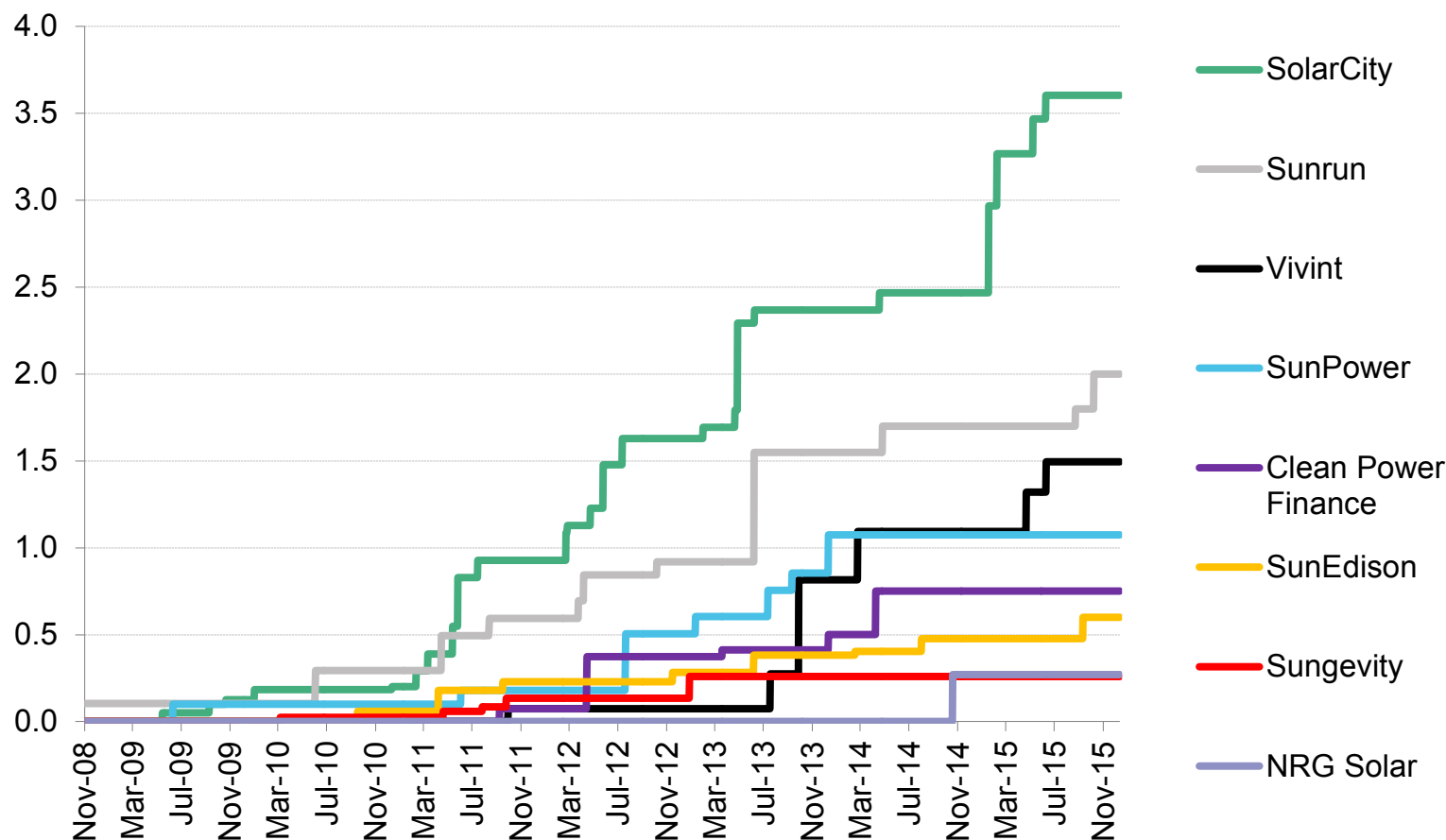


- Distributed PV had yet another record-year in 2015, driven by growth in both the residential and commercial segments.
- The economics for both segments benefit from premium retail electricity rates (compared to wholesale power for utility-scale projects), and a secondary, behavioral driver of consumer dynamics – ie, the more people go solar near you, the more likely you are to consider it.

Source: Bloomberg New Energy Finance

Notes: Figures for 2015 are on average of optimistic and conservative analyst estimates.

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



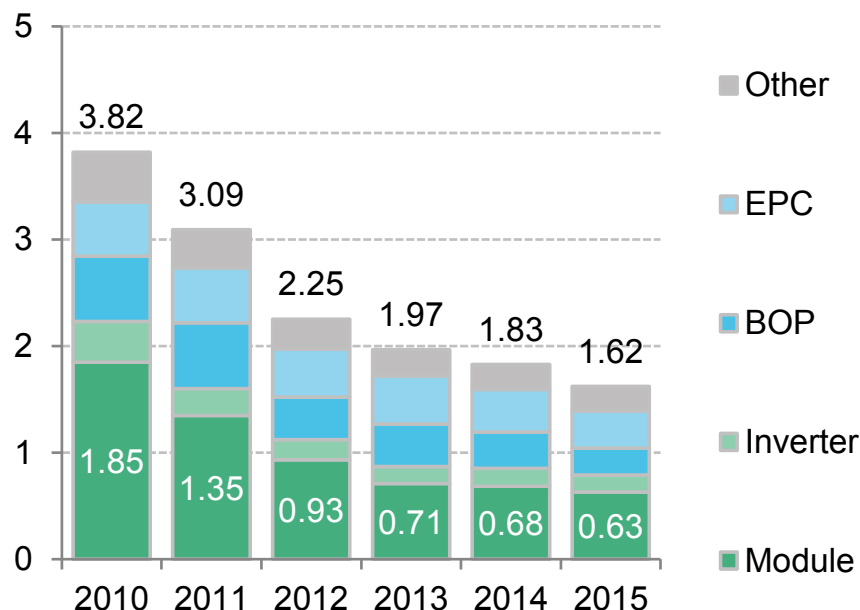
- In 2015, tax equity funds totaled an estimated \$1.9bn, dominated by SolarCity, Sunrun, SunEdison and Vivint, each of which raised \$100m or more. SolarCity raised the most at an estimated \$700m in 2015 alone.

Source: Bloomberg New Energy Finance

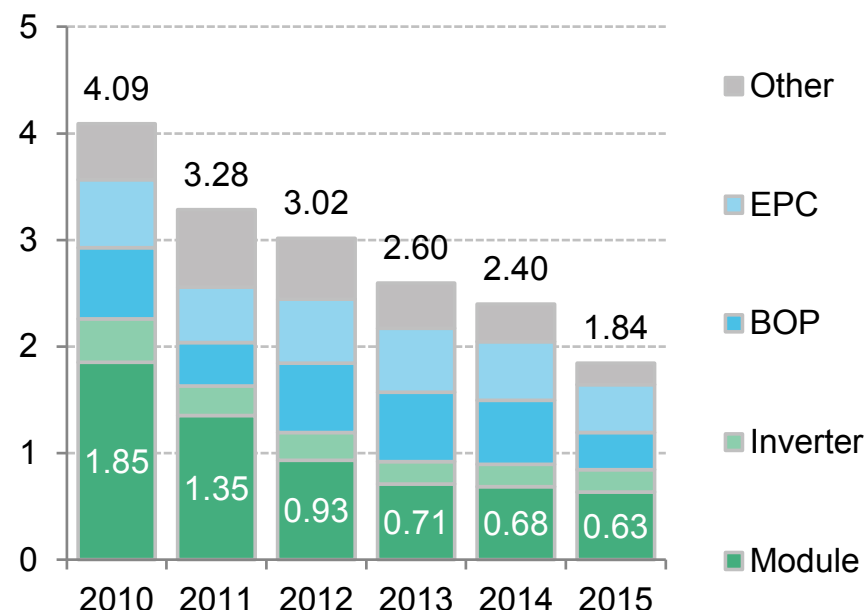
Notes: This represents fund size; actual capital invested is lower and non-public. Data is from publicly available documents and submissions from investors; this figure does not capture any undisclosed deals. Each fund contains an unknown combination of equity, tax equity, or debt (or an absence of tax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

Economics: Best-in-class capex of small-scale solar (\$/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 \$1.6/W driven largely by falling module prices and declines in 'balance of plant' (BOP) costs. Capex for residential PV continues to see strong declines as well.
- 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, including fragmented regulatory regimes, the prevalence of third-party owned solar, longer build time, higher acquisition costs and greater profit margins (among other reasons).

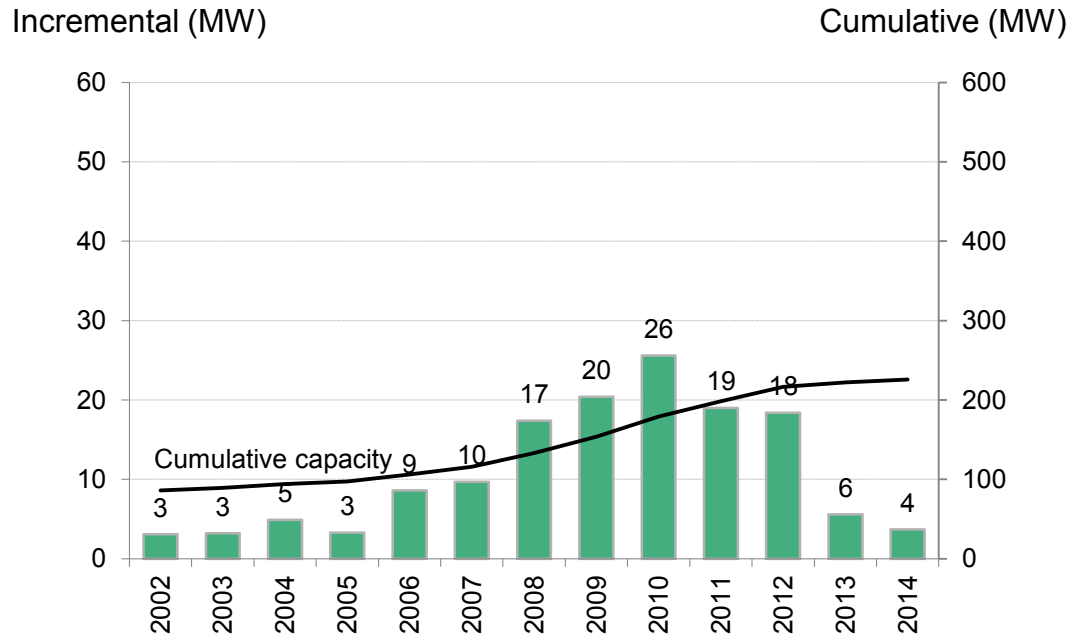
Source: Bloomberg New Energy Finance

Notes: 'EPC' refers to 'engineering, procurement and construction'; 'BOP' refers to 'balance of plant.'

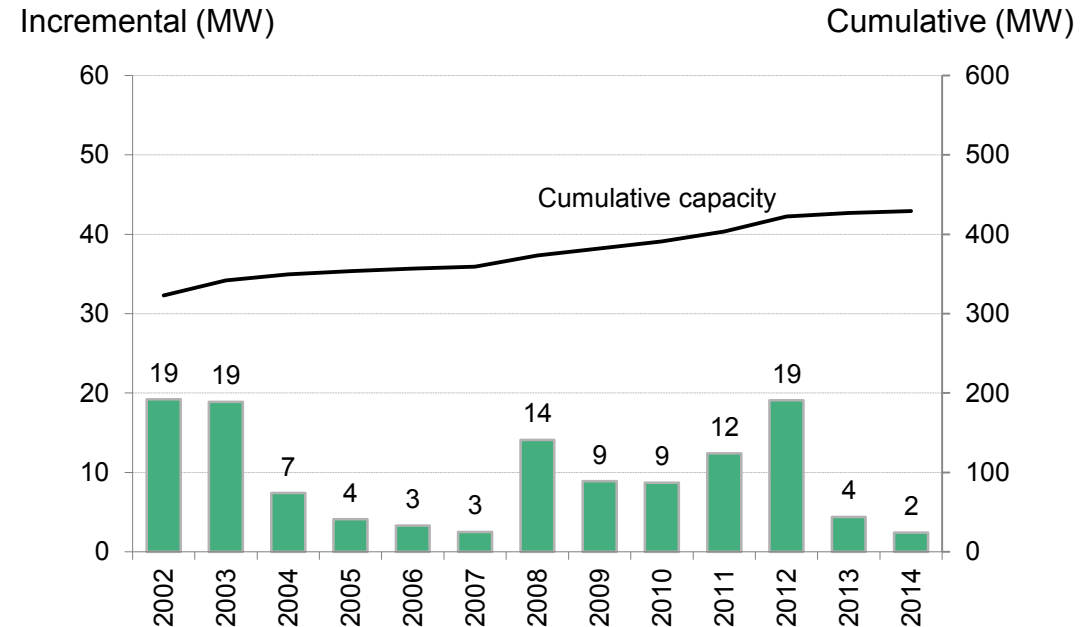
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Deployment: US small- and medium-scale wind build

US small-scale ($\leq 100\text{kW}$) wind build

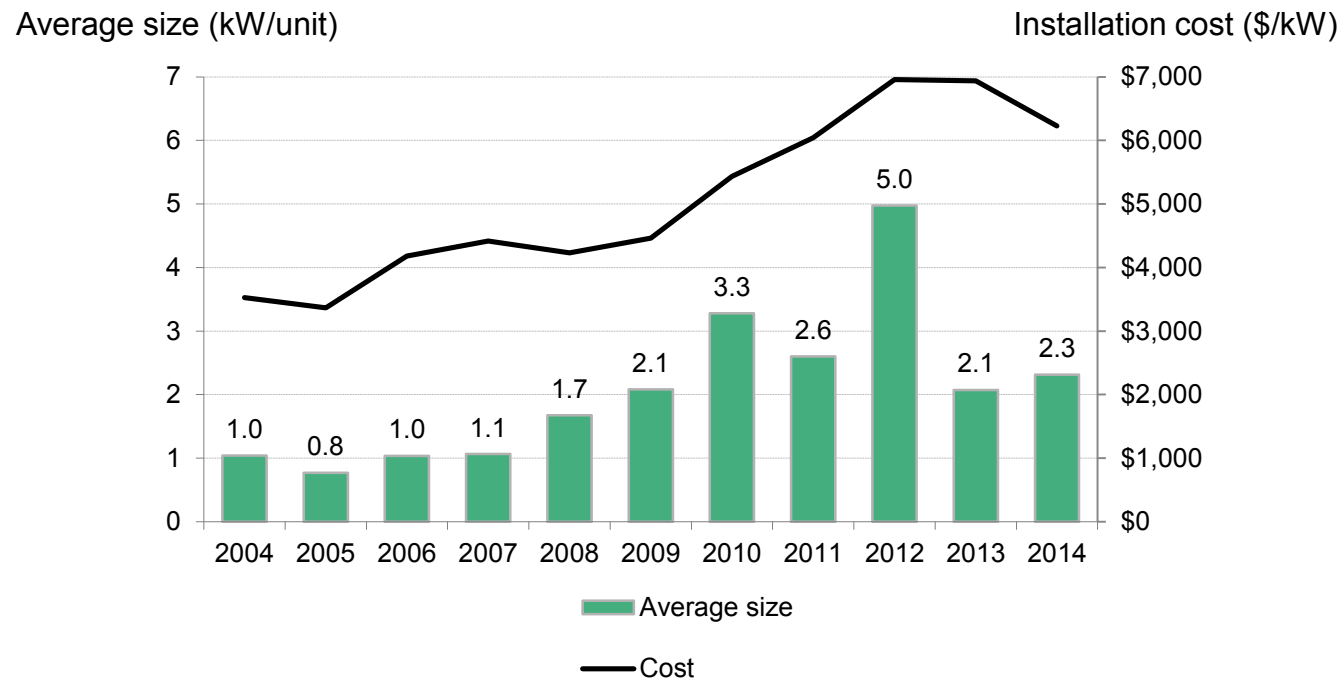


US medium-scale (101kW-1MW) wind build



- Deployments of both small-scale and medium-scale distributed wind fell by about half in 2014, continuing the decline seen in 2013.
- Cumulative capacity for small- and medium-scale wind thus remained fairly steady at 226MW and 429MW, respectively.

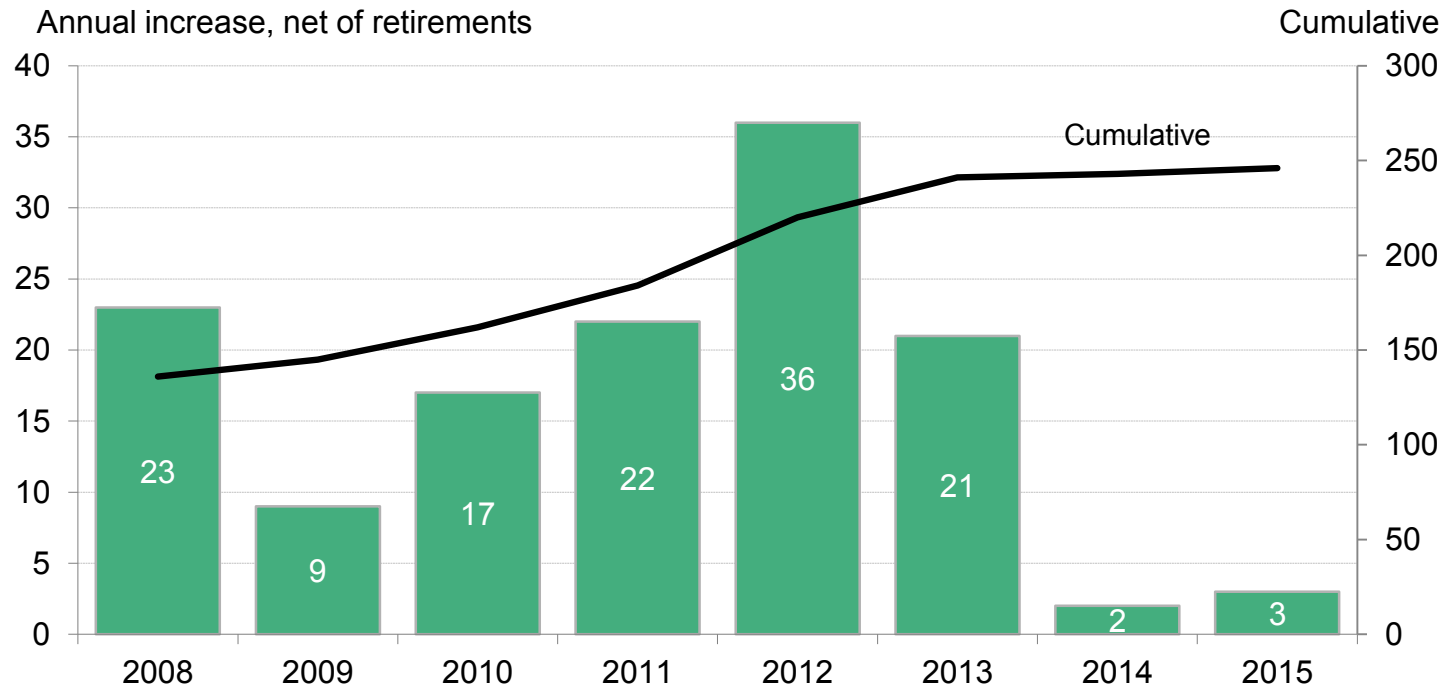
Economics: US small-scale ($\leq 100\text{kW}$) wind turbine average size and installed cost



- 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.
- 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 was calculated by the US Department of Energy in its report on distributed wind, using a sample size of 1.45MW from 73 projects across the country.

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



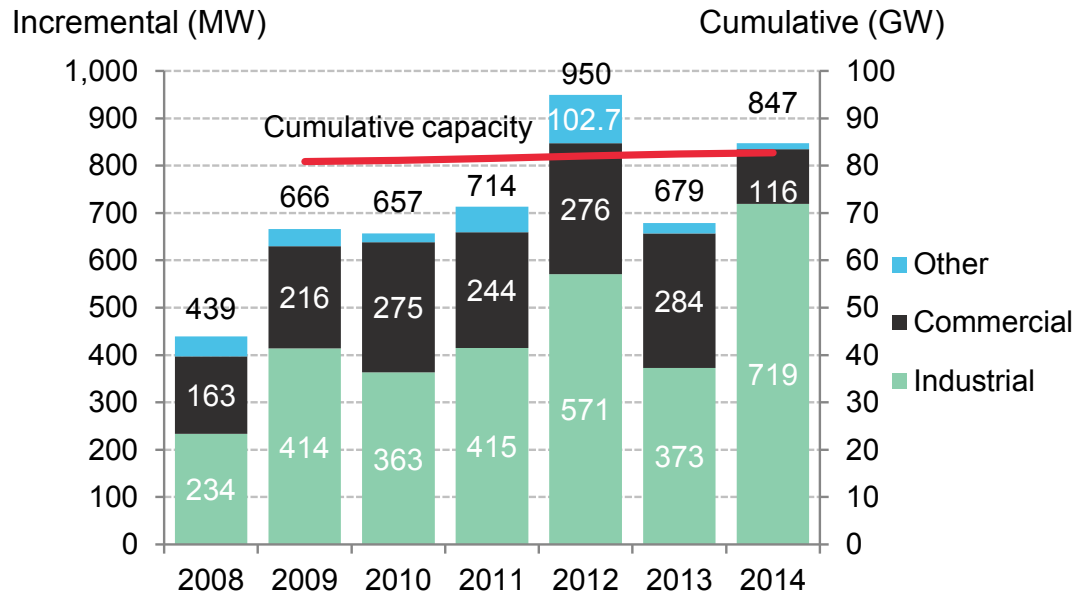
- Development of small anaerobic digester projects collapsed after 2013, with a net increase of only two digesters in 2014 and three in 2015. This followed a wave of build between 2008 and 2013, when yearly build ranged from 21 to 40 (and 29 closed over the entire period). There are currently 247 operational anaerobic digester projects at farms in the US.
- The falloff in installations in 2014 and 2015 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 in 2014 and 2015 as natural gas prices collapsed to the lowest levels seen since 1999. 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.
- These facilities average 707kW. 169 are smaller than 1MW and add up to a cumulative capacity of 59MW.

Source: US EPA AgSTAR program

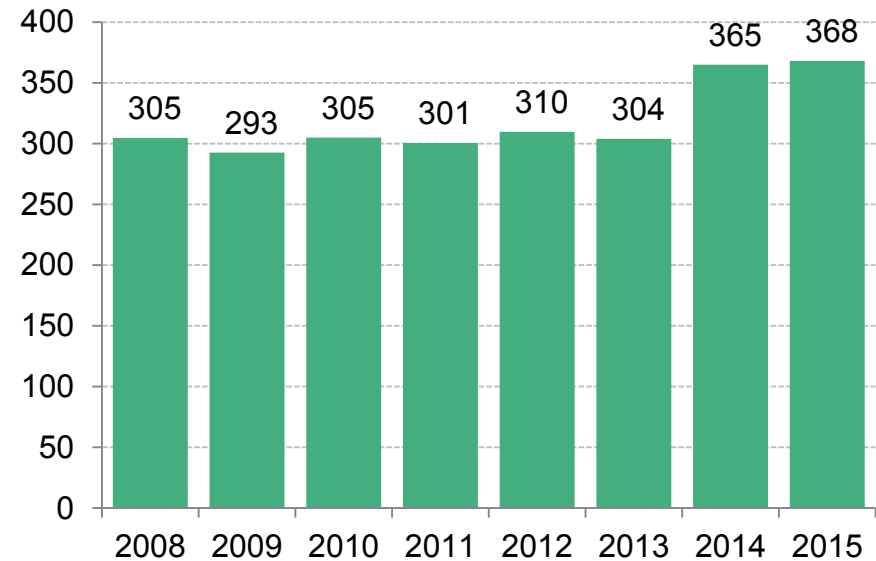
Notes: Columns show annual net increase (accounting for retirements).

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US CHP build (MW) and capacity (GW)



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

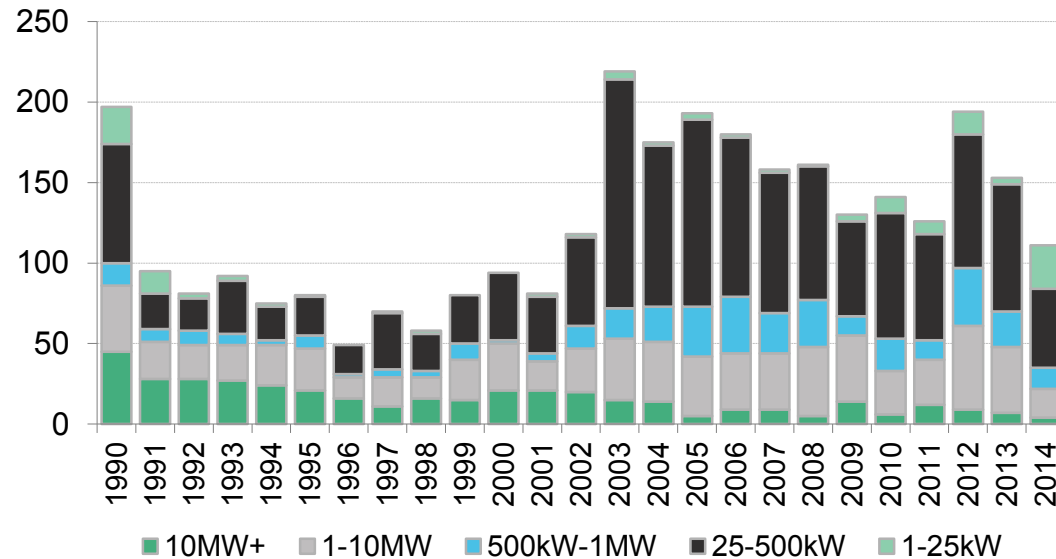


- 2014 saw a jump in installations from 679MW to 847MW, including the most industrial CHP build of the past seven years. However, cumulative capacity remains static as CHP systems using dirtier fuels have been retired. Overall, growth is still stymied due to a lack of supportive policies at the federal or state level and demanding standby charges that undermine system economics.
- Annual generation has been notably higher in 2014 and 2015 than in the previous five years. Higher utilization of CHP may be due to cheaper gas.
- 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).

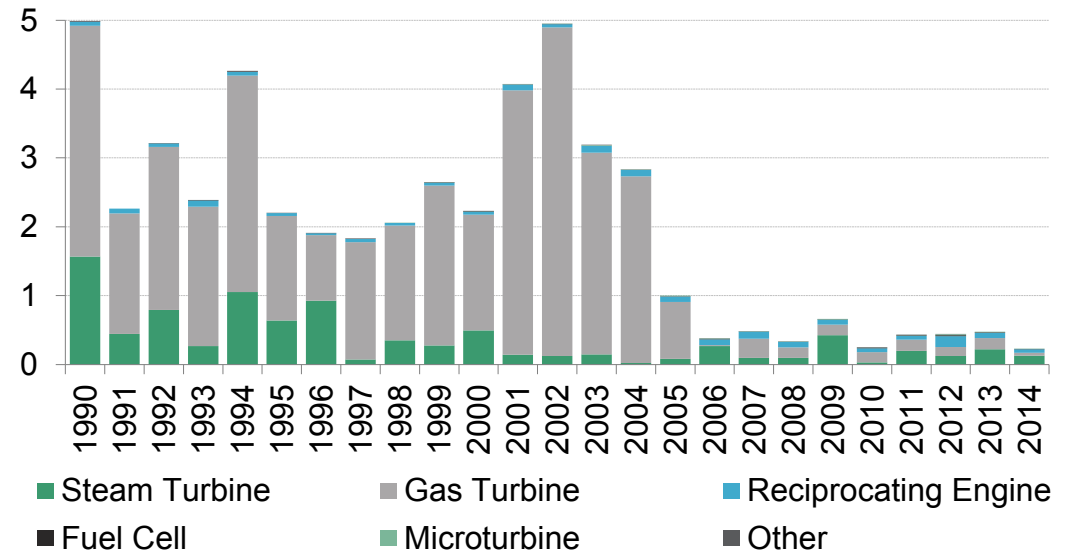
Source: Bloomberg New Energy Finance, DOE CHP Installation Database (maintained by ICF International) Notes: EIA is the best available source for generation data. However, EIA data on CHP is not comprehensive and so the generation figures are underestimated. Specifically, EIA does not collect data for 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 2015 are projected, accounting for seasonality, based on latest monthly values from EIA (data available through October 2015).

