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 natural gas-fired and the fall of coal-fired generation in the Southeast and PJM (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.
A testament to the resilience of clean energy development, 2020 represented another brisk year for total power-generating capacity additions, with 42GW commissioned. 2020 was the strongest year for generating capacity build since before 2005.

Natural gas-fired power plant build continued as developers installed 7.5GW, seeking to take advantage of persistently low fuel prices and high profitability in the Northeast and mid-Atlantic regions. However, 2020 build was approximately one-third of the capacity added in 2018.

Non-hydro renewable energy build was the highest of all time. These technologies (wind, solar, biomass, geothermal, others) accounted for 80% of total 2020 additions, also the highest percentage of all time. In all, they account for 60% of total additions in the last decade.

Between them, natural gas and all renewables have accounted for 95% of all build in the last decade.

Source: EIA, BloombergNEF  Note: All values are shown in AC except solar, which is included as DC capacity. “All capacity figures represent summer generating capacity. Includes installations or planned installations reported to the EIA through October 2020, as well as BloombergNEF projections.”
Policy: Infrastructure and resilience

The U.S. in 2020 experienced a record 22 climate disasters causing at least $1 billion in damage, far exceeding the previous record of 16 events in each of 2011 and 2017. The 2020 events, made up of tropical cyclones, severe storms, droughts and wildfires, are estimated to have caused $95 billion in damage.

California last year recorded five of the six largest wildfires in its history. Millions of utility customers in the state were left without electricity as utilities cut service to address fire risk from arcing transmission lines.

Motivated by policy incentives and concerns about grid reliability, California utility customers installed more than 11,500 residential energy storage systems in Q1-Q3 2020. This number is 52% greater than that of the same time period in 2019.

Additional investment in transmission will be key to meet renewable energy goals as well as to enhance grid resilience and reliability in the face of increasingly frequent extreme weather events. Additionally, transmission projects also deliver significant economic benefits via job creation as well as cost savings for consumers and millions of dollars in new state and local tax revenue.

Source: National Oceanic and Atmospheric Administration, BloombergNEF. Note: Portrays annual counts of drought, flooding, freeze, severe storm, tropical cyclone, wildfire and winter storm events in the U.S. with losses of more than $1 billion each.
Global energy transition investment hit $500 billion for the first time in 2020 – a 9% increase over 2019 – marking the largest growth since 2016-2017.

The U.S. accounted for $85 billion (or nearly 20% of this global investment), but decreased 11% below 2019. The nation continues to spend the lion’s share of its energy transition capital on renewable energy (58% of total spend) while transport remained a strong growth area (a 42% investment increase in the last 5 years, relative to power’s 31%). Notably, the U.S. now invests roughly $100 million/year in hydrogen, the vast majority of which is tied to fuel cell vehicle sales.

U.S. renewable energy was not immune to the multi-sector investment dip in 2020. Last year, $12 billion less was invested in renewable technologies (a 20% decrease) than in 2019. Solar and wind continued to pull the majority of the capital, accounting for 99% of all renewable energy investment.

Source: BloombergNEF, “Energy Transition Investment Trends, 2021”
Finance: U.S. midstream infrastructure investment

U.S. electric transmission investment by IOUs and independent developers

- Investor-owned utilities and independent transmission developers spent a record $23.4 billion on electric transmission in 2019, Edison Electric Institute (EEI) estimates. This is up 5% from 2018 and up 14% from 2015. Based on company reports, investor presentations and a survey, transmission investment likely jumped 12% in 2020 to $26.1 billion, EEI estimates. Current capex plans suggest that investment will peak in 2021 and investment will then slow. However, future-year budgets are not yet finalized, and these numbers may be revised upward.

- The electric transmission investment upswing is driven by a number of factors, all of which concern the utility’s fundamental aim of providing reliable, affordable, increasingly clean 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.

- Midstream gas utility construction expenditures also continued to rise in 2019, with the increase in distribution expenditures overwhelming the decrease seen in transmission. Total expenditure grew by 5% in 2019, after two years of near 25% growth.

Source: Edison Electric Institute, American Gas Association, BloombergNEF. Note: IOU means investor-owned utility. Gas 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.
There are 2.9GW of operational and 1.6GW of planned microgrids in the U.S. spread across 462 and 221 sites, respectively. This is up from 2.7GW (242 sites) of operational and 1.4GW (138 sites) of planned in 2019.

Of these, 1,065MW of operational and 374MW of planned microgrid capacity come from combined heat and power (CHP) systems, representing around 33% of all operational and planned capacity. There are currently 44 CHP sites paired with solar generating capacity, 19 with diesel generators and 30 with storage. Other technologies have ten or fewer sites paired with CHP.

