2020

Sustainable Energy in America

FACTBOOK

Growth Sectors of the U.S. Energy Economy

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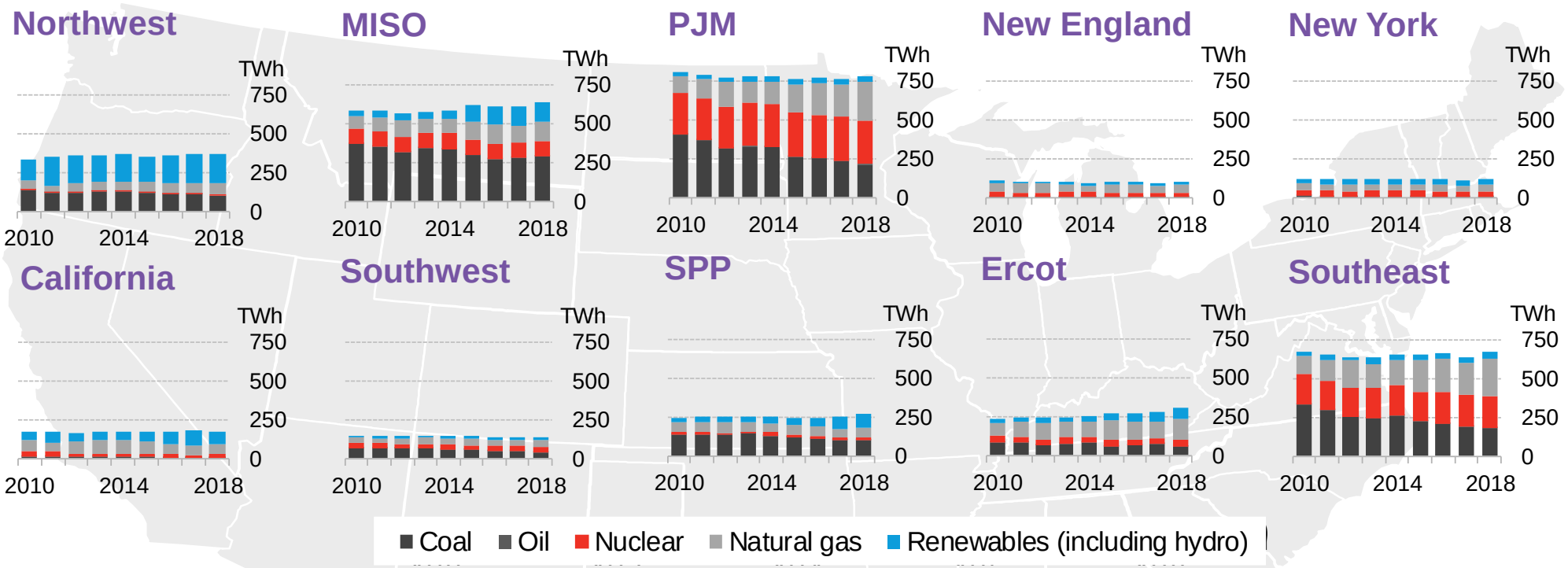
U.S. energy overview: Electricity generation mix by U.S. power market

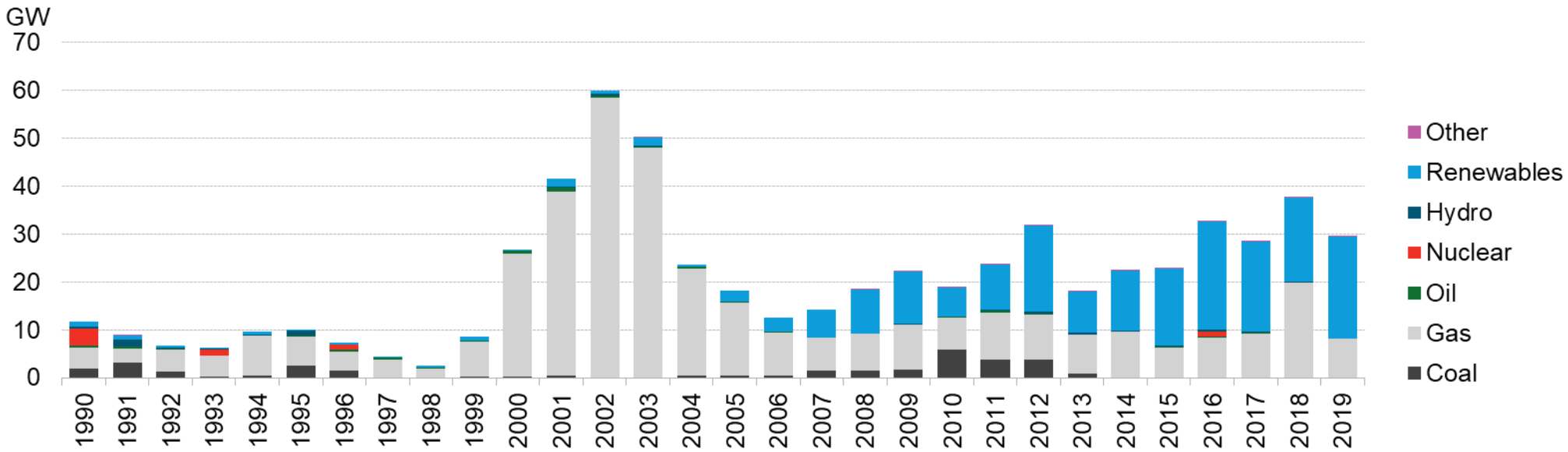


- The energy generation mix varies throughout the U.S. with different power-generating technologies contributing various amounts in different power markets. The top-line volume of generation also varies, with higher demand in some regions. Energy can also be sold between regions, incentivizing areas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

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

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

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

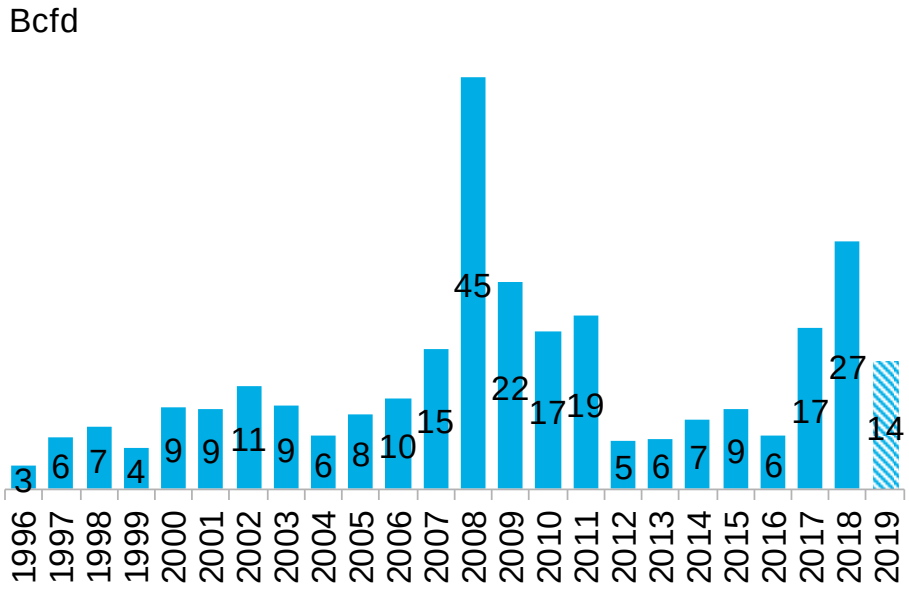


- 2019 represented another brisk year for total power-generating capacity additions, with just under 30GW commissioned. While this was down from 2018 it was still one of the strongest of the last 15 years.
- Natural gas-fired power plant build continued as developers installed 8.2GW, seeking to take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