Deployment: US small-scale CHP build

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



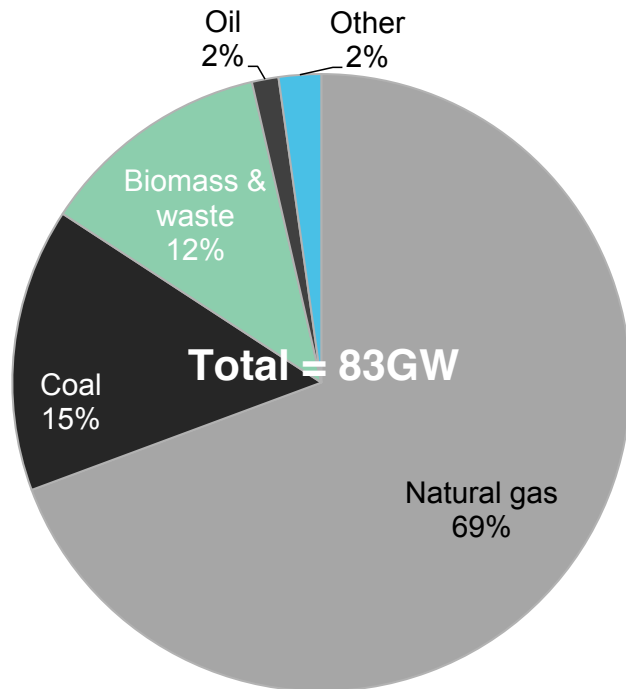
US Annual CHP build by technology (MW)



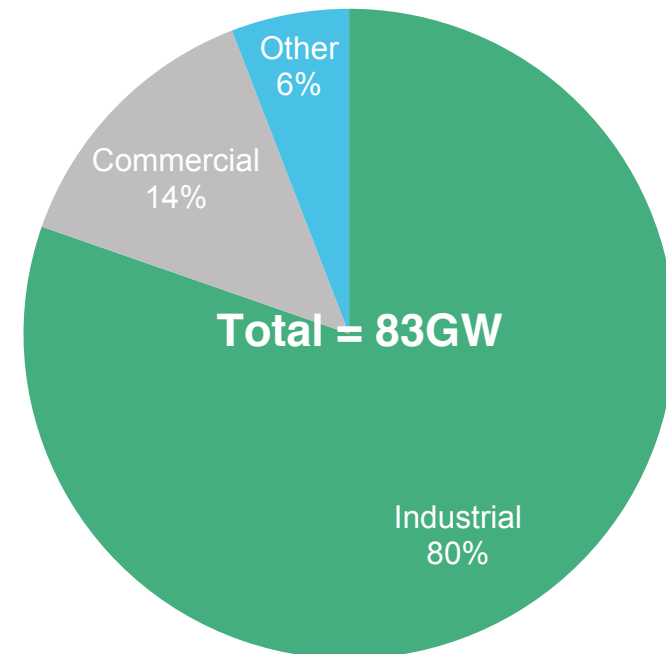
- Over the past twenty years, the average size of a CHP system shrank, suggesting a lack of market incentives for large-scale projects. 2003 saw total construction starts nearly double from the previous year (from 118 to 219 projects) amid an increase in projects sized between 500 and 1000 kilowatts.
- In the past decade, annual new build has been muted. Absent any financial enticements, facility owners appeared reluctant to upgrade to newer small-scale technologies like fuel cells and microturbines, when conventionally reliable technologies provide cheaper power at a larger scale.

Deployment: US CHP deployment by fuel and by sector, 2014

US CHP deployment by fuel source



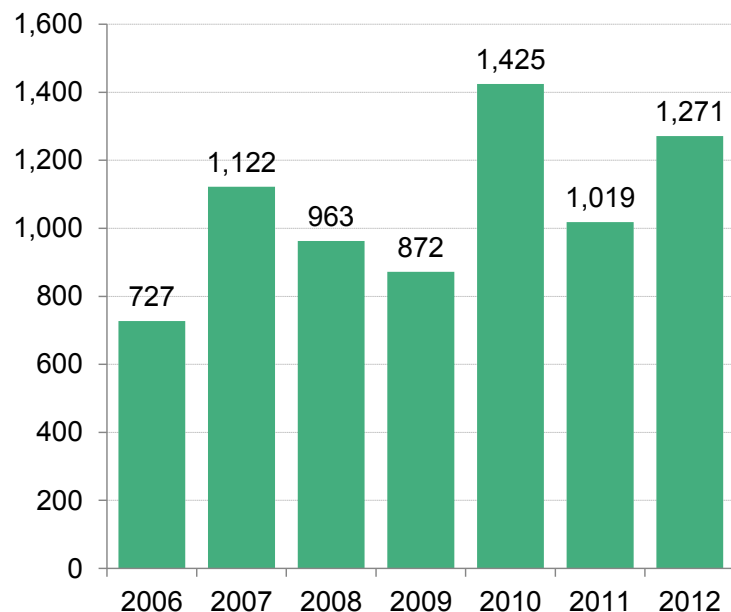
US CHP deployment by sector



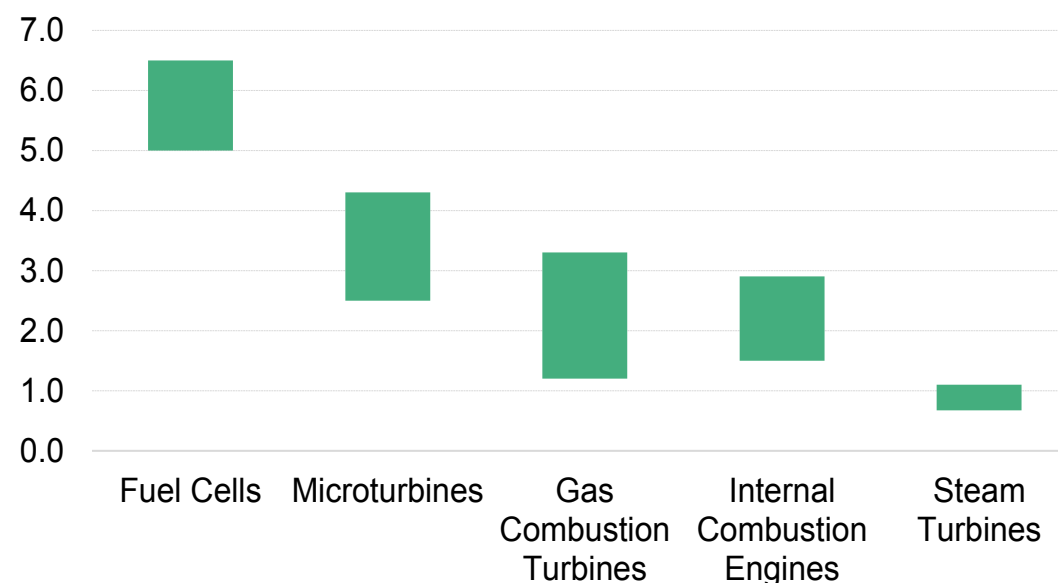
- Natural gas continues to be the most common fuel source for cogeneration. The Northeast and California saw a notable uptick in installations in recent years, though historically large CHP projects have often been located near petrochemical plants and refineries along the Gulf Coast.
- The majority of CHP is used for industrial applications, since the technology is clearly beneficial in situations with high heat demand relative to electric demand, such as in a factory. But while industrial CHP makes up the majority by installed capacity, the commercial sector leads by number of projects, with an equally high growth rate for new build (not pictured).
- New deployments in 2014 were exclusively natural gas, coal, and biomass-fuelled installations.

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

Asset finance for US CHP (\$m)



Capital cost of CHP by technology (\$/W)



- From a price standpoint, steam turbines, internal combustion engines and gas combustion turbines are the cheapest to build, however, prices have become more competitive for microturbines, which could lead to growth in the residential and small commercial space.

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

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 2012 since deployment figures are only available through 2014 (and there is an assumed two-year lag between financing and deployment).

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

Notes: ICF International 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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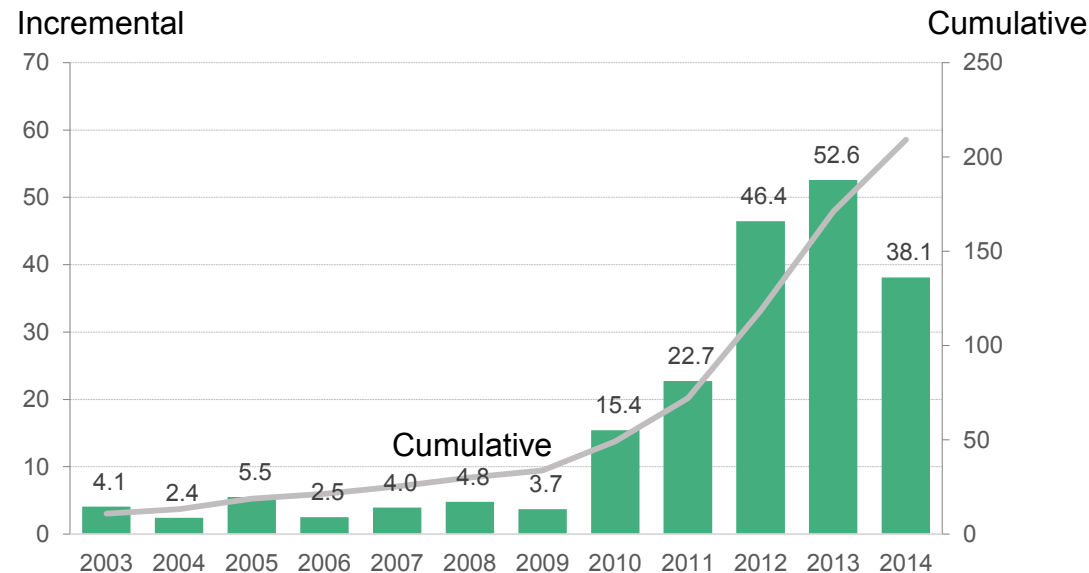
Deployment: Comparison of fuel cell technology performance and applications

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)	200-2,800	Natural gas, hydrogen, biogas	52-60%	Yes, but typically heat is used internally with the system to increase electrical efficiency	Distributed generation, utility	Bloom Energy
Phosphoric acid (PAFC)	100-400	Natural gas, hydrogen, biogas	42%	Yes	Distributed generation	Doosan Fuel Cell America
Alkaline (AFC)	10-100	Hydrogen	60%	No	Military, space	
Polymer electrolyte membrane (PEM)	1-100	Hydrogen	35-60%	Yes, but limited to low temperature applications, such as space and water heating	Backup power, distributed generation, transportation, telecom	Plug Power (using Ballard stacks), Alteryx
Direct methanol fuel cell (DMFC)	<10	Methanol	<40%	No	Auxiliary power, telecom, transport	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.

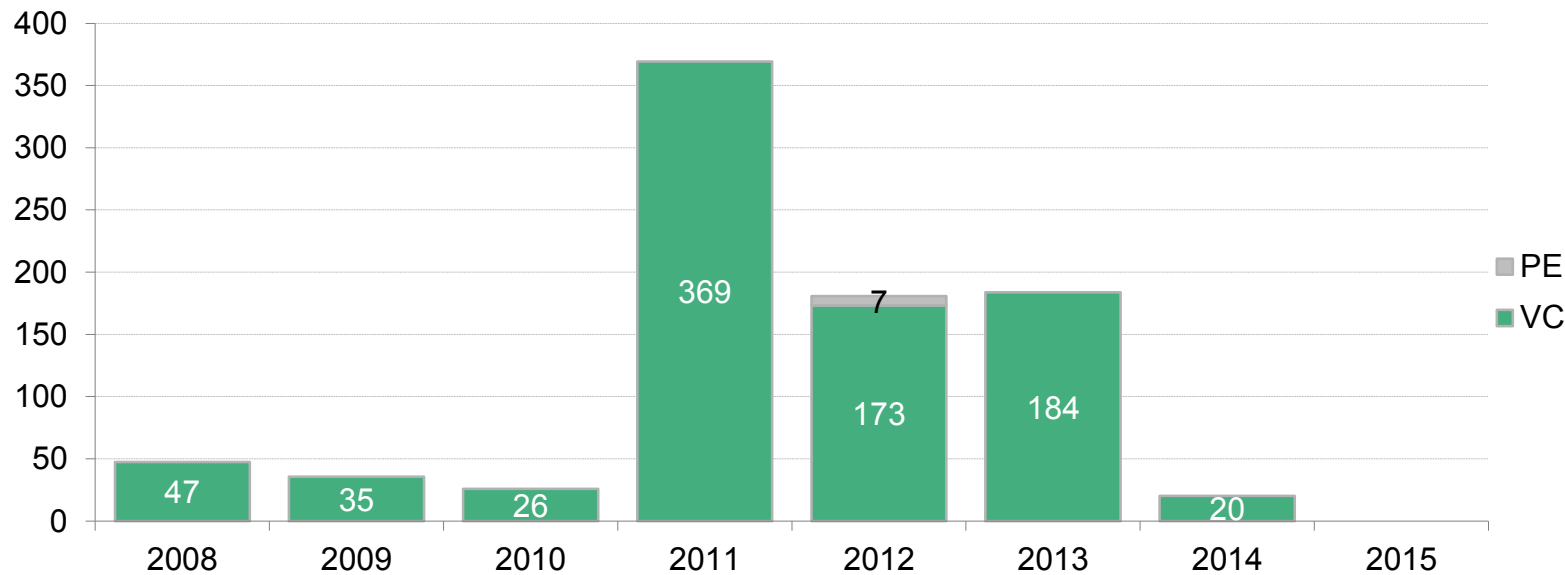
Deployment: US stationary fuel cell build (MW)



- Fuel cell projects in the US surged from 2011 to 2013 on the back of several very large projects, with a slowdown in 2014. Complete data for 2015 is not yet public, but key developments included:
 - FuelCell Energy's 63.3MW Beacon Falls Connecticut project with O&G Industries and CT Energy & Technology;
 - Constellation (Exelon) is financing an additional 170 additional Bloom Energy projects (40MW) in four states;
 - Corporations such as IKEA, Comcast, Equinix, Pepperidge Farm, Hyatt, Morgan Stanley and Johnson & Johnson have announced and/or commissioned fuel cell capacity in 2015.
- Most fuel cell activity in the US is concentrated in five states:
 - California: Self-Generation Incentive Program (SGIP) provided a subsidy of \$1.65/W in 2015;
 - Connecticut: Supported by tax credits, net metering, low-emission energy credits (LRECs);
 - Delaware: Mostly Bloom Energy's projects in Delmarva Power and Light substations;
 - New York: High retail electricity prices encourage project development; and
 - North Carolina: Mostly a 10MW Bloom project using biogas to power an Apple data center.

Source: Fuel Cells 2000, SGIP, Bloomberg New Energy Finance Notes: Fuel cells installed before 2003 are excluded due to the expected 10-year lifetime of these installations. 'Planned' refers to projects which are announced and at various stages of development.

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



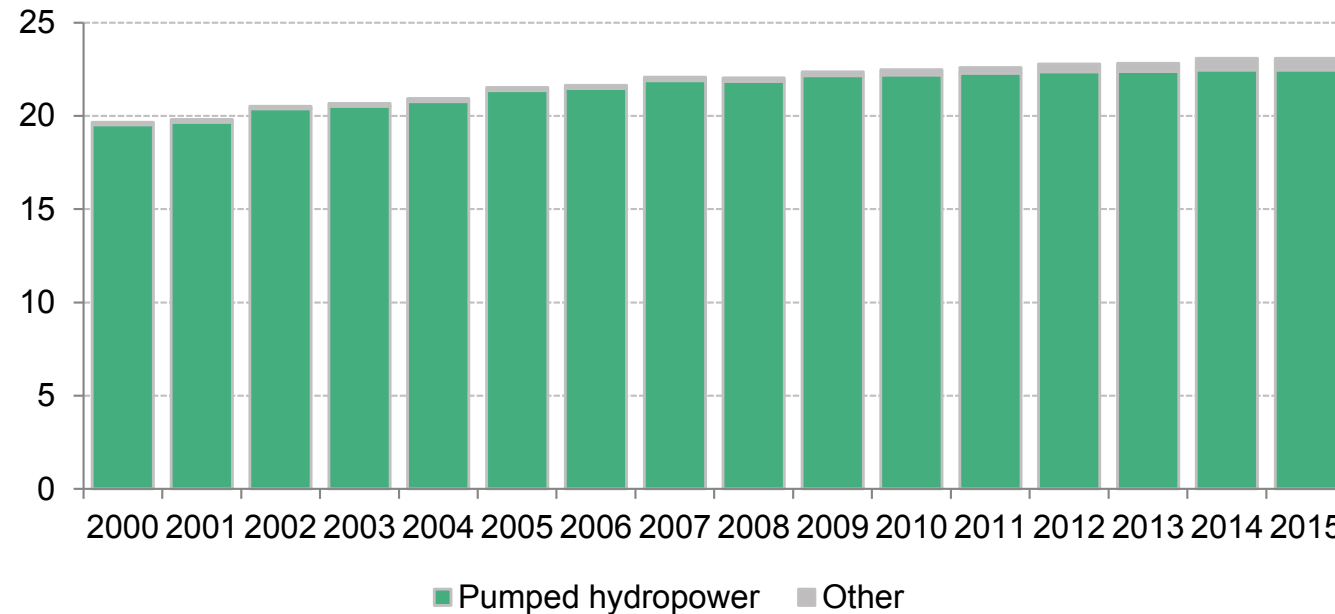
- There was no venture capital / private equity investment in US-based fuel cell companies in 2015. The increased scaling of activities from companies like Bloom Energy, FuelCell Energy and acquisitions such as Korea-based Doosan's acquisition of United technologies Corp (UTC) in 2014 suggest companies are using alternative forms of growth to finance fuel cell projects and are consolidating operations the fuel cell space.
- Asset financing has been small relative to renewable sectors such as wind and solar. Because fuel cell projects generate substantial tax credits, tax equity financing has been popular.
- However, the new ITC extension would not apply to fuel cells. Fuel cell projects in service before 2017 can still qualify for credits through the current law.

Source: Bloomberg New Energy Finance

Notes: Values include estimates for undisclosed deals.

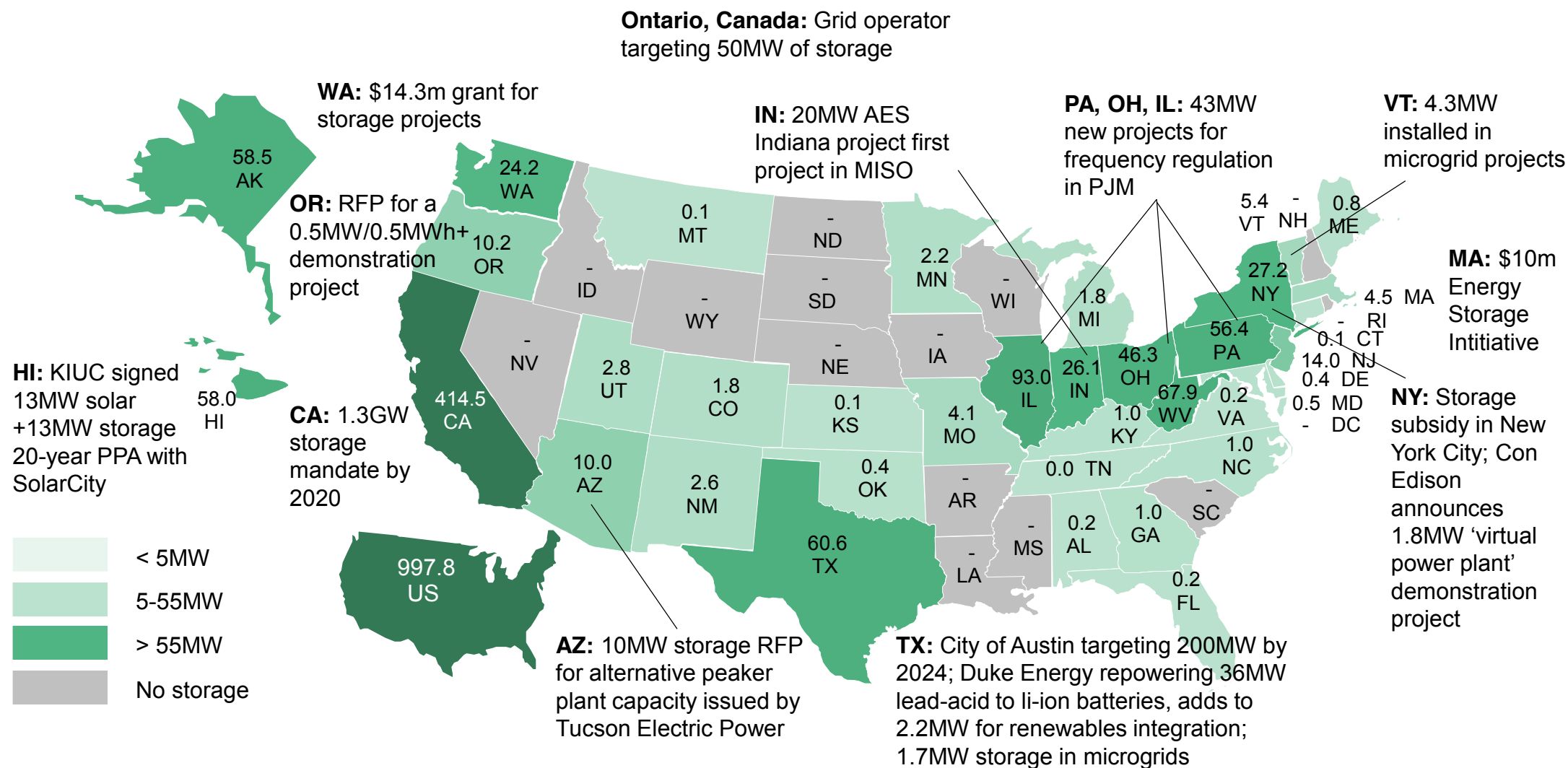
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Deployment: US cumulative energy storage (GW)



- Pumped hydropower storage projects account for over 97% of installed energy storage capacity in the US.
- As of October 2015, FERC counted three pending licenses for further pumped storage projects, totaling 1,640MW in new capacity. The largest project is a 1,000MW closed-loop facility in Utah, and the other are closed-loop facilities in Montana (400MW) and New York (240MW).
- State-level energy storage mandates or solicitations generally exclude pumped storage.

US COMMISSIONED AND ANNOUNCED ENERGY STORAGE PROJECTS, AS OF H2 2015 (MW)

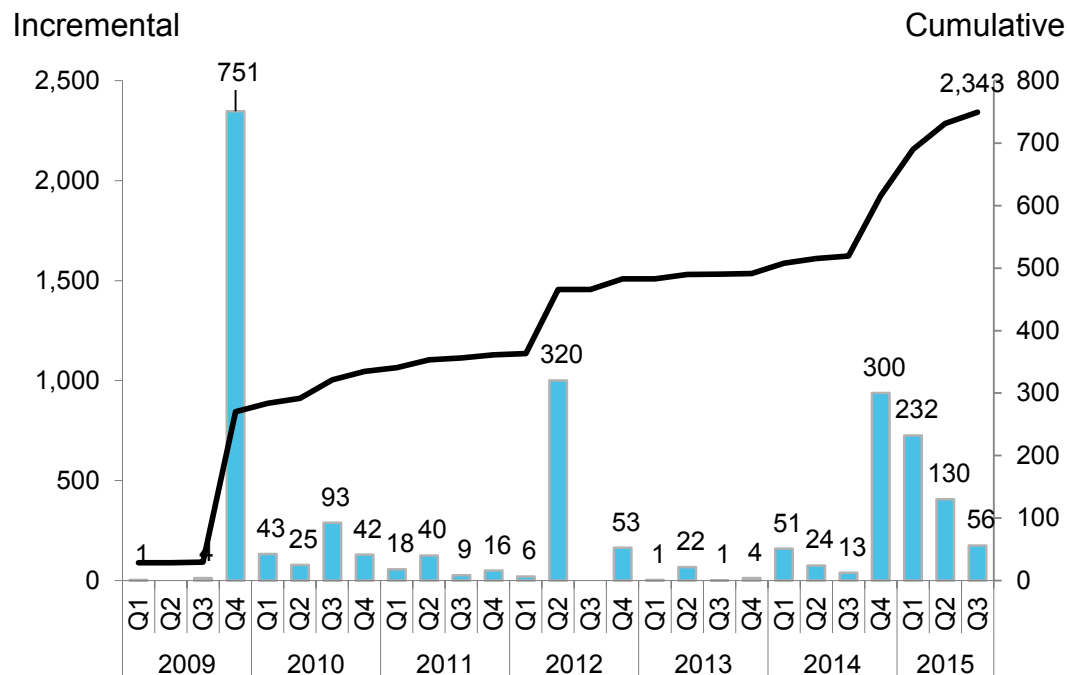


Source: Bloomberg New Energy Finance

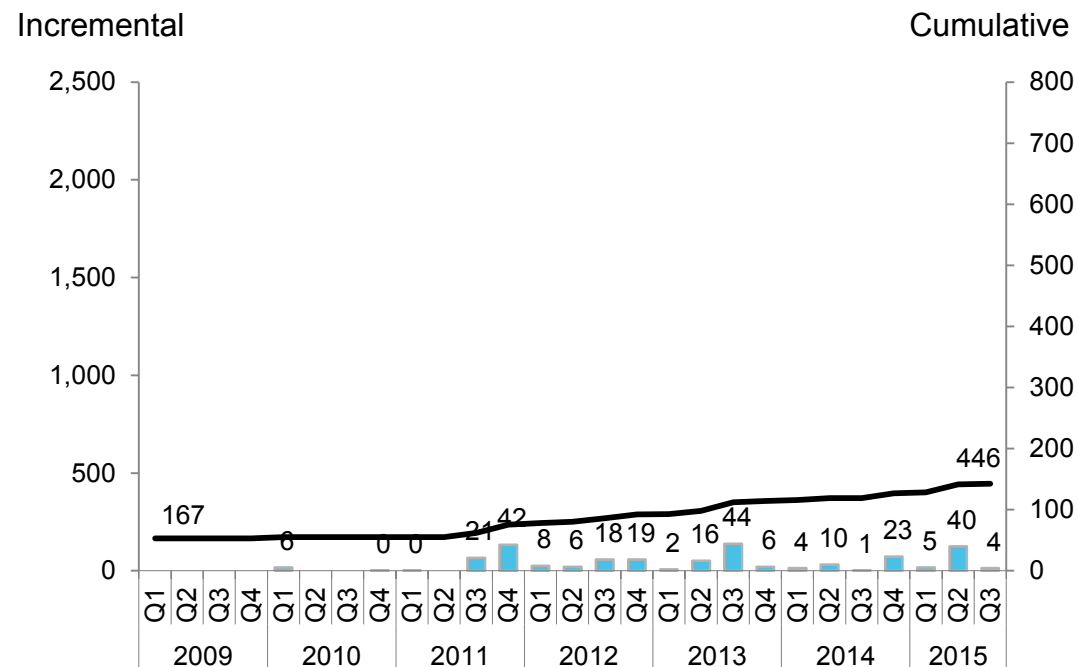
Note: Does not include underground compressed air energy storage, pumped hydro, or lead-acid batteries for non-grid applications; minimum threshold for projects is either 100kW or 100kWh. Note that Alevo's 200MW project with Customized Energy Solutions and Amergin's 60MW project in PJM are not included because their exact locations are not yet announced.

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

Announced



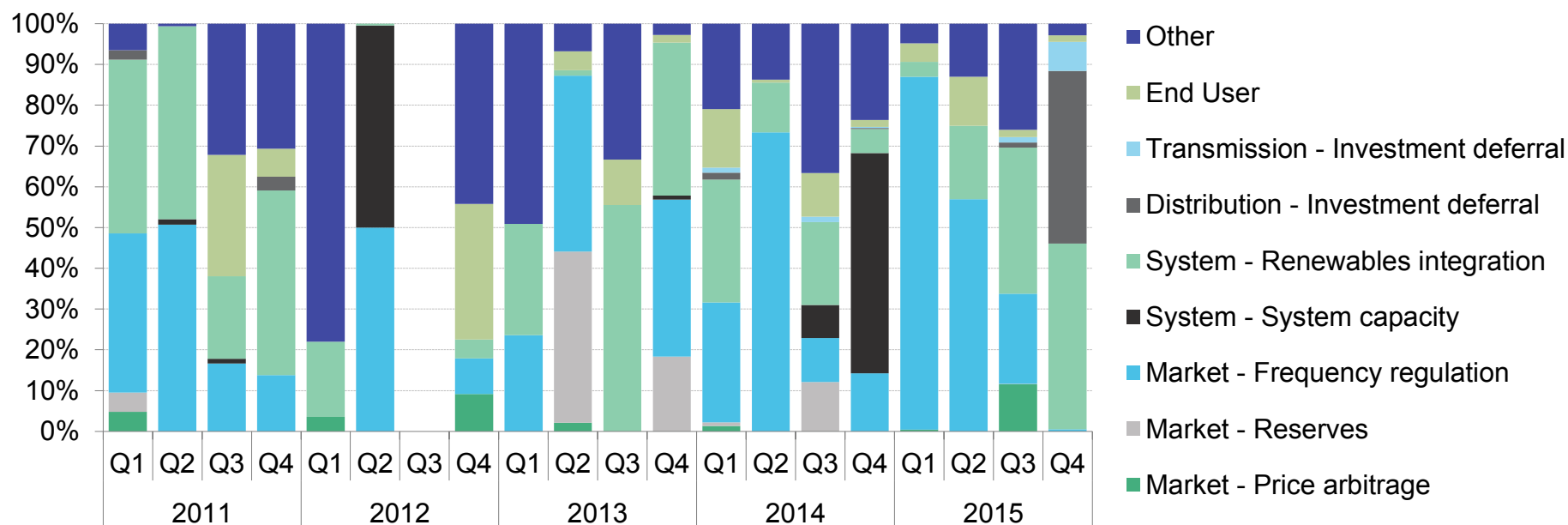
Commissioned



- 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 2014-15.
- Most activity is policy-driven. The 2009 American Recovery and Reinvestment Act (ARRA) funded the majority of projects commissioned between 2011 and 2014. Utilities solicited for over 350MW of storage in 2014 due to California's 1.3GW California energy storage mandate for 2015-2020.
- There is also over 170MW of energy storage providing frequency regulation in the PJM RegD market. Frequency regulation looks like an attractive near-term opportunity for storage developers in PJM and other US territories.

