U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

2018 Renewable Energy Data Book

Acknowledgments

This data book was produced by Sam Koebrich, Thomas Bowen, and Austen Sharpe; edited by Mike Meshek and Gian Porro; and designed by Al Hicks and Besiki Kazaishvili of the National Renewable Energy Laboratory (NREL). We greatly appreciate the input, review, and support of Jenny Heeter (NREL); Yan (Joann) Zhou (Argonne National Laboratory); and Paul Spitsen (U.S. Department of Energy).

Notes

Capacity data are reported in watts (typically megawatts and gigawatts) of alternating current (AC) unless indicated otherwise.

The primary data represented and synthesized in the 2018 Renewable Energy Data Book come from the publicly available data sources identified on page 142.

Solar photovoltaic generation data include all grid-connected utility-scale and distributed photovoltaics. Total U.S. power generation numbers in this data book may difer from those reported by the U.S. Energy Information Administration (EIA) in the Electric Power Monthly and Monthly Energy Review. Reported U.S. wind capacity and generation data do not include smaller, customer-sited wind turbines (i.e., distributed wind).

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About the Renewable Energy Data Book

The objective of the Renewable Energy Data Book (data book) is to synthesize data and information from a number of verified sources to support cross-cutting analysis of the domestic and global renewable energy landscape. Facts and figures within the data book often are based on a synthesis of multiple sources of information. As such, aggregated statistics reported in the data book might differ from those reported by any single data source cited in the data book. For example, U.S. renewable energy generating capacity data for hydropower, geothermal, biomass energy , and utility-scale solar resources is generally sourced from Energy Information Administration (EIA) mandatory reporting, however capacity data for other technologies such as distributed solar PV and wind are sourced from trusted industry market reports which include more complete or detailed data sets for specific technologies (e.g.., rooftop PV).

Methodologically, this requires data from multiple sources to be combined to report discrete statistics (such as cumulative U.S. renewable energy generating capacity). Whenever data is combined, substitutions are made—generally at the state or sectoral level—to ensure that resources are not being double-counted or excluded from reporting.

For instance, U.S. renewable energy capacity data for hydropower, geothermal, biomass energy, and utility-scale solar resources is generally sourced from Energy Information Administration (EIA) Form-860 at the generator level, however capacity data from other technologies such as distributed solar PV and wind is sourced from trusted industry and market reports which capture a larger variety of resources (i.e. rooftop PV). As such, solar generators less than 1 MW in size, and all wind resources are filtered out from EIA-860 data, and merged with aggregated data at the state level from industry reports. Likewise, while data from the International Renewable Energy Agency (IRENA) is used for global estimates, values reported within individual technology sections are used in place of IRENA estimates for the United States. Wherever possible, footnotes inform the reader about the underlying sources and methods used to represent the data.

Data sources may change between versions of the data book as more complete data sets emerges or data sources cease publication. Additionally, many sources consistently modify historical data as improved information becomes available.

The data book considers the following technologies as renewable: wind, solar photovoltaic (PV), concentrated solar power (CSP), geothermal, biomass energy (including wood and agricultural residues, landfill gas, and municipal solid waste), hydropower, and marine and hydrokinetic power (MHK). Other reporting in the data book details the market evolution of energy storage technologies, hydrogen and fuel cells, plug-in electric vehicles (PEVs), and renewable and alternative fuels (i.e. biofuel); data from these sections is generally excluded from cumulative renewable energy generation and capacity figures within the data book. Pumped storage hydropower (PSH) is generally excluded from the data book, including from the energy storage section which is intended to specifically detail electrochemical, electromechanical (i.e. flywheel), and thermal storage technologies. In some places, PSH data is included when specifically mentioned.

Recommended Citation

Koebrich, Samuel, Bowen, Thomas, & Sharpe, Austen. *2018 Renewable Energy Data Book. U.S. Department of Energy (DOE), Office of Energy Efficiency & Renewable Energy (EERE)*.

Key Findings

- In 2018, U.S. **renewable energy capacity**[1] (249 GW) **surpassed 20% of total electricity generating capacity** (1.2 TW) for the first time, as it reached 20.5%.
- Despite this capacity milestone, **renewable energy generation remained constant as a percentage of total U.S. electricity generation**—17.6% (741 terawatt-hours [TWh]) in 2018. The share of natural gas generation rose to 31.9% (1,468 TWh) from 34.9% in 2017 to meet rising electricity consumption.
- U.S. hydropower produced over 39.4% (292 TWh) of total renewable electricity generation, wind produced nearly 36.8% (272 TWh), solar (photovoltaic [PV] and concentrating solar power [CSP])[2] produced nearly 13.3% (98 TWh), biomass energy produced over 8% (61 TWh), and geothermal produced more than 2% (16 TWh).
- **Overall U.S. energy consumption increased significantly** to 101 quadrillion British thermal units (Btu) in 2018—a nearly 3.7% increase from 2017, the largest increase since 2010. Energy consumption from natural gas increased from 28.8% in 2017 to 30.8% in 2018 but declined for coal (14.2% to 13.1%), nuclear (8.6% to 8.3%), petroleum (37% to 36.5%), and renewables (11.5% to 11.3%).
- **U.S. electricity generation increased 3.6%** from 4,063 terawatt-hours (TWh) in 2017 to 4,209 TWh in 2018.
- In 2018, natural gas represented 56.4% (21.8 gigawatts [GW]) and **renewables represented 42.9% (16.6 GW) of all new U.S. capacity additions**.

Source: U.S. Energy Information Administration (EIA); full references are provided beginning on page 145.

[1] Renewable energy resources includes solar, wind, geothermal, hydropower, and biomass energy unless indicated otherwise.

[2] Reported solar data combine utility-scale PV, distributed PV, and CSP unless indicated otherwise.

Key Findings (continued)

- After subtracting capacity retired in 2018, **cumulative U.S. natural gas capacity grew by 15.1 GW**, **renewable capacity grew by 16.4 GW**, and coal-fired generating capacity fell by 15.1 GW, which represented 56.8% of all capacity retirements.
- In 2018, U.S. **wind capacity increased almost 8.4%** (7.5 GW), accounting for more than 44.9% of newly installed renewable electricity capacity, U.S. wind generation reached a total of 273 TWh by the end of 2018.
- **U.S. solar PV electricity capacity increased by 20.6% (61.7 GW_{AC}[1])**, accounting for **more than 52.9% of newly installed U.S. renewable electricity capacity** in 2018.[2] Solar generation reached a total of 94.9 TWh in 2018.
- **U.S. hydropower capacity remained relatively stable** from 2017 to 2018. **U.S. Biomass Energy decreased by 364.7 MW** and **geothermal capacity increased by 73.6 MW** in 2018.
- **Almost 361,000 plug-in electric vehicles (PEVs) were sold in the United States in 2018**, an increase of 84.7% **from 2017 (196,000 sales)**. **PEV sales in 2018 —represented over 2% of total light-duty vehicle sales**. **The cumulative number of PEVs sold in the United States since 2010 surpassed 1 million for the first time in 2018**.
- From 2017 to 2018, cumulative **global capacity of renewable electricity grew by 8.0%** (from 2,181 GW to 2,355 GW), which continued the steady growth of recent years (7.6% compound annual growth rate [CAGR] from 2009 to 2018).
- **Globally**, **new investments in clean energy in 2018 decreased by 11%** from 2017—down to $288 billion.

Sources: EIA and SEIA/GTM

[1] Solar generator capacity estimates are derived from EIA-860 compliance reporting for generators greater than 1 MW in capacity. Smaller solar generator capacity is based on data from the Solar Energy Industries Association/ Greentech Media (SEIA/GTM) *Solar Market Insight 2018 Year-in-Review* report.

[2] Capacity data are reported in watts of alternating current (AC) unless indicated otherwise. While EIA-860 reports utility-scale solar capacity in MWAC, SEIA/GTM reports small-scale grid-connected PV capacity in MW_{DC}. The solar industry typically reports capacity in MW_{DC}. Based on consultation with developers, SEIA/GTM use an 87% MW_{DC}-to-MW_{AC} derate factor for small-scale generators. The data book uses the 87% derate factor when small-scale capacity figures are added to a cumulative MW_{AC} total.

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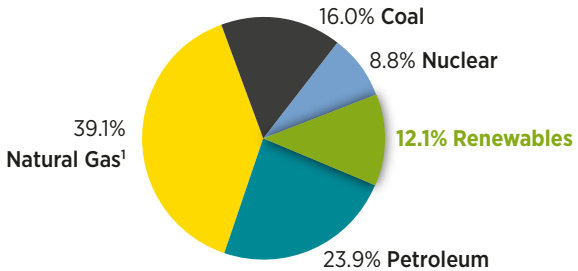
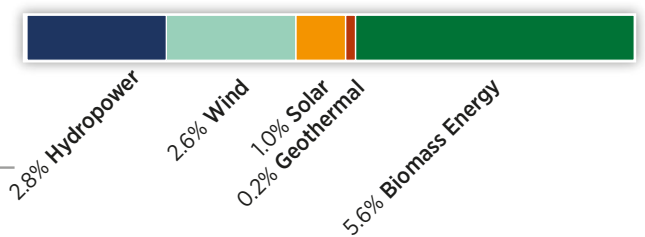
I. U.S. Energy Background Information

U.S. Energy Production and Consumption (2018)

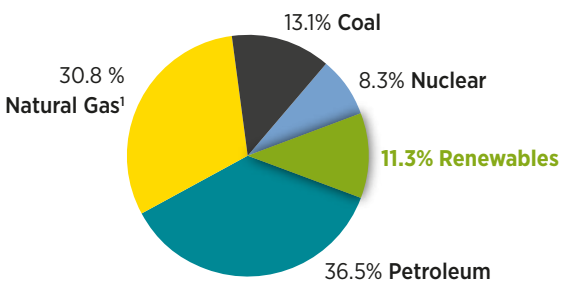
U.S. Energy Production (2018): 95.7 Quadrillion Btu



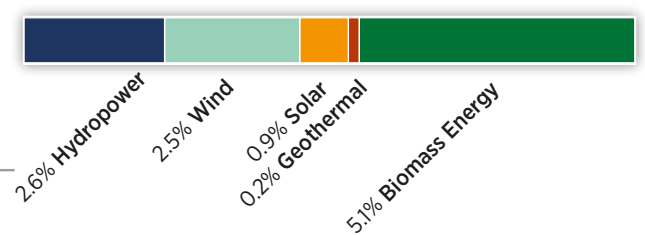
U.S. Renewable Energy Production: 11.6 Quadrillion Btu



U.S. Energy Consumption (2018): 101.1 Quadrillion Btu



U.S. Renewable Energy Consumption: 11.4 Quadrillion Btu



Sources: EIA and GTM

The difference in the amount of energy consumed and produced is made up by net imports and changes in stockpiles of energy. All data are reported as primary energy. Reported values may vary from those included in previous editions of the Renewable Energy Data Book (data book) due to retroactive changes in source data.

[1]Includes natural gas liquids.

U.S. Energy Production by Energy Source

	Coal	Natural Gas[1]	Petroleum	Nuclear	Renewables	Total Production (Quadrillion Btu)
2009	29.8%	32.6%	15.6%	11.5%	10.5%	72.6
2010	29.4%	32.7%	15.5%	11.3%	11.1%	74.9
2011	28.5%	33.7%	15.4%	10.6%	11.9%	78.1
2012	26.1%	35.1%	17.5%	10.2%	11.2%	79.2
2013	24.4%	34.6%	19.4%	10.1%	11.5%	81.8
2014	23.1%	35.0%	21.2%	9.5%	11.1%	87.7
2015	20.3%	36.9%	22.3%	9.4%	11.0%	88.3
2016	17.4%	38.3%	22.0%	10.0%	12.4%	84.3
2017	17.7%	37.7%	22.2%	9.6%	12.8%	88.2
2018	16.1%	38.9%	23.9%	8.8%	12.1%	95.7

Source: EIA

Totals and percentages may not correspond due to rounding.

Reported values may vary from those included in previous editions of the data book due to retroactive changes in source data.

[1] Includes natural gas liquids.