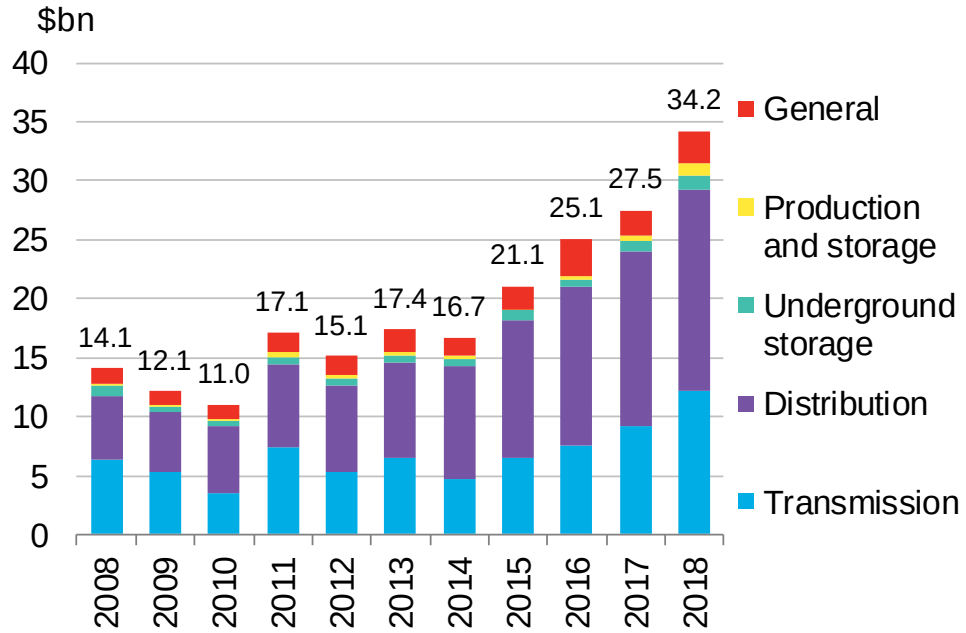
Source: EIA, BloombergNEF Note: All values are shown in AC except solar, which is included as DC capacity. "Renewables" here does not include hydro, which is shown separately. All capacity figures represent summer generating capacity. Includes installations or planned installations reported to the EIA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

Deployment: U.S. midstream infrastructure capacity and investment

U.S. transmission pipeline capacity additions



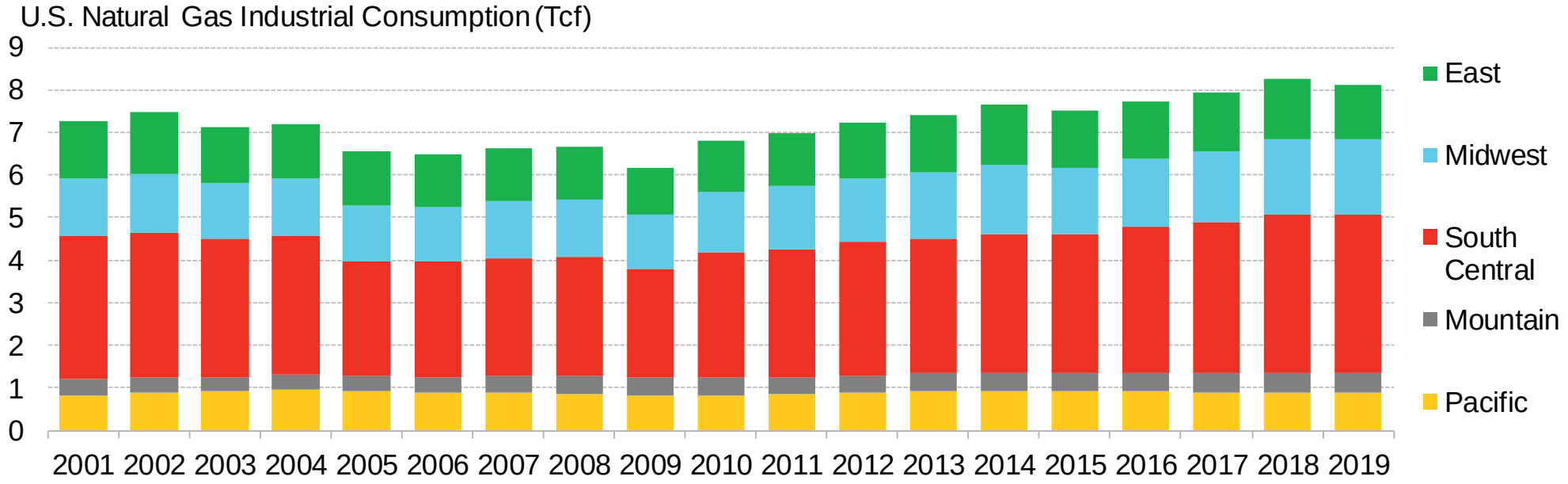
U.S. gas utility construction expenditures



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

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

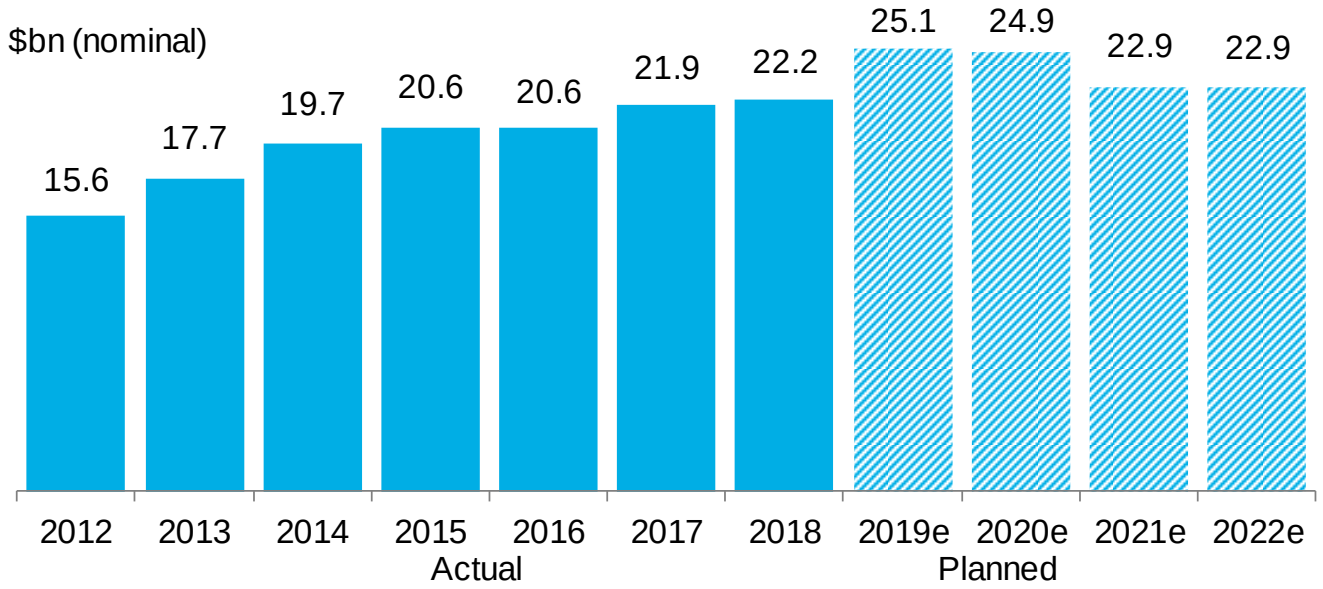
Deployment: Industrial gas demand by region



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

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

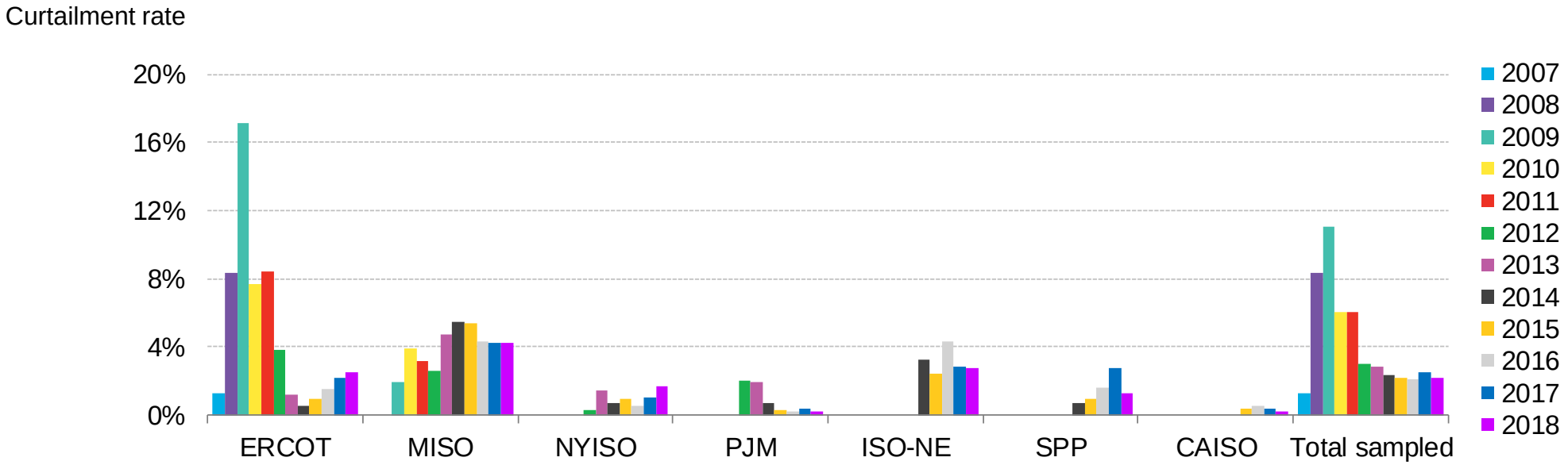
Finance: U.S. electric transmission investment by investor-owned utilities and independent developers