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.

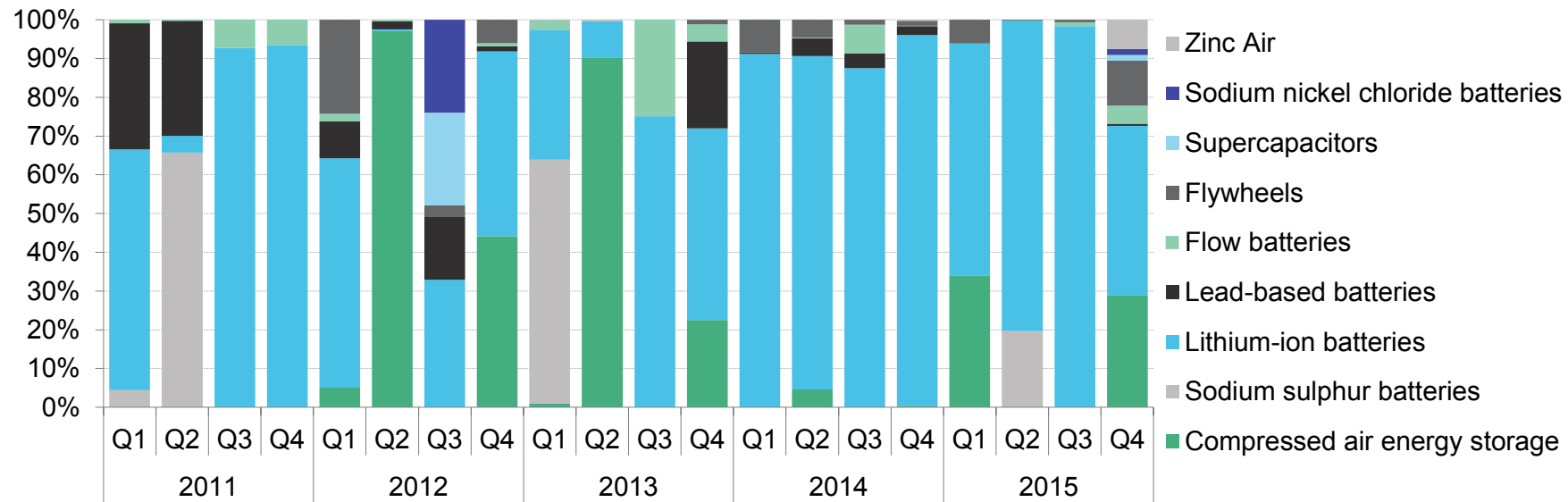
Deployment: Mix of *applications* for US non-hydropower energy storage for announced projects (% by MW)



- Key applications include frequency regulation in PJM, renewable energy integration and behind-the-meter demand charge management at commercial and industrial end-user facilities.
 - Stem, Green Charge Networks, Demand Energy, and others are continuing to deploy behind-the-meter storage for commercial customers in California, Hawaii, and New York for peak demand shaving. Stem used aggregated customer storage systems to successfully bid into CAISO's real-time market. This came through PG&E's supply-side pilot. Stem is also using aggregated storage to provide grid services for Southern California Edison.
 - In 2015, Invenergy commissioned Grand Ridge in Illinois and Beech Ridge in West Virginia, two 31.5MW BYD lithium-ion battery storage systems for frequency regulation in PJM.
- In September, Kaua'i Island Utility Cooperative and SolarCity applied for regulatory approval for a 20-year PPA. This would be the first combined PV and storage PPA in the US.
- RES and Prudential Capital Group are applying non-recourse financing to energy storage. The firms closed financing for two 19.8MW/7.8MWh storage facilities in October—the Elwood and Jake Energy Storage Centers in Chicago.

Source: Bloomberg New Energy Finance Notes: Pumped hydropower storage is not included in this chart as it would dwarf all other technologies. Empty columns represent quarters with no new project announcements. '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.

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

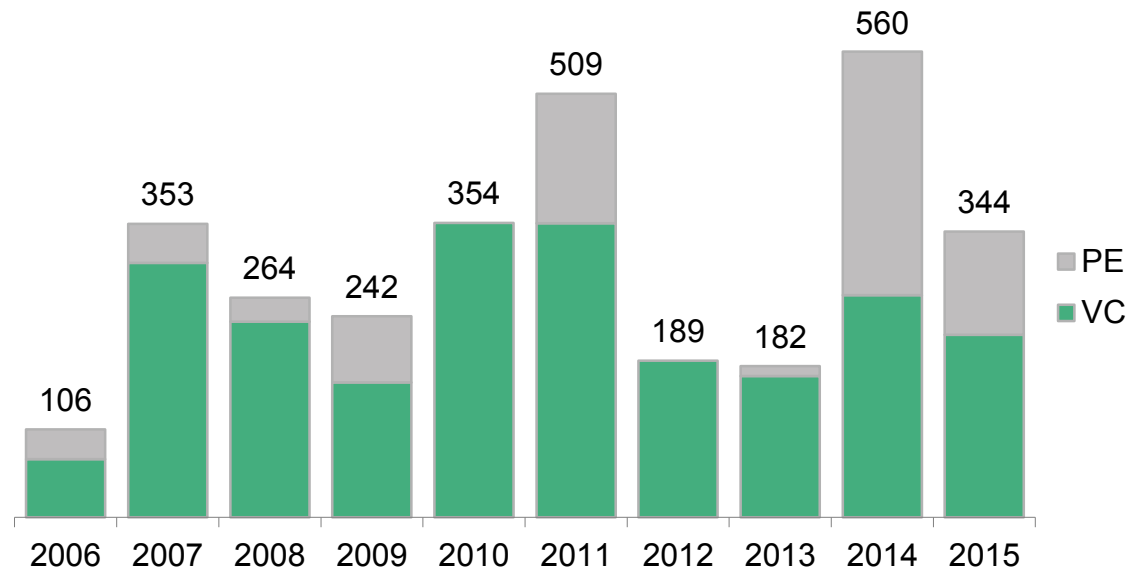


- The lithium-ion battery has been the technology of choice by project developers for projects of all sizes, because:
 - It is widely available and mass produced all over the world;
 - It can provide high power for short-duration applications (eg frequency regulation) and up to four hours of energy capacity 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 perceived risk of smaller emerging companies. In 2014, two prominent pure-play companies (Xtreme Power, A123 System) filed for Chapter 11.
- New technologies have been tested in pilot projects supported by government stimulus funding but were announced before 2011 and are not on this chart.
- Additional new technologies are in the works, but start-ups pursuing these are only in early-stage commercial development.

Source: Bloomberg New Energy Finance

Notes: Pumped hydropower storage is not included in this chart as it would dwarf all other technologies. Empty columns represent quarters in which there were no new projects announced.

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



- There has been over \$3bn invested by VC/PEs in US energy storage companies since 2006, including \$344m in 2015 according to latest available data.
- The top three disclosed investments for stationary storage in 2015 were
 - \$58m for Vionx Energy and \$25m for UniEnergy Technologies, both vanadium redox flow battery providers;
 - \$33m for Stem, an energy storage and energy management company focused on behind-the-meter energy storage. The company raised nearly \$60m throughout 2015 over multiple funding rounds; and
 - \$23m for Primus Power, a zinc flow battery provider.
- There was renewed interest in alternative battery technologies to lithium-ion throughout 2015, despite some notable setbacks for companies such as Enervault and Ambri. Energy storage software providers and management companies also secured considerable funding over the same period, which underlined their growing importance. In this field, Stem was joined by Greensmith Energy Management and Advanced Microgrid Solutions.

Source: Bloomberg New Energy Finance

Notes: Values include estimates for undisclosed deals.

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4. Large-scale renewable electricity and CCS

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5.6 Energy storage

6. Demand-side energy efficiency

6.1 Energy efficiency

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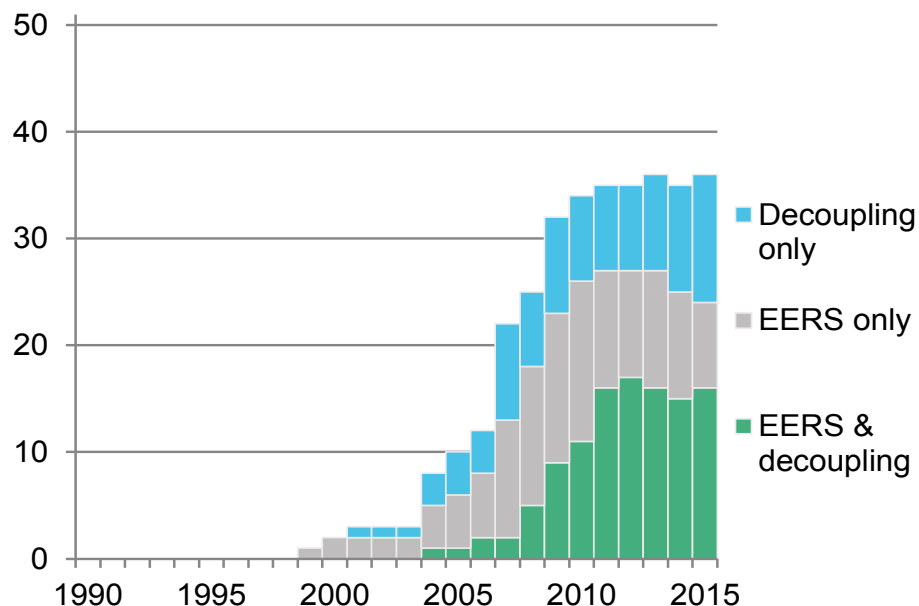
8. Themes

8.1 EPA Clean Power Plan

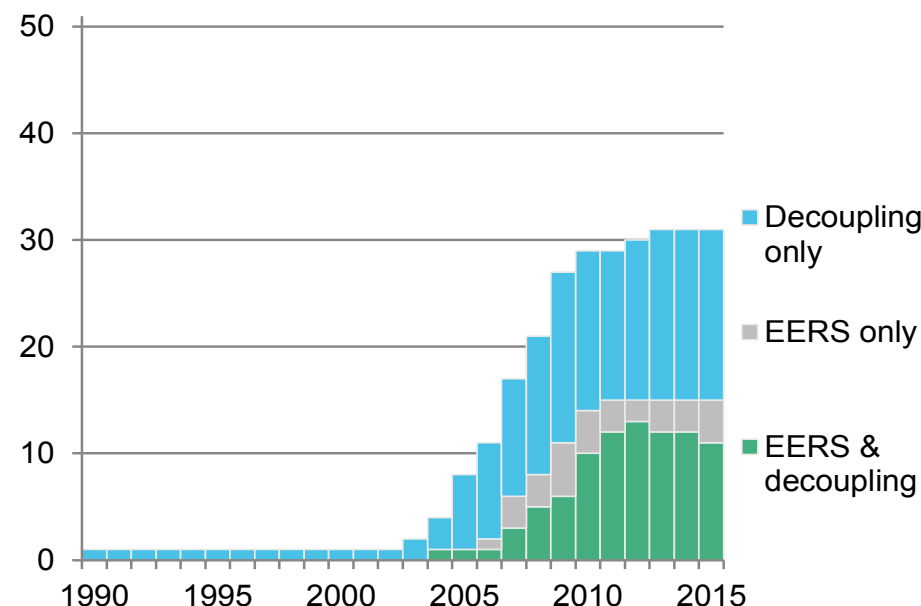
8.2 Global context

Policy: US states with EERS and decoupling legislation for electricity and natural gas, 2015 (number of states)

Electricity



Natural Gas

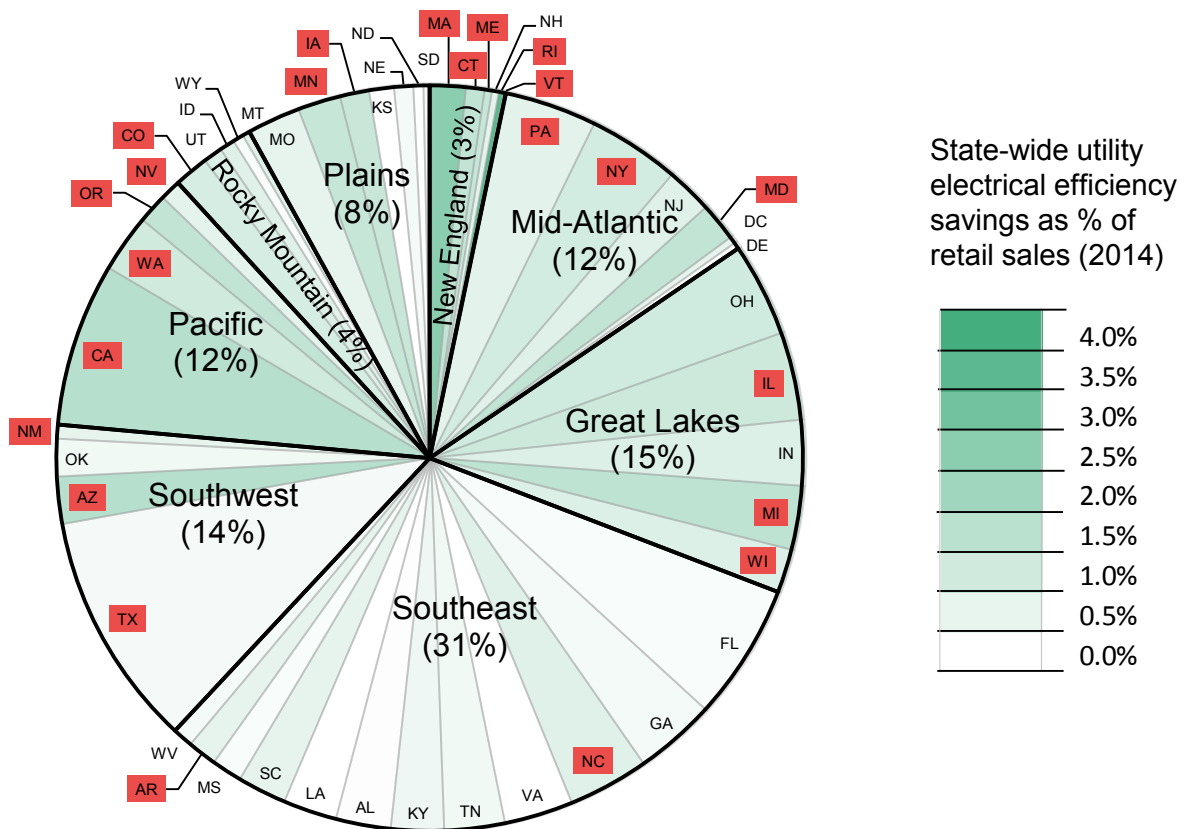


- The key policy story of the past decade has been the uptake of EERS targets and decoupling legislation among US states. However, momentum has slowed since 2010.
- Florida and Indiana removed their EERS schemes in 2014. In 2015, the “freeze” on the Ohio electricity EERS came into effect – this allows utilities that have achieved certain levels of savings to remove their efficiency programs.
- Louisiana, Washington and Minnesota added decoupling policies for electricity in 2015 (the latter two states already had gas decoupling legislation). Meanwhile, similar policies in Wisconsin drew to a close.
- Delaware, Utah and New Hampshire are working towards adopting EERS policies and electricity decoupling is planned for Colorado, Mississippi, Missouri, Nevada and New Mexico.

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, 2014 (%)

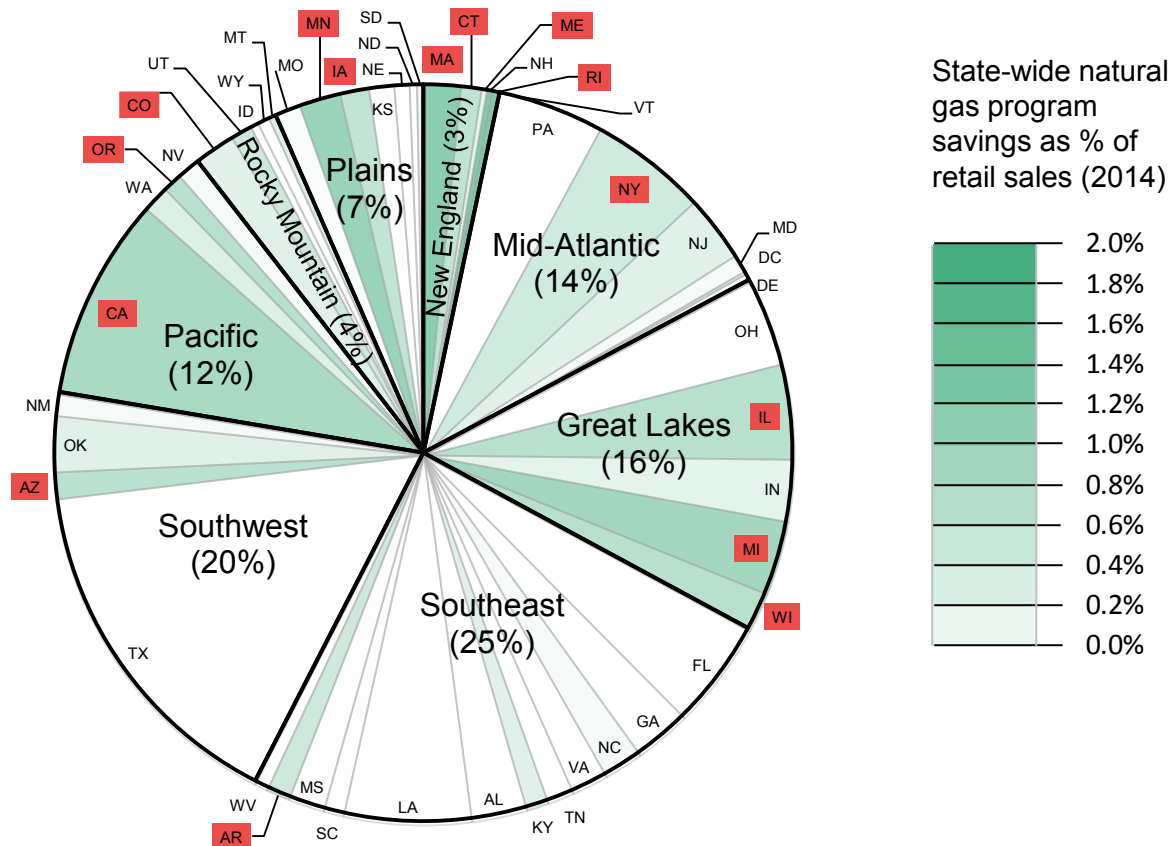


- As in previous years, the states with the greatest energy savings as a share of retail sales are in New England, Pacific, Mid-Atlantic and Great Lakes regions, due to their adoption of EERS legislation.
- Rhode Island extended its tenure as the state with the highest proportion of electrical efficiency savings as a percentage of retail sales, followed again by Massachusetts.
- The Southeast remains an untapped market for energy efficiency with great potential for further development. No new policy changes were reported there for 2015.

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, 2014 (%)

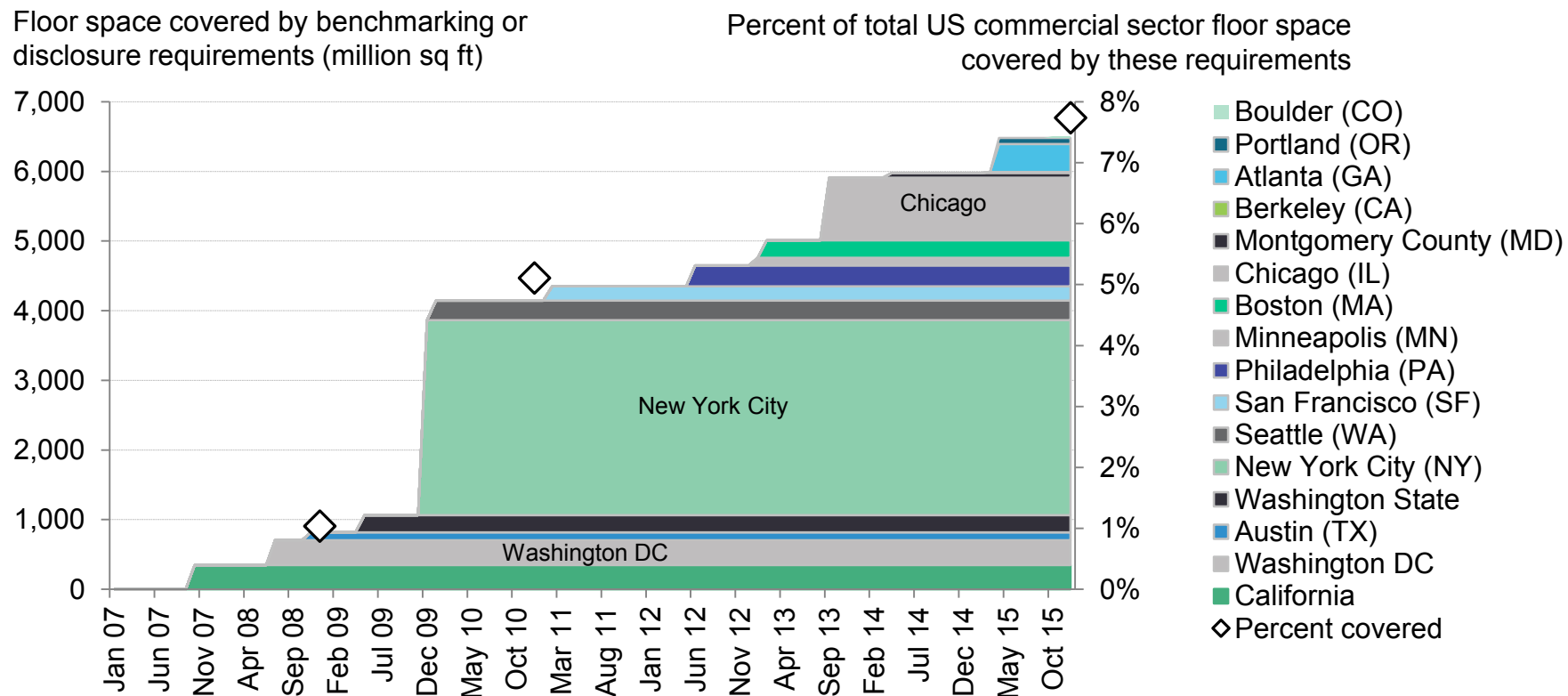


- The Southeast, Southwest and Texas are important areas for potential natural gas as well as electricity savings.
- Generally, energy savings measured as a share of consumption is lower for natural gas than for electricity, as utilities budget less for natural gas savings initiatives than for electricity ones.

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.

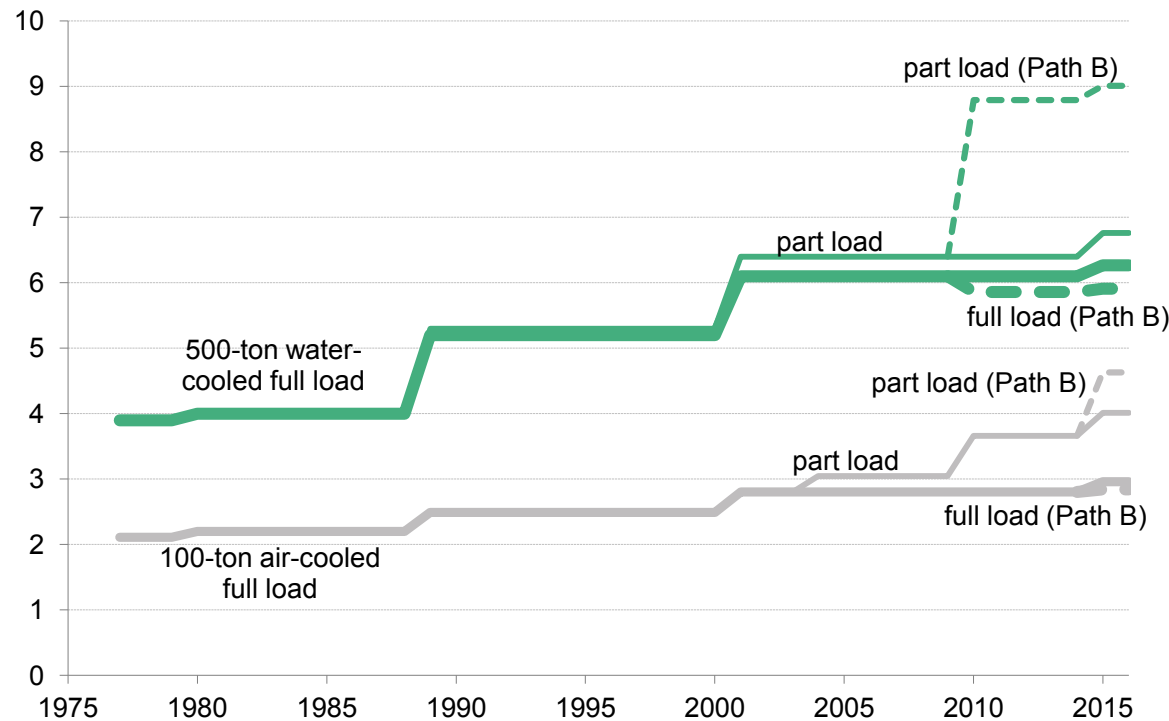
Policy: US building floor space covered under state or local building energy use benchmarking / disclosure policies



- 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 2015, 6.5bn square feet of commercial floor space, or around 7.7% of total US commercial sector floor space, was covered by such policies. This represents an 8% uptick over the 2014 tally.
- In 2015, California passed a law to increase building energy efficiency 50% by 2030 for both residential and non-residential properties. The state also enacted a law to require benchmarking and disclosure for most commercial and multi-family buildings.

Source: Institute for Market Transformation (IMT), US DOE's Buildings Energy Data Book, Bloomberg New Energy Finance Notes: Cambridge is not shown in the chart, as the square footage numbers for the city are still being tallied. 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.

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



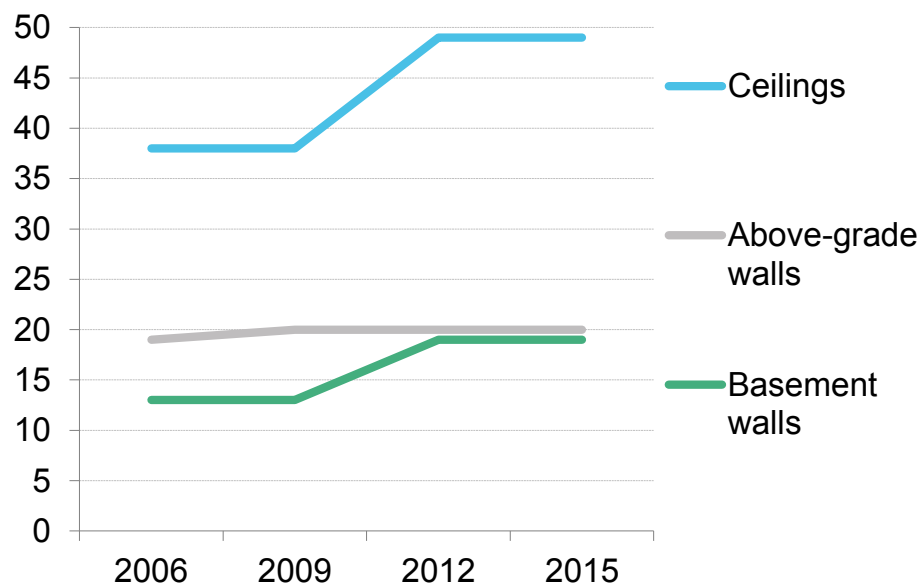
- Performance standards help to drive improvements in appliance efficiency. This chart shows how the standards for chillers have evolved since the late 1970s in terms of “coefficient of performance.”
- The standards have not only come to require greater efficiency, but have also become more nuanced. 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

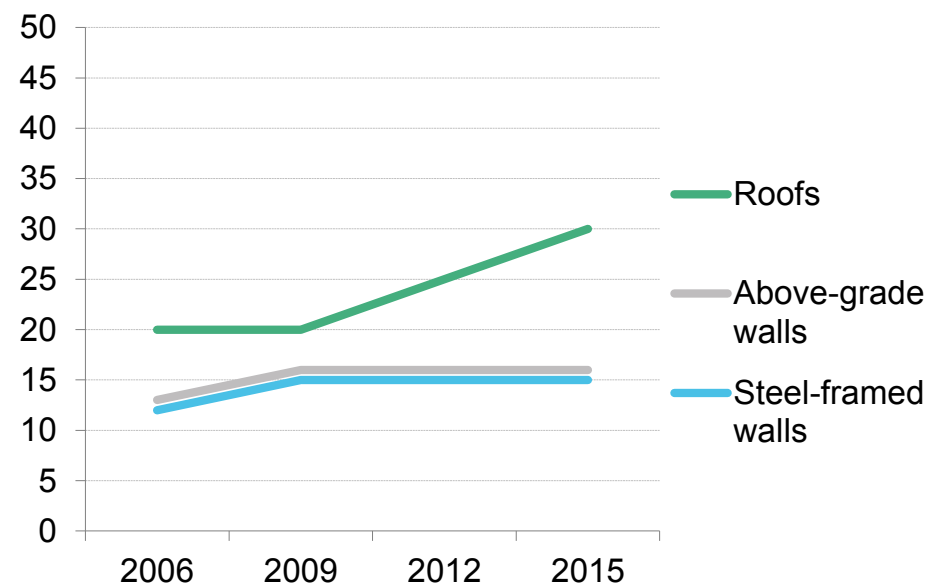
Notes: ASHRAE is the American Society of Heating, Refrigerating and Air Conditioning Engineers. The standard shown in the chart is part of Standard 90.1, which dictates minimum requirements for energy efficient designs for buildings. The standard is on “continuous maintenance,” allowing it to be updated 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.