The commercial sector has the largest number of microgrid systems with a combined 250 operational and planned sites. The municipal and military sectors have the second and third largest with 92 and 63 sites. The commercial and military sectors have 181 and 52 sites currently in operation. With only 35 current sites, the city/municipal sector has the second largest “planned” pipeline (commercial’s is 69).

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.
Total industrial sector energy consumption had risen 24% in the decade before 2020. In 2019, it accounted for 23% of total U.S. primary energy demand. The sector’s total emissions of greenhouse gases rose at a slower, 14% pace over the same period. The industrial sector also accounted for 23% of total U.S. GHG emissions in 2019. However, 2020 was an anomaly: the sector’s consumption fell by 5.8% last year.

Industrial sector, on-site power generation is when electricity is produced at an industrial plant’s premises rather than coming from the grid. From 2019 to 2020, on-site industrial power generation fell 2%. Before 2020, it was up 12% since the start of the decade.

In 2020, natural gas was responsible for an estimated 99TWh of on-site generation at industrial facilities. Other sources provided an additional 47TWh. In total, industrial on-site generation decreased 3TWh over 2019 levels. Prior to 2020, the percent of on-site generation provided by natural gas had increased in the last decade, from 57% in 2009 to 66% 2019, as natural gas displaced other, more expensive fuels, namely coal. This shrunk the size of an otherwise more carbon-intensive, coal-dominated fuel mix.

Source: BloombergNEF, EIA; Note: Values for 2020 are projected, accounting for seasonality, based on latest monthly values from EIA (data available through October 2020)
Deployment: U.S. midstream gas infrastructure capacity and investment

U.S. transmission pipeline capacity additions

U.S. gas transmission and distribution rate base (gas utility plant)

- Growth in the lower 48 states pipeline network slowed considerably in 2020 with the lowest level of capacity additions since 2016. Only two projects completed were new pipelines (as opposed to conversions, expansions, laterals, or upgrades) for combined capacity of less than 1 Bcfd.

- Natural gas infrastructure investment grew in 2019, hitting $601 billion. The vast majority of this investment was spent on the natural gas transmission and distribution systems, accounting for 47% and 43% of the spending, respectively.

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.
There are two primary types of natural gas power plants in the U.S.: combined cycle gas turbines (CCGTs) and open cycle gas turbines (OCGTs). CCGTs tend to be larger and run as “baseload” power plants used to meet power demand in the majority of – if not all – hours of the day. OCGTs are smaller and more nimble, operating as “peaking” systems during high demand hours.

Natural gas-fired power plant build accounted for 35% of total power plant build over the last 10 years. CCGT build boomed in the late 2010s with the shale revolution depressing gas prices in PJM. In the U.S., power is the primary source of natural gas demand elasticity. When the price of natural gas falls below that of coal, gas burn rises until the price differential (in $/MWh) between the two fuels closes.

Despite mandated and announced ambitions on both the state and federal levels to decarbonize the power sector, the numbers of natural gas-fired power plants filed with the EIA to come online in the next five years totals 38GW: 33GW of CCGTs and 5GW of OCGTs. Considering historical trends, not all of these plants will come online and it is likely that many will be canceled and remove their filings before turning on.

PJM remains the most popular region for gas build, totaling 46% of the total, filed natural gas 2021-2025 build. The region continues to have ample, stable fuel for power plants that are filed to be built among an aging coal plant fleet across the region, including in Appalachia.

Source: BNEF
Deployment: Commissioned and planned transmission lines serving wind

- Wind tends to be one of the first sources 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. American Clean Power Association (ACP) estimates that new transmission lines across the U.S. set for commission by 2024 could enable tens of thousands of megawatts of new wind capacity.

- From 2017-2020, MISO led the way on new transmission lines, commissioning projects serving wind across Iowa, Minnesota, Missouri, Illinois, Wisconsin, North Dakota and South Dakota. There are several projects in development in the Northwest and Southwest. Many of these aim to bring more wind energy to power-hungry California to help the state meet its renewable energy targets. Historically, U.S. curtailment rates have declined by about 80% since 2009 thanks to transmission buildouts. 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.

- There are plans for lines in several other regions in coming years, including two 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 2023 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, American Clean Power (ACP)  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.
The U.S. offshore wind sector is poised for rapid growth but has been in limbo as the country’s first potential large-scale project awaits a federal permit. Despite the sector’s great promise, there are still only 42MW of turbine installed in U.S. waters.

At the end of 2020, Congress extended a 30% investment tax credit for offshore wind farms until 2025. The Internal Revenue Service also increased the commissioning deadline for offshore wind from four to 10 years. This means every project installed until at least 2030 will receive the subsidy. BNEF estimates this could cost the U.S. government a total of over $16 billion.

Northeastern states have among them approved measures targeting 31.6GW offshore by 2035.