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

Source: Edison Electric Institute, BloombergNEF

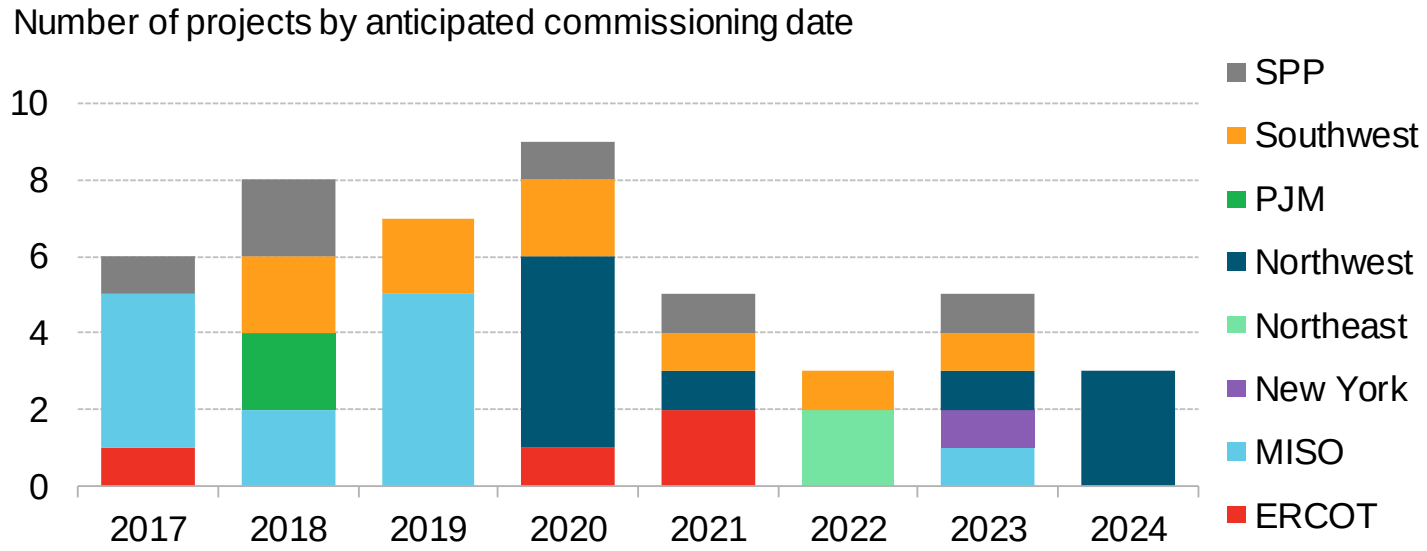
Deployment: U.S. wind curtailment



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

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

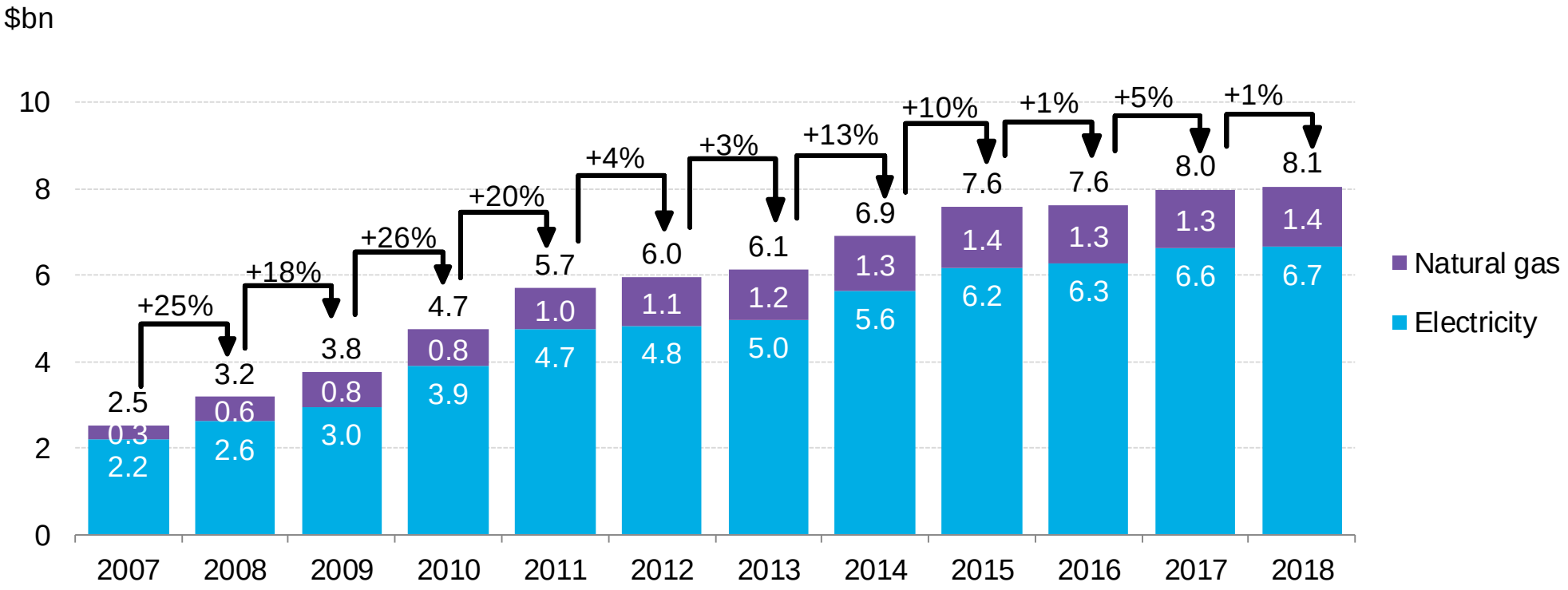
Deployment: Commissioned and planned transmission lines serving wind



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

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

Financing: U.S. utility energy efficiency spending

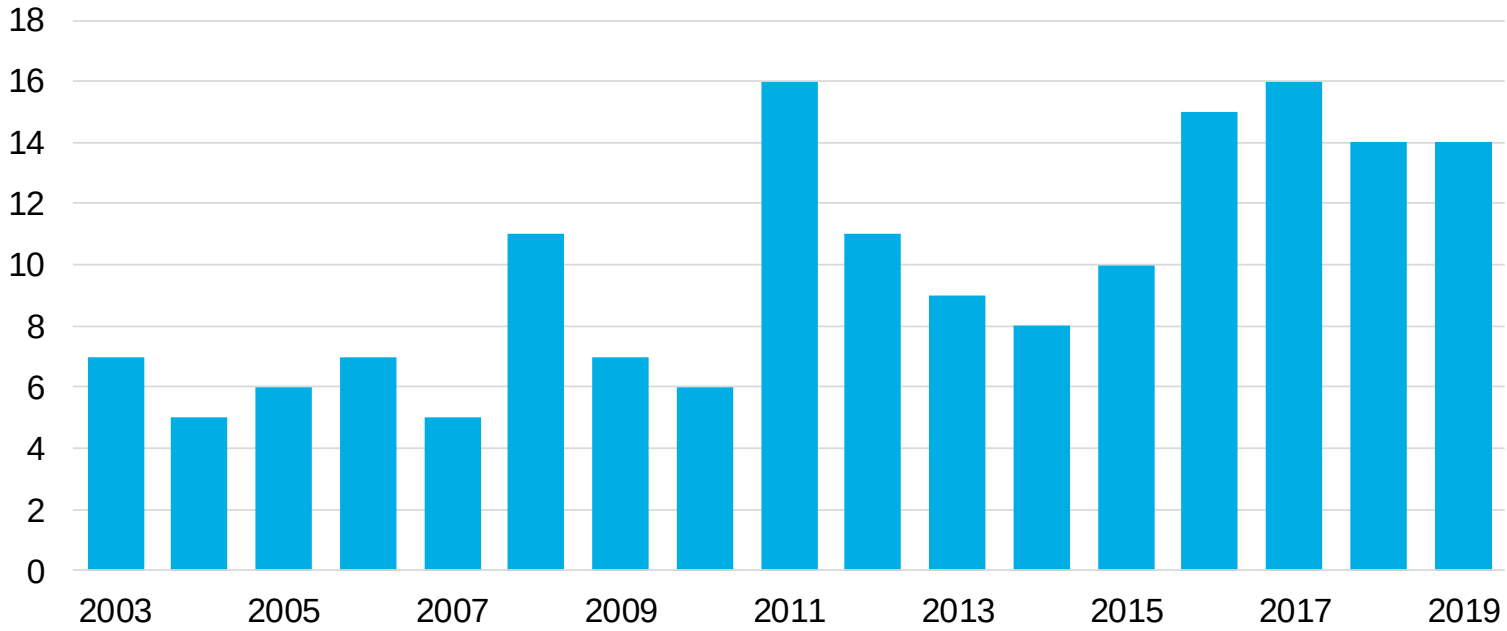


- In 2018, utility spending on energy efficiency kept pace at $6.65bn for electricity and $1.4bn for natural gas. Total spending was just 1% higher than the previous year.
- While investment stayed steady nationwide, the picture was more dynamic at the state level. California invested the most in both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