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

Residential buildings



Commercial buildings

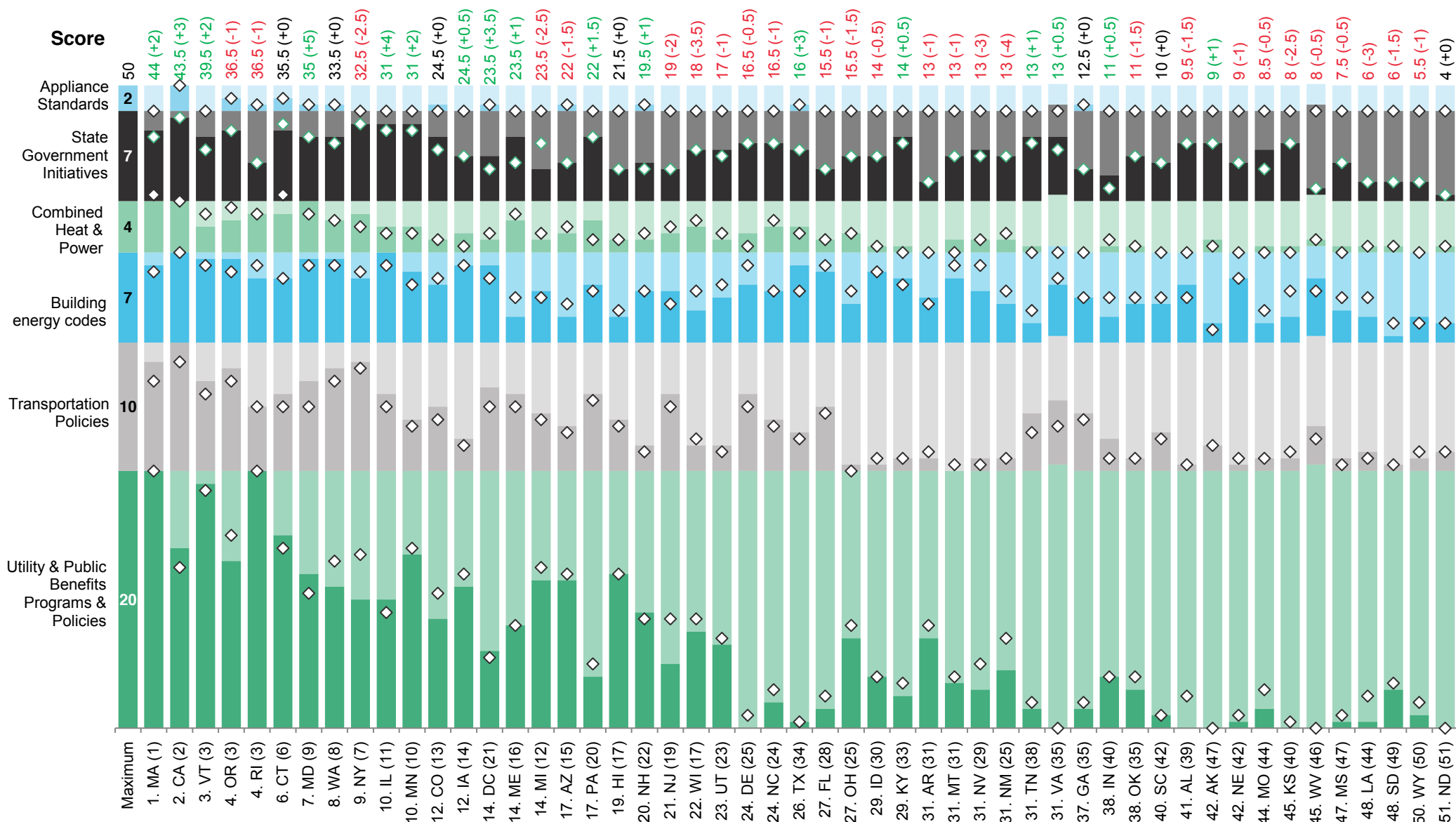


- New buildings face increasingly stringent insulation requirements.
- There is also a growing effort to improve the energy efficiency of existing buildings. ICC and ASHRAE now require insulation upgrades during the replacement of existing roofs. Due to the size of the market for “re-roofing,” this new focus on existing buildings may impact building energy use more quickly than changes to new construction requirements.
- In 2015, 10 states adopted stricter residential and commercial building codes, including Maryland, Texas, California and New Jersey.

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.

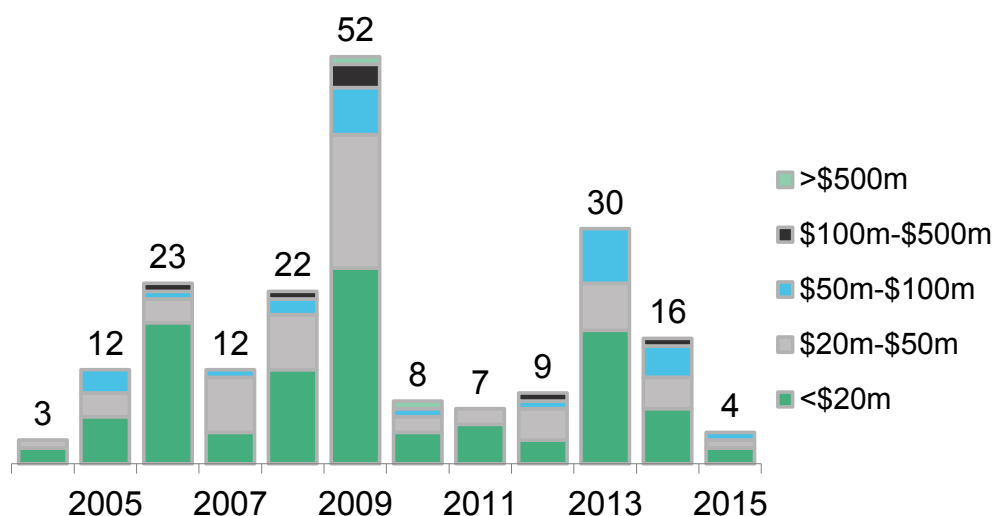
Policy: ACEEE state-by-state scorecard for energy efficiency policies, 2015



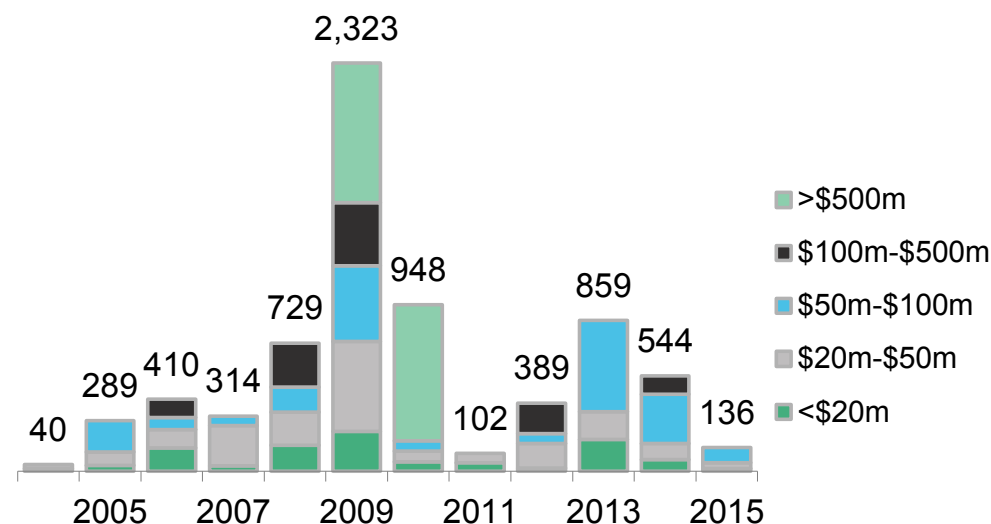
Source: ACEEE, EIA, Bloomberg New Energy Finance Notes: Numbers in parentheses at the bottom of the chart indicate 2015 ranking. Numbers in parenthesis at the top denote the change in score from 2014 levels. Diamond symbols indicate 2014 score within each category.

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)

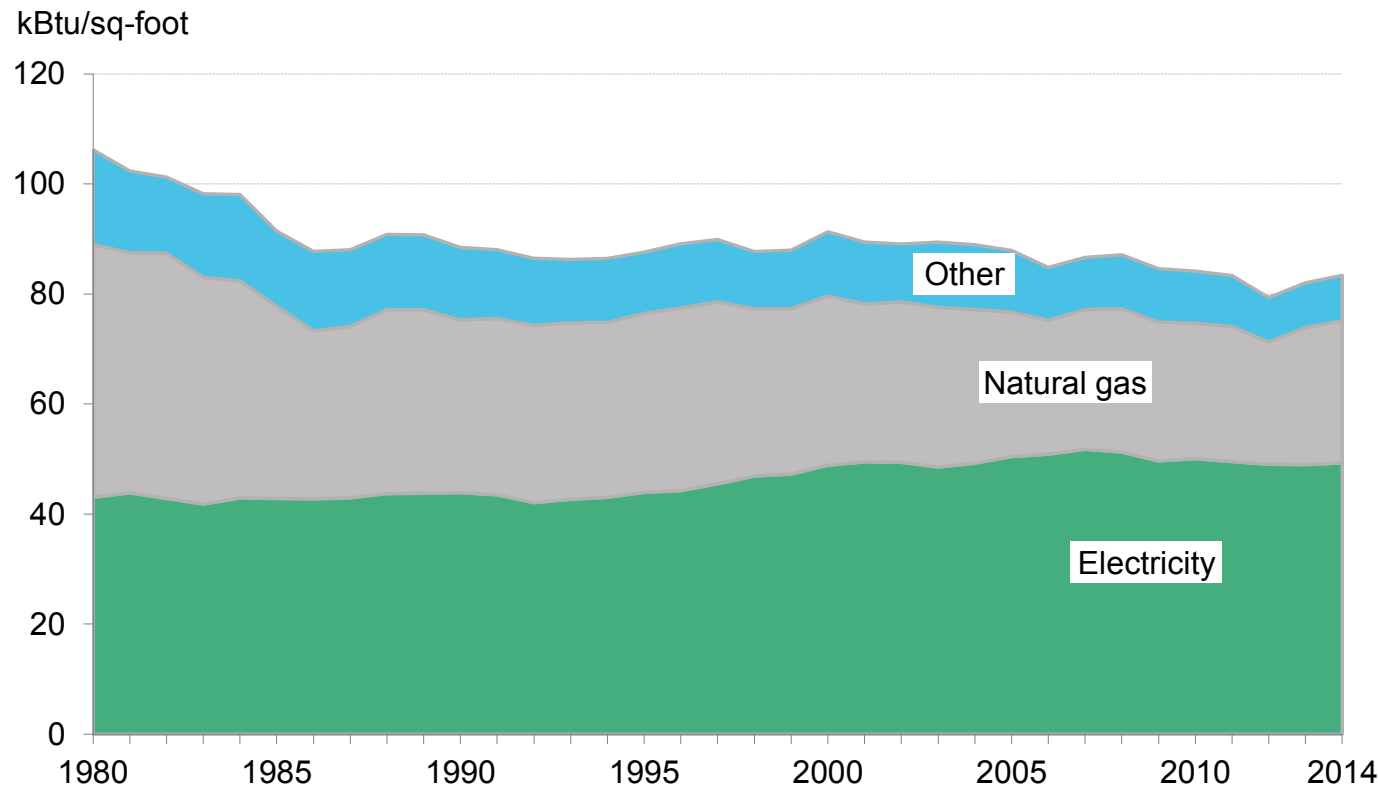


- Energy savings performance contracts (ESPCs) at federal facilities can showcase to other sectors the benefits of energy savings for financing energy upgrades.
- In March 2015 President Obama issued the Executive Order 'Planning for Federal Sustainability in the Next Decade,' which aims to reduce emissions from federal buildings by at least 40% over the next decade. It also re-stated the President's goal of completing \$4bn in federal performance-based contracts by the end of 2016.
- 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.

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

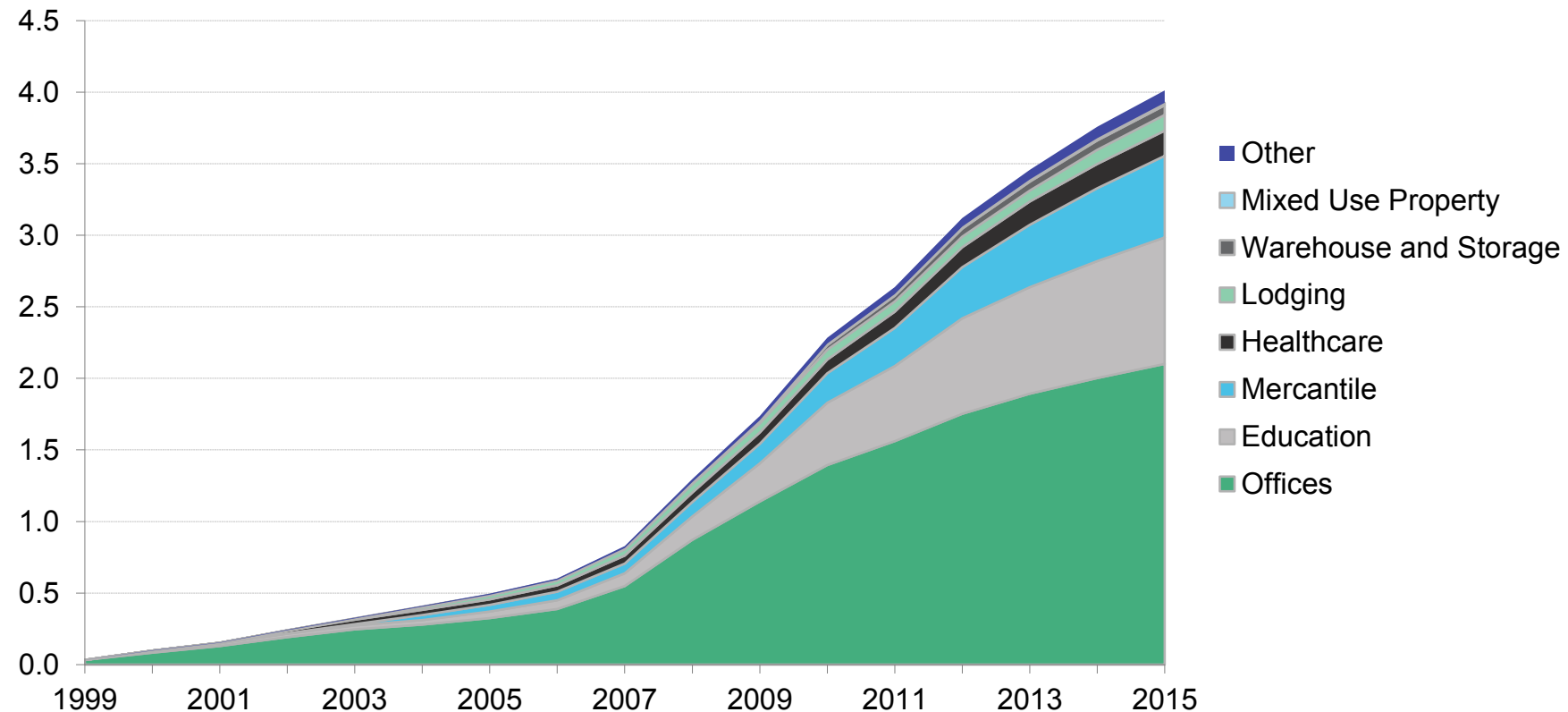


- The figures here are based on EIA data for overall consumption of the commercial sector; the latest information on total commercial floor space; and other estimates on the consumption profile of the commercial sector based on previous editions of the Commercial Buildings Energy Consumption Survey (CBECS).
- Estimates suggest a slight increase in efficiency (slight decrease in energy intensity) between 2010 and 2014, the latest year for which data is available.

Source: EIA, Bloomberg New Energy Finance

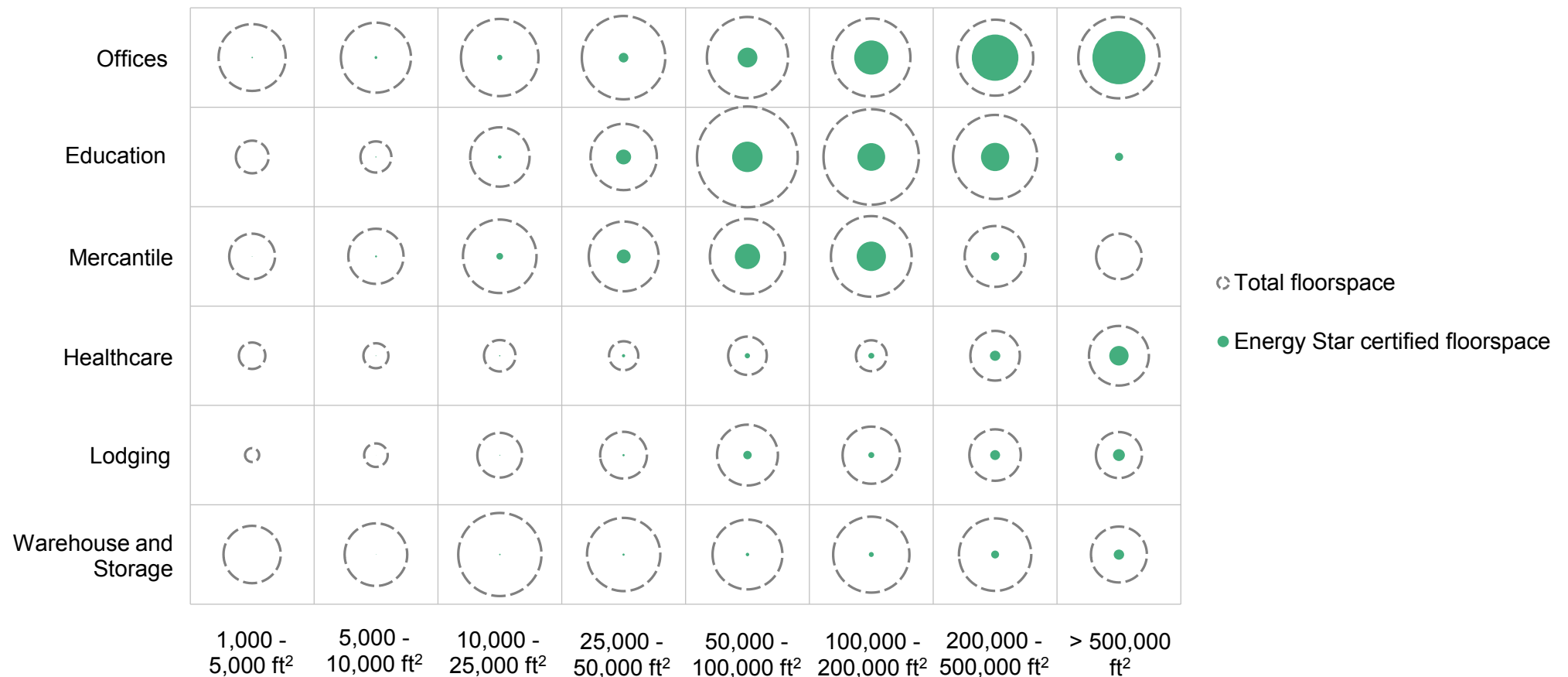
Notes: This analysis is based on (i) EIA data on US commercial building energy consumption and floor space for the years 1979, 1983, 1986, 1989, 1992, 1995, 1999, 2003 and (ii) EIA data for total US commercial sector energy consumption for every year between 1979-2013.

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



- The number of buildings certified has grown almost fivefold since 2006, despite a slow down in growth rates across all sectors since 2012.
- The office segment has consistently topped the list in terms of certified floor space. However, other sectors have been playing catch-up, and the office segment's share of total certified floor space fell to a low of 52% in 2015.
- The education and mercantile segments continued to account for 22% and 14% of all certified floor space, respectively.

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

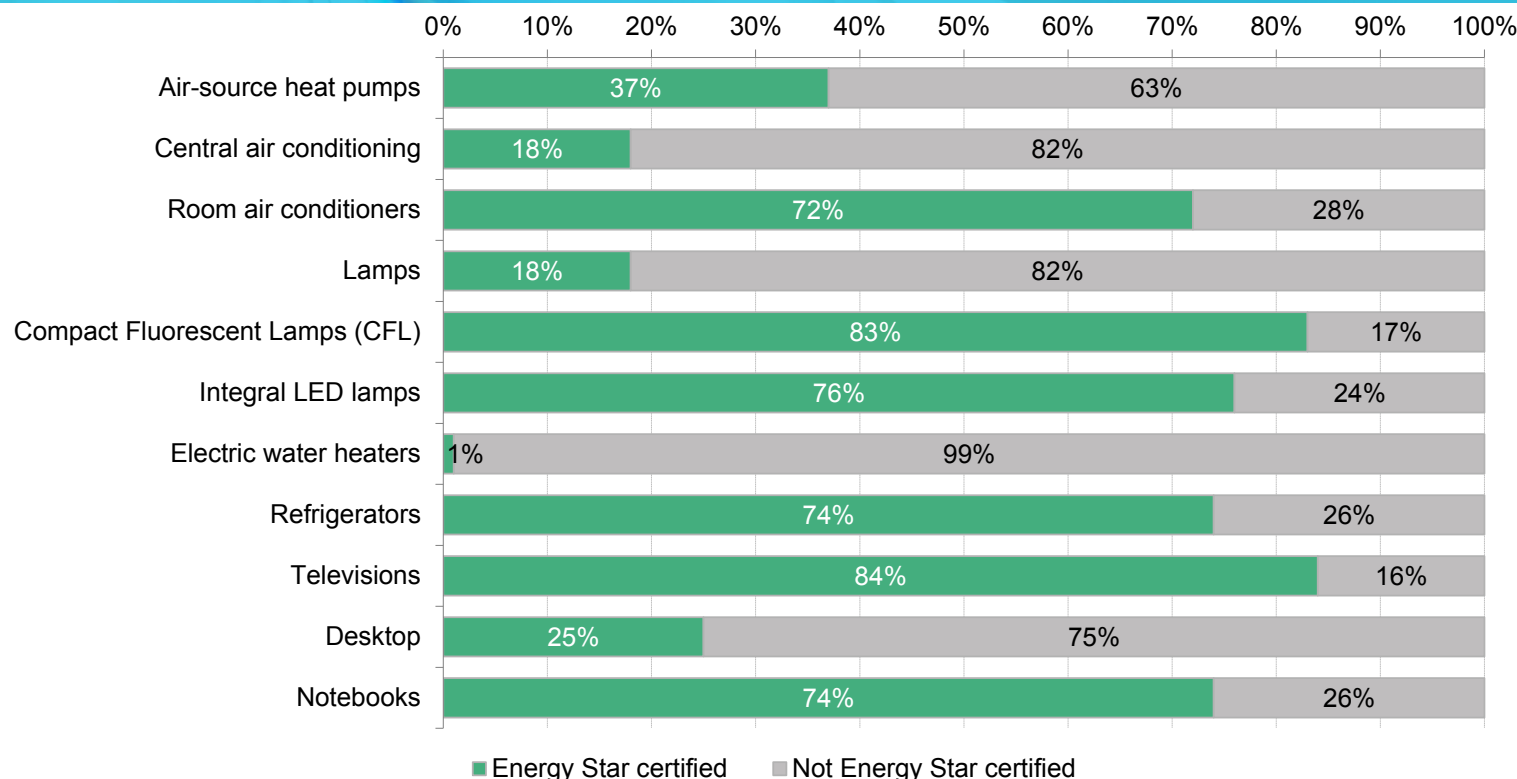


- In 2015, offices in excess of 500,000ft² emerged as the category with the highest proportion of certified space. While the office sector has traditionally had the greatest proportion of certified floor space, this shift toward the largest offices is new.
- Buildings in the education and mercantile sectors continue to see high certification rates in the 50,000 – 500,000ft² range.
- There is little activity outside of these segments and virtually no buildings smaller than 50,000ft² have been certified.

Source: EPA, EIA, Bloomberg New Energy Finance

Notes: There is insufficient data for total US floor space of educational buildings in excess of 500,000ft².

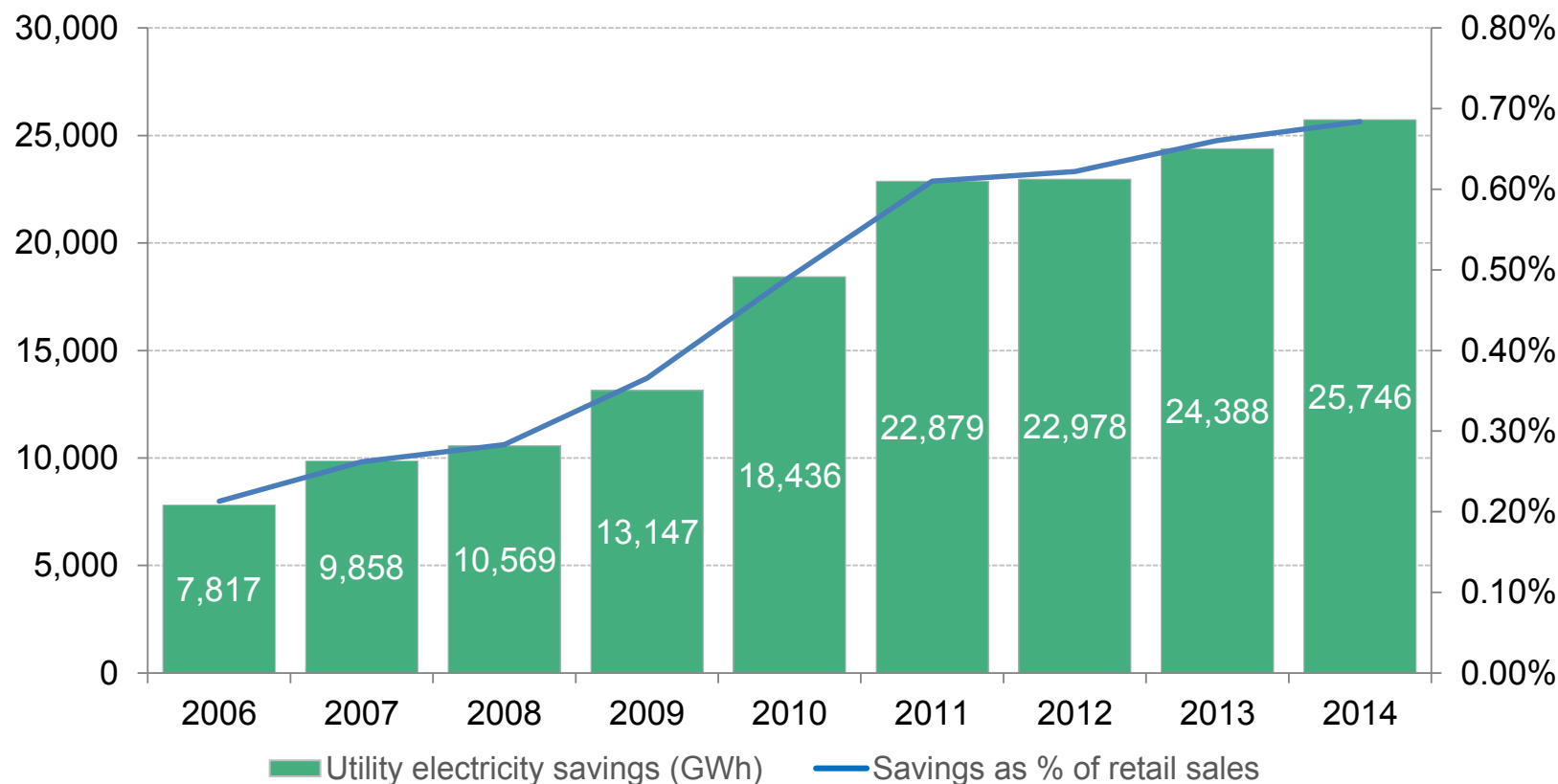
Deployment: Percent of Energy Star-certified products sold by product type, 2013



- Refrigerators, televisions and notebooks have some of the highest Energy Star certification rates. 74% of refrigerators sold in 2013 were certified. 84% of all television sales in the US that year (32.9 million sets) were certified. 74% of notebooks sold in 2013 were also certified (compared to only 25% of desktop computers).
- Energy star certification rates in the space heating category varies depending on the heating method. Only 18% of central air conditioning and 37% of air-source heat pumps sold were certified, compared to 72% for room air conditioning. Space cooling and heating represents 23% of total household electricity consumption.
- The majority of LED and CFL lamps sold in 2013 were Energy Star-certified, but out of the whole lamps market, these only represent 18% of all lamps sold. Lighting accounts for 11% of household electricity consumption.