Vineyard Wind, which stands to become the first large-scale project in U.S. waters, continued to experience permitting delays in 2020. The 804MW project, a joint venture between Avangrid and Copenhagen Infrastructure Partners, was originally scheduled for commissioning in 2021. After several further delays this year, the project’s original preferred turbine supplier agreement expired. The project has temporarily withdrawn from federal permitting while it incorporates a new turbine model into the project design.

Despite the industry’s teething problems, states continue to hold large-scale solicitations for offshore wind power. In the final quarter of 2020, New York and New Jersey closed requests-for-proposals for up to a total almost 5GW. Results are expected in 2021.

Source: Bloomberg New Energy Finance, Bloomberg, CARTO, Mapbox, OpenStreetMap, BOEM. Notes: This map was created using MAPS <GO> on the Bloomberg Terminal. The shape file of U.S. offshore wind zones can be found on BOEMs website (link).
Deployment: U.S. cumulative energy storage

- **Commissioned capacity**

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- Pumped hydropower storage projects account for about 91% 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 targets and utility solicitations generally exclude pumped storage.

- Three new pumped storage projects with a combined capacity of 2.1GW have received licenses in the last few years – Eagle Mountain in California, Swan Lake in Oregon, and Gordon Butte in Montana. Construction on all could potentially start in 2021. The last large pumped storage facility was built in 1995.

- As of the end of 2020, all six U.S. jurisdictional wholesale market operators were at least partially compliant with FERC Order 841 (some operators have extended their compliance timelines to finalize specific components). Issued in February 2018, Order 841 is a landmark rule that will remove barriers to energy storage and bring a measure of consistency to how these assets participate across organized power markets. By enabling energy storage systems to obtain compensation for the services they can provide to the wholesale markets, the rule allows energy storage to compete fairly against other generators. This will create new opportunities for energy storage and encourage additional storage deployments.

- While lithium-ion holds the majority of the remaining market share, thermal energy storage in the form of ice-based systems is emerging in North America. 12.5MW of these systems were installed in 2020 with projections showing a potential of 38MW by 2028.

Source: EIA, FERC, BloombergNEF Note: “Other” includes projects where the technology is unknown, which is frequently lithium-ion batteries.
Deployment: U.S. announced and commissioned energy storage projects

**OR:** energy storage target equivalent to 1% peak load

**CA:** 1.325GW storage target by 2020, with an additional 500MW led by utilities

**NV:** set 1GW storage target by 2030

**HI:** HECO plans to procure 3GWh of storage to meet renewable goals

**US:** 21,496

**CA:** 8,495

**NV:** 1,513

**OR:** 1,262

**CA:** 1,325

**HI:** 1,399

**US:** 21,496

**MA:** 1,000MWh aspirational energy storage target + clean peak standard approved

**NY:** 2GW proposed projects in pipeline to meet 3GW storage mandate by 2035

**VA:** 3.1GW of storage target for utilities by 2035

**FL:** FPL announces 409MW/900MWh project co-sited to solar expected on-line in 2021

**CA:** HECO plans to procure 3GWh of storage to meet renewable goals

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**NY:** 2GW proposed projects in pipeline to meet 3GW storage mandate by 2035

**VA:** 3.1GW of storage target for utilities by 2035

**FL:** FPL announces 409MW/900MWh project co-sited to solar expected on-line in 2021

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

U.S. CHP build and cumulative capacity

- CHP new capacity build rebounded in 2019 (the last year for which complete data are available) after a 2018 lull with 580MW coming online.
- However, operational CHP capacity continued to decline from its 2014 peak of 82.7GW to 80.8GW in 2020, its lowest level since 2008. This is mostly due to industrial plant site retirements of approximately 1GW outpacing new build.
- Generation from CHP plants remained consistent between 2018 and 2019, accounting for 350TWh (8.6% of total 2019 U.S. generation), but then fell 6% to 330TWh in 2020.

Source: BloombergNEF, DOE CHP Installation Database (maintained by ICF)   Notes: EIA is the best available source for generation data, but runs through November 2020 (December is estimated) and is not comprehensive for CHP. The generation figures here are thus underestimated. Specifically, EIA does not collect data for sites <1MW, and EIA categorizes some CHP systems as “electric power” rather than “industrial CHP,” among other reasons.
Fuel source distribution of CHP essentially remained the same from 2018 to 2019 (the last year for which complete data exists). Natural gas continued to supply the majority of CHP fuel at 72% (58MW). 14% of total operational capacity relies on units using biomass, wood, or waste. Coal’s contribution ticked down 1%, from 12% to 11%. Additionally, there are 13 propane systems operating in the U.S. and its territories. And two of these systems help provide energy to critical infrastructure.

For both the commercial and industrial sectors, CHP facility build and retirements balanced in 2019, leading to relatively flat shares of the market held at 16% and 78%, respectively.