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

Policy: Infrastructure and resilience

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

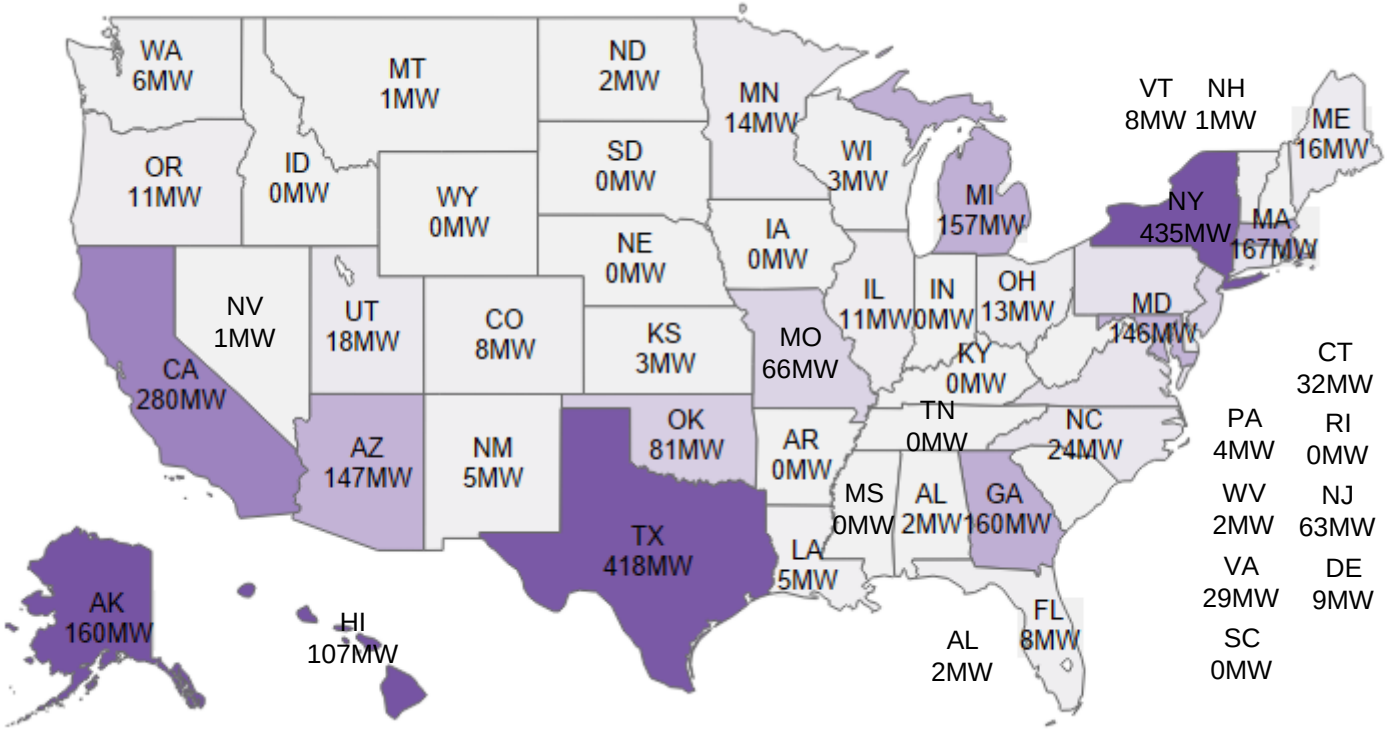


- Congress appropriated more than $20 billion in disaster funding in 2019, of which $3.3 billion was earmarked for the Army Corps of Engineers for flood and storm-damage restoration. The federal Department of Housing and Urban Development also made available about $7.6 billion to states and communities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

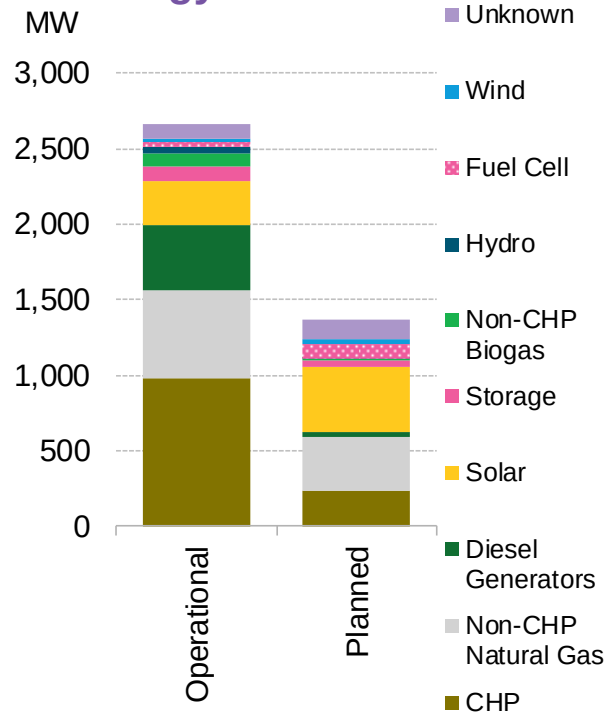
Source: National Oceanic and Atmospheric Administration, National Defense Authorization Act, BloombergNEF. Note: Portrays annual counts of drought, flooding, freeze, severe storm, tropical cyclone, wildfire and winter storm events in the U.S. with losses of more than $1 billion each.

Deployment: National microgrid penetration

Microgrid penetration by state



Microgrid capacity by technology

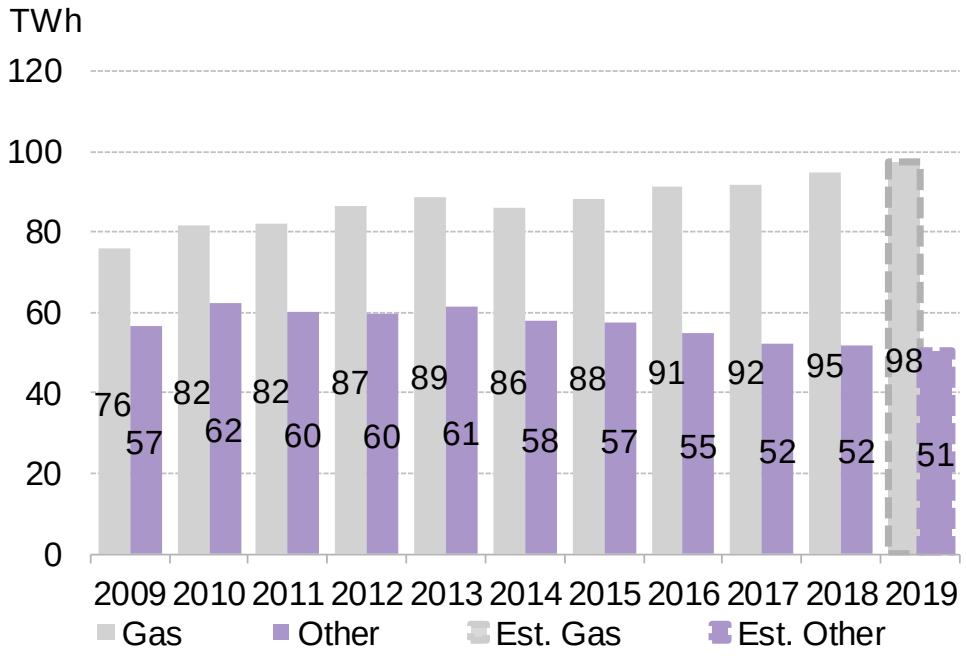


- There are currently 2.7GW of operational and 1.4GW of planned microgrids in the U.S. spread across 242 and 138 sites, respectively.
- Of these, 976MW of operational and 230MW of planned microgrid capacity come from combined heat and power (CHP) systems, representing around 30% of all operational and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