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.

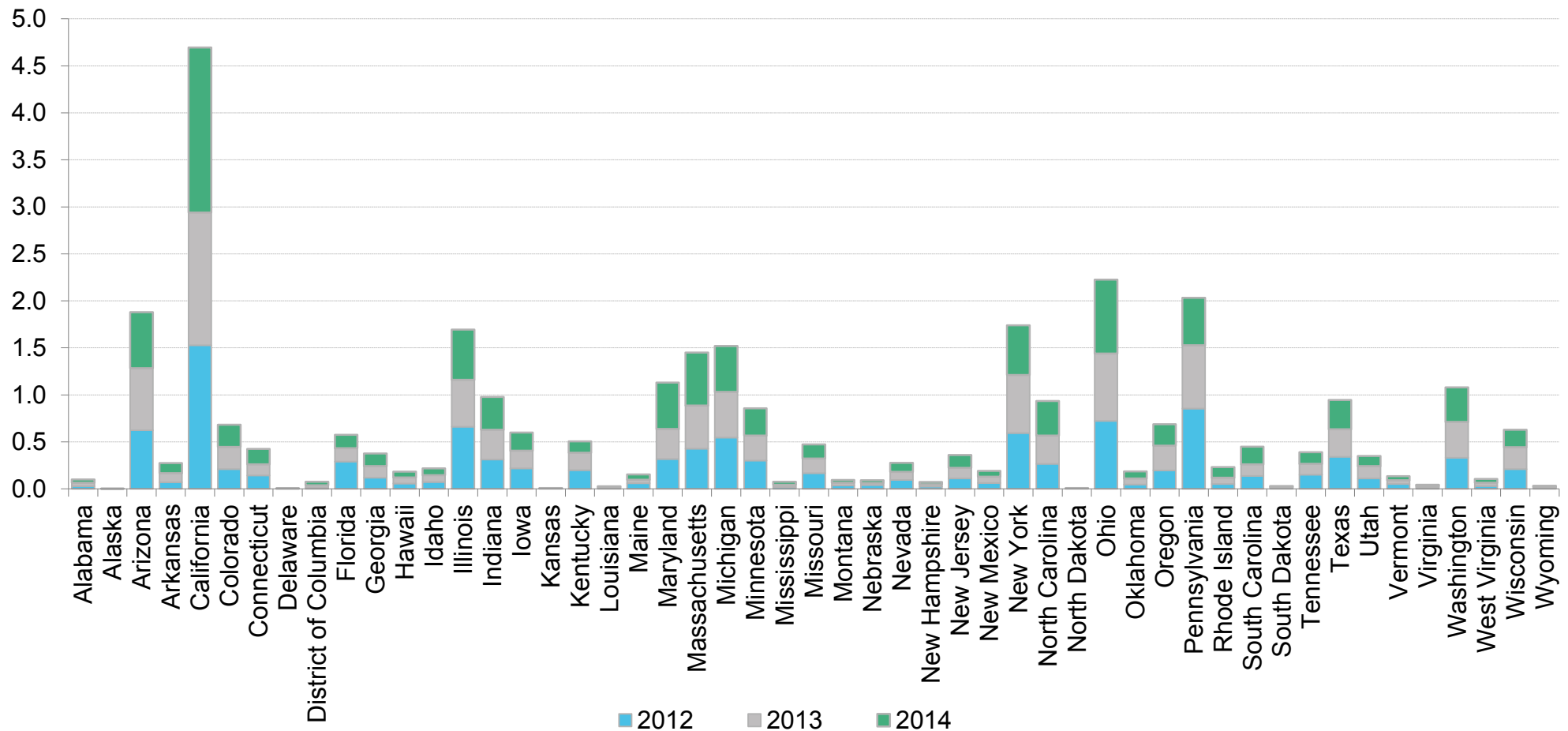
Deployment: Incremental annual energy efficiency achievements by electric utilities to date (GWh)



- Incremental achievements from energy efficiency programs managed by utilities have averaged a 17% year-on-year growth rate between 2006 and 2014.
- Between 2013 and 2014, savings ticked up by 6%. Utilities realized a record 25.7TWh of incremental annual savings in 2014, equivalent to 0.7% of total retail sales in the US.
- States with the highest incremental savings as a percentage of total retail sales in 2014 were Rhode Island (3.51%), Massachusetts (2.5%), Vermont (1.85%) and California (1.58%).
- Massachusetts' Green Communities Act of 2008 committed the state to energy efficiency.

Source: ACEEE Note: ACEEE historical achievement data substituted 2014 savings with 2013 where data was not yet available at the time of the publication of the 2015 ACEEE State Energy Efficiency Scorecard. The Scorecard points to caveats in the energy efficiency savings data reported by states. ACEEE uses a standard factor of 0.9 to convert gross savings to net savings for those states that report in gross rather than net terms.

Deployment: GHG savings as a result of energy efficiency achievements by electric utilities to date, 2012-14 (MtCO₂e)



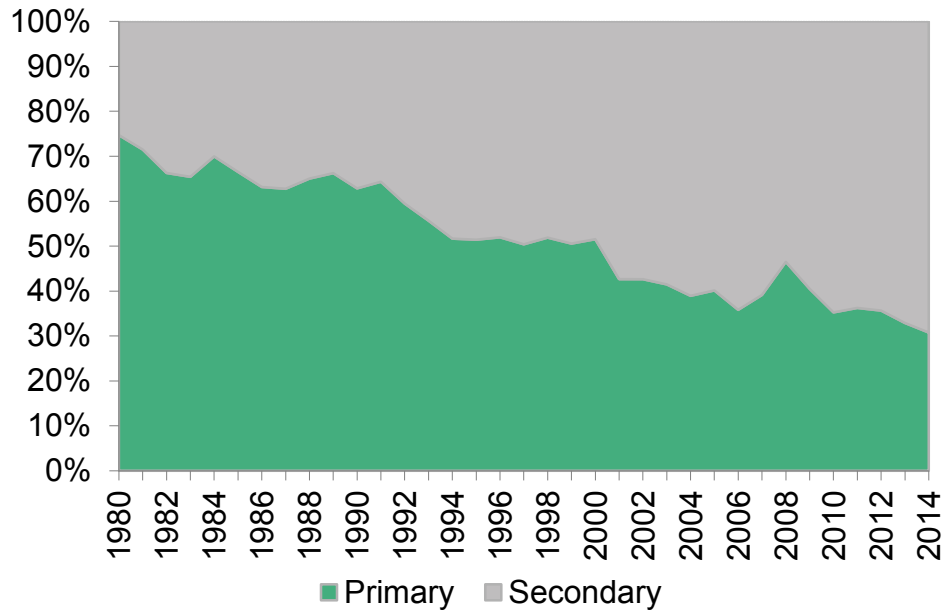
- Electric utility energy efficiency programs saved a total of 32MtCO₂e in greenhouse gas emissions from 2012 to 2014. Nearly 15% of the savings were due to efforts made in California.
- Ohio, Pennsylvania and Arizona are the next largest savers, followed by Illinois and Michigan.

Source: Bloomberg New Energy Finance, ACEEE

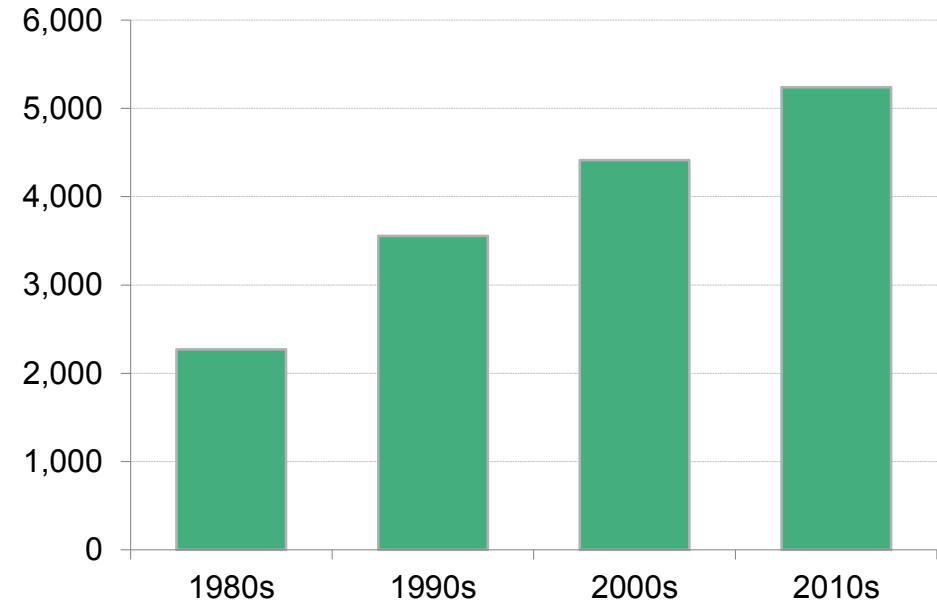
Note: Uses ACEEE data on electric efficiency program savings and Bloomberg Terminal data on historical emissions factors. Emissions factors are calculated assuming that the displaced consumption would have been generated by the marginal natural gas combined-cycle unit; data on historical power and natural 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)



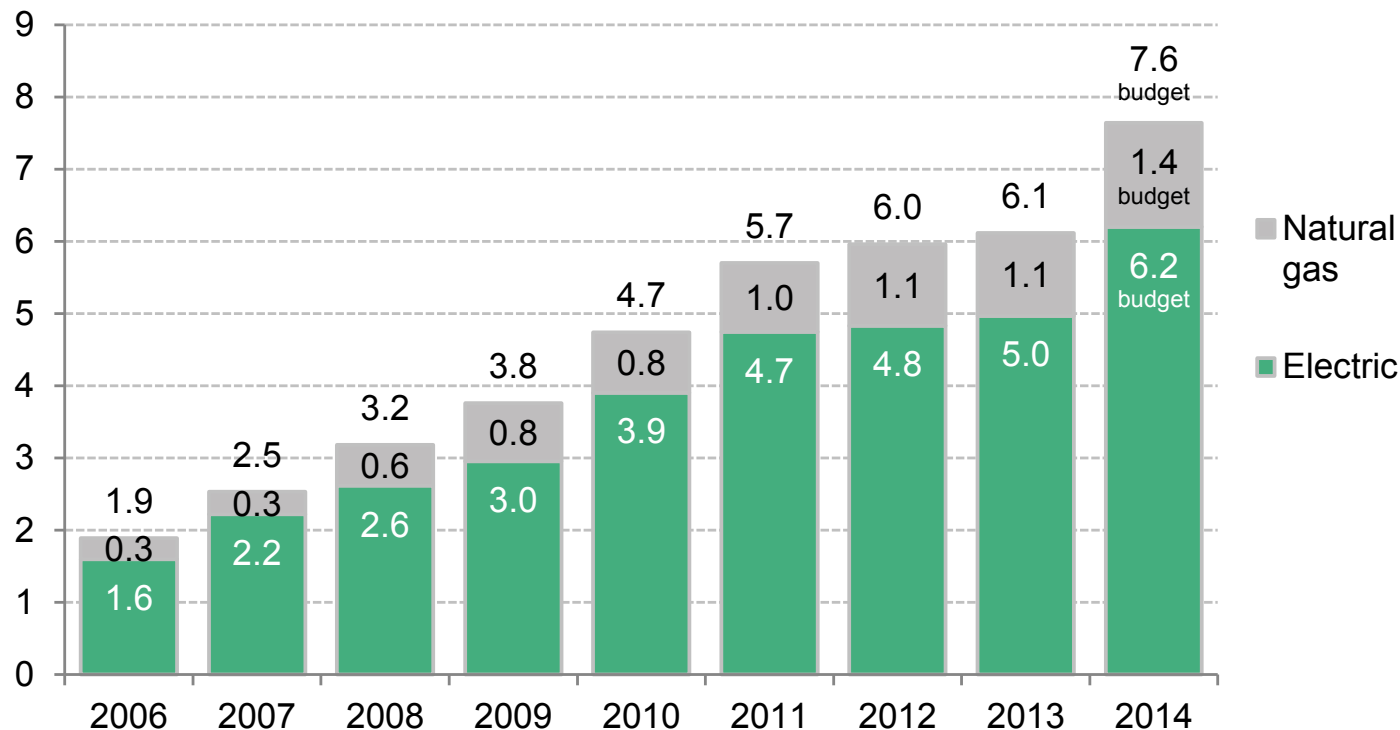
- Because producing aluminum from secondary sources (ie, recycled post-consumer and industrial scrap) consumes significantly less energy than making new aluminum, the industry provides insights into industrial sector adoption of energy efficiency.
- The share of aluminum pulled from secondary sources increased to 69% in 2014 from 67% in 2013 and 48% in 2000.
- Scrap recycling shot up 19% between the previous and 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 40% of US demand.

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

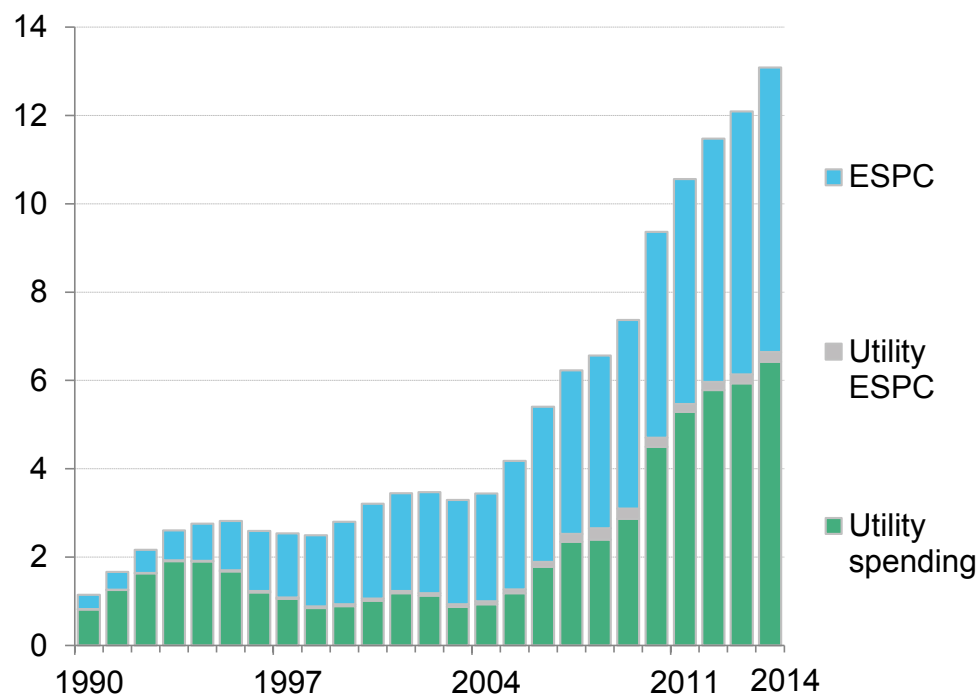
Financing: US utility energy efficiency spending and budgets (\$bn)



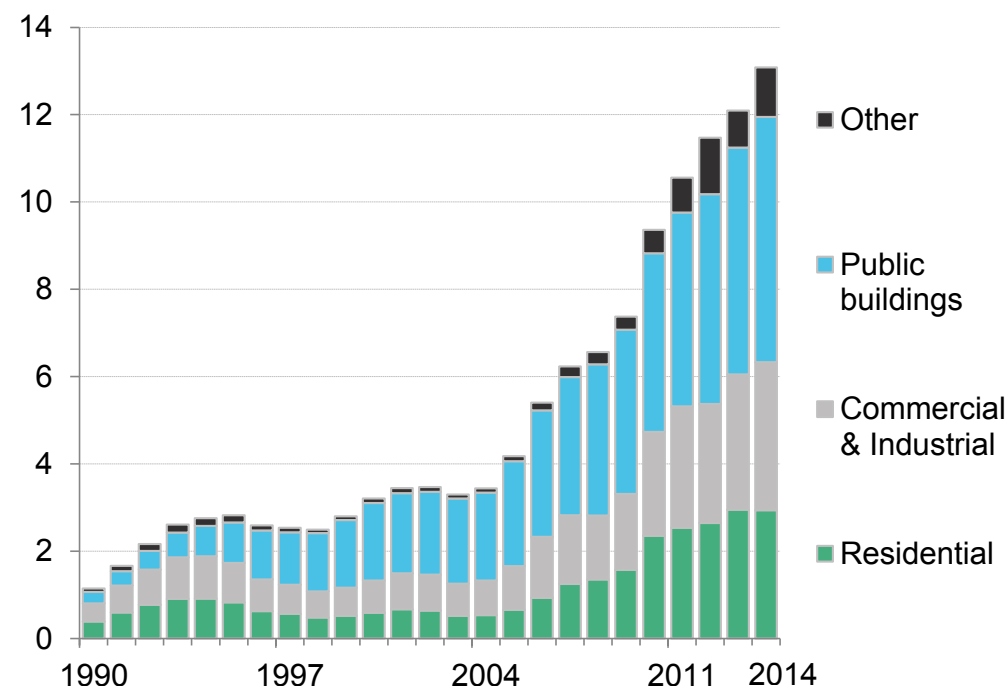
- From 2006 to 2011, US utility expenditure for energy efficiency grew 25% per year. Between 2011 and 2013, as the uptake of state-level policies slowed, expenditure growth also decelerated, falling to 5% between 2011 and 2012 and 2% between 2012 and 2013.
- If the spending were fully realized, the budgeted amount for 2014 would represent a 25% jump from 2013 levels.
- Budgets in Maryland grew from \$119m in 2013 to \$292m in 2014, the largest upswing of any state.
- In December 2015, the US Congress renewed the energy-efficient commercial buildings tax deduction and non-business (ie, residential) Energy-Efficient Property Credit that retroactively reinstates tax credits for projects completed in 2015 and 2016. These had previously expired at the end of 2014 and are now expiring at the end of 2016. Energy efficiency companies will actively seek to benefit from these in 2016.

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

By framework



By sector



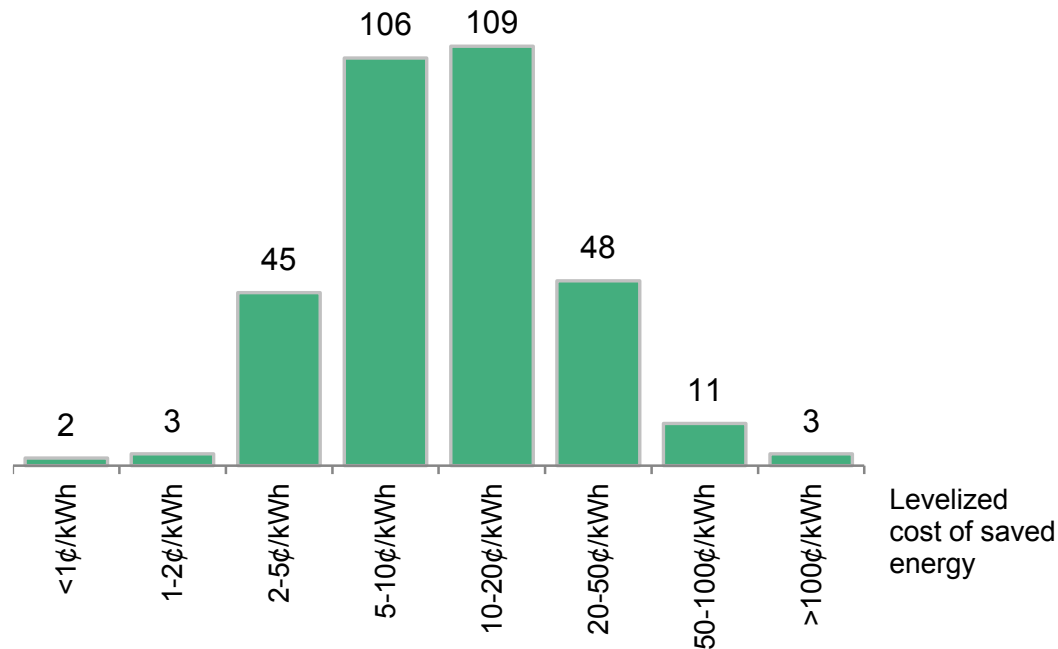
- Utility spending on energy efficiency remains the fastest growing driver of investments in energy efficiency. This is based primarily on state EERS targets and decoupling legislation.
- In 2014, electric and natural gas utilities are estimated to have invested a record \$6.7bn in energy efficiency.
- Utility spending will continue to increase if more states adopt EERS targets in response to the EPA Clean Power Plan.
- Energy savings performance contracts (ESPCs) are mainly focused on public buildings.

Source: ACEEE, NAESCO, LBNL, CEE, IAEE, Bloomberg New Energy Finance

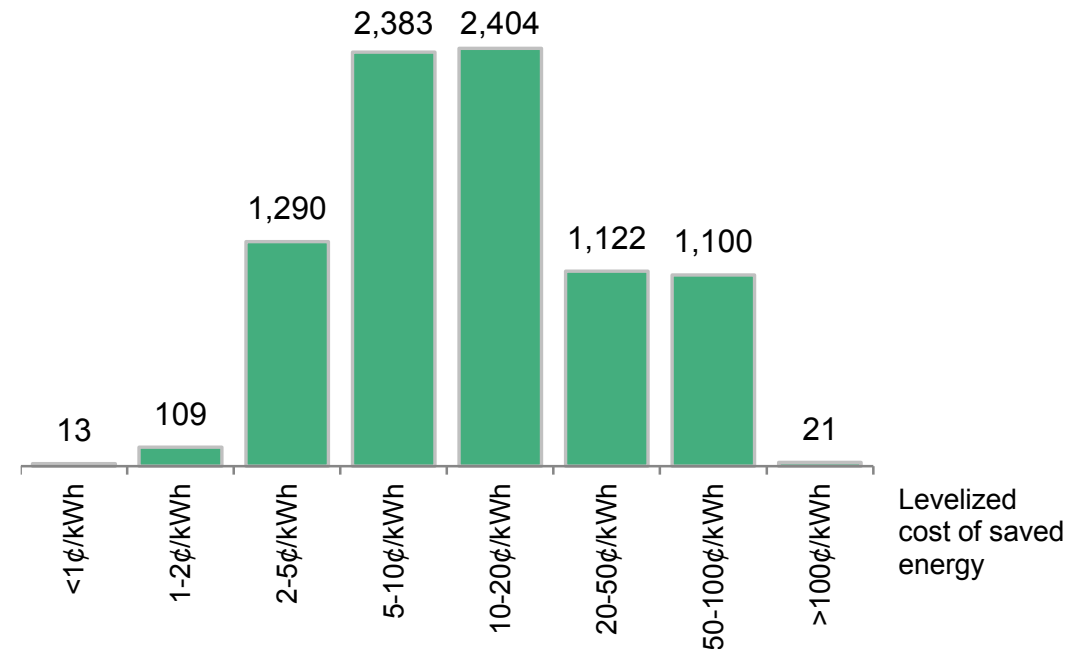
Notes: The values for the 2012-2014 ESPC market size shown here are estimates. The most recent published data from LBNL puts reported revenues at \$5.3bn in 2011. In the same report, the forecast for 2013 was >\$6.5bn. The \$6.2bn estimate for 2013 and the \$6.7bn for 2014 are based on a continuation of 2008-11 growth rates, sitting between the most recently reported data and LBNL's forecast. LBNL will publish an updated report in spring 2016 that will provide more accurate data for the estimated period.

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

Number of ESPCs



Total contract value of the ESPCs (\$m)



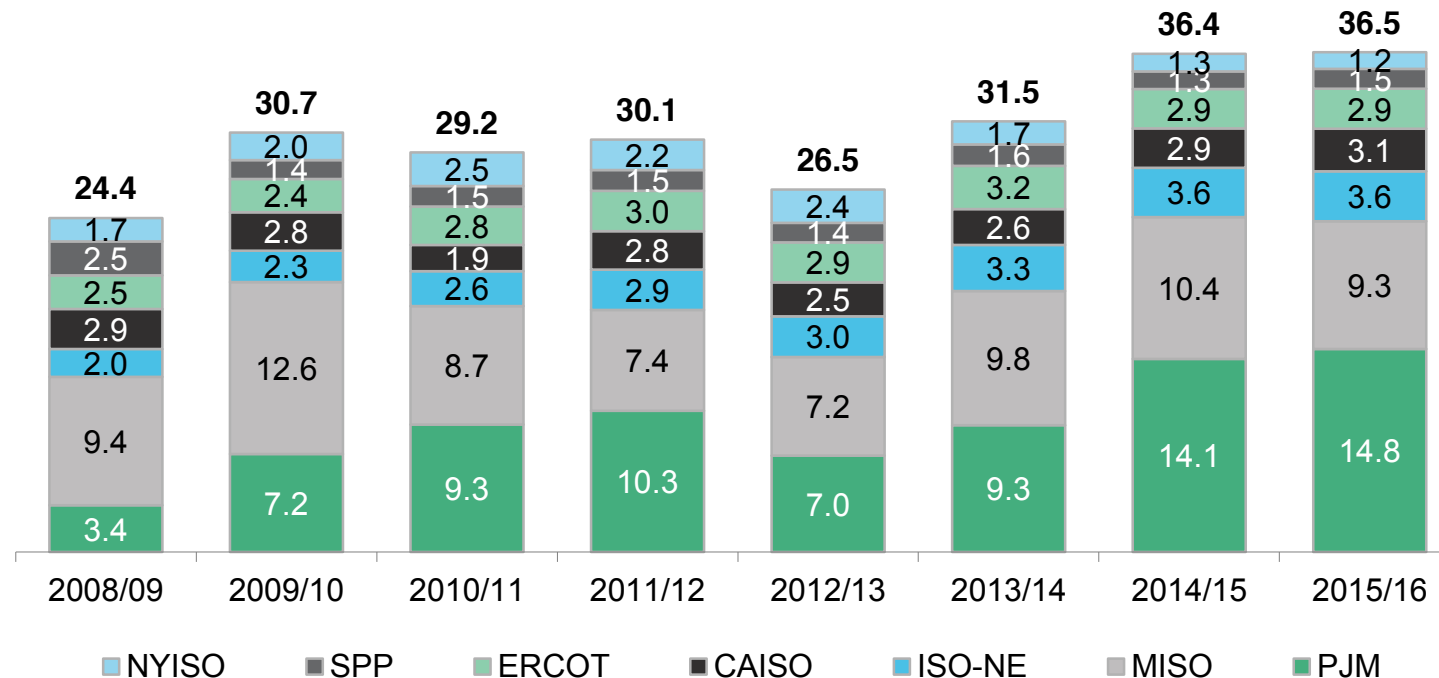
- In most cases, the cost of saved energy were in the range of 5-20¢/kWh.
- The cost of energy saved under energy savings performance contracts (ESPCs) ranges widely, due to factors such as:
 - variation in the type of energy saved;
 - variation in the price of energy saved; or
 - the fact that energy savings are sometimes used as a means of paying for necessary infrastructure improvements (ie, investors do not always seek to maximize the financial returns of the energy savings project itself).