Source: BloombergNEF, DOE CHP Installation Database (maintained by ICF)  Note: totals may not add to 100% due to rounding.
Deployment: Incremental annual energy efficiency achievements by electric utilities to date

- The years leading up to 2011 saw a growing number of states introducing Energy Efficiency Resource Standards (EERS) mandating utilities to invest in energy savings among their customer-base. There was a corresponding increase in investment in utility energy efficiency programs.

- Since 2011, the number of states with EERS policies in place has leveled off at 27 as investment growth has slowed. 2019 utility energy efficiency savings decreased slightly by 1% from the previous year, totaling 26.9TWh of energy and 0.7% of retail sales. The percentage savings relative to overall retail sales also declined by 0.8% from previous year.

- The ACEEE, which collects this data, attributes the difference to adjustments in its qualifying criteria for utility energy efficiency savings, rather than a decrease in energy efficiency activity.

Source: ACEEE  Note: The ACEEE Scorecard points to caveats in the energy efficiency savings data reported by states. ACEEE uses a standard factor of 0.825 to convert gross savings to net savings for those states that report in gross rather than net terms. The ACEEE currently reports electric and natural gas savings separately in their report but a handful of states have been considering savings in a fuel-neutral basis, which is appropriate when electrification brings net positive effect on emissions. ACEEE may adjust methodology if practice becomes commonplace.
In 2019, utility spending on energy efficiency kept pace at $6.84 billion for electricity and $1.53 billion for natural gas. Total spending is 4% higher than the previous year.

Investment increased marginally nationwide, although the picture was more dynamic at the state level. Large states continue to spend large amounts. California invested the most in both natural gas, $386 million, and electricity, $1.5 billion. Texas saw the largest jump in electric program spending, up 19% to $92 million, and New York saw the largest jump in gas program spending, up 25% to $177 million.

Nine states cut their efficiency budgets by more than 10% in 2019. Florida was the largest, dropping to $132 million (-41%). Florida was followed by Washington ($218 million, -27%), Iowa ($57 million, -37%) and Wisconsin ($99 million, -14%).

Source: CEE, ACEEE, BloombergNEF. Note that data for 2010-14 was sourced from CEE, and for 2006-2009 and 2015-20 from the ACEEE.
Demand response (DR) capacity in U.S. wholesale markets declined in 2020. Gains in MISO were more than offset by declines in CAISO and PJM. ERCOT, ISO-NE and NYISO remained more or less flat compared to 2019. The vast majority of wholesale demand response is concentrated in capacity markets and reliability mechanisms.

In PJM, there is 1.3GW, or 16%, less demand response capacity committed for 2020/21 than the previous year. PJM has been phasing in its annual capacity requirement for the past four capacity auctions and the 2020/21 delivery year was the first time that 100% of capacity must be available year-round. It does, however, provide a matchmaking service for summer and winter resources.

In CAISO, the Demand Response Auction Mechanism capacity halved in 2020 from 373MW to 176MW. In 2019, the California Public Utilities Commission ordered a four-year extension of the program. It also required utilities to make a number of changes such as penalties for underperformance and requiring providers to provide customer composition information.

Source: BloombergNEF; Federal Energy Regulatory Commission, 2020 Assessment of Demand Response and Advanced Metering. Note: Capacity is the peak amount of capacity available, ancillary services are the annual average. Demand response was only formally integrated with the CAISO market in 2015.
Deployment: Progress in the digitalization of the energy sector

Industrial digitalization activity in U.S. by sector and technology, 2020

Most common technologies adopted in U.S. industrial digitalization for energy, 2020

- Of U.S.-based companies, Honeywell, Halliburton and Microsoft announced the most digital projects and partnerships in the energy sector in 2020. With the ongoing pandemic, energy companies have become more reliant on remote monitoring and cloud computing to continue operations. Analytics software such as artificial intelligence and predictive maintenance accounted for around half of 2020 activity.

- In the U.S., energy companies are fast adopting smart meters, IoT sensors, analytics platforms, cloud computing, drones and other technologies. The oil and gas sector was the most active, comprising 50% of total U.S. activity in 2020. Service providers Halliburton and Schlumberger were particularly active in partnering with cloud providers Microsoft, Amazon and IBM. In the power sector, utilities such as Edison, Ameren, Southern and NYPA are all building smart grid technologies and working with software providers GE, Schneider Electric, Siemens and startups to reap the benefits of reduced operating costs and less outages.

- However, regulated utilities have not been the most active corporations in announcing new projects because they cannot 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

- 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 2019, 60% of U.S. electricity customers had a smart meter, but with enormous regional variation. The top 10 states all had penetration greater than 86% whereas 22% or fewer customers had smart meters in the bottom 10 states. In 2019, Florida accounted for 15% of new smart meters, with 1.2 million deployed. The next most active states were Texas, Indiana, Ohio, New York, the District of Columbia, and Louisiana, each deploying 400,000 to 600,000.

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