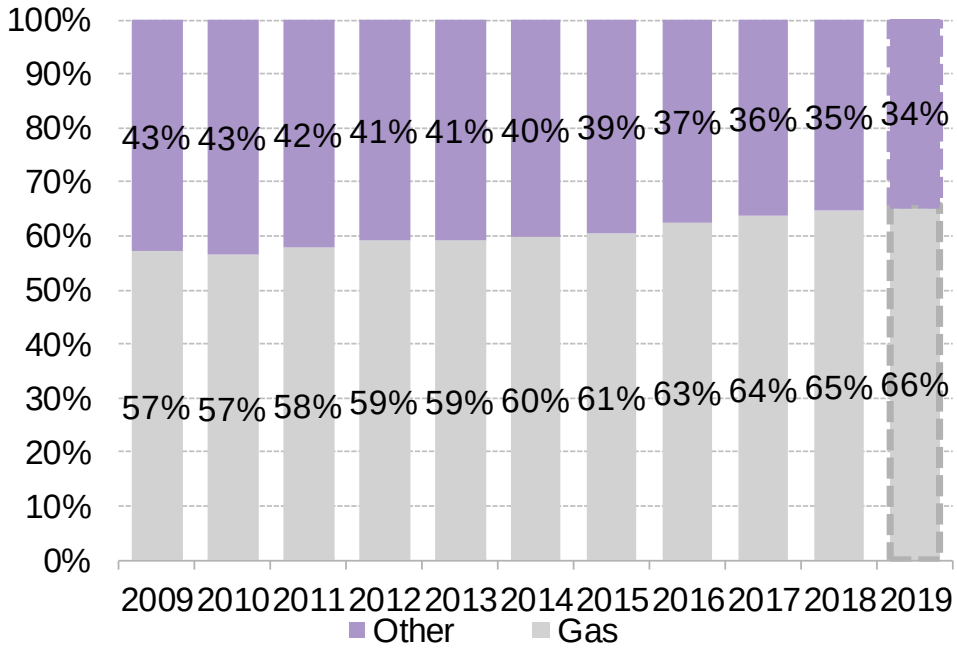
Source: ICF Microgrid Database, BloombergNEF Note: Microgrid is defined as a group of interconnected loads and distributed energy resources (DERs) that can disconnect and re-connect to the utility grid as a single entity, allowing facilities to remain operational during utility outages.

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

Industrial, on-site power generation, TWh



Industrial, on-site power generation, % total

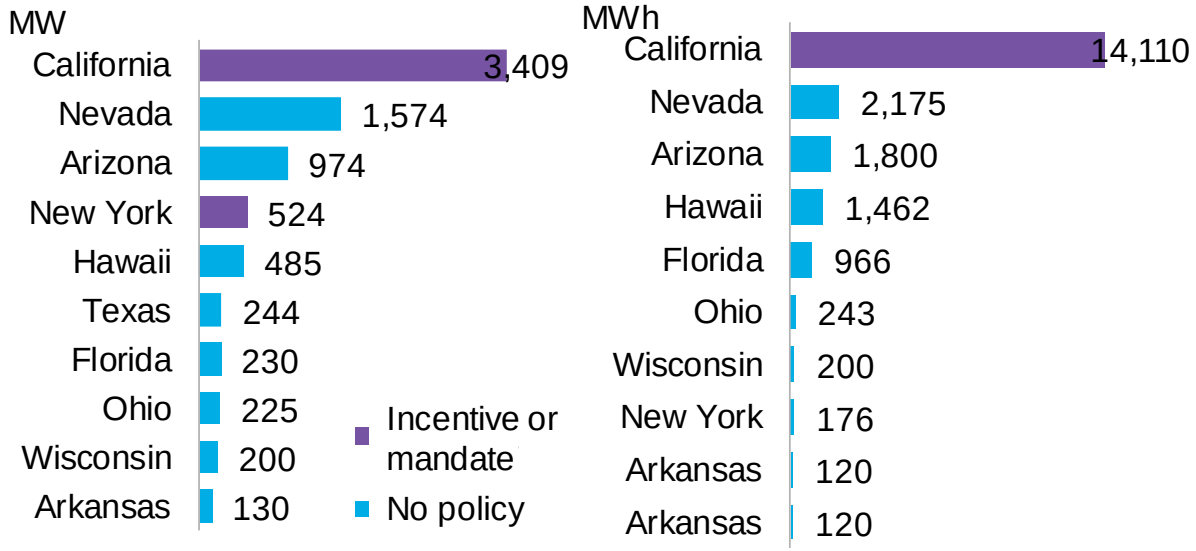


- The industrial sector's energy consumption has risen 24% over the last decade and now accounts for 23% of total U.S. primary energy demand. The sector's total emissions of harmful greenhouse gases rose at a slower, 14% pace over the same period. The industrial sector now accounts for 23% of total U.S.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

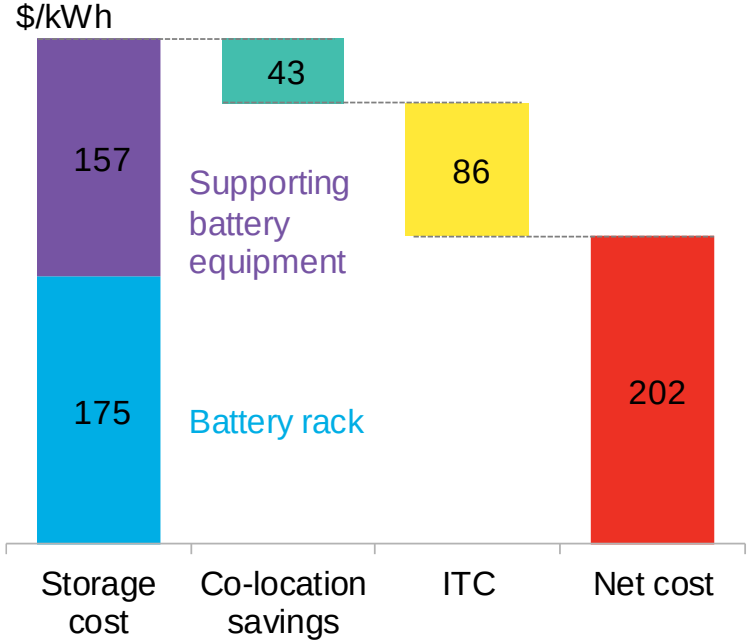
Source: BloombergNEF, EIA; Note: Values for 2019 are projected, accounting for seasonality, based on latest monthly values from EIA (data available through October 2019)