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 by delivery year (GW)



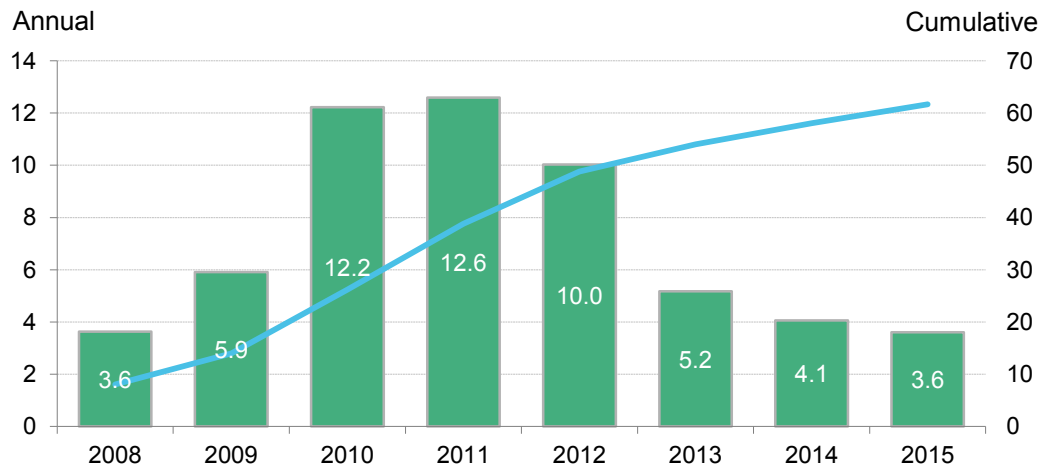
- Most demand response (DR) is found in the PJM capacity market, where it is sold via three-year-ahead auctions.
 - The 14.8GW of PJM DR capacity for the 2015/16 delivery year was sold in a 2012 auction.
 - PJM DR capacity procured in 2015 for delivery year 2018/19 is 11GW (not shown). This drop in capacity from previous years is due to rule changes that made it harder for DR resources to qualify, as well as stricter performance penalties. The changes were introduced after the 2014 polar vortex when many resources were unavailable.
- On 25 January 2016, the US Supreme Court upheld FERC's authority to regulate DR in wholesale energy markets. The decision brings several years of uncertainty to an end for DR players and should allow the market to flourish more broadly.

Source: Bloomberg New Energy Finance, data from various independent system operators (ISOs) and regional transmission organizations (RTOs)

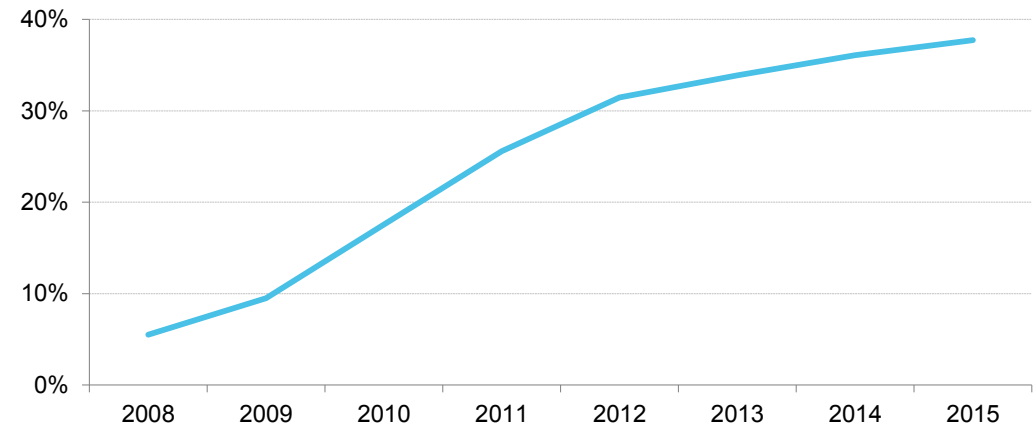
Notes: These figures include demand response activity driven by customer curtailment as well as behind-the-meter generation, because some ISOs do not separate the two demand response sources. This figure does not include residential demand response programs that do not bid into capacity markets. Years shown are "delivery years," which typically run from June to May.

Deployment: US electric smart meter installations

US smart meter installations (million units)



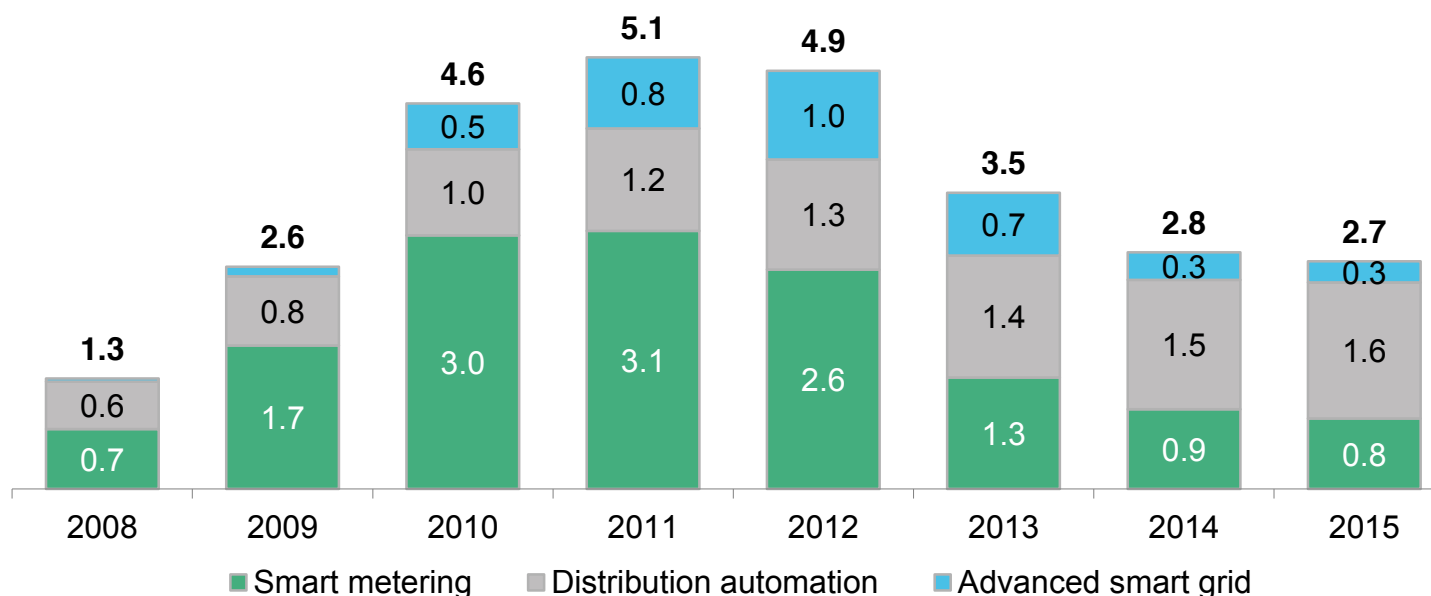
Smart meters deployed as a percentage of US electricity customers



- Smart meter installations hit a peak in 2010 and 2011, supported by stimulus funding awarded in 2009. Most of the large US utilities took advantage of the Smart Grid Investment Grant to roll out smart meters across their territories. Deployments have slowed considerably since 2013.
- In recent years, smaller utilities have received regulatory approval to pay for projects through customer rates.
- While only 38% of all consumers have smart meters, another 29% use older, less advanced, automated meters.
 - Removing the need to manually read meters by installing smart or automated meters is the largest cost saving line-item for utilities when upgrading from analogue meters.
 - Eight of the 10 largest utilities yet to provide the majority of their customers with smart or automated meters are in New York, New Jersey and Ohio. In New York and New Jersey, smart meter penetration is less than one percent.
- Utilities with a large installed base of smart meters are now investing in additional services to provide through the meter and analytical tools that help them to take advantage of metering data.

Source: Bloomberg New Energy Finance, EIA Notes: Charts above show values for smart meters, excluding automated meters. Smart meters are defined as those capable of “two-way communication” (ie, the grid communicates with meter and vice versa), whereas automated meters provide one-way communication (ie, meter delivers automated readings). As a result of updates to meter deployment timelines, some historical numbers may have changed since the previous edition of the Factbook.

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

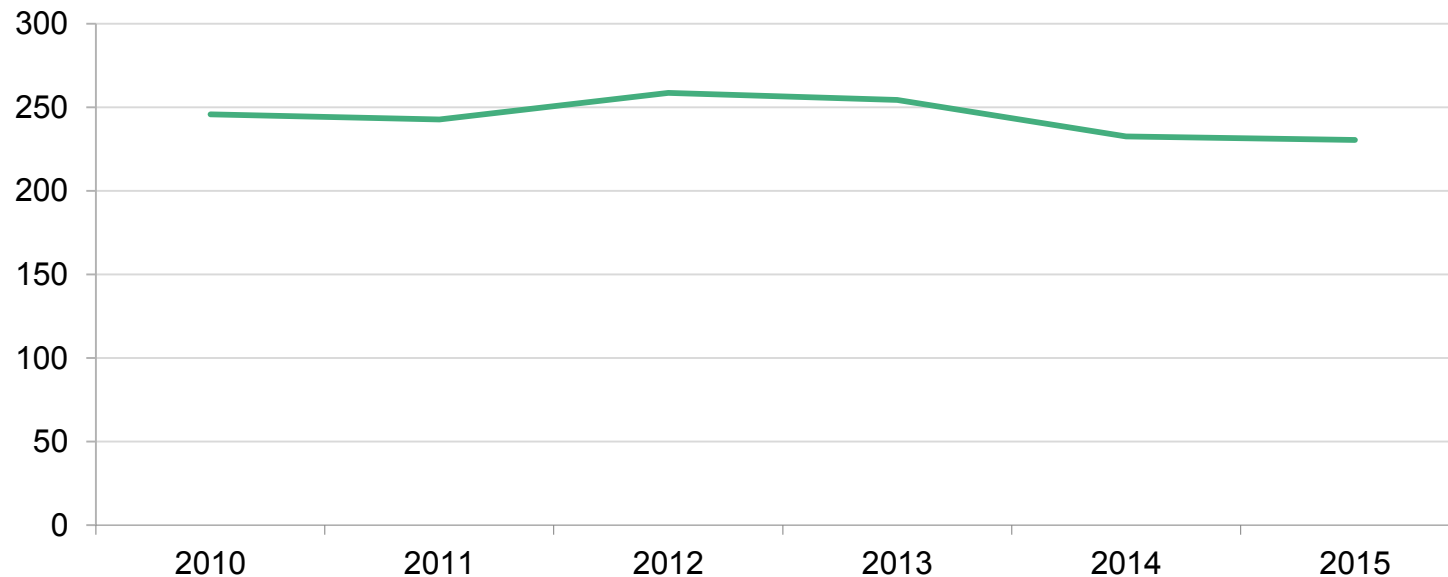


- Smart meter installations, driven by the 2009 Smart Grid Investment Grant, accounted for most of the overall US smart grid spending from 2009 to 2012. Smart meter spending has more than halved since its peak due to a reduction in smart meter projects and the deployment of cheaper meters.
- Distribution automation spending has remained fairly constant. These investments represent utility projects within the distribution system to reduce outage frequency and duration and to more efficiently manage electricity flow within the grid.
- On 21 April 2015, the White House released the inaugural Quadrennial Energy Review (QER), which addresses future investment in transmission, distribution and energy storage. Specific pledges included \$3.5bn in new Department of Energy funding for smart grid R&D over 2016–25 and \$300–250m in grants to states for projects that improve resiliency over 2016–20. Such spending would provide a boost to smart grid investment and help bring advanced technologies to market. The proposed budgets are subject to Congressional approval.

Source: Bloomberg New Energy Finance, Edison Electric Institute

Notes: The “advanced smart grid” category includes projects that are cross-cutting, such as load control, home energy management, EV charging and smart grid pilots.

Economics: US average smart meter sale price (\$ per meter installed)



- Meter prices hovered around \$250 per unit between 2010 and 2013 but have since declined. The reduction in costs can be attributed to a variety of factors:
 - Hardware and networking costs have gradually declined as smart metering becomes more widespread.
 - Competition from Chinese and Indian metering manufacturers entering Western markets has put downward pressure on costs. In Spain, utilities have procured meters priced for as low as EUR 30 (\$41) per unit, excluding installation costs.
- However, the slowdown in US smart metering means prices are not declining as rapidly as elsewhere.
- Many of the pure-play metering vendors have expanded their product offerings to differentiate themselves and diversify their revenue as the US market cools. Two areas of focus are smart grid analytics platforms, which leverage metering and other grid data, and smart cities where communication specialists can potentially connect a growing number of devices.

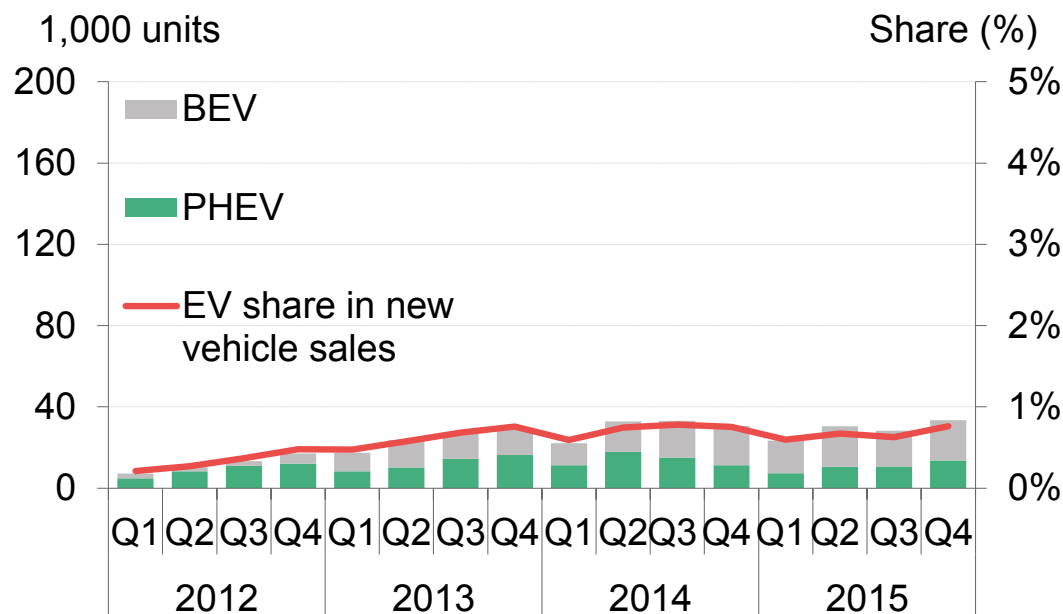
Source: Bloomberg New Energy Finance

Notes: Price per meter includes meters, advanced metering infrastructure communications network, 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.

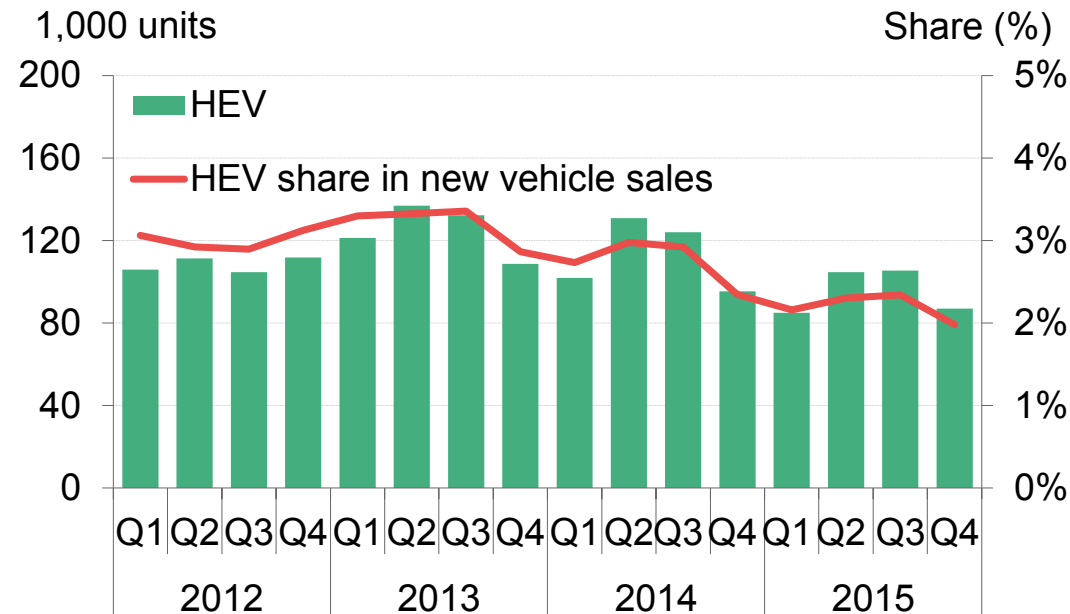
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Deployment: US electric vehicle and hybrid electric vehicle sales

US EV sales

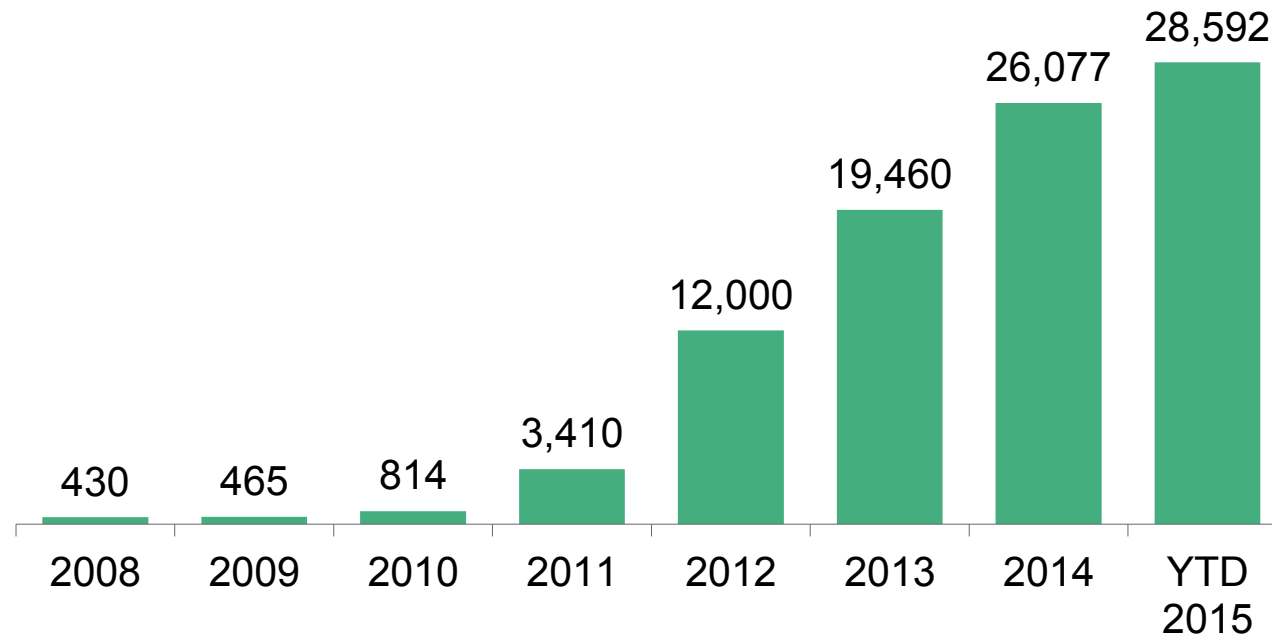


US HEV sales



- Sales of electric vehicles – a category that includes battery electric vehicles (BEV) and plug-in hybrid electric vehicles (PHEV) – decreased 2% from 118,731 units in 2014 to 115,765 units in 2015.
- PHEVs took the brunt of the hit, with sales collapsing 24%. BEVs actually saw a 16% jump, as tax credits reduce lifetime costs and sales continue to be driven by non-economic factors.
- Sales of hybrid electric vehicles (HEV) were 381,950 units in 2015 – a 16% decrease compared to 2014. HEV sales were relatively slow this year amid low gasoline prices.
- Prolonged periods of low gasoline prices, restricted model availability, a high number of EVs coming off-lease and a delay in the introduction of some highly anticipated models contributed to the decline in US EV sales.

Deployment: US public electric vehicle charging outlets



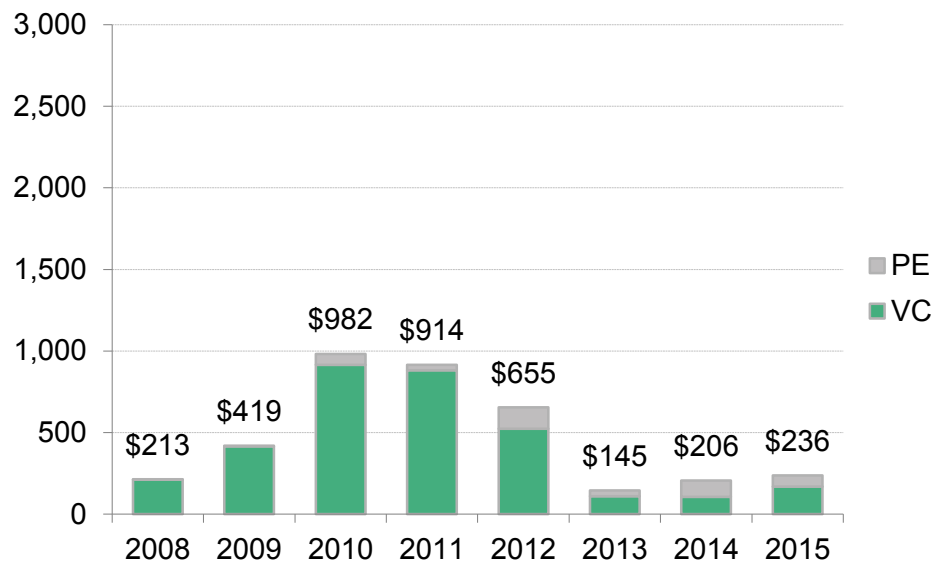
- The number of public EV charging stations has climbed steeply after 2008, but since 2013 the growth in the number of available outlets has visibly slowed. The number of publicly available EV charging outlets increased 10% in 2015 compared to previous year.
- The uncertainty around profitability means that there is still no clarity on who will be the major owner and network operator for public EV chargers. In the US, utilities have proposed to rate-base over \$1bn in public charging which would cover over 60,000 chargers. However, paying for chargers through electricity rates is controversial and California's regulator – the CPUC – has pushed back on PG&E's \$664m proposal to build 25,200 electric vehicle charging stations.

Source: Alternative Fuels Data Center, Bloomberg New Energy Finance

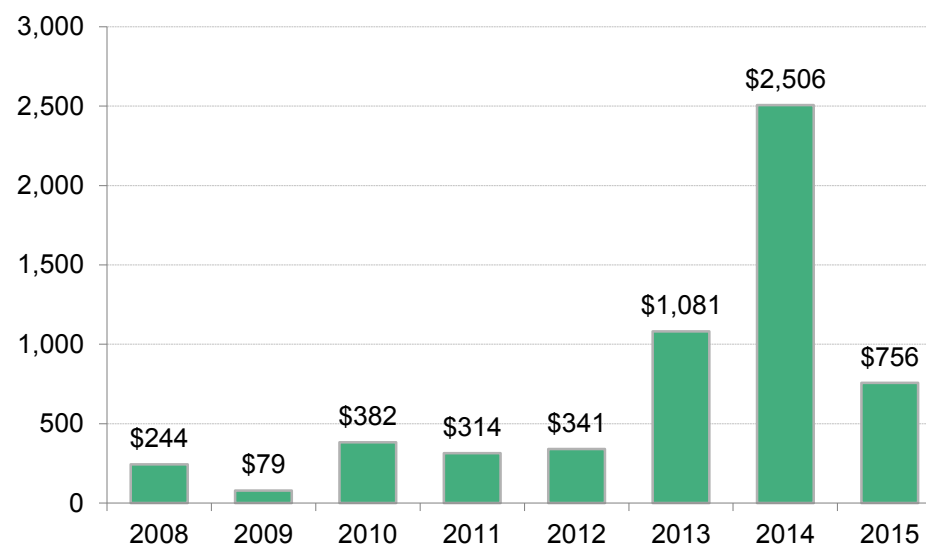
Notes: Does not include residential electric charging infrastructure. 2015 numbers updated through November 2015.

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

Venture capital / private equity

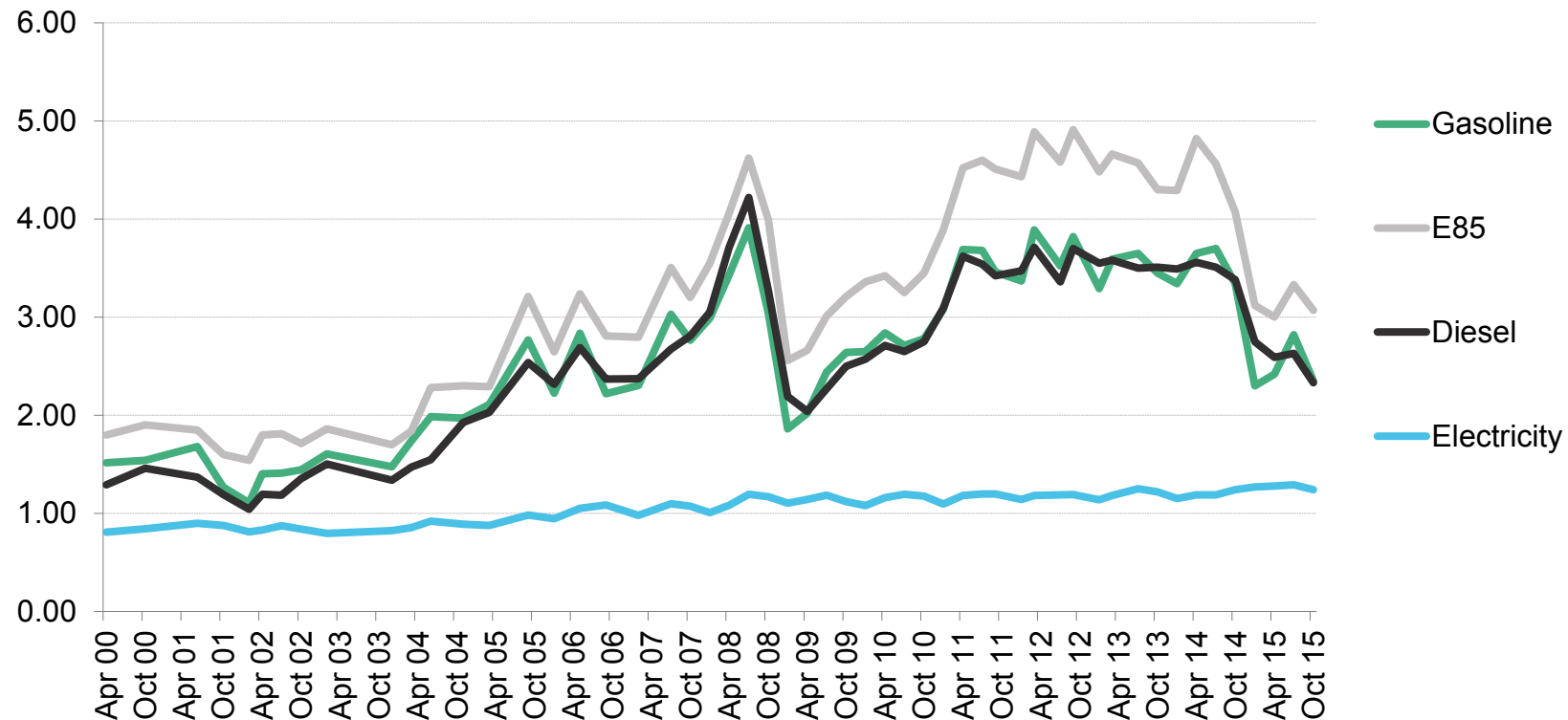


Public markets



- Venture capital and private equity firms invested over \$3.7bn of private capital in the US electrified transport sector since 2008. Public markets investment stands at \$5.7bn over the same period.
- Notable deals in 2015 included:
 - Tesla raised \$750m via secondary share placement to be used for working capital and for corporate purposes.
 - Proterra raised \$55m in private equity expansion capital from undisclosed participants. The proceeds were to be used as working capital for the next phase of capacity expansion.