U.S. Energy Consumption by Energy Source

	Coal	Natural Gas[1]	Petroleum	Nuclear	Renewables	Total Consumption (Quadrillion Btu)
2009	21.0%	25.0%	37.1%	8.9%	8.1%	93.8
2010	21.4%	25.2%	36.3%	8.7%	8.5%	97.4
2011	20.3%	25.8%	35.8%	8.5%	9.5%	96.7
2012	18.4%	27.7%	35.9%	8.6%	9.4%	94.2
2013	18.6%	27.7%	35.5%	8.5%	9.7%	96.9
2014	18.3%	27.9%	35.3%	8.5%	9.9%	98.1
2015	16.0%	29.0%	36.4%	8.6%	10.0%	97.2
2016	14.6%	29.2%	36.8%	8.7%	10.7%	97.1
2017	14.2%	28.8%	37.0%	8.6%	11.5%	97.5
2018	13.1%	30.8%	36.5%	8.3%	11.3%	101.1

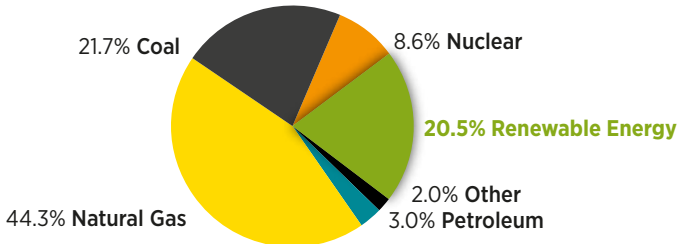
Source: EIA

Totals and percentages may not correspond due to rounding.
Reported values may vary from those included in previous editions of the data book due to retroactive changes in source data.

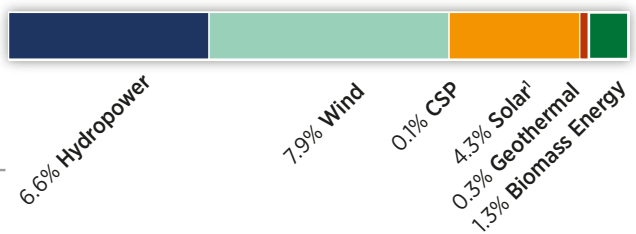
[1] Includes natural gas liquids.

U.S. Electricity Nameplate Capacity and Generation (2018)

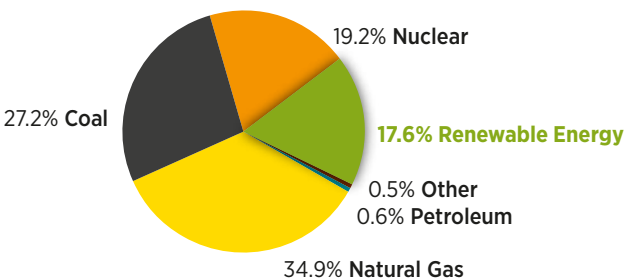
U.S. Electric Nameplate Capacity (2018): 1,219 GW



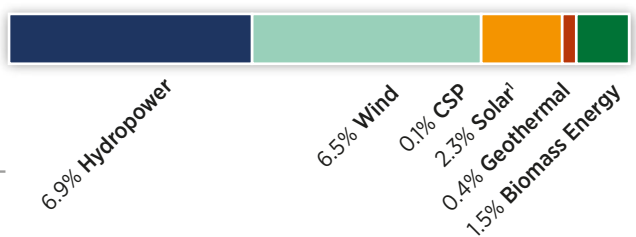
U.S. Renewable Capacity: 249 GW



U.S. Electric Net Generation (2018): 4,209 TWh



U.S. Renewable Generation: 742 TWh



Sources: EIA, Lawrence Berkeley National Laboratory (LBNL), and SEIA/GTM

Other includes pumped-storage hydropower, batteries, chemicals, hydrogen, pitch, purchased steam, sulfur, tire-derived fuels, and miscellaneous technologies.

Totals and percentages may not correspond due to rounding.

[1] Grid-connected only; Distributed PV capacity data from GTM, while capacity data from utility-scale systems larger than 1 MW in size is from EIA-860 filings. Generation data for distributed PV is calculated by using state level annual capacity factor estimates from NREL's PVWatts tool. Small-scale generating capacity from sources other than solar PV is not specifically included beyond the scope of EIA-860 filings, which generally only includes capacity resources larger than 1 MW in size.

U.S. Electricity Generating Capacity by Source

	Coal	Petroleum	Natural Gas	Nuclear	Renewables	Other	Total Capacity (MW)
2009	30.2%	5.6%	41.1%	9.5%	11.7%	2.0%	1,123,062
2010	30.1%	5.5%	41.0%	9.4%	12.0%	2.1%	1,140,712
2011	29.7%	5.0%	41.5%	9.3%	12.6%	1.9%	1,156,439
2012	28.7%	4.6%	41.7%	9.2%	13.9%	2.0%	1,172,040
2013	28.2%	4.3%	41.9%	8.9%	14.6%	2.1%	1,169,703
2014	27.6%	4.0%	42.1%	8.8%	15.4%	2.1%	1,180,413
2015	25.9%	3.6%	43.0%	8.8%	16.7%	2.0%	1,177,954
2016	24.4%	3.3%	43.3%	8.8%	18.2%	2.0%	1,190,996
2017	23.2%	3.2%	43.6%	8.7%	19.3%	2.1%	1,205,168
2018	21.7%	3.0%	44.3%	8.6%	20.5%	2.0%	1,219,394

Sources: EIA, LBNL, and SEIA/GTM

Other includes pumped-storage hydropower, batteries, chemicals, hydrogen, pitch, purchased steam, sulfur, tire-derived fuels, and miscellaneous technologies.

Previous editions of the data book reported "petroleum liquids" and "petroleum coke" separately, these sources have now been combined as "petroleum". Likewise, previous editions of the data book separately reported "other gases" which are now combined with "other".

Reported values may vary from those included in previous editions of the data book due to retroactive changes in source data.

U.S. Electricity Generation by Source

	Coal	Petroleum	Natural Gas	Nuclear	Renewables	Other	Total Generation (GWh)
2009	44.4%	1.0%	23.3%	20.2%	10.6%	0.5%	3,951,873
2010	44.8%	0.9%	23.9%	19.6%	10.4%	0.5%	4,127,400
2011	42.2%	0.7%	24.7%	19.3%	12.6%	0.5%	4,104,045
2012	37.3%	0.6%	30.2%	19.0%	12.3%	0.5%	4,053,793
2013	38.8%	0.7%	27.6%	19.4%	12.8%	0.5%	4,074,626
2014	38.5%	0.7%	27.4%	19.4%	13.0%	0.5%	4,105,468
2015	33.0%	0.7%	32.6%	19.5%	13.4%	0.5%	4,093,946
2016	30.2%	0.6%	33.6%	19.7%	15.4%	0.5%	4,099,013
2017	29.7%	0.5%	31.9%	19.8%	17.6%	0.5%	4,062,744
2018	27.2%	0.6%	34.9%	19.2%	17.6%	0.5%	4,209,085

Sources: EIA, LBNL, and SEIA/GTM

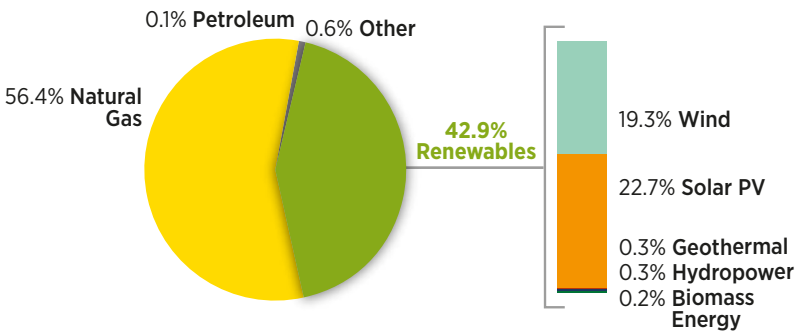
Other includes pumped-storage hydropower, batteries, chemicals, hydrogen, pitch, purchased steam, sulfur, tire-derived fuels, and miscellaneous technologies.

Previous editions of the data book reported "petroleum liquids" and "petroleum coke" separately, these sources have now been combined as "petroleum". Likewise, previous editions of the data book separately reported "other gases" which are now combined with "other".

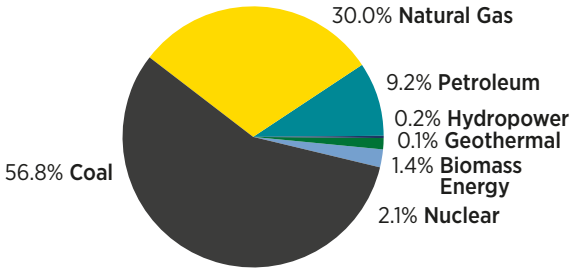
Reported values may vary from those included in previous editions of the data book due to retroactive changes in source data.

U.S. Electricity Generating Capacity Additions and Retirements (2018)

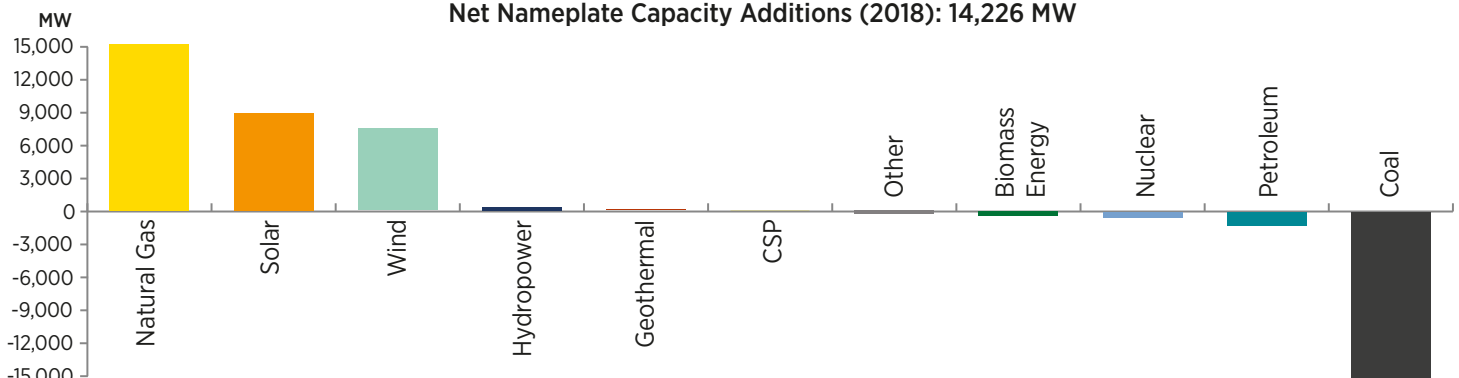
Capacity Additions (2018): 38,683 MW



Capacity Retirements (2018): 25,721 MW



Net Nameplate Capacity Additions (2018): 14,226 MW



Sources: EIA, LBNL, and SEIA/GTM

Other, includes pumped-storage hydropower, batteries, chemicals, hydrogen, pitch, purchased steam, sulfur, tire-derived fuels, and miscellaneous technologies. *Other* now includes a larger subset of technologies relative to previous editions of the data book.

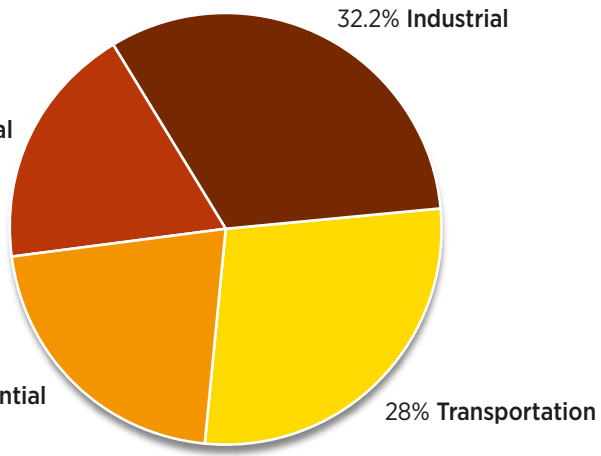
Totals and percentages may not equal 100% due to rounding.

Retired resources are those listed in EIA Form 860 as retired which include generators that were canceled before project completion. Other decreases in capacity such as nameplate capacity reduction, or converting a resource to a different fuel type are not included in retirements.