Deployment: Solar + storage

Co-located solar and storage projects commissioned, by state



Cost advantage to co-locating storage with solar

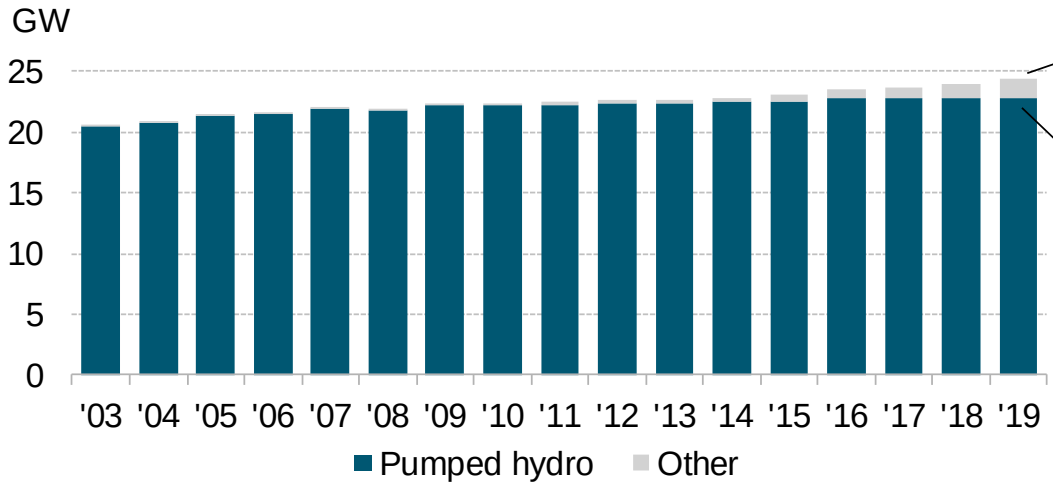


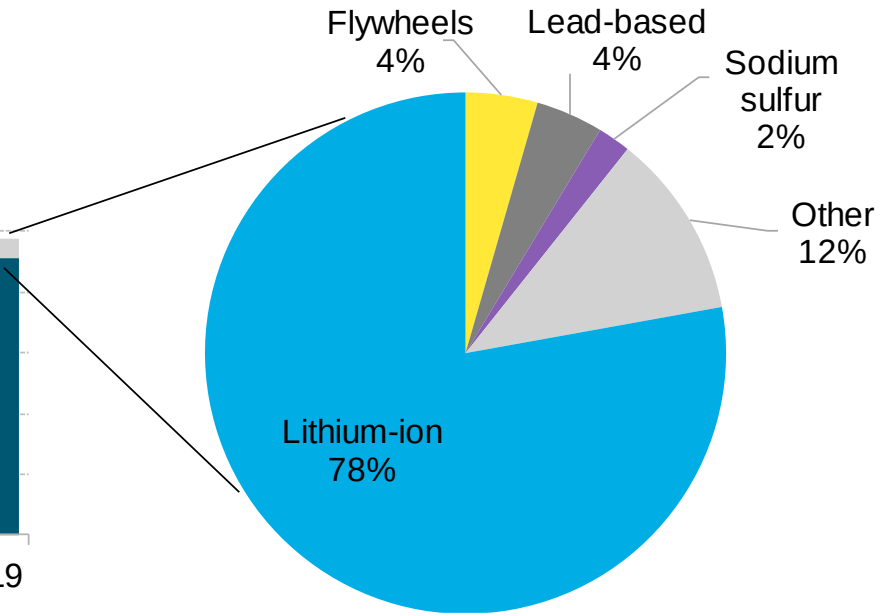
- With 8.3GW solar and 6GW/21.6Wh of paired storage announced through the end of 2019, co-located photovoltaics and storage (PVS) is steadily becoming a part of mainstream U.S. solar. It is common practice for solar developers to offer both PVS as well as PV projects in competitive solicitations. Contract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

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

Deployment: U.S. cumulative energy storage

Commissioned capacity

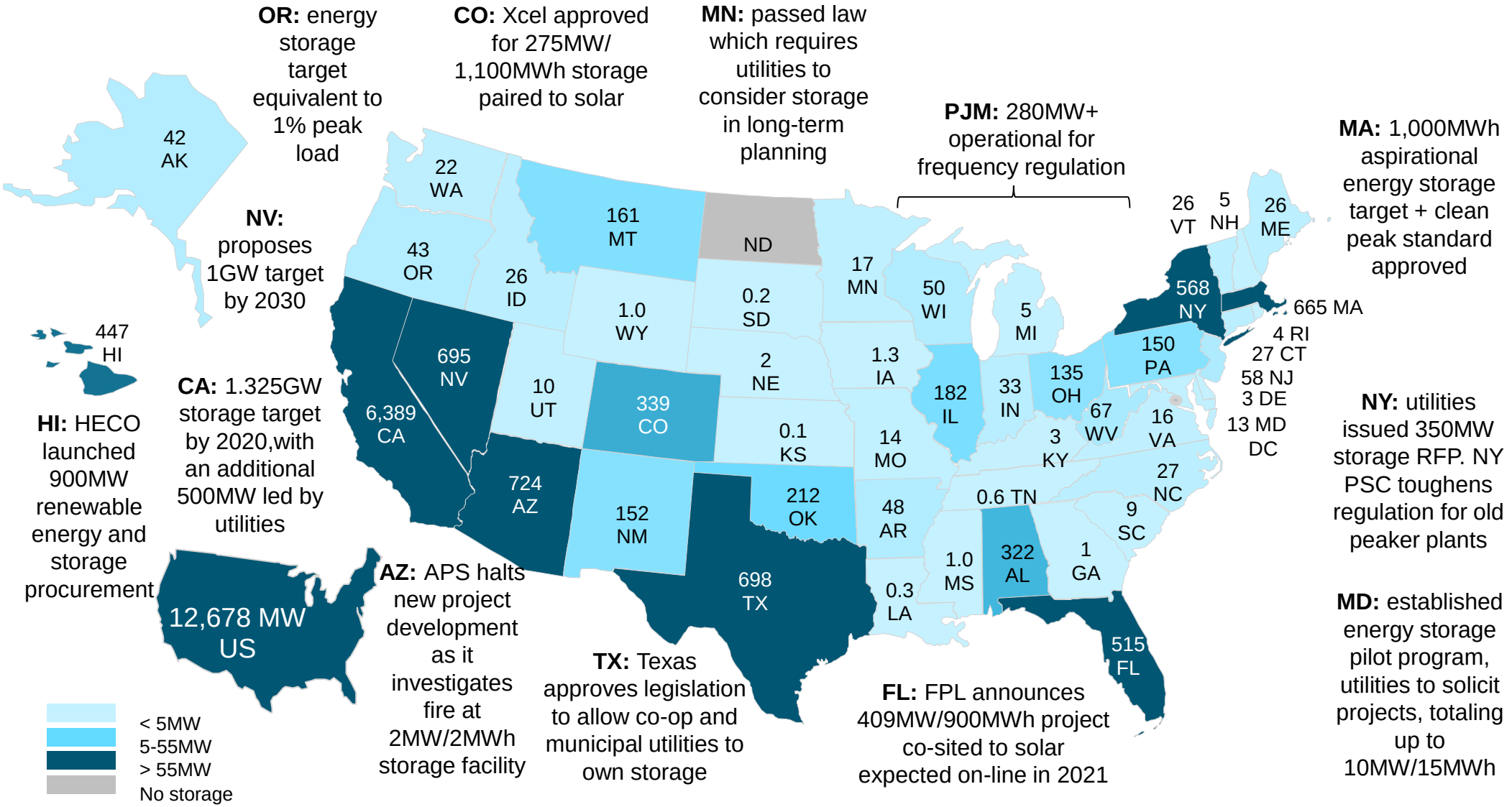




- Pumped hydropower storage projects account for around 93% of installed energy storage capacity in the U.S. While pumped hydro will remain the bulk of energy storage capacity in the U.S., other technologies, mainly lithium-ion batteries, have dominated new build since 2011. State-level energy storage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

Source: EIA, FERC, BloombergNEF, Navigant

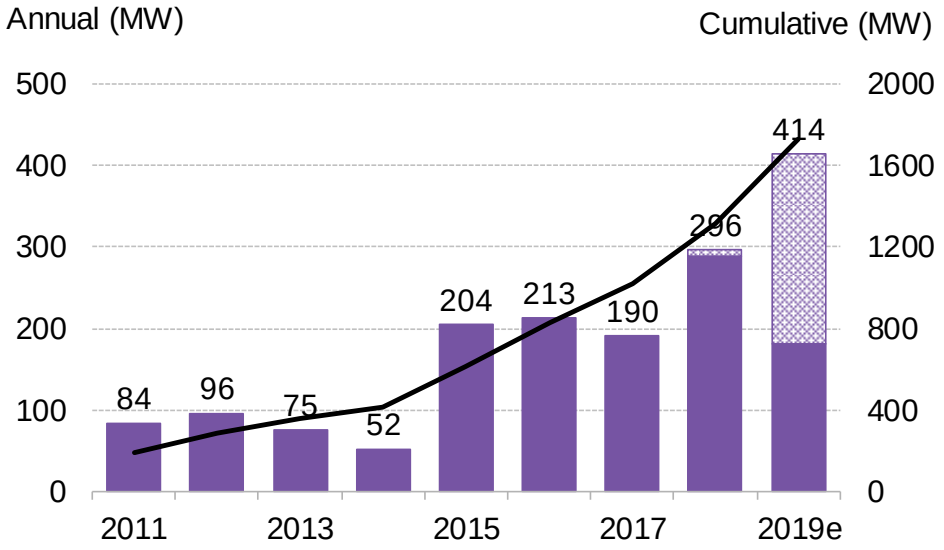
Deployment: U.S. announced and commissioned energy storage projects