Economics: US average monthly retail fuel prices (\$/GGE)

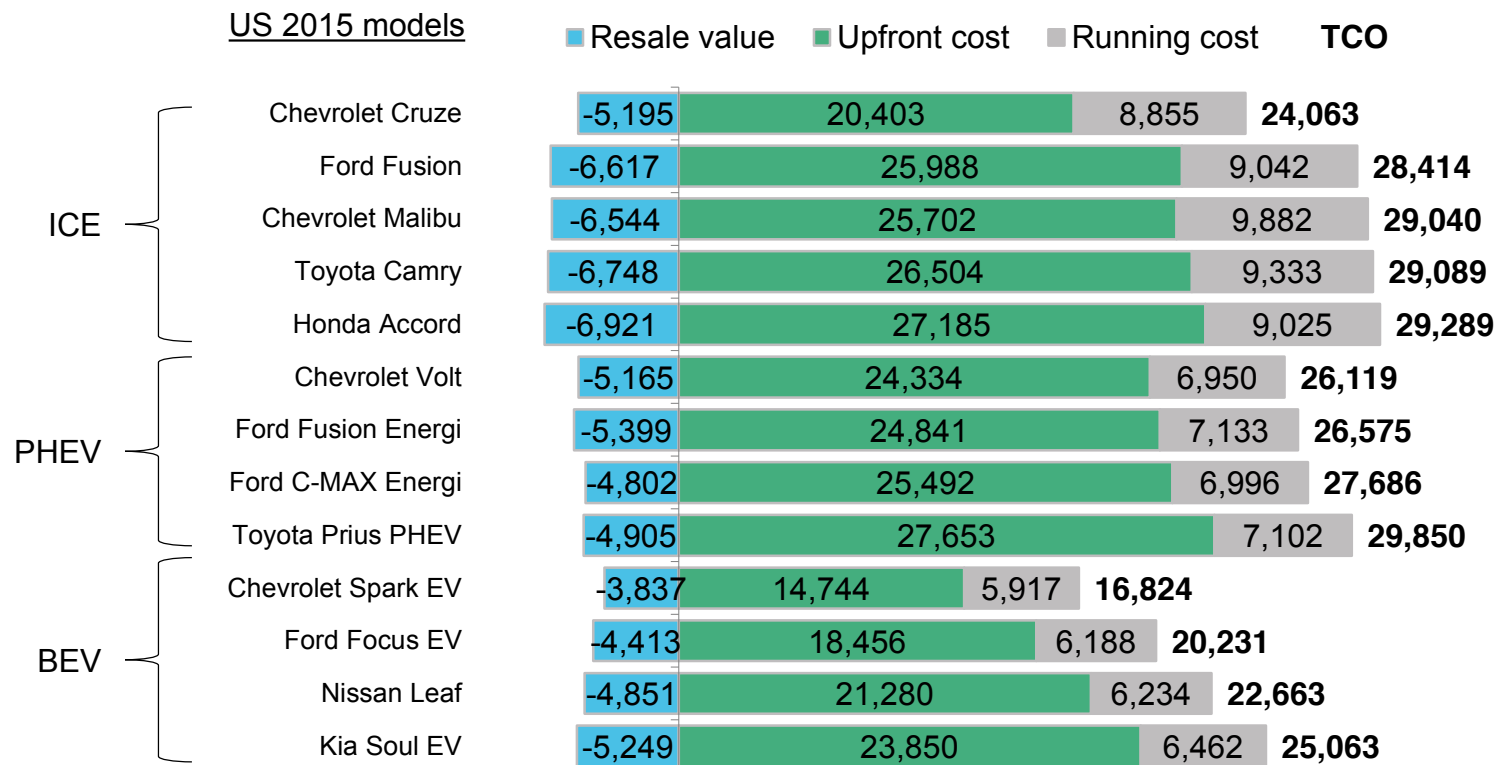


- Electricity has been the most competitive transport fuel in the US on a \$/GGE basis for over a decade.
- But vehicle economics also depend heavily on upfront costs (next slide).
- Plummeting oil prices beginning in the summer of 2014 have eroded the price advantage of alternative fuels.

Source: Alternative Fuels Data Center

Notes: Fuel prices per gasoline-gallon equivalents (GGEs). Electricity prices are reduced by a factor of 3.4 because electric motors are 3.4 times more efficient than internal combustion engines.

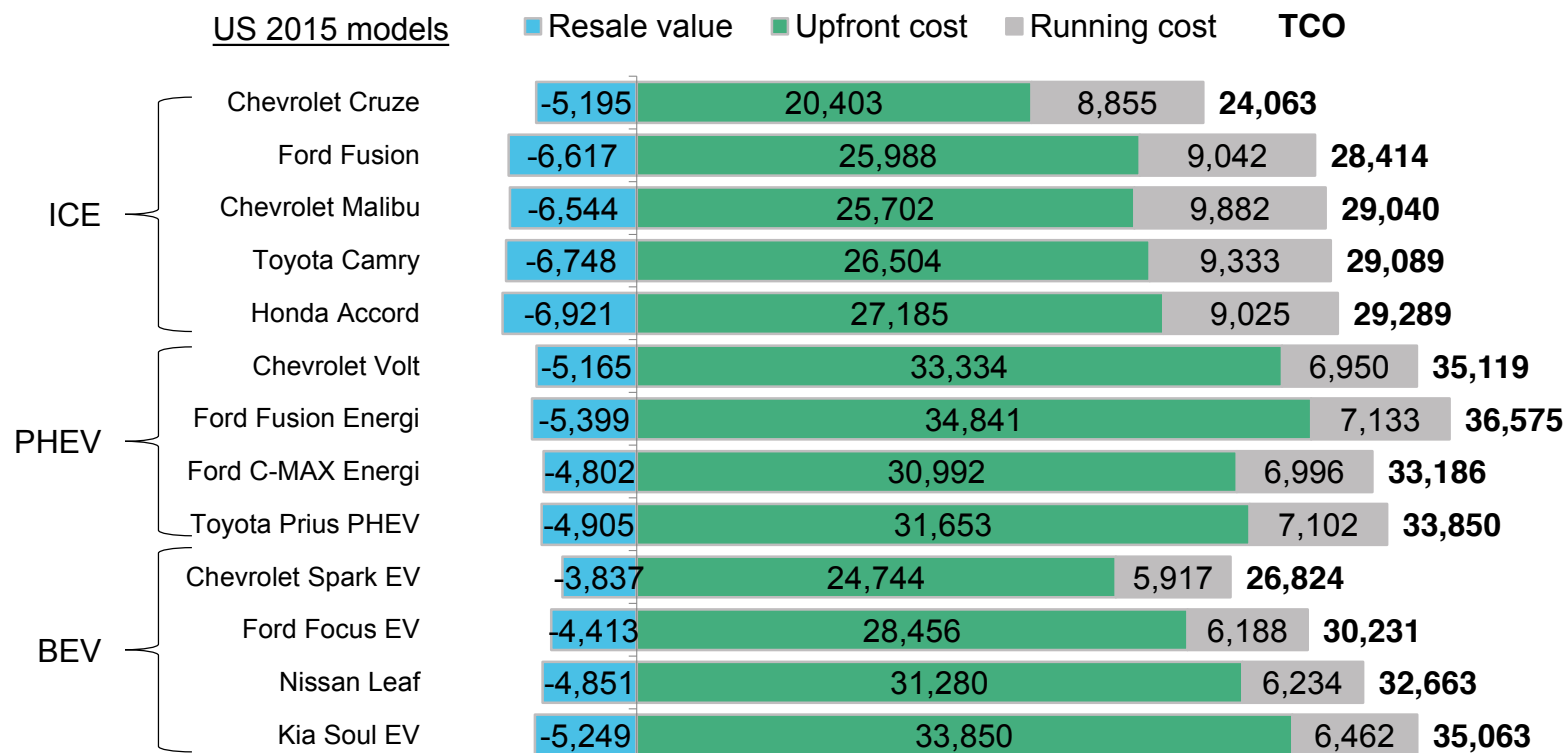
Economics: BEVs are cheaper than all but the cheapest gasoline vehicles in the US, when using purchasing credit incentives



- Owning a battery electric vehicle is up to 25% cheaper than owning an average midsize gasoline car.
 - In the US, state and federal purchasing incentives of up to \$10,000 make BEV capital costs lower than that of midsize gasoline vehicles.
 - Fuel and running costs are 33% lower for a BEV.
 - The cost range of different BEV models reflects the variation in purchasing prices.
- Plug-in hybrids cost the same as 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, \$2.5/gallon cost of gasoline and \$0.125/kWh cost of electricity.

Economics: But BEVs are more expensive without purchasing credit incentives

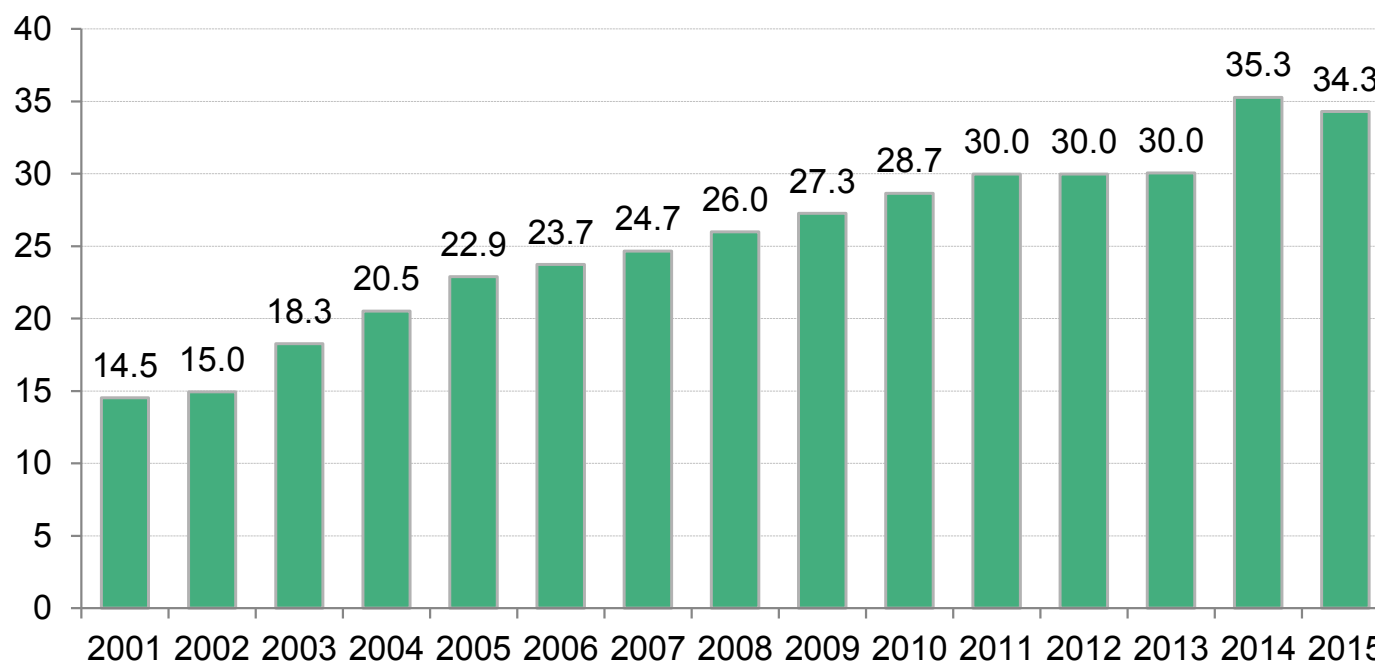


- Without price subsidies:
 - Current BEV models are more expensive than midsize gasoline cars by around 13%.
 - The Chevrolet Spark EV is still cheaper due to its low upfront price (~\$25k).
 - Plug-in hybrids are ~15% more expensive than midsize cars.

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)

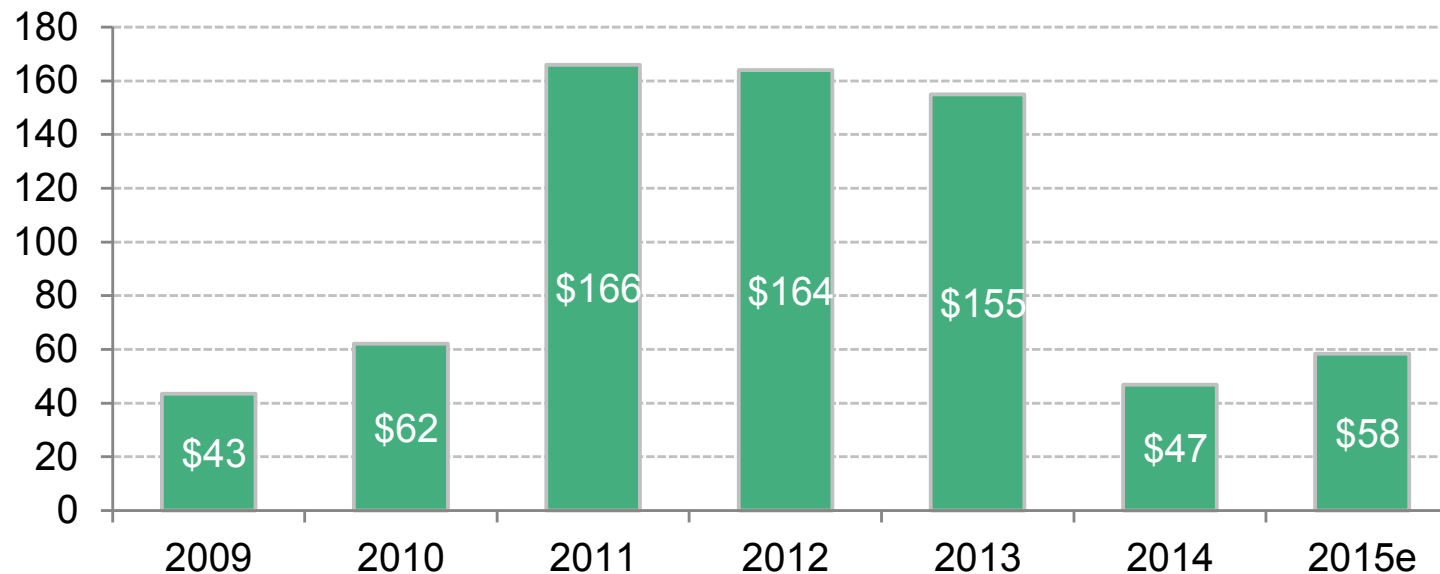


- Natural gas use in vehicles likely inched down 2.8% to 34.3Bcf, after surging by 17.4% from 2013 to 2014.
- 2015 is the first year since 2001 to see a clear decrease in vehicle natural gas demand, potentially due to the tumble in oil prices and the consequent shift back towards gasoline vehicles.
- Compressed natural gas (CNG) remains more widely used than liquefied natural gas (LNG).
- The number of new public and private CNG and LNG stations ticked up, but at a slower pace than in 2014:
 - 232 new CNG fuelling stations were added in 2014, compared to 115 in 2015.
 - 22 new LNG fuelling stations were added in 2014, compared to 14 in 2015.

Source: EIA, Alternative Fuels Data Center

Notes: Values for natural gas demand in 2015 are projected, accounting for seasonality, based on latest monthly values from EIA (data available through October 2015). 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)

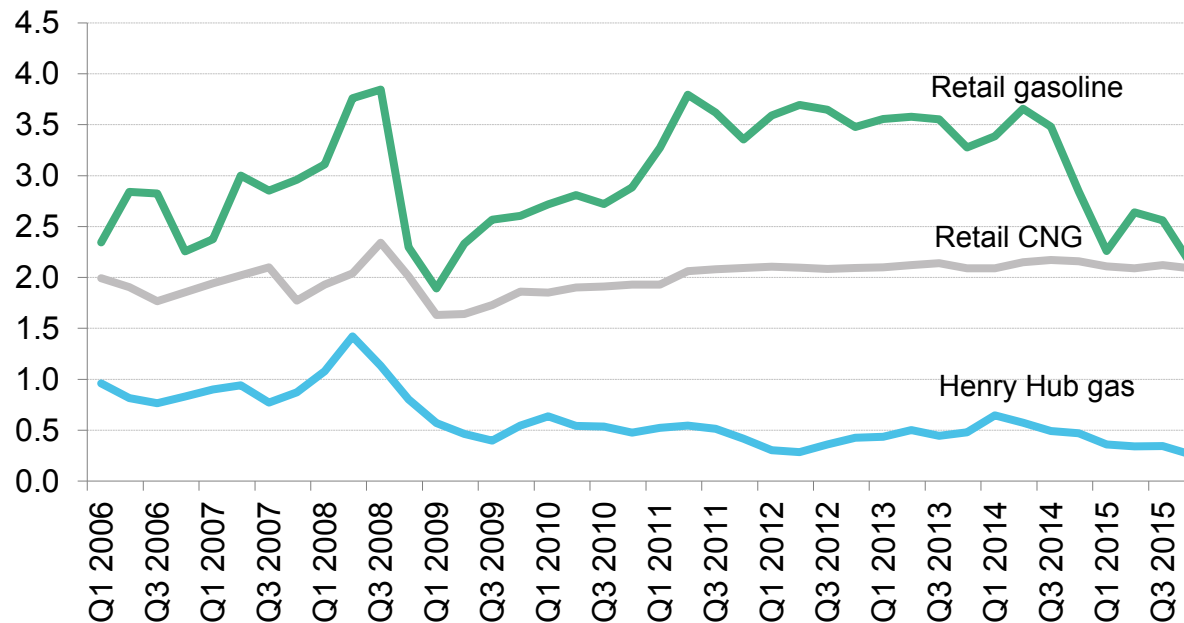


- Clean Energy Fuels is a leading natural gas fuel supplier, owning, operating or supplying 34% US retail and private CNG and LNG fuelling stations as of the beginning of 2015. The company's spending plans are used here as a proxy for financing flows into the natural gas vehicle sector.
- The company directs most of its asset financing toward fuelling infrastructure. Spending plummeted in 2014 to \$47m, even though the company had initially anticipated spending \$135m in that year. Clean Energy Fuels anticipates a slight increase in capex investments to \$58m in 2015.
- Heavy-duty trucks provide the major market for LNG, but 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 the oil price plummet in 2014 and 2015.

Source: Clean Energy Fuels 2014 annual report

Notes: Figures from 2009-14 reflect 'net cash used in investing activities' as per the company's cash flow statement. The amount for 2015 is based on company plans ("Our business plan calls for approximately \$58.3 million in capital expenditures in 2015").

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

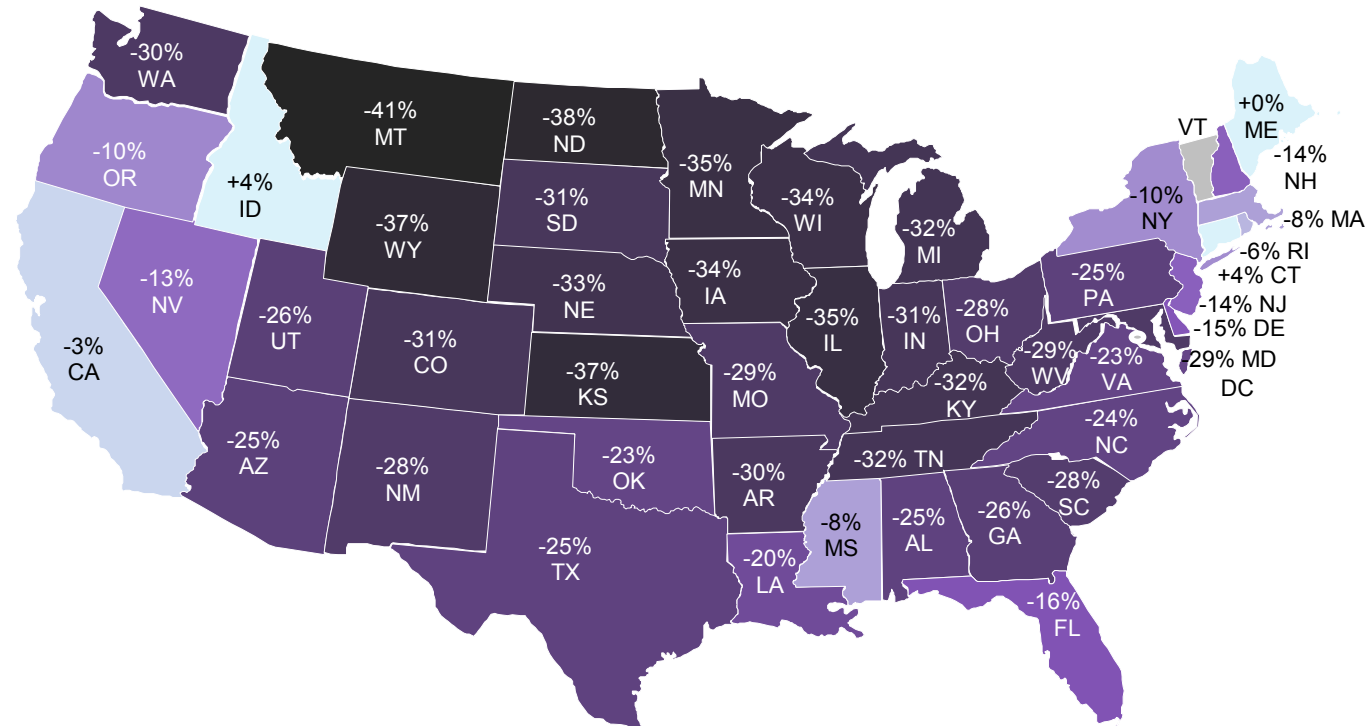


- Natural gas engines function almost identically to gasoline/diesel engines, but require new fuelling systems. A fuel price discount is therefore needed to incentivize consumers to convert.
- The fuel price discount enjoyed by CNG collapsed from \$1.51/GGE in Q2 2014 to \$0.05/GGE in Q4 2015 due to the oil market downturn.
- Retail CNG prices are much less volatile than that of retail gasoline.

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EPA Clean Power Plan (1 of 5): Overview

Emissions reductions required by the Clean Power Plan between 2012 and 2030, under mass-based compliance

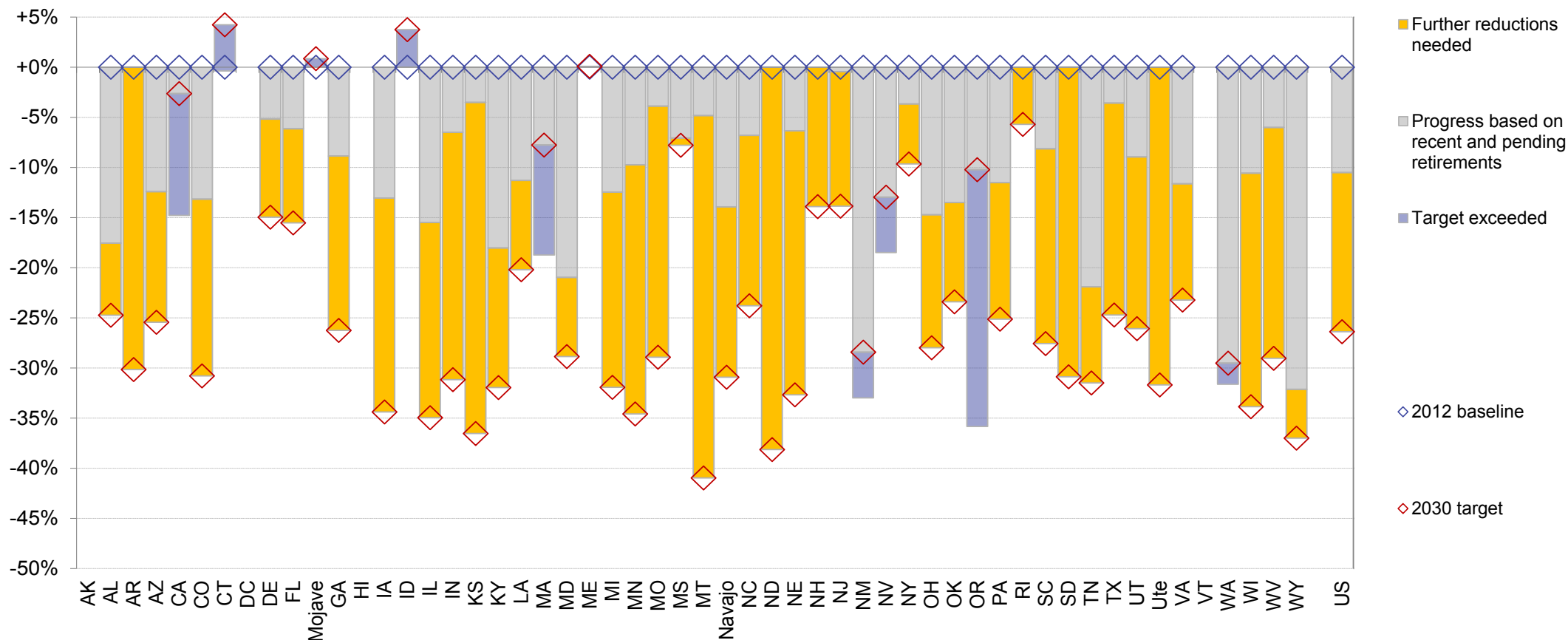


- EPA finalized the Clean Power Plan (CPP) in August 2015. The Plan took a new approach to calculating necessary emissions reductions, resulting in different state emission targets than under the original proposal. It also explicitly provided mass-based goals (tCO₂) in addition to rate-based goals (tCO₂/MWh).
- States must implement their own programs (or collaborate with other states) to reduce either overall emissions or the emissions intensity of their existing fossil fuel-fired fleet.
- According to headline figures from EPA's modelling results, the Plan could cut emissions 32% from 2005 levels by 2030.
- Legal action to suspend or void the Plan took off the moment the Plan became official in the Federal Register. In January 2016, the DC Circuit Court denied opponents a motion to stay the CPP and said it will consider the Plan's legality this upcoming June.

Source: Bloomberg New Energy Finance, based on analysis of EPA Clean Power Plan. Notes: Darker colors indicate deeper emissions cuts. Light blue states may actually increase their overall emissions while remaining in compliance with the Clean Power Plan. Alaska, Hawaii, Vermont and DC are not covered by EPA's regulations. Data is based on EPA's modelling and historical emissions inventories.

EPA Clean Power Plan (2 of 5): State progress toward mass-based goals, and work left to do

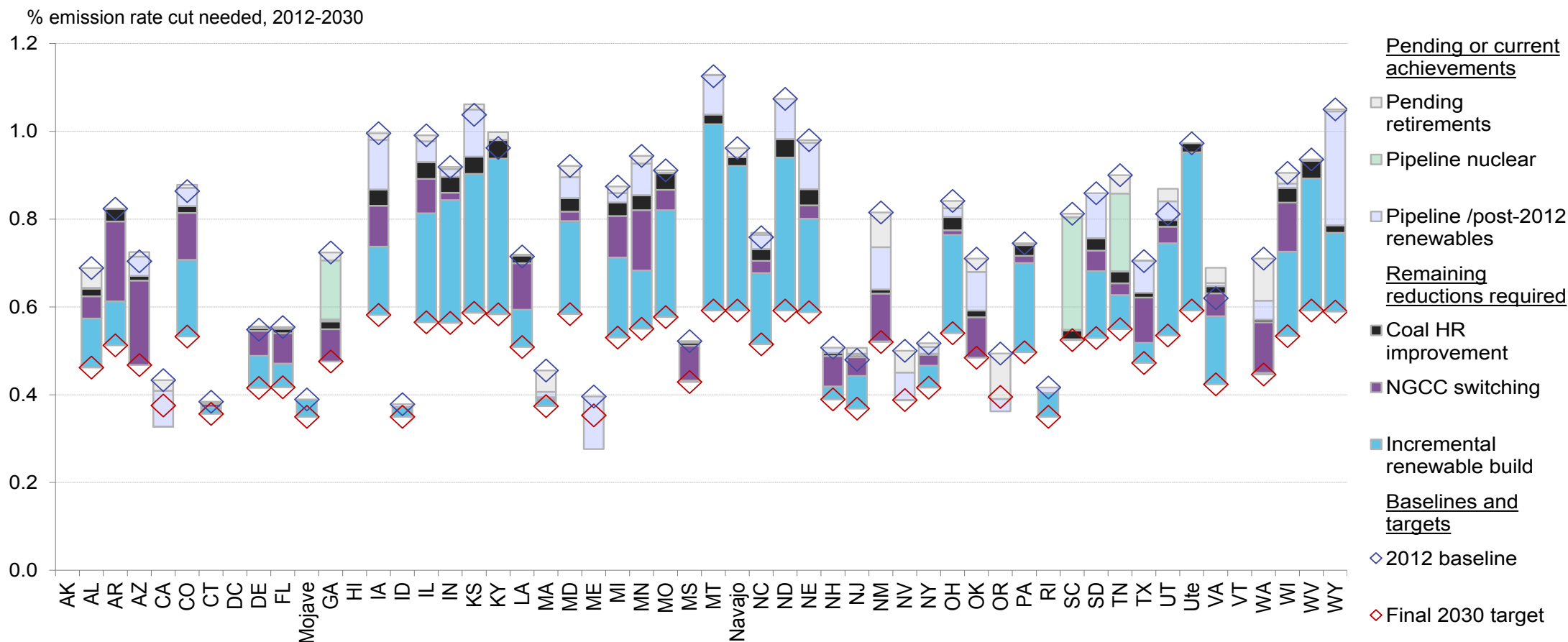
% emission cut needed, 2012-2030



- The CPP emission reduction targets were built on EPA's calculation of possible heat rate improvements at existing coal plants; new renewables build; and increased capacity factors for existing natural gas combined-cycle generators due to coal-to-gas switching.
- However, states have free rein to use other compliance methods such as energy efficiency, new nuclear plants and the replacement of retiring coal plants with new natural gas plants (which are not covered under the Plan).
- Solely on the basis of retirements that have occurred or been announced since the CPP's 2012 baseline year, many states have already made significant progress toward meeting their mass-based goals. On the back of this alone, the US overall is on its way to achieving one-third of necessary emissions reductions.