U.S. Energy Consumption by Sector (2018)

U.S. Energy Consumption (2018): 101.1 Quadrillion Btu

U.S. buildings represent 39.8% of total energy use (residential and commercial sectors combined).[1]



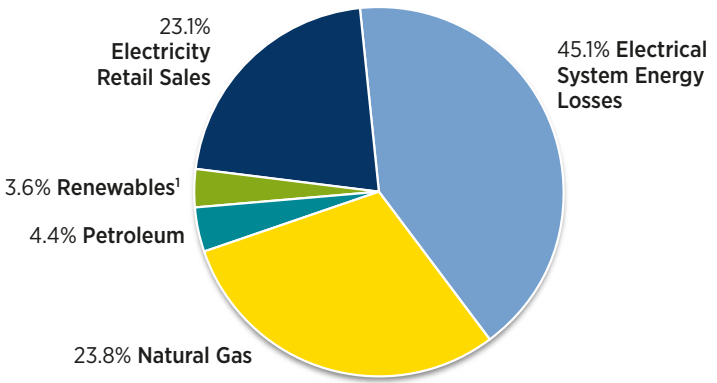
Source: EIA

Totals and percentages may not equal 100% due to rounding.

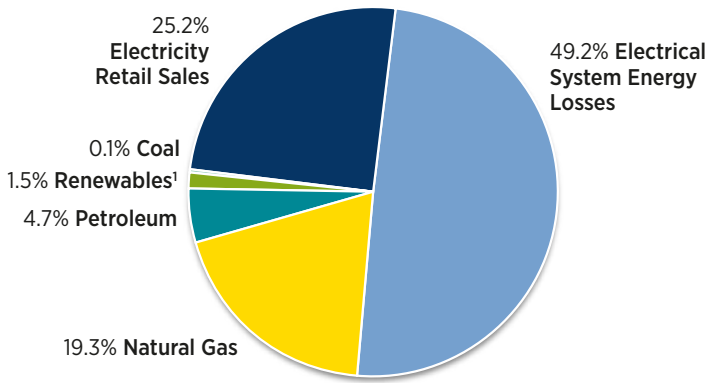
[1] U.S. buildings represent 39.8% of total energy use (residential and commercial sectors combined).

U.S. Energy Consumption – Residential and Commercial (2018)

2018 Residential Energy Consumption
21.6 Quadrillion Btu



2018 Commercial Energy Consumption
18.6 Quadrillion Btu



Source: EIA

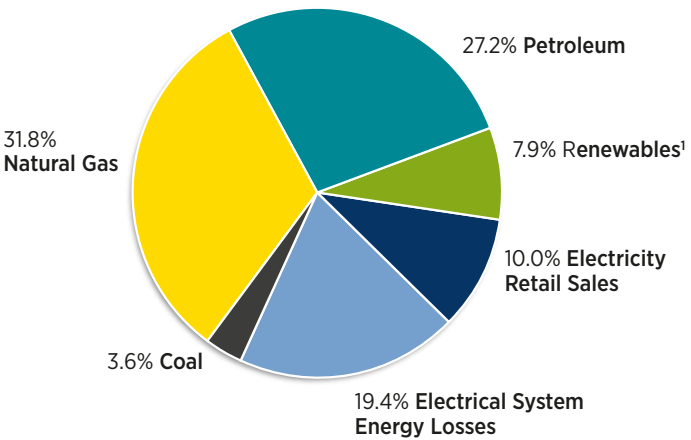
Totals and percentages may not equal 100% due to rounding.

[1] The direct renewables contribution consists primarily of biomass energy, solar thermal direct-use energy and PV electricity net generation, and geothermal heat pump and direct-use energy.

U.S. Energy Consumption – Industry and Transportation (2018)

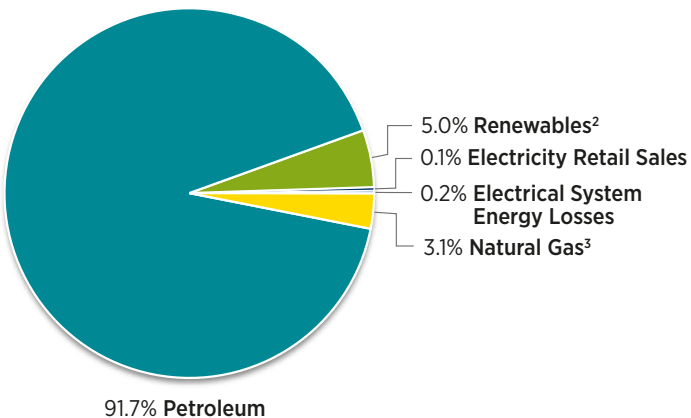
2018 Industrial Energy Consumption

32.7 Quadrillion Btu



2018 Transportation Energy Consumption

28.4 Quadrillion Btu



Source: EIA

Totals and percentages may not equal 100% due to rounding.

Industrial consumption includes building energy usage and equipment used in agriculture, forestry, fishing, hunting, mining, and construction

[1] For industrial consumption, the direct renewables contribution consists primarily of biomass energy, solar photovoltaic, and conventional hydropower.

[2] For transportation consumption, the direct renewables contribution consists primarily of fuel ethanol and biodiesel.

[3] For transportation consumption, more than 94.5% of natural gas is used in the operation of pipelines, primarily in compressors.

II. Renewable Electricity in the United States

Renewable Electricity in the United States: Summary

- In 2018, renewable electricity was **20.5% of cumulative electricity capacity** and provided **17.6% of total annual generation** in the United States—the same share of total annual generation as in 2017. This was the first year renewable electricity represented more than 20% of U.S. cumulative electricity capacity.

- **Since 2009, cumulative renewable electricity capacity has grown 90.6%**—from 130.9 GW to **more than 249.4 GW** in 2018. This growth is equivalent to an average of 13.2 GW of installed capacity per year and a **7.4%** CAGR.

- U.S. **renewable electricity cumulative capacity expanded by 7.0%** 2018 (adding 16.4 GW to the 2017 cumulative capacity of 233.0 GW)—down in percentage terms from a 7.3% (15.9 GW) increase of renewable electricity capacity between 2016 and 2017.

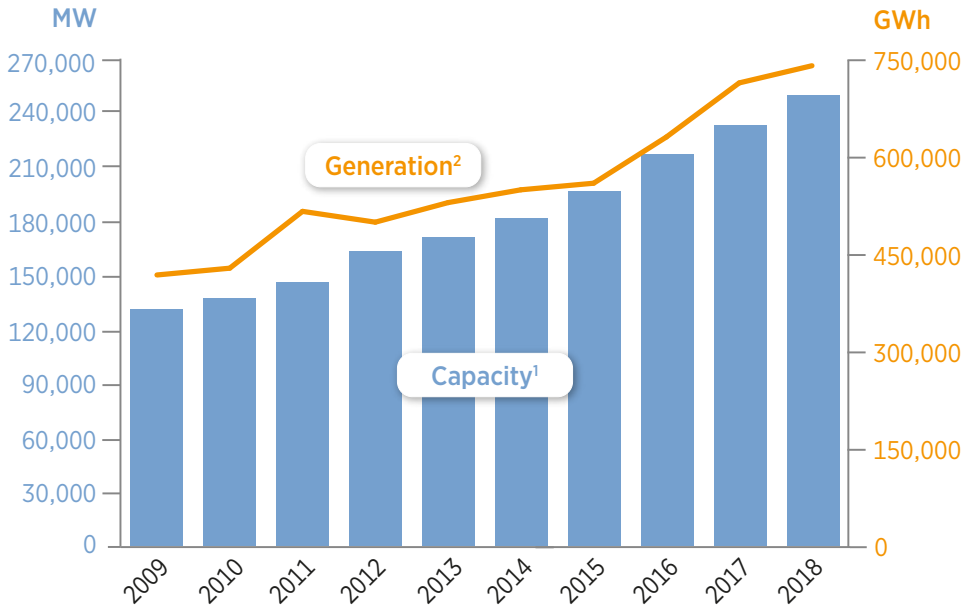
- Overall, **renewable generation increased 3.7%** in 2018—down from an increase of 13.2% in 2017. Solar electricity generation increased by 20.5% (to 98.5 terawatt-hours [TWh]), and wind electricity generation increased by 7.2% (to 272.6 TWh). Generation from hydropower decreased by 2.6% (to 292.5 TWh).

- **U.S. annual electricity generation from solar and wind has increased by a factor of five since 2009**, from 76.3 TWh to 371.2 TWh.

- **Wind capacity grew by 7.5 GW (8.4%) in 2018**, which is more than the 6.8 GW (8.3%) of growth seen in 2017. Wind now represents **7.9% of U.S. cumulative electricity capacity**. In 2018, wind accounted for more than **44.9% of U.S. renewable electricity capacity growth** and **19.3% of electricity capacity growth for all generation sources**.
- **Solar PV[1] capacity expanded by 8.9 GW_{AC}** while CSP capacity remained constant during 2018. Solar electricity, including solar PV and CSP, represents **4.4% of U.S. cumulative electricity capacity**. In 2018, solar PV accounted for more than **53.0% of U.S. renewable electricity capacity growth** and **22.7% of installed electricity capacity growth from all generation sources**.
- While new capacity additions for natural gas (21.8 GW) exceeded those for renewable generation (16.6 GW) in 2018, the opposite was true for net additions (including capacity retirements): the net increase in renewable energy capacity (16.4 GW) exceeded that of natural gas capacity (14.7 GW) —compared with net increases of 15.9 GW and 9.8 GW respectively in 2017
- In 2018, **hydropower produced 39.4% of total renewable electricity generation in the United States, wind produced 36.8%, solar produced (PV and CSP) 13.3%, biomass produced 8.3%, and geothermal produced 2.2%.**

[1]Grid-connected only; Distributed PV capacity data from GTM/SEIA, while capacity data from utility-scale systems larger than 1 MW in size is from EIA-860 filings. Generation data for distributed PV is calculated by using state level annual capacity factor estimates from NREL's PVWatts tool.

U.S. Capacity and Generation: All Renewables



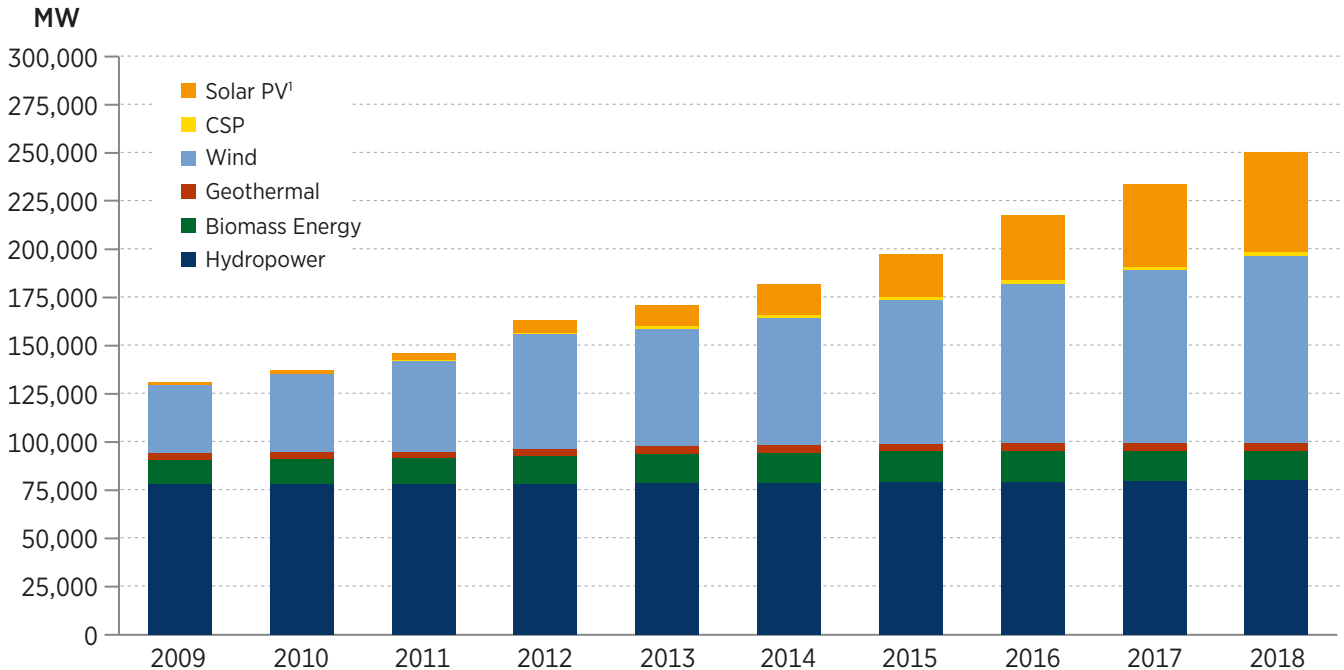
	Cumulative RE Nameplate Capacity[1] (MW)	Annual RE Generation[2] (GWh)
2009	**130,867**	**419,266**
2010	**137,272**	**429,716**
2011	**145,737**	**517,240**
2012	**162,901**	**500,601**
2013	**170,722**	**530,735**
2014	**181,606**	**550,441**
2015	**196,609**	**560,586**
2016	**217,156**	**631,783**
2017	**233,044**	**715,084**
2018	**249,396**	**741,554**

Sources: EIA, LBNL, and SEIA/GTM

Reported values may vary from those included in previous editions of the data book due to retroactive changes in source data.