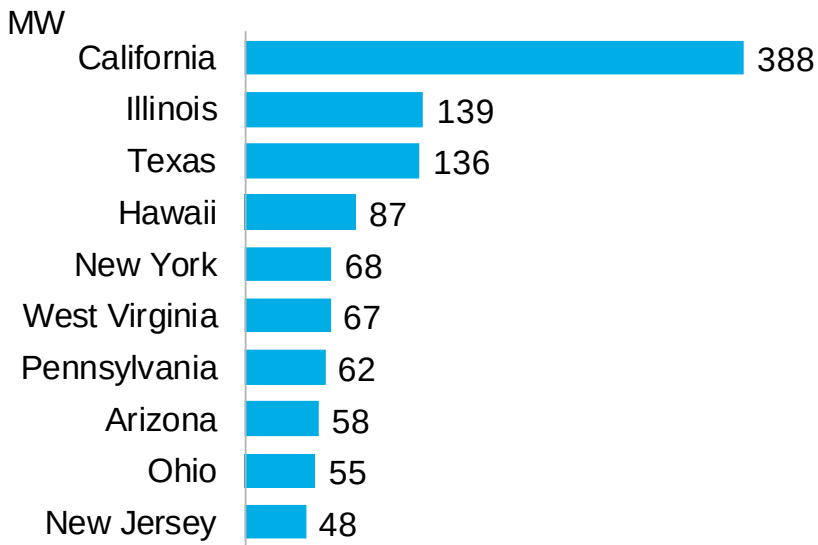
Source: BloombergNEF Note: Includes projects larger than 500kW/500kWh that have announced specific locations and been confirmed by relevant companies through public data. Indiana NIPSCO capacity not included in state capacity because individual project capacity is not yet disclosed. Capacity excludes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

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

Commissioned capacity



Installations by state (top 10 states in 2019)

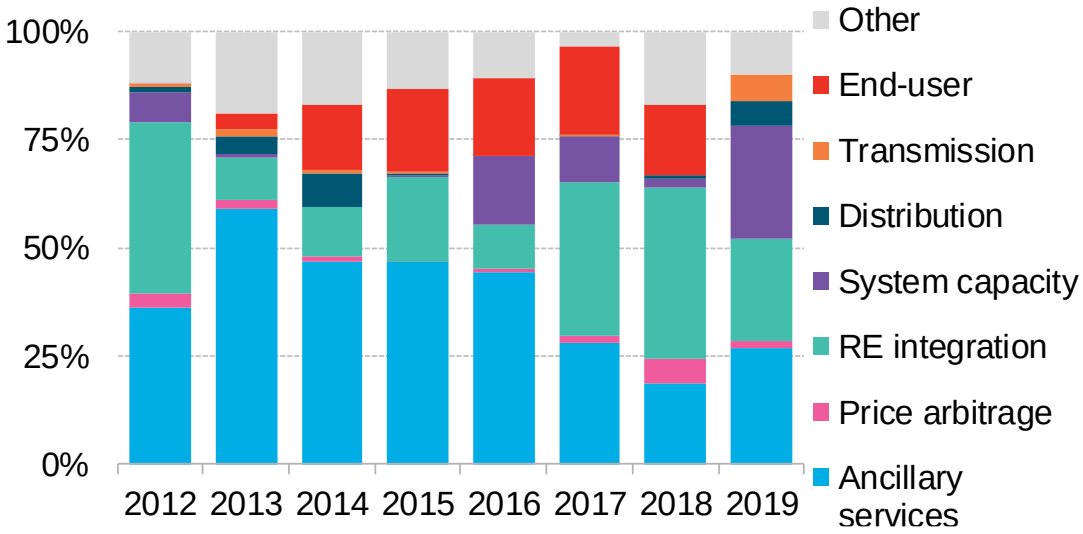


- Annual energy storage installations have increased significantly since 2014. Build ramped in 2015 from projects seeking to participate in the PJM frequency regulation market and these assets represent most of the capacity in Illinois, West Virginia, Ohio and Pennsylvania. Between 2018-2019, the amount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

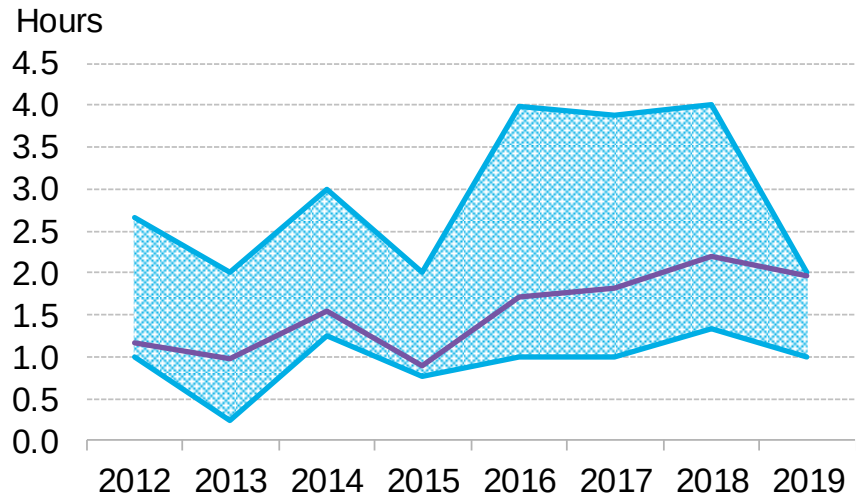
*Source: BloombergNEF, NC State University Notes: *2019 includes expected but unconfirmed capacity as of January 15, 2020. Unconfirmed capacity is marked in white. Does not include underground compressed air energy storage or flooded lead-acid batteries. Minimum project size included is 500kW or 500kWh.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

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

Applications (% by MW)



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

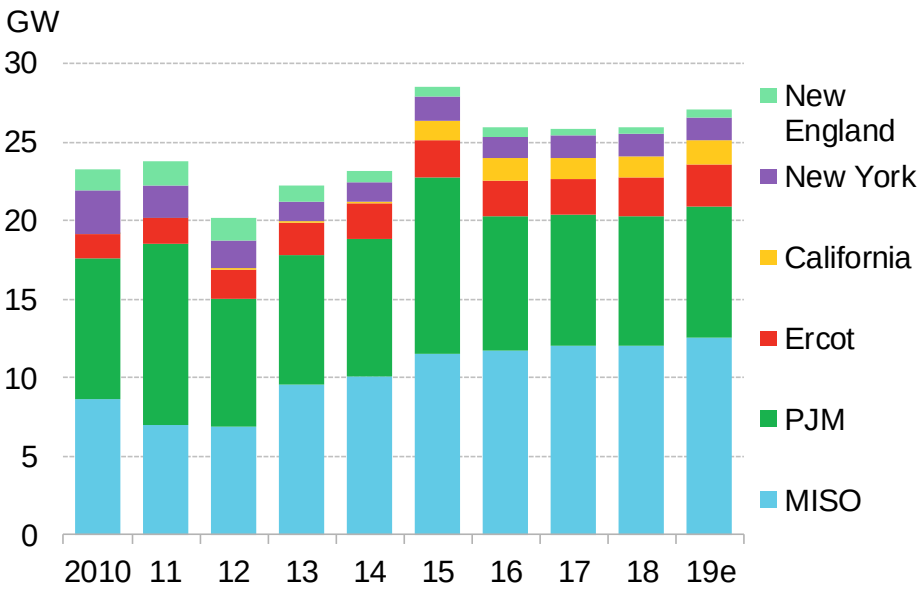


- Since 2017, the major application for energy storage projects has been renewable energy (RE) integration. Such projects support wind and solar additions to the grid. In 2019, system capacity and RE integration together accounted for half of total deployments on a megawatt basis.
- System capacity rose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

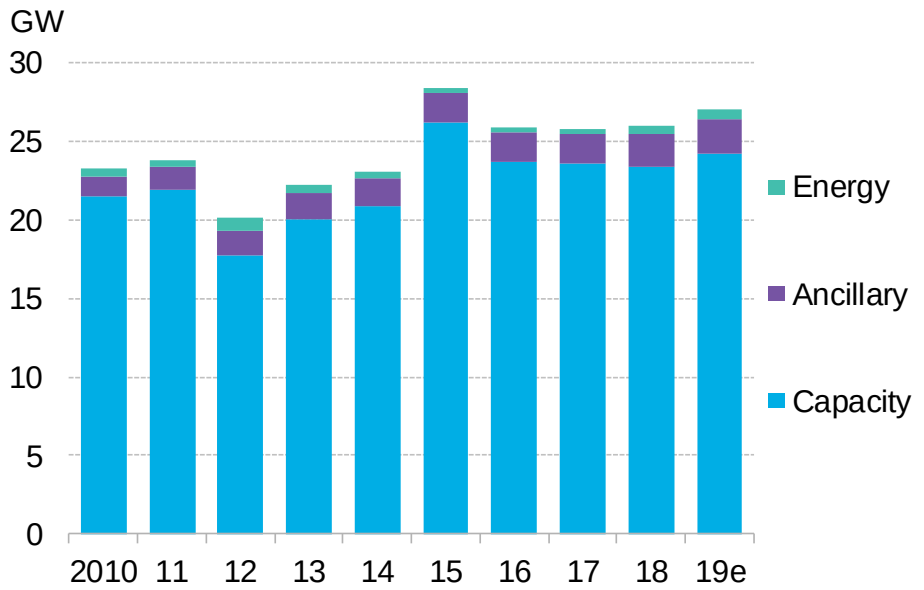
Source: BloombergNEF Notes: Pumped hydropower storage is not included as it would dwarf all other technologies. "Other" refers to applications not represented in the legend; many of these are government-funded technology testing or proof-of-concept pilot projects. Purple duration line represents volume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