Source: EPA Clean Power Plan, EPA eGRID data, Bloomberg New Energy Finance

EPA Clean Power Plan (3 of 5): State progress toward rate-based goals, and work left to do

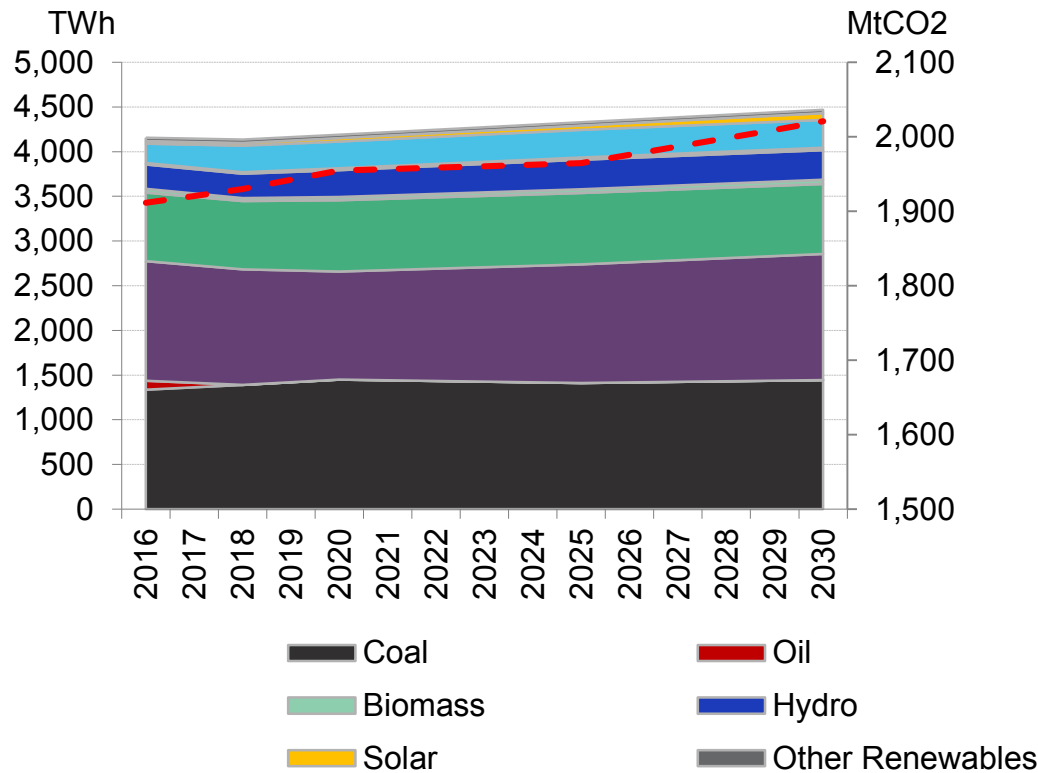


- States may also choose to comply with the CPP by reducing their emissions *rate*, as under the original proposal from 2014.
- Most states have made more progress toward achieving their mass-based than their rate-based goals based on actions taken since the 2012 baseline.
- Exception: Unlike under mass-based goals, the accounting for the rate-based goals directly credits new nuclear and new renewables built after 2012. As a result, two states with large pipeline nuclear projects—Georgia and South Carolina—are better positioned for compliance under their rate-based rather than mass-based targets.

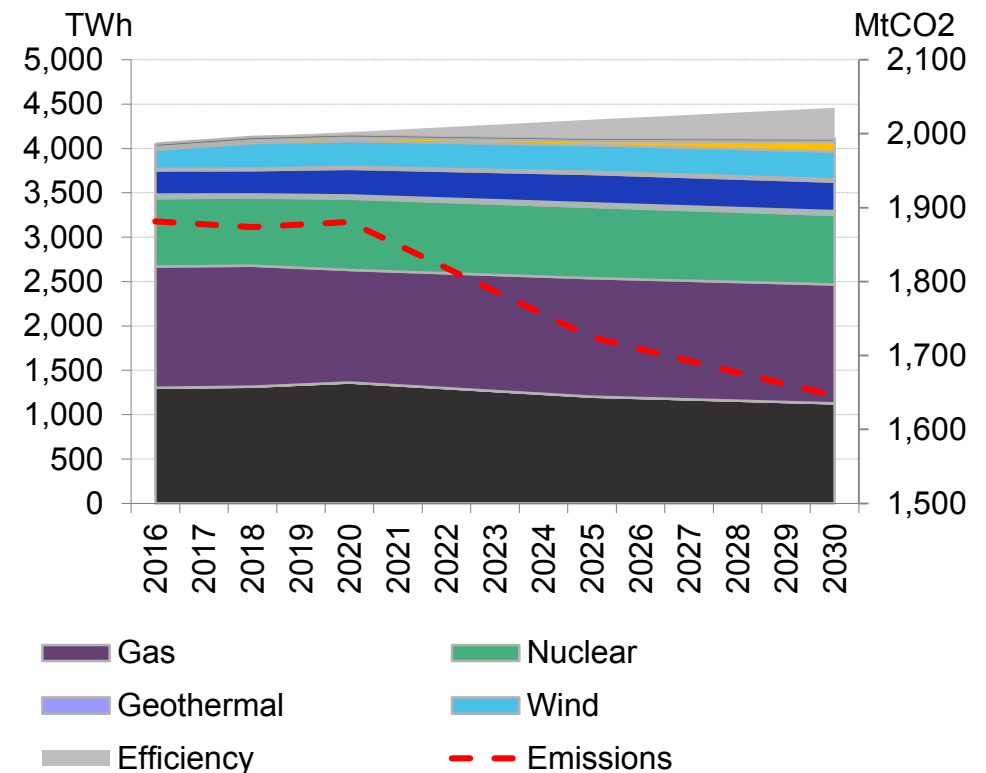
Source: EPA Clean Power Plan, EPA eGRID data, Bloomberg New Energy Finance Note: "NGCC" stands for combined cycle natural gas. This progress chart assumes states will meet remaining reductions through coal heat rate improvements, coal-to-gas switching, and renewables build—the three methods EPA used to set emission targets.

EPA Clean Power Plan (4 of 5): US power generation mix by technology under two scenarios according to the EPA (TWh)

Business-as-usual (BAU, no CPP)



Clean Power Plan
(mass-based compliance)*



- Mass-based compliance is expected to produce a 375Mt emissions reduction from the business-as-usual case (BAU).
- EPA also forecasts generation falling by 357TWh under the mass-based compliance scenario relative to BAU, as states implement energy efficiency measures.

Source: EPA modelling results from the Integrated Planning Model (IPM)

Note: BAU is business-as-usual (ie, forecasts assuming no new policies such as the CPP). (*) The scenario shown here for the Clean Power Plan is one of mass-based compliance, in which each state adopts carbon trading as its method of compliance.

EPA Clean Power Plan (5 of 5): Compliance Timeline

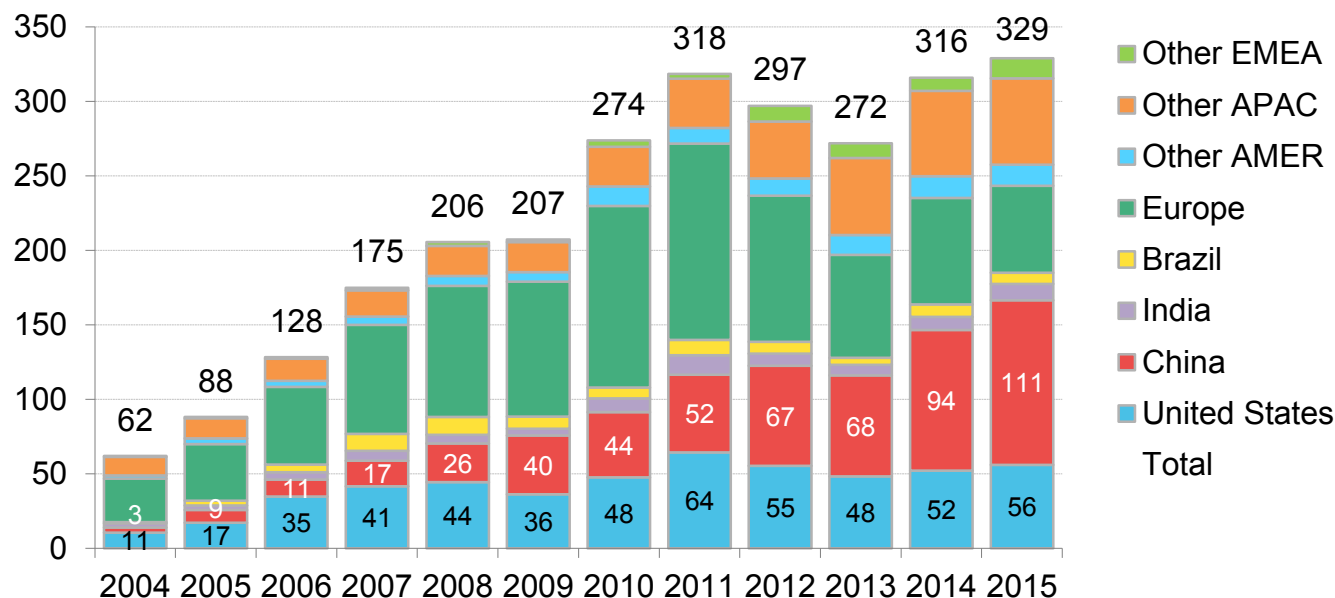
- States must draft their State Implementation Plans (SIPs) by September 2016 and file extension requests if the SIPs are not final.
- States will have until September 2018 to complete their final SIPs and submit them to the EPA. Failure to do so would obligate states to adopt the Federal Implementation Plan (FIP) prepared by the EPA.
- The timeline for litigation suggests that states will have to prepare SIPs while battling EPA in the courts, unless they are willing to risk taking the FIP.
- For states seeking to capitalize on early action in renewables and energy efficiency, the EPA has created a Clean Energy Incentive Program (CEIP) which distributes carbon credits prior to the CPP compliance period.
- The compliance period runs from 2022-2030, although states are also expected to maintain their emissions reductions in later years.

6 Sep 2016	Deadline for finalized SIPs or drafts with requests for extension
6 Sep 2017	States with extensions file progress updates
6 Sep 2018	SIPs due
2022-2021	Clean Energy Incentive Program credit period
1 Jul 2021	State milestone reports due
1 Jan 2022	Compliance begins
1 Jul 2025	2022-2024 Interim Period Step 1 compliance report
1 Jul 2028	2025-2027 Interim Period Step 2 compliance report
1 Jan 2030	Final compliance deadline
1 Jul 2030	2028-2029 Interim Period Step 3 compliance report & Interim Goal (2022-2029) compliance report
1 Jul 2032	Final Goal (2030) compliance report
every 2 years beyond 2032	Regular compliance updates

Source: EPA

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Global context: Total new investment in clean energy by country or region (\$bn)

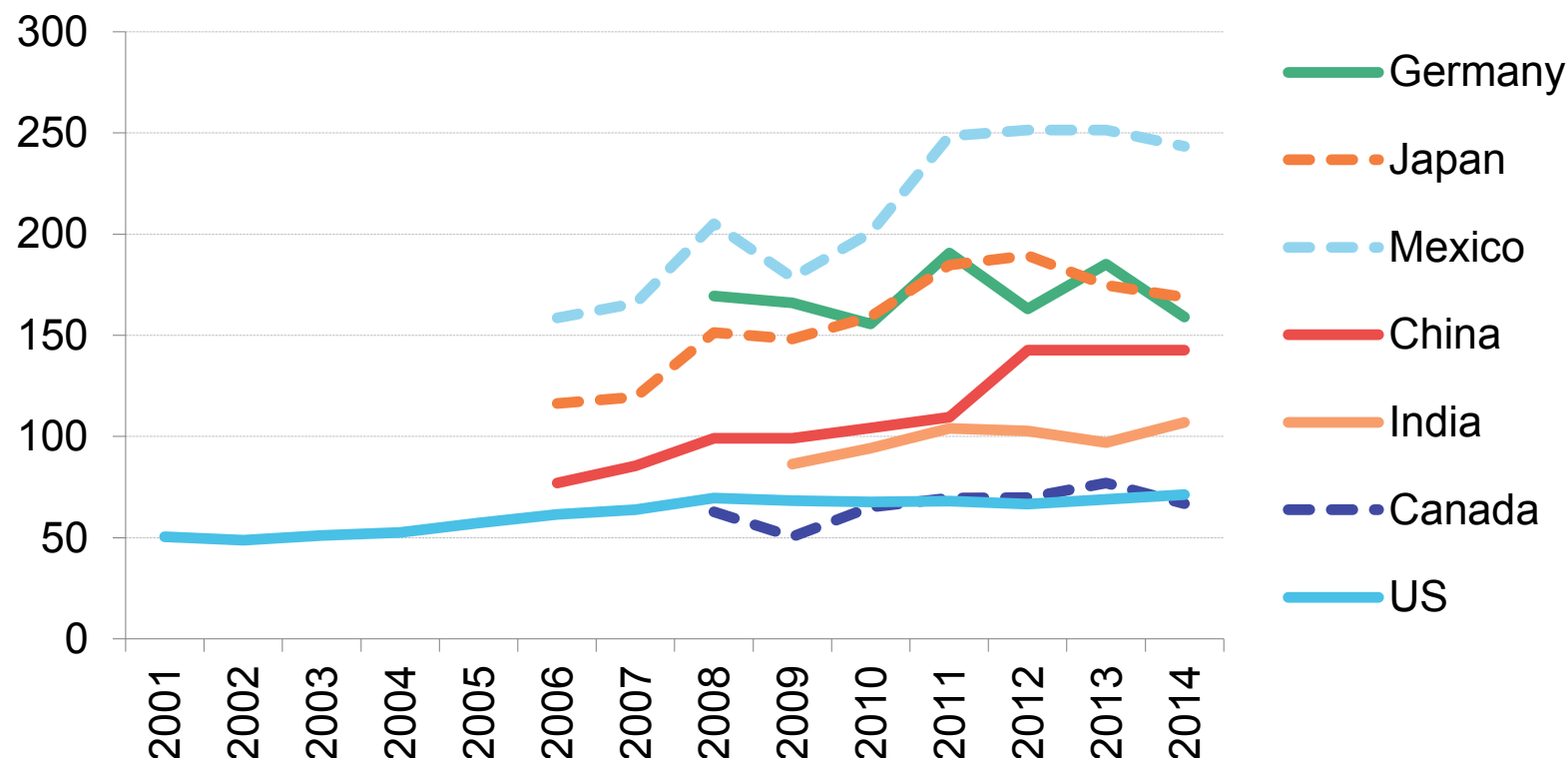


- Total US and global new investment in clean energy ended 2015 slightly up from the previous year, setting a new record high of \$329bn.
- Europe saw a significant rout in investments, which fell 18% from \$72bn in 2014 to \$59bn in 2015. Investments in the Americas outside of the US also suffered declines, slumping 10% in Brazil and 4% elsewhere. Both dips came on the back of general economic weakness.
- Investments climbed 8% in the US, mostly in wind and solar, as developers rushed to complete projects before the former expiration date of the PTC and ITC. The US currently makes up 17% of new world investment in clean energy.
- Driven by solar projects, EMEA countries outside of Europe experienced a 53% jump in investments, although from a much smaller base.

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.

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

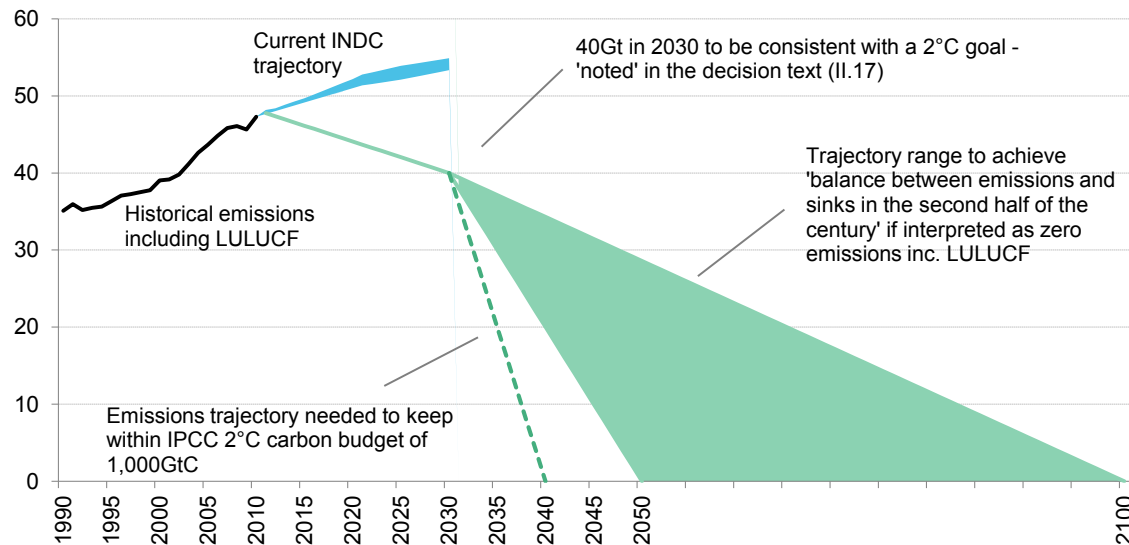


- The US – and North America in general – has among the lowest costs of electricity in the world for industrial customers (7.12¢/kWh for the US industrial sector in 2013, according to the EIA).
- Regions in the US with the lowest costs of power include the Midwest, Southwest and Northwest.

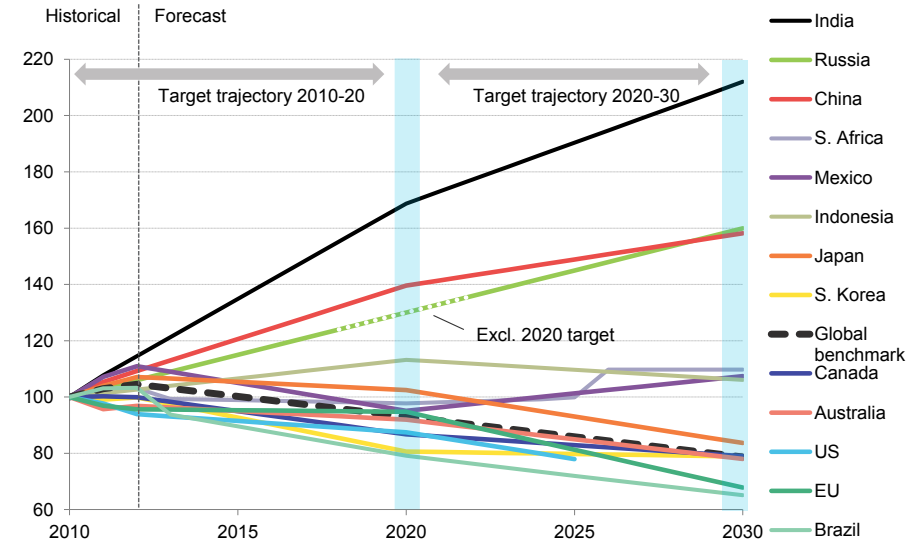
Source: Bloomberg New Energy Finance, government sources (EIA for the US)

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

Global emission trajectory under INDCs and COP21 deal



Emission target trajectories relative to 2010 levels (MtCO₂e)

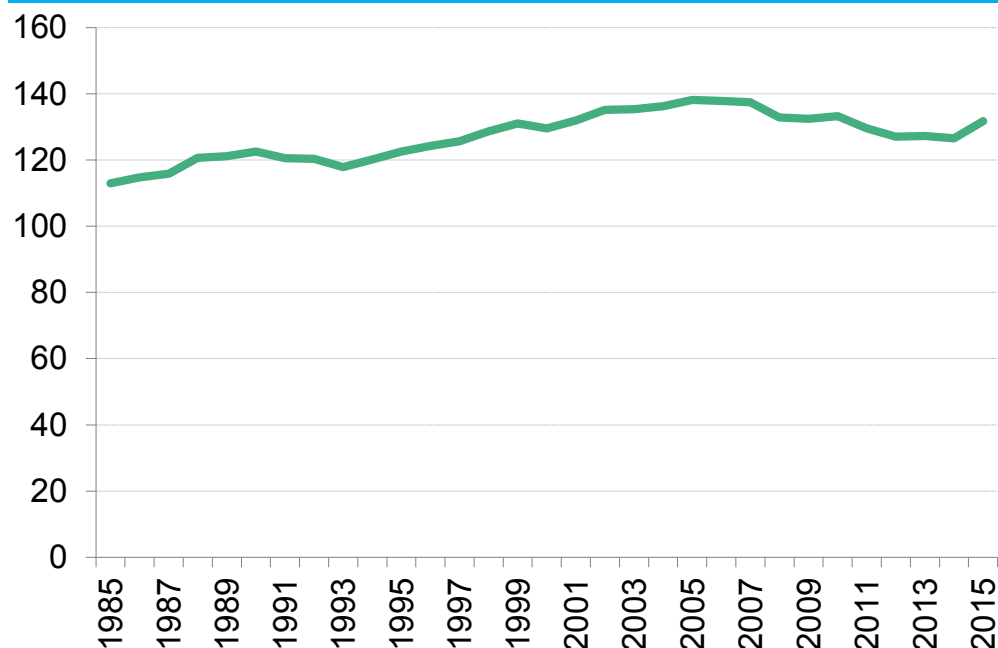


- The COP21 climate talks in Paris culminated in a framework for addressing global carbon emissions. The deal is based on five-yearly reviews of Intended Nationally Determined Contributions (INDC) beginning in 2020, and five-yearly global stocktakes beginning in 2023. The binding agreement also called for arresting temperature increases to 2°C, while directing the IPCC to report on the impacts of 1.5°C warming.
- The other major binding agreement states that parties will commit to achieving a “a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of the century.” Emission trajectories under either this situation or current INDCs would not limit the world to 2°C warming.
- The key problem of differentiation – a divide in abatement obligations between rich versus poor countries – remains. Developing countries are not required to cut emissions, only to try over time. The INDCs partly reflect this: India and China have set an emission *intensity* target, which allows them to increase total emissions. On the other hand, Brazil has one of the most ambitious emission reduction goals.

Source: Bloomberg New Energy Finance, IEA, UNEP, CAIT. Notes: LULUCF stands for land use, land-use change and forestry. Country-level emission trajectories modelled using BNEF's power generation forecasts including impact of existing and expected policies; emissions from non-power sectors are extrapolated from historical relationships between emissions and per capita GDP.

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

US gasoline consumption (bn gallons per year)

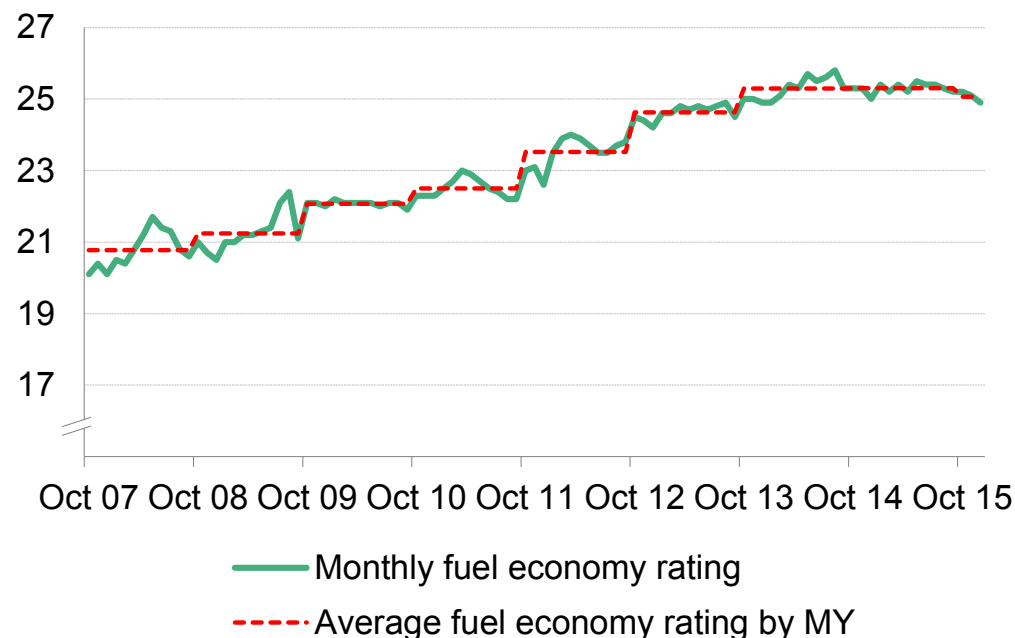


- Gasoline consumption in the US is estimated to have ticked up 4% from the previous year to 132bn gallons per year in 2015. This was the first increase in a decade.
- However, gasoline consumption is still 4.6% below the 2005 peak, and both corporate average fuel economy (CAFE) standards and emissions targets have tightened over the past decade.
- Average US vehicle fuel economy flatlined from 2014 to 2015, ending the trend of steady improvement seen in 2007-2013. Americans used more gasoline and bought less fuel-efficient vehicles as prices at the pump took a nose dive and economic activity sped up.

Source: EIA

Notes: Analysis is based on daily averages of 'total gasoline all sales / deliveries by prime supplier'. Values for 2015 are projected, accounting for seasonality, based on latest monthly values from EIA (data available through October 2015).

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

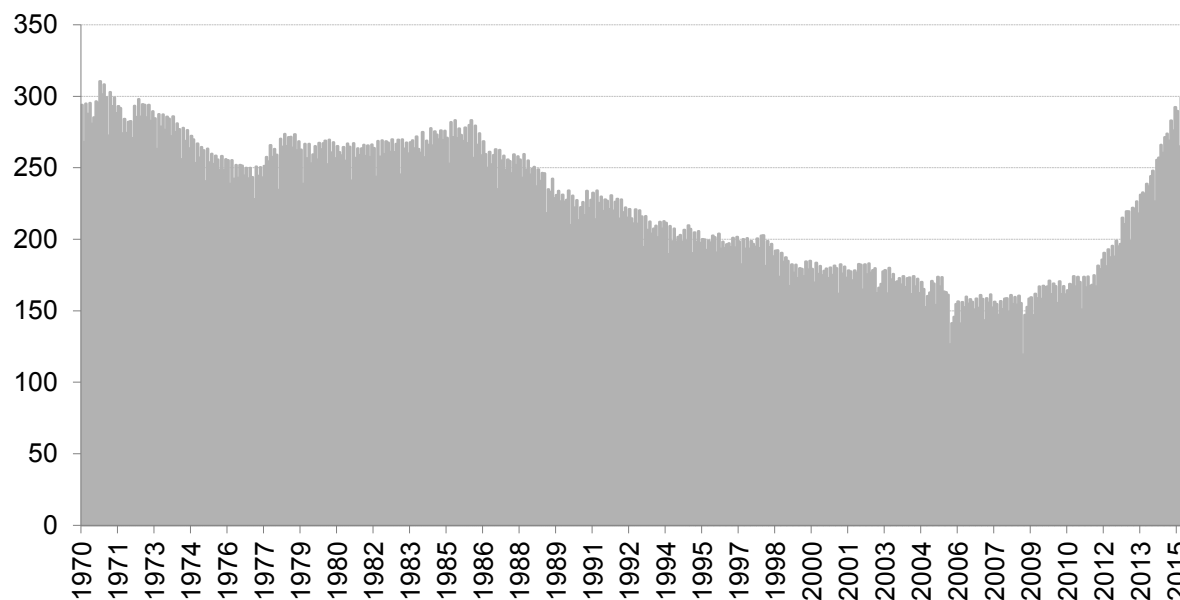


Source: UMTRI, Bloomberg New Energy Finance

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 has skyrocketed from a low of 5.1m barrels per day on average in October 2007 to 9.3m barrels per day in the same month of 2015, an 85% increase. The US is producing its own supply of crude oil at a level not seen since the 1980s.
- Increasing domestic production coupled with slowing demand growth abroad helped to slash oil prices, which collapsed to \$34 per barrel in December 2015. The price drop is especially noteworthy given the strong US economy, which might otherwise have driven up oil demand and therefore prices.
- Oil prices do not directly impact most sustainable energy technologies in the US. Most of those technologies operate in the power sector, while oil is mostly used for transportation and only rarely for power in the US. However, the oil price crash could have a 'second-order' effect on the power mix by stimulating the US economy, which could propel greater use of natural gas and renewable energy.

Source: EIA

Notes: Data through October 2015.

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sales.bnef@bloomberg.net

Contributors:

Ethan Zindler
Colleen Regan
Rachel Jiang

Economics and Policy: Richard Chatterton,
Luke Mills, Stephen Munro

Natural Gas: Anastacia Dialynas, Joanna Wu

Renewable Energy: Meredith Annex, Joseph
Byrne, Amy Grace, Kyle Harrison, William
Nelson, Nathan Serota, Dan Shurey, Nick
Steckler, Kieron Stopforth

**Energy Smart Technologies and
Transportation:** Nicole Aspinall, Logan
Goldie-Scot, Aleksandra Rybczynska, James
Sprinz, Colin McKerracher, Thomas Rowlands-
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