Pumped-storage hydropower is excluded from renewable capacity and generation metrics unless specifically mentioned, as the quantity and source of the electricity powering pumps is indistinguishable. Pumped-storage hydropower is also referred to in Section XII.

U.S. Renewable Electricity Nameplate Capacity by Source



Sources: EIA, LBNL, and SEIA/GTM

Reported values may vary from those included in previous editions of the data book due to retroactive changes in source data.

[1] Grid-connected only; A de-rate factor of 87% has been applied to convert small-scale PV installed nameplate capacity from MW_{DC} to MW_{AC}. This factor has been adapted from SEIA/GTM.

U.S. Renewable Electricity Nameplate Net Capacity Added (MW)

	Solar PV[1]	CSP	Wind	Geothermal	Biomass Energy	Hydropower	Total Capacity Added	Capacity Added as a Percentage of Total Renewable Energy
2009	994	14	9,918	199	377	26	**11,529**	**8.8%**
2010	753	0	5,116	24	233	22	**6,147**	**4.5%**
2011	1,598	0	6,650	7	243	161	**8,659**	**5.9%**
2012	2,924	0	13,089	192	388	345	**16,938**	**10.4%**
2013	4,288	796	1,105	91	833	424	**7,537**	**4.4%**
2014	5,259	405	4,770	20	243	178	**10,875**	**6.0%**
2015	5,927	125	8,115	77	259	132	**14,635**	**7.4%**
2016	11,759	0	8,151	0	112	380	**20,401**	**9.4%**
2017	8,908	0	6,830	37	210	207	**16,192**	**6.9%**
2018	8,796	0	7,461	123	96	135	**16,611**	**6.7%**

- annual decrease | annual increase +

Sources: EIA, LBNL, and SEIA/GTM

Reported values may vary from those included in previous editions of the data book due to retroactive changes in source data.

[1] Grid-connected only; A de-rate factor of 87% has been applied to convert small-scale PV installed nameplate capacity from MW_{DC} to MW_{AC}.

Cumulative U.S. Renewable Electricity Nameplate Capacity (MW) and Annual Percentage Change

	Hydropower	Solar PV[1]	CSP	Wind	Geothermal	Biomass Energy	Total Renewables
2009	**77,910** (0.3%)	**1,054** (75.5%)	**491** (17.2%)	**35,155** (39.3%)	**3,421** (1.4%)	**12,836** (2.8%)	**130,867** (9.3%)
2010	**78,204** (0.4%)	**1,816** (72.2%)	**491** (0.0%)	**40,271** (14.6%)	**3,498** (2.3%)	**12,992** (1.2%)	**137,272** (4.9%)
2011	**78,194** (0.0%)	**3,426** (88.7%)	**490** (-0.3%)	**46,921** (16.5%)	**3,500** (0.1%)	**13,207** (1.6%)	**145,737** (6.2%)
2012	**78,241** (0.1%)	**6,390** (86.5%)	**490** (0.0%)	**60,010** (27.9%)	**3,724** (6.4%)	**14,047** (6.4%)	**162,901** (11.8%)
2013	**78,581** (0.4%)	**10,667** (67.0%)	**1,285** (162.4%)	**61,115** (1.8%)	**3,765** (1.1%)	**15,309** (9.0%)	**170,722** (4.8%)
2014	**78,793** (0.3%)	**15,995** (49.9%)	**1,693** (31.8%)	**65,885** (7.8%)	**3,757** (-0.2%)	**15,483** (1.1%)	**181,606** (6.4%)
2015	**78,957** (0.2%)	**21,966** (37.3%)	**1,775** (4.8%)	**74,000** (12.3%)	**3,812** (1.5%)	**16,100** (4.0%)	**196,609** (8.3%)
2016	**79,376** (0.5%)	**34,057** (55.0%)	**1,775** (0.0%)	**82,151** (11.0%)	**3,805** (-0.2%)	**15,993** (-0.7%)	**217,156** (10.5%)
2017	**79,595** (0.3%)	**43,034** (26.4%)	**1,775** (0.0%)	**88,981** (8.3%)	**3,732** (-1.9%)	**15,928** (-0.4%)	**233,044** (7.3%)
2018	**79,912** (0.4%)	**51,899** (20.6%)	**1,775** (0.0%)	**96,442** (8.4%)	**3,806** (2.0%)	**15,563** (-2.3%)	**249,396** (7.0%)

Sources: EIA, LBNL, and SEIA/GTM

Reported values may vary from those included in previous editions of the data book due to retroactive changes in source data.

[1]Grid-connected only; A de-rate factor of 87% has been applied to convert small-scale PV installed nameplate capacity from MW_{DC} to MW_{AC}.

U.S. Renewable Electricity Capacity as a Percentage of Total Electricity Capacity

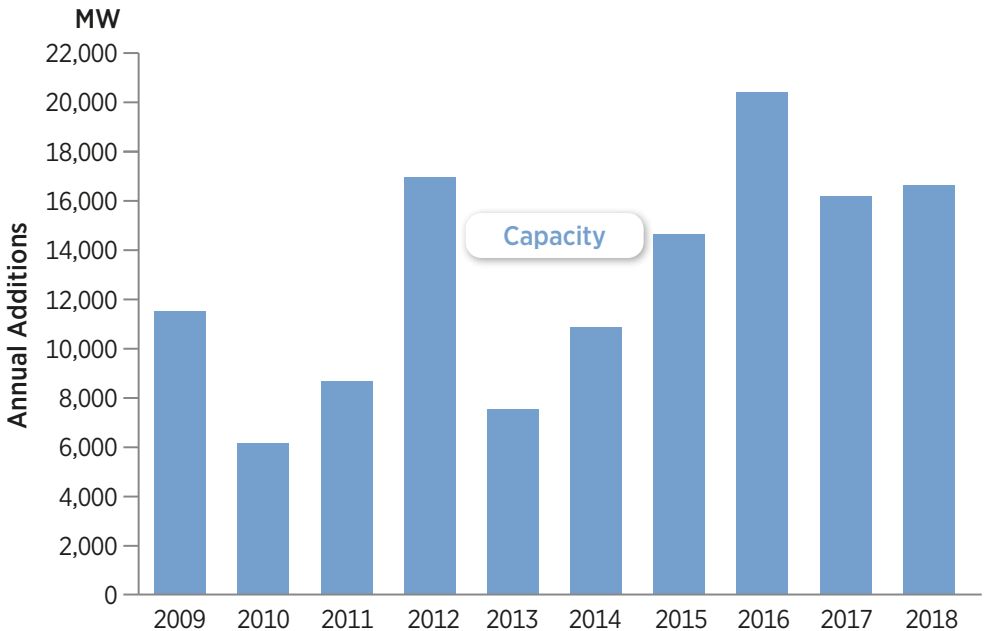
	Hydropower	Solar PV[1]	CSP	Wind	Geothermal	Biomass Energy	All Renewables
2009	6.9%	0.1%	0.0%	3.1%	0.3%	1.1%	**11.7%**
2010	6.9%	0.2%	0.0%	3.5%	0.3%	1.1%	**12.0%**
2011	6.8%	0.3%	0.0%	4.1%	0.3%	1.1%	**12.6%**
2012	6.7%	0.5%	0.0%	5.1%	0.3%	1.2%	**13.9%**
2013	6.7%	0.9%	0.1%	5.2%	0.3%	1.3%	**14.6%**
2014	6.7%	1.4%	0.1%	5.6%	0.3%	1.3%	**15.4%**
2015	6.7%	1.9%	0.2%	6.3%	0.3%	1.4%	**16.7%**
2016	6.7%	2.9%	0.1%	6.9%	0.3%	1.3%	**18.2%**
2017	6.6%	3.6%	0.1%	7.4%	0.3%	1.3%	**19.3%**
2018	6.6%	4.3%	0.1%	7.9%	0.3%	1.3%	**20.5%**

Sources: EIA, LBNL, and SEIA/GTM

Reported values may vary from those included in previous editions of the data book due to retroactive changes in source data.

[1]Grid-connected only; A de-rate factor of 87% has been applied to convert small-scale PV installed nameplate capacity from MW_{DC} to MW_{AC}.

U.S. Annual Installed Renewable Electricity Capacity Growth



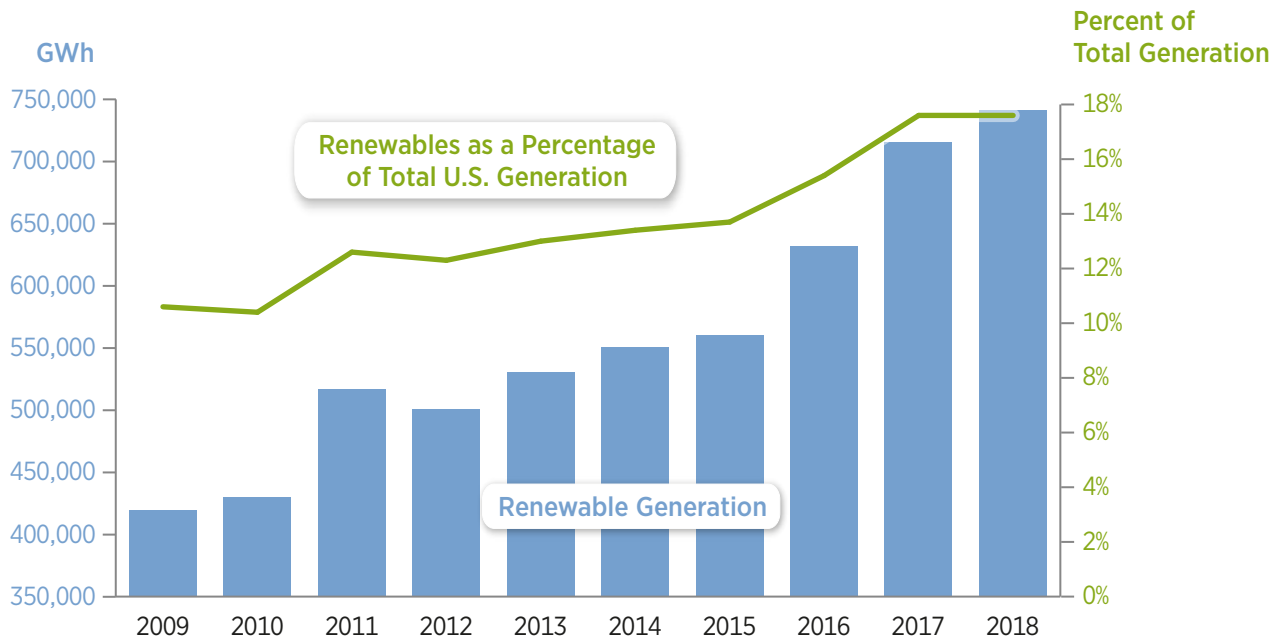
	Compound Annual Growth Rate (2009–2018)
Solar PV[1]	**47.6**
CSP	**13.7**
Wind	**10.6**
Geothermal	**1.1**
Hydropower	**0.3**
Biomass energy	**1.9**
All Renewables	**6.7**

Sources: EIA, LBNL, and SEIA/GTM

Reported values may vary from those included in previous editions of the data book due to retroactive changes in source data.

[1] Grid-connected only; A de-rate factor of 87% has been applied to convert small-scale PV installed nameplate capacity from MW_{DC} to MW_{AC}.

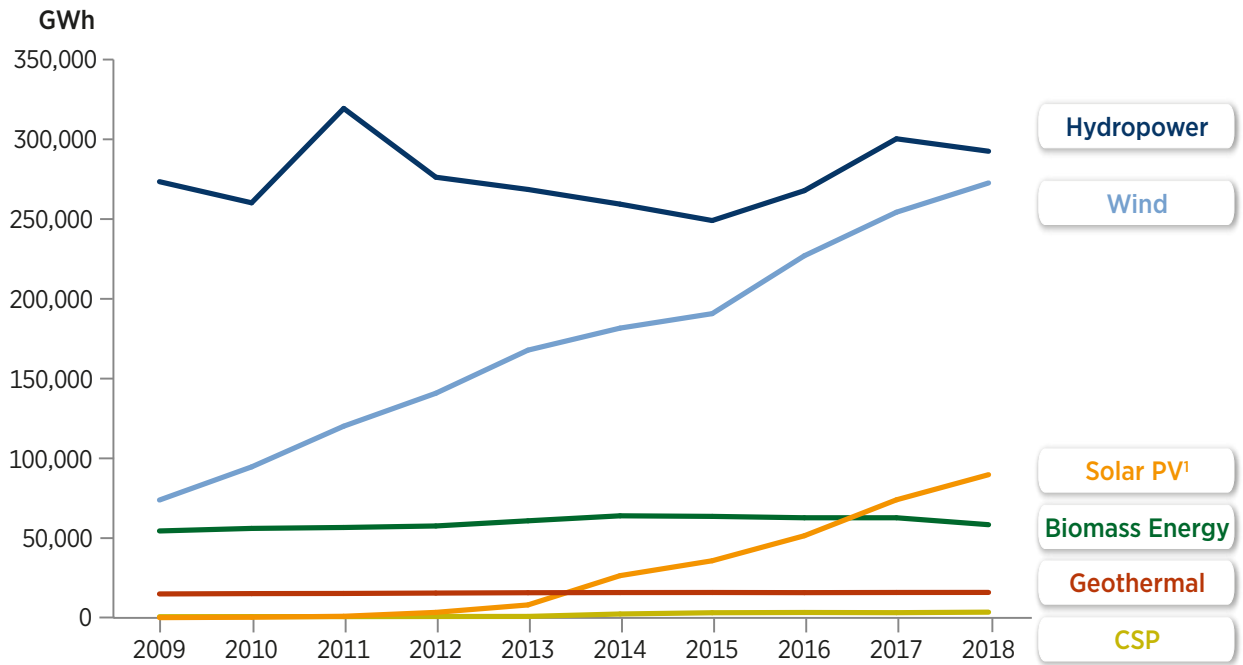
U.S. Renewable Electricity Generation



Sources: EIA, LBNL, and SEIA/GTM

Reported values may vary from those included in previous editions of the data book due to retroactive changes in source data.

U.S. Renewable Electricity Generation by Technology



Sources: EIA, LBNL, and SEIA/GTM

Reported values may vary from those included in previous editions of the data book due to retroactive changes in source data.

[1] Grid-connected only; Generation data for Distributed PV is calculated by using state level annual capacity factor estimates from NREL's PVWatts tool.

U.S. Renewable Electricity Generation (GWh) and Annual Percentage Change

	Hydropower	CSP	Wind	Geothermal	Biomass Energy	Solar PV[1]	Total Renewables
2009	6.9%	0.0%	1.9%	0.4%	1.4%	0.0%	**10.6%**
2010	6.3%	0.0%	2.3%	0.4%	1.4%	0.1%	**10.4%**
2011	7.8%	0.0%	2.9%	0.4%	1.4%	0.1%	**12.6%**
2012	6.8%	0.0%	3.5%	0.4%	1.4%	0.2%	**12.3%**
2013	6.6%	0.0%	4.1%	0.4%	1.5%	0.4%	**13.0%**
2014	6.3%	0.1%	4.4%	0.4%	1.6%	0.7%	**13.4%**
2015	6.1%	0.1%	4.7%	0.4%	1.6%	0.9%	**13.7%**
2016	6.5%	0.1%	5.5%	0.4%	1.5%	1.3%	**15.4%**
2017	7.4%	0.1%	6.3%	0.4%	1.5%	1.9%	**17.6%**
2018	7.0%	0.1%	6.5%	0.4%	1.5%	2.3%	**17.6%**

Sources: EIA, LBNL, and SEIA/GTM

Total will not equal 100% as renewables represent only a fraction of total U.S. electricity generation.

Reported values may vary from those included in previous editions of the data book due to retroactive changes in source data.

[1]Grid-connected only; Generation data for Distributed PV is calculated by using state level annual capacity factor estimates from NREL's PVWatts tool.

U.S. Renewable Electricity Generation (GWh) and Annual Percent Change

	Hydropower	Solar PV[1]	CSP	Wind	Geothermal	Biomass Energy	All Renewables
2009	273,445 (7.3%)	1,699 (41.2%)	735 (17.2%)	73,886 (33.5%)	15,009 (1.4%)	54,493 (-1.0%)	419,266 (9.8%)
2010	260,203 (-4.8%)	2,763 (62.6%)	789 (7.5%)	94,652 (28.1%)	15,219 (1.4%)	56,089 (2.9%)	429,716 (2.5%)
2011	319,355 (22.7%)	4,915 (77.9%)	806 (2.1%)	120,177 (27.0%)	15,316 (0.6%)	56,671 (1.0%)	517,240 (20.4%)
2012	276,240 (-13.5%)	9,478 (92.8%)	876 (8.7%)	140,822 (17.2%)	15,562 (1.6%)	57,622 (1.7%)	500,601 (-3.2%)
2013	268,565 (-2.8%)	16,783 (77.1%)	915 (4.4%)	167,840 (19.2%)	15,775 (1.4%)	60,858 (5.6%)	530,735 (6.0%)
2014	259,367 (-3.4%)	27,112 (61.5%)	2,441 (166.9%)	181,655 (8.2%)	15,877 (0.6%)	63,989 (5.1%)	550,441 (3.7%)
2015	249,080 (-4.0%)	38,011 (40.2%)	3,227 (32.2%)	190,719 (5.0%)	15,918 (0.3%)	63,632 (-0.6%)	560,586 (1.8%)
2016	267,812 (7.5%)	55,009 (44.7%)	3,384 (4.9%)	226,993 (19.0%)	15,826 (-0.6%)	62,761 (-1.4%)	631,783 (12.7%)
2017	300,333 (12.1%)	78,491 (42.7%)	3,269 (-3.4%)	254,303 (12.0%)	15,927 (0.6%)	62,762 (0.0%)	715,084 (13.2%)
2018	292,524 (-2.6%)	94,921 (20.9%)	3,592 (9.9%)	272,650 (7.2%)	15,967 (0.3%)	61,901 (-1.4%)	741,554 (3.7%)

Sources: EIA, LBNL, and SEIA/GTM

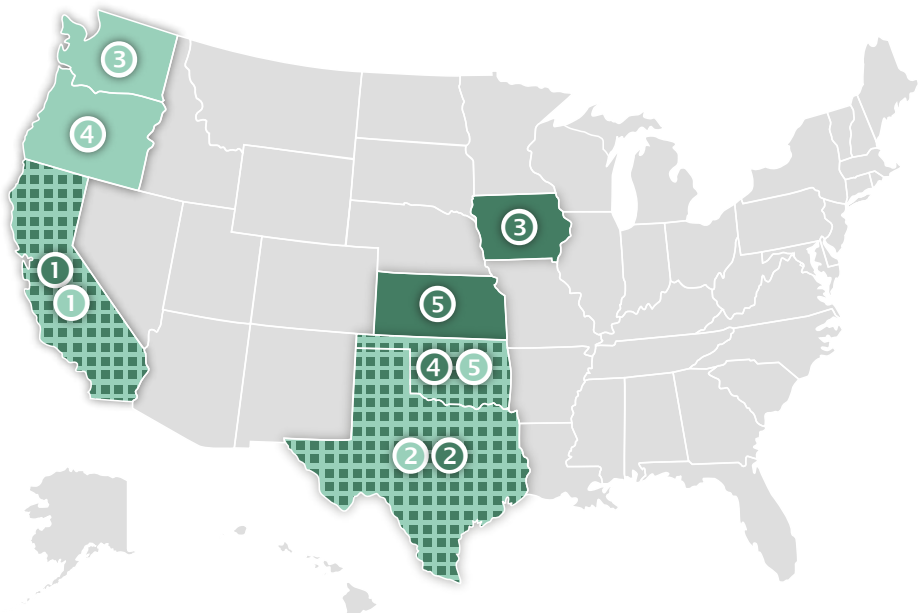
Reported values may vary from those included in previous editions of the data book due to retroactive changes in source data.

[1]Grid-connected only; Generation data for Distributed PV is calculated by using state level annual capacity factor estimates from NREL's PVWatts tool. Previous editions of the data book did not include estimates for small-scale distributed PV generation before 2013, which are now included in this edition.

State Renewable Energy Information: Summary

- In 2018, **California continued to have the highest cumulative renewable electricity capacity** of any state (more than 40.3 GW), followed by Texas (more than 28.4 GW), and Washington (nearly 24.9 GW).
- **Rhode Island had the highest annual growth rate (59.3%) of renewable electricity capacity additions** in 2018, followed by Florida (37.0%), Nebraska (31.4%), the District of Columbia (24.9%), and Connecticut (19.5%). Additions in solar capacity were the main driver of renewable electricity capacity growth in Connecticut, the District of Colombia, Florida, and Rhode Island, while additions in wind capacity accounted for most of the growth in Nebraska.
- **North Dakota continued to have the most renewable electricity capacity per capita**, followed by Montana and Washington. North Dakota also continued to have the most wind electricity capacity per capita. Nevada continued to lead all states in PV capacity per capita.
- **California installed the most total solar PV capacity** of all states in 2018 (nearly 2.1 GW_{AC}).
- **Texas**, the state with the greatest amount of wind capacity in 2018, **experienced 10.2% growth of wind capacity (2.3 GW)** and s**aw an increase of solar PV capacity of more than 53.6%** (823 MW_{AC}).

Top States for Cumulative Renewable Electricity Installed Capacity (2018)



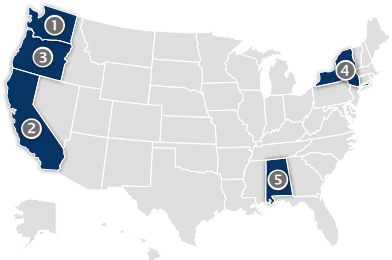
Total Renewables[1]
1 California
2 Texas
3 Washington
4 Oregon
5 Oklahoma

Non-Hydro Renewables
1 California
2 Texas
3 Iowa
4 Oklahoma
5 Kansas

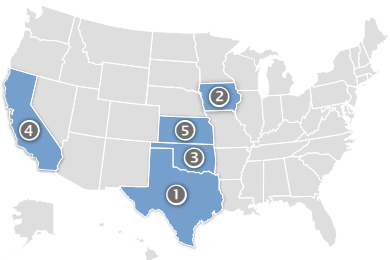
Sources: EIA, LBNL, and SEIA/GTM, and U.S. Census Bureau

[1]Includes grid-connected solar, wind, geothermal, hydropower and biomass energy.

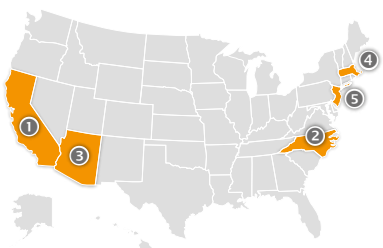
Top States for Cumulative Renewable Electricity Installed Capacity (2018)



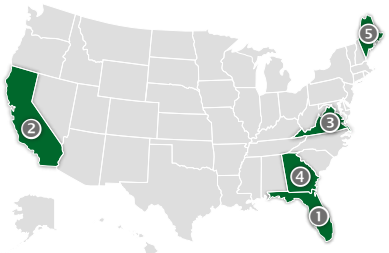
Hydropower
1 Washington
2 California
3 Oregon
4 New York
5 Alabama



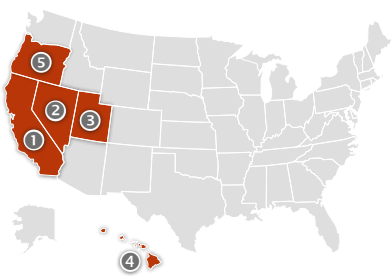
Wind
1 Texas
2 Iowa
3 Oklahoma
4 California
5 Kansas



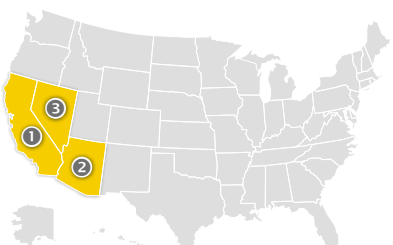
Solar PV[1]
1 California
2 North Carolina
3 Arizona
4 Massachusetts
5 New Jersey



Biomass Energy
1 Florida
2 California
3 Virginia
4 Georgia
5 Maine



Geothermal
1 California
2 Nevada
3 Utah
4 Hawaii
5 Oregon



CSP
1 California
2 Arizona
3 Nevada

Sources: EIA, LBNL, SEIA/GTM, and U.S. Census Bureau

[1]Grid-connected only; A de-rate factor of 87% has been applied to convert small-scale PV installed nameplate capacity from MW_{DC} to MW_{AC}.

Sources: EIA, LBNL, and SEIA/GTM

[1]Grid-connected only; A de-rate factor of 87% has been applied to convert small-scale PV installed nameplate capacity from MW_{DC} to MW_{AC}.

Cumulative Renewable Electricity Installed Capacity (MW) (2018)
NORTHEAST

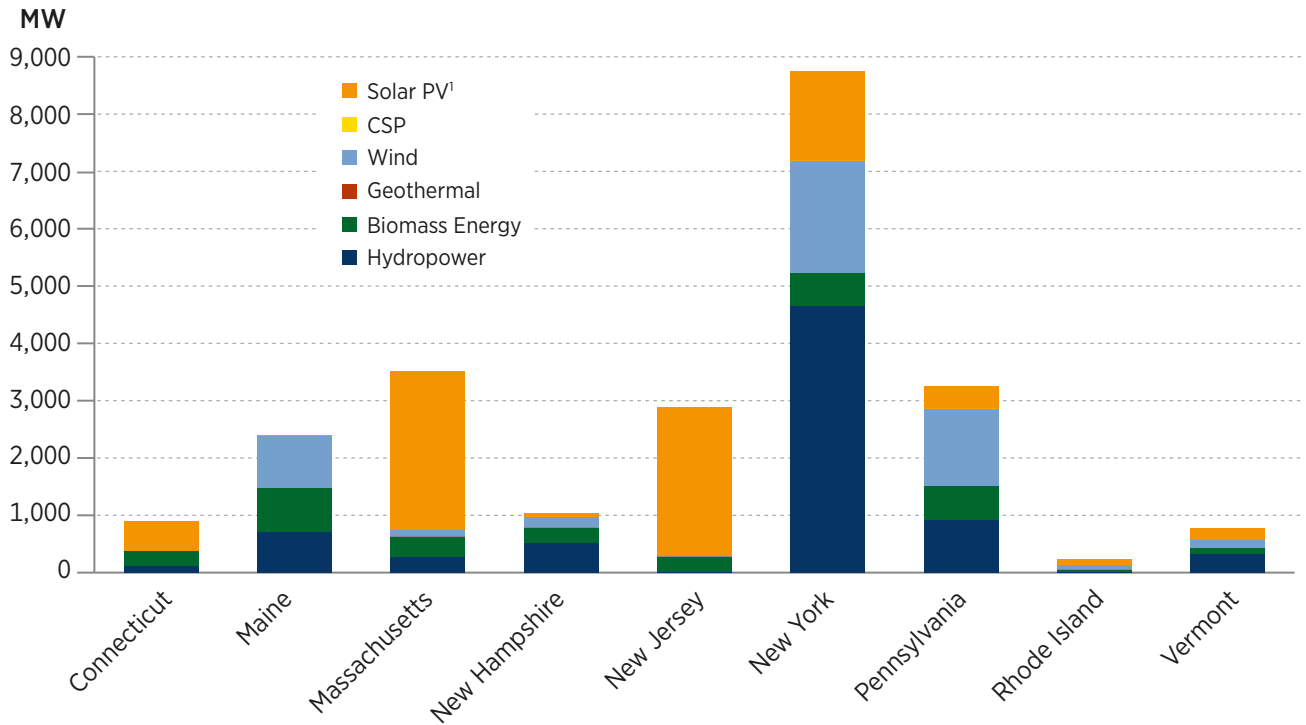
	Wind	Solar PV[1]	CSP	Geothermal	Biomass Energy	Hydropower	Total Renewables[1]	Non-Hydro Renewables
Connecticut	5	534	0	0	254	119	**912**	**793**
Maine	924	6	0	0	769	715	**2,414**	**1,699**
Massachusetts	112	2,814	0	0	361	271	**3,558**	**3,287**
New Hampshire	185	74	0	0	277	514	**1,050**	**536**
New Jersey	10	2,639	0	0	262	15	**2,926**	**2,911**
New York	1,987	1,574	0	0	586	4,692	**8,838**	**4,146**
Pennsylvania	1,370	402	0	0	601	920	**3,292**	**2,373**
Rhode Island	75	114	0	0	45	3	**237**	**234**
Vermont	149	221	0	0	92	328	**790**	**462**

Sources: EIA, LBNL, and SEIA/GTM, and U.S. Census Bureau

Regions do not correspond to U.S. census designations.

[1] Grid-connected only; A de-rate factor of 87% has been applied to convert small-scale PV installed nameplate capacity from MW_{DC} to MW_{AC}.

Cumulative Renewable Electricity Installed Capacity (2018)
NORTHEAST



Sources: EIA, LBNL, and SEIA/GTM, and U.S. Census Bureau

Regions do not correspond to U.S. census designations.

[1] Grid-connected only; A de-rate factor of 87% has been applied to convert small-scale PV installed nameplate capacity from MW_{DC} to MW_{AC}.

Cumulative Renewable Electricity Installed Capacity (MW) (2018)
MIDWEST

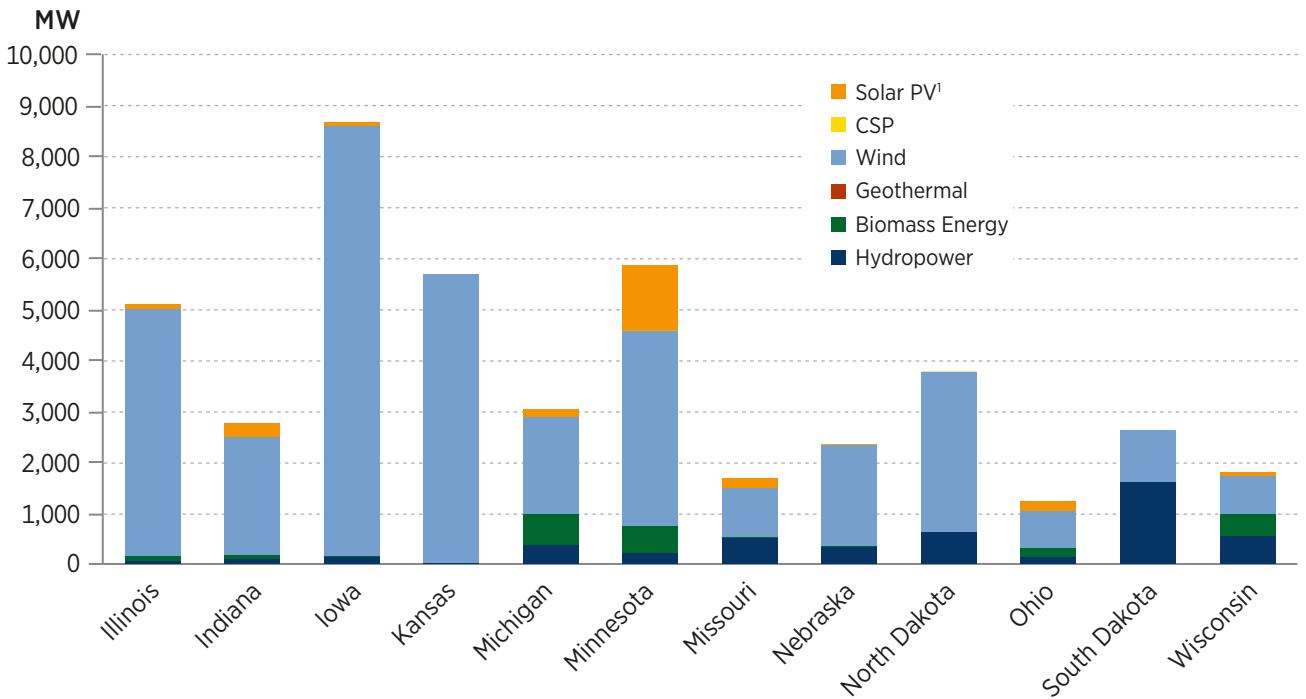
	Wind	Solar PV[1]	CSP	Geothermal	Biomass Energy	Hydropower	Total Renewables	Non-Hydro Renewables
Illinois	4,853	102	0	0	102	40	**5,097**	**5,057**
Indiana	2,315	284	0	0	74	92	**2,765**	**2,673**
Iowa	8,440	80	0	0	21	129	**8,671**	**8,541**
Kansas	5,658	4	0	0	9	7	**5,678**	**5,671**
Michigan	1,905	143	0	0	616	362	**3,025**	**2,664**
Minnesota	3,844	1,289	0	0	517	215	**5,865**	**5,650**
Missouri	961	204	0	0	15	506	**1,686**	**1,180**
Nebraska	1,987	18	0	0	16	332	**2,353**	**2,021**
North Dakota	3,145	0	0	0	10	614	**3,769**	**3,155**
Ohio	725	203	0	0	180	129	**1,237**	**1,108**
South Dakota	1,020	1	0	0	0	1,602	**2,623**	**1,021**
Wisconsin	747	73	0	0	438	538	**1,796**	**1,258**

Sources: EIA, LBNL, and SEIA/GTM, and U.S. Census Bureau

Regions do not correspond to U.S. census designations.

[1] Grid-connected only; A de-rate factor of 87% has been applied to convert small-scale PV installed nameplate capacity from MW_{DC} to MW_{AC}.

Cumulative Renewable Electricity Installed Capacity (2018)
MIDWEST



Sources: EIA, LBNL, and SEIA/GTM, and U.S. Census Bureau

Regions do not correspond to U.S. census designations.

[1] Grid-connected only; A de-rate factor of 87% has been applied to convert small-scale PV installed nameplate capacity from MW_{DC} to MW_{AC}.

Cumulative Renewable Electricity Installed Capacity (MW) (2018)
SOUTH

	Wind	Solar PV[1]	CSP	Geothermal	Biomass Energy	Hydropower	Total Renewables	Non-Hydro Renewables
Alabama	0	215	0	0	666	3,319	**4,200**	**881**
Arkansas	0	110	0	0	391	1,321	**1,823**	**502**
Delaware	2	113	0	0	12	0	**127**	**127**
District of Columbia	0	59	0	0	25	0	**84**	**84**
Florida	0	1,703	0	0	1,417	56	**3,175**	**3,120**
Georgia	0	1,064	0	0	1,007	1,963	**4,034**	**2,071**
Kentucky	0	41	0	0	113	1,097	**1,252**	**155**
Louisiana	0	85	0	0	557	192	**834**	**642**
Maryland	191	1,121	0	0	160	551	**2,022**	**1,472**
Mississippi	0	164	0	0	313	0	**477**	**477**
North Carolina	208	4,155	0	0	633	1,890	**6,887**	**4,997**
Oklahoma	8,072	35	0	0	88	819	**9,015**	**8,195**
South Carolina	0	538	0	0	585	1,351	**2,474**	**1,123**
Tennessee	29	253	0	0	200	2,522	**3,005**	**483**
Texas	24,896	2,358	0	0	448	709	**28,411**	**27,703**
Virginia	0	525	0	0	1,018	822	**2,365**	**1,543**
West Virginia	687	0	0	0	0	371	**1,058**	**687**

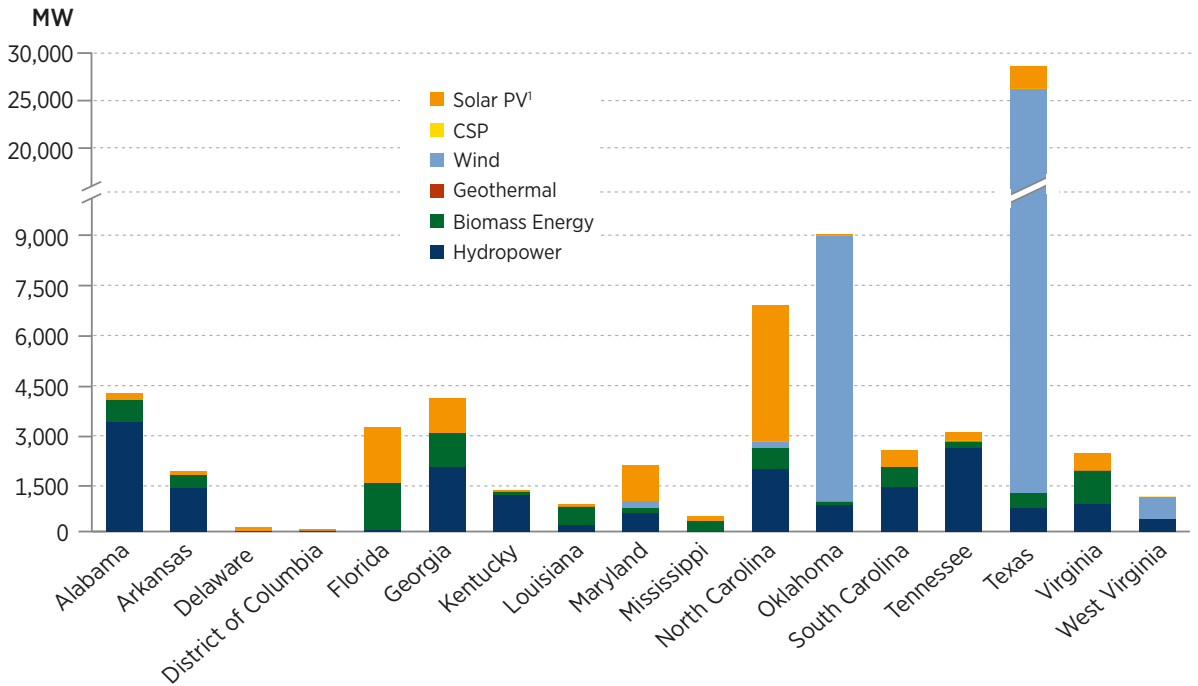
Sources: EIA, LBNL, and SEIA/GTM, and U.S. Census Bureau

Regions do not correspond to U.S. census designations.

[1] Grid-connected only; A de-rate factor of 87% has been applied to convert small-scale PV installed nameplate capacity from MW_{DC} to MW_{AC}.

Cumulative Renewable Electricity Installed Capacity (2018)
SOUTH

II



Sources: EIA, LBNL, and SEIA/GTM, and U.S. Census Bureau

Please note the discontinuity in the vertical axis (Cumulative Renewable Electricity Installed Capacity [MW]) between 9,000 MW and 27,000 MW.

Regions do not correspond to U.S. census designations.

[1] Grid-connected only; A de-rate factor of 87% has been applied to convert small-scale PV installed nameplate capacity from MW_{DC} to MW_{AC}.

Cumulative Renewable Electricity Installed Capacity (MW) (2018)
WEST

	Wind	Solar PV[1]	CSP	Geothermal	Biomass Energy	Hydropower	Total Renewables	Non-Hydro Renewables
Alaska	63	0	0	0	12	476	**551**	**75**
Arizona	268	3,019	280	0	36	2,718	**6,321**	**3,603**
California	5,840	18,936	1,294	2,792	1,394	10,068	**40,324**	**30,256**
Colorado	3,704	1,025	0	0	34	670	**5,433**	**4,763**
Hawaii	206	753	0	51	280	27	**1,317**	**1,290**
Idaho	974	266	0	18	130	2,687	**4,075**	**1,388**
Montana	800	26	0	0	3	2,703	**3,532**	**829**
Nevada	152	2,042	201	805	15	1,052	**4,267**	**3,215**
New Mexico	1,731	690	0	19	5	82	**2,527**	**2,446**
Oregon	3,213	454	0	37	359	8,452	**12,514**	**4,062**
Utah	391	1,130	0	84	14	275	**1,894**	**1,618**
Washington	3,076	148	0	0	402	21,273	**24,898**	**3,626**
Wyoming	1,488	95	0	0	0	303	**1,886**	**1,583**

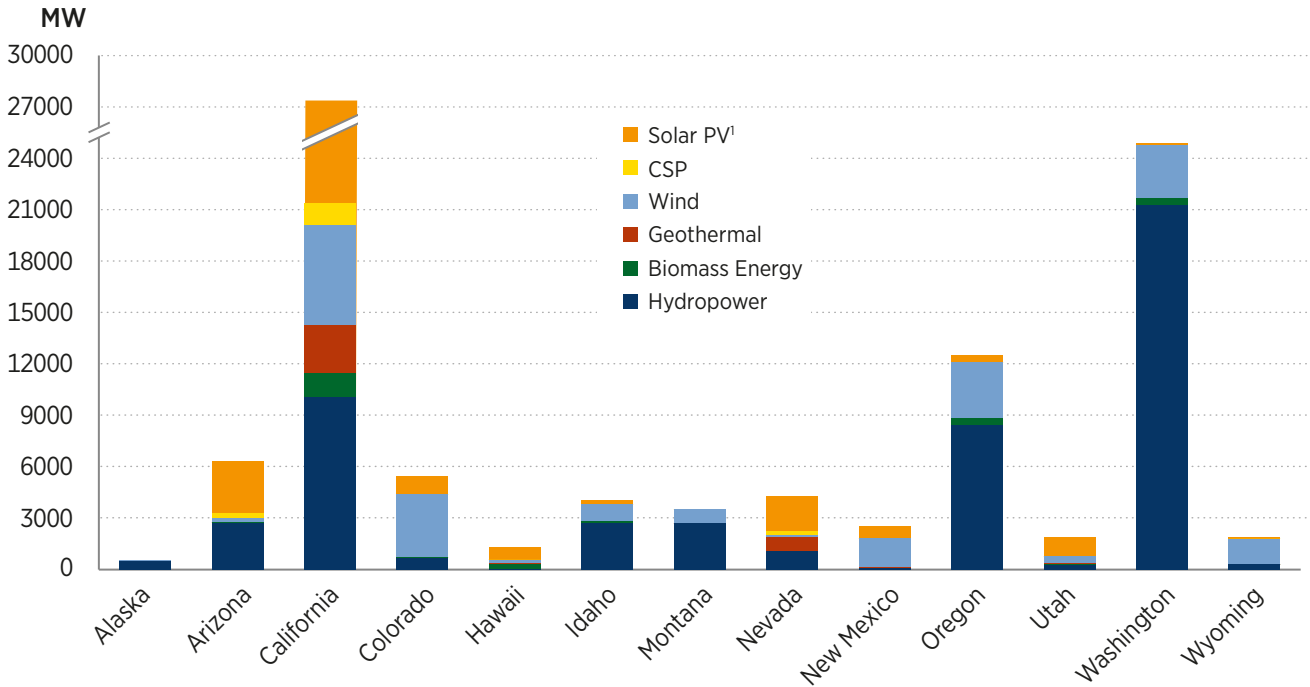
Sources: EIA, LBNL, and SEIA/GTM, and U.S. Census Bureau

Please note the discontinuity in the vertical axis (Cumulative Renewable Electricity Installed Capacity [MW]) between 24,000 MW and 40,000 MW.

Regions do not correspond to U.S. census designations.

[1] Grid-connected only; A de-rate factor of 87% has been applied to convert small-scale PV installed nameplate capacity from MW_{DC} to MW_{AC}.

Cumulative Renewable Electricity Installed Capacity (2018)
WEST



Sources: EIA, LBNL, and SEIA/GTM, and U.S. Census Bureau

Please note the discontinuity in the vertical axis (Cumulative Renewable Electricity Installed Capacity [MW]) between 24,000 MW and 40,000 MW.

Regions do not correspond to U.S. census designations.

[1] Grid-connected only; A de-rate factor of 87% has been applied to convert small-scale PV installed nameplate capacity from MW_{DC} to MW_{AC}.

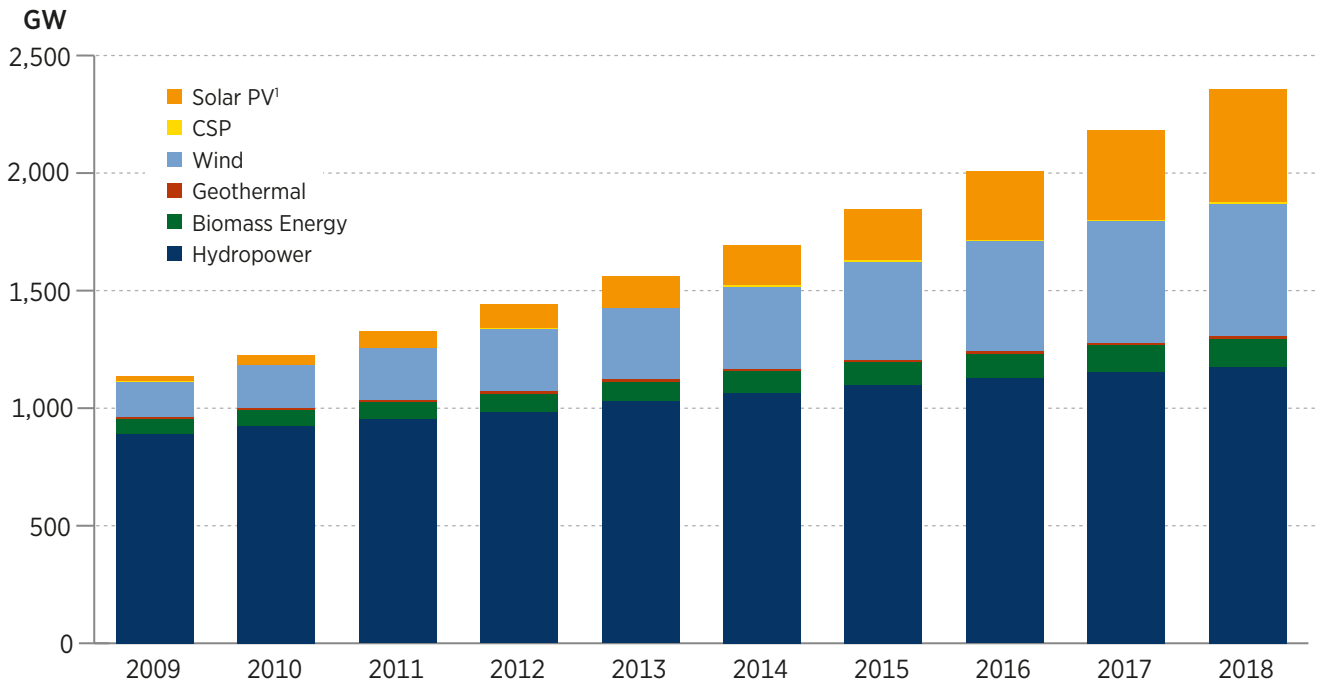
III. Global Renewable Energy Development

Global Renewable Energy Development: Summary

- In 2018, cumulative **global capacity of renewable electricity grew by 8.0%** (from 2,181 GW to 2,355 GW), which continued the steady growth of recent years (7.6% CAGR from 2009 to 2018).
- Globally, **hydropower comprised 49.9% of cumulative renewable electricity capacity**, followed by wind (23.9%), solar PV and CSP (20.6%), biomass (5.0%), and geothermal (0.6%) in 2018.
- Renewable sources accounted for **26.3% (6,523 TWh) of all electricity generation worldwide** in 2018.
- **Global solar PV cumulative capacity increased by 25.4% in 2018. Global wind cumulative capacity grew by 9.5%**.
- **China continued to lead the world in cumulative renewable electricity capacity in 2018**. China also led in cumulative hydropower, solar PV, and wind capacity. Spain led in cumulative CSP capacity. Brazil led in cumulative biomass energy capacity. The United States continued to lead in cumulative geothermal capacity and was second in cumulative renewable electricity capacity.

Reported values may vary in this section from those included in previous editions of the data book due to a change of sources; in previous years REN21 was used for global renewable capacity estimates. Beginning this year, IRENA is used for global renewable capacity and generation estimates, except for the United States which is based on other sources used by the data book as reported within individual technology sections.

Global Renewable Electricity Capacity



Source: International Renewable Energy Agency (IRENA), EIA, LBNL, SEIA/GTM

[1] Grid-connected only

Global Renewable Cumulative Electricity Capacity Annual Percent Change

	Hydropower	Solar PV[1]	CSP	Wind	Geothermal	Biomass Energy	All Renewables
2009	3%	55%	60%	30%	5%	13%	8%
2010	4%	77%	62%	20%	2%	8%	8%
2011	3%	79%	31%	22%	1%	10%	9%
2012	3%	41%	53%	21%	4%	6%	9%
2013	5%	34%	46%	12%	2%	9%	8%
2014	4%	26%	18%	16%	5%	7%	8%
2015	3%	27%	7%	19%	5%	7%	9%
2016	3%	34%	2%	12%	4%	8%	9%
2017	2%	32%	2%	10%	3%	6%	9%
2018	2%	25%	10%	9%	5%	5%	8%
CAGR (2009–2018)	3%	36%	21%	14%	3%	7%	8%

Sources: IRENA, EIA, LBNL, and SEIA/GTM

Reported values may vary from those included in previous editions of the data book due to a change of sources.

[1] Grid-connected only

Renewable Electricity as a Percentage of Total Installed Global Electricity Capacity

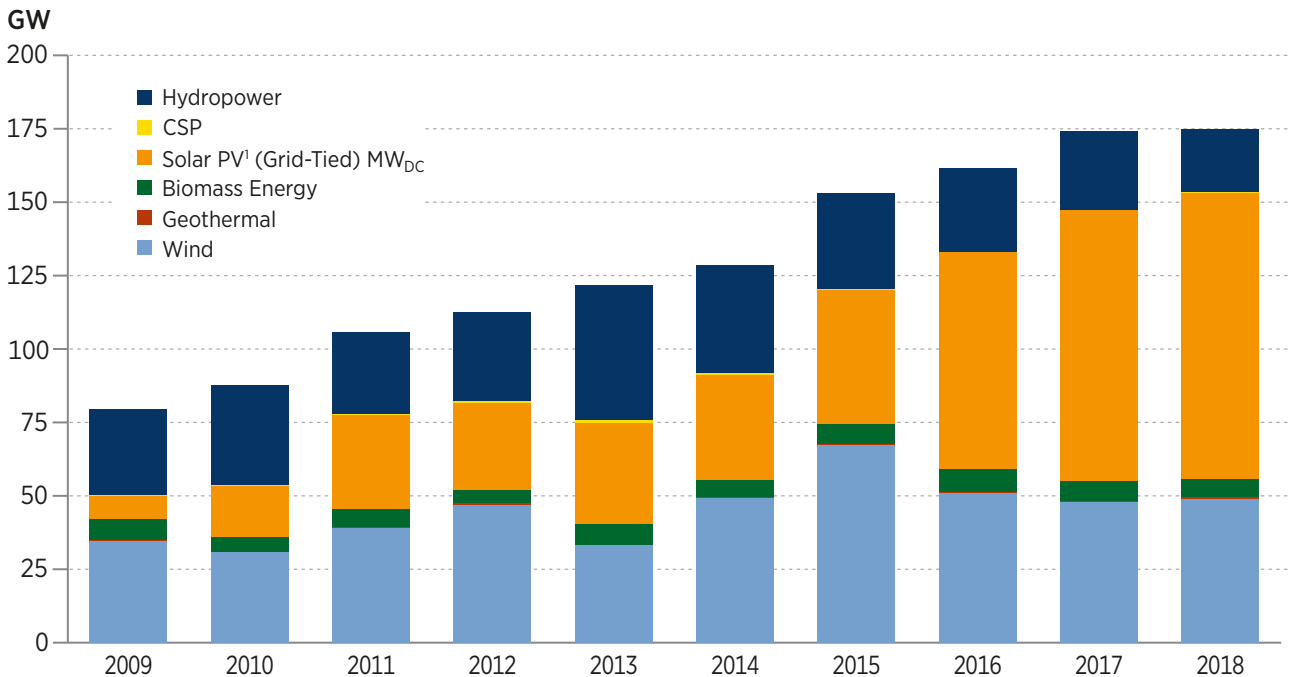
	Hydropower	Solar PV[1]	CSP	Wind	Geothermal	Biomass Energy	All Renewables	Renewable Capacity (GW)
2009	18.4%	0.5%	0.0%	3.1%	0.2%	1.3%	**23.5%**	**1,135**
2010	18.2%	0.8%	0.0%	3.6%	0.2%	1.3%	**24.1%**	**1,223**
2011	17.9%	1.4%	0.0%	4.1%	0.2%	1.4%	**25.0%**	**1,329**
2012	17.8%	1.8%	0.0%	4.8%	0.2%	1.4%	**26.1%**	**1,441**
2013	17.9%	2.4%	0.1%	5.2%	0.2%	1.5%	**27.2%**	**1,563**
2014	17.7%	2.9%	0.1%	5.8%	0.2%	1.5%	**28.1%**	**1,692**
2015	17.5%	3.5%	0.1%	6.6%	0.2%	1.5%	**29.4%**	**1,845**
2016	17.2%	4.4%	0.1%	7.1%	0.2%	1.6%	**30.7%**	**2,006**
2017	16.9%	5.6%	0.1%	7.5%	0.2%	1.6%	**32.0%**	**2,181**
2018	16.5%	6.8%	0.1%	7.9%	0.2%	1.7%	**33.1%**	**2,355**

Sources: IRENA, EIA, LBNL, SEIA/GTM

Reported values may vary from those included in previous editions of the data book due to a change of sources.

[1] Grid-connected only

Global Annual Installed Renewable Electricity Capacity Growth



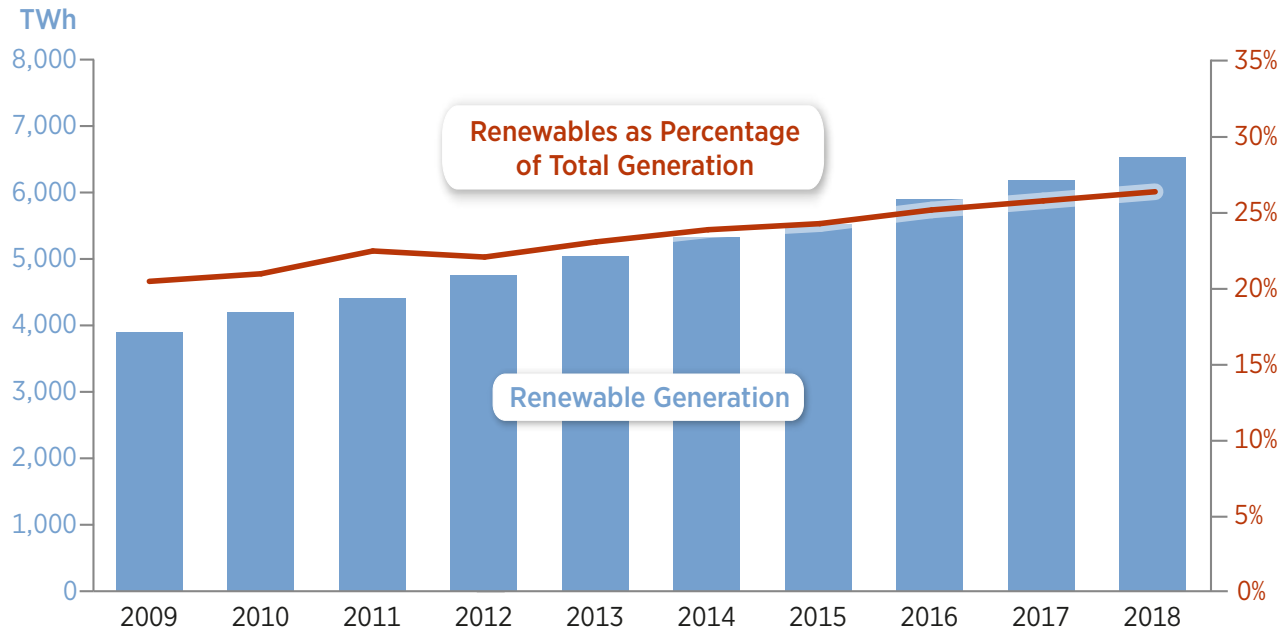
Sources: IRENA, EIA, LBNL, and SEIA/GTM

Reported values may vary from those included in previous editions of the data book due to a change of sources.

[1]Grid-connected only

Sources: IRENA, EIA, LBNL, and SEIA/GTM

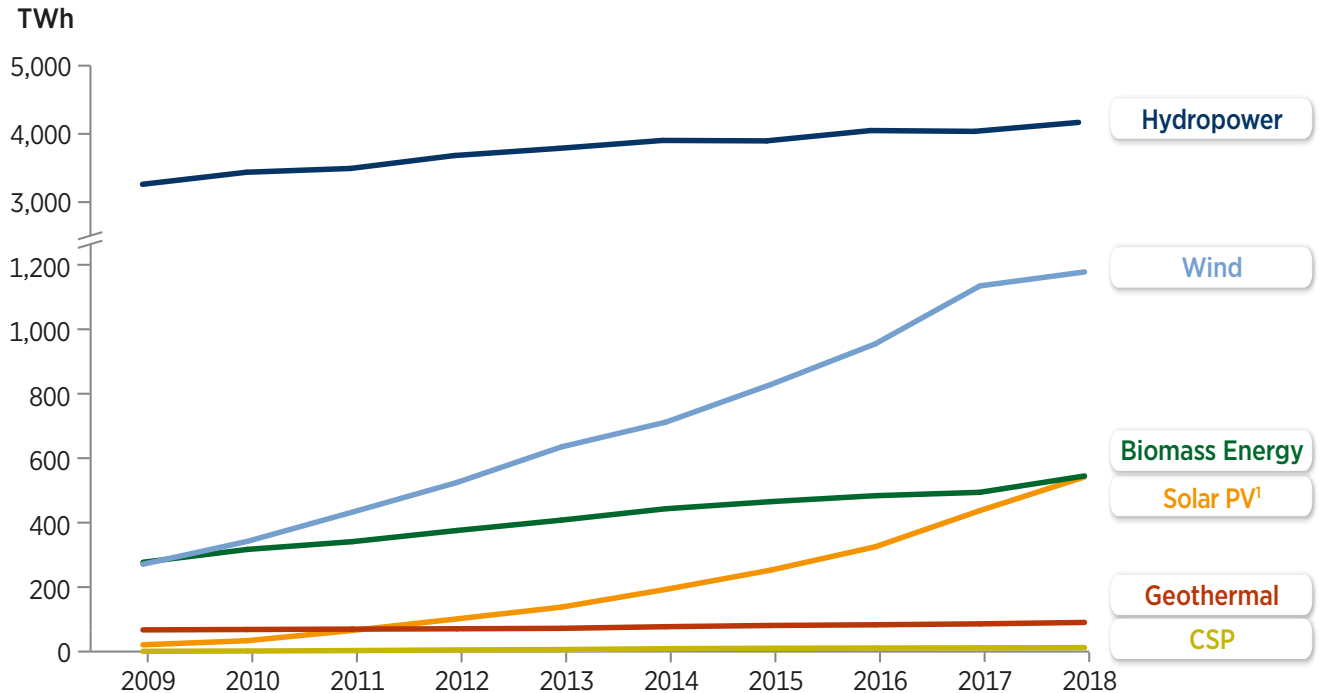
Global Renewable Electricity Generation



Sources: IRENA, EIA, LBNL, and SEIA/GTM

Reported values may vary from those included in previous editions of the data book due to a change of sources.

Global Renewable Electricity Generation by Technology



Sources: IRENA, EIA, LBNL, and SEIA/GTM

Reported values may vary from those included in previous editions of the data book due to a change of sources.

Please note the discontinuity in the vertical axis (Global Renewable Electricity Generation by Technology [TWh]) between 1,200 TWh and 3,000 TWh.

[1]Grid-connected only; capacity is reported in MW_{AC}.

Global Renewable Electricity Generation as a Percentage of Total Generation