Deployment: U.S. wholesale demand-response capacity

By market



By application

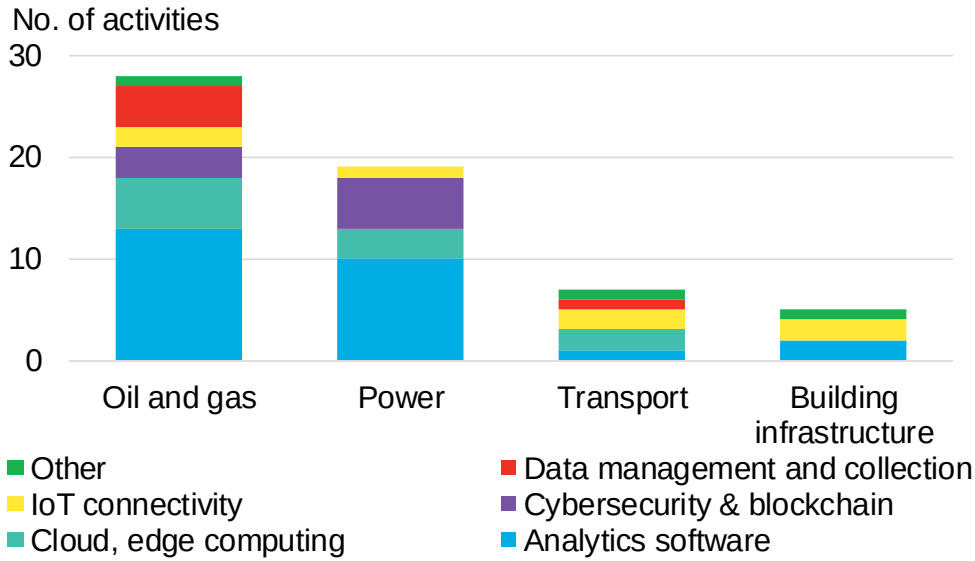


- Demand response (DR) capacity in U.S. wholesale markets grew in 2019 for the second straight year. There were gains in MISO, PJM, Ercot, California and New England, which more than offset a decline in New York. In California, the demand response auction mechanism more than doubled to 373MW. Ercot increased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

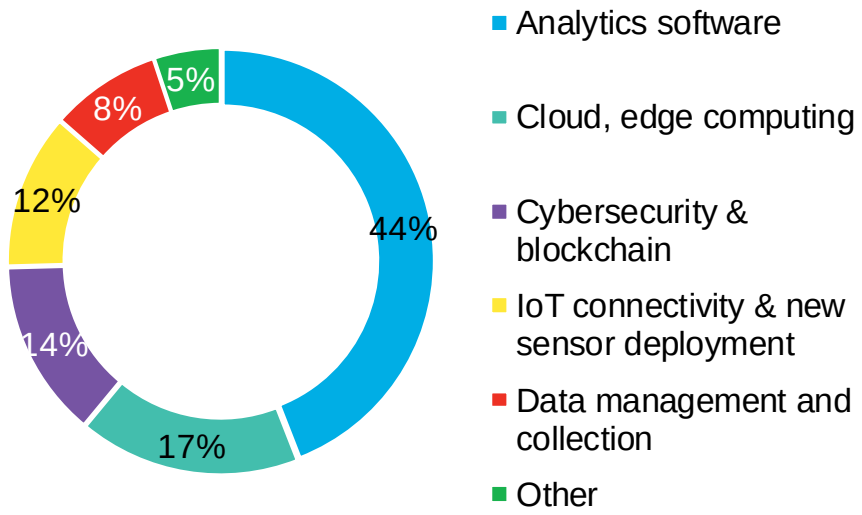
Source: BloombergNEF. Note: Demand response was only formally integrated with the CAISO market in 2015.

Deployment: Progress in the digitalization of the energy sector

Industrial digitalization activity by sector and technology, 2019



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

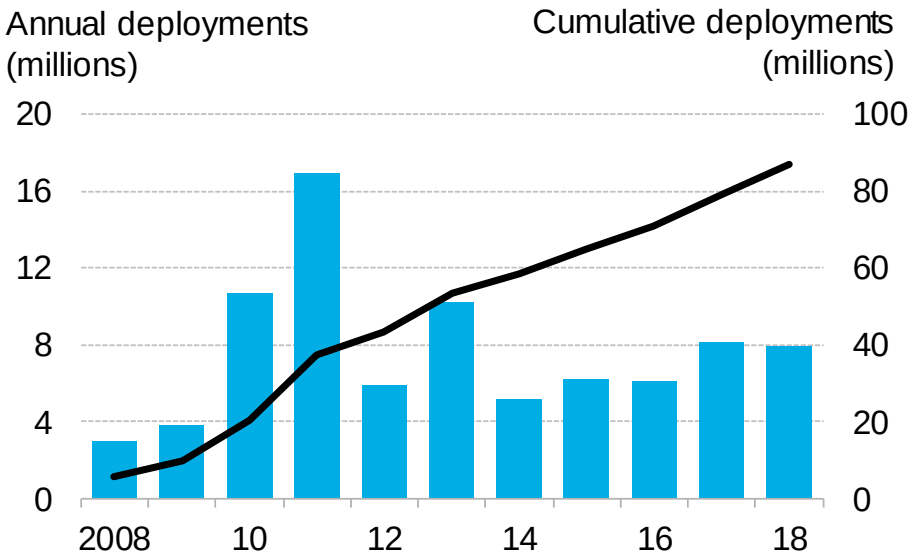


- Microsoft, Schlumberger and Honeywell were the top three companies announcing the highest number of digital projects and partnerships in 2019.
- The oil and gas sector was the most active in 2019, reflecting a global trend. In the U.S., energy companies are fast adopting smart meters, IoT sensors,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

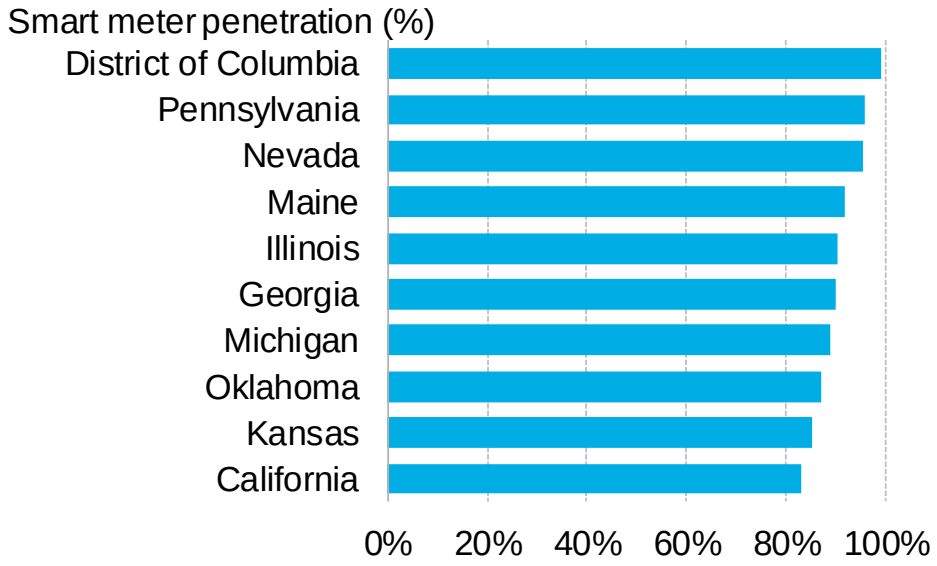
Source: BloombergNEF

Deployment: U.S. smart electricity meter deployments

U.S. smart meter deployments



Top 10 states by penetration, 2018



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

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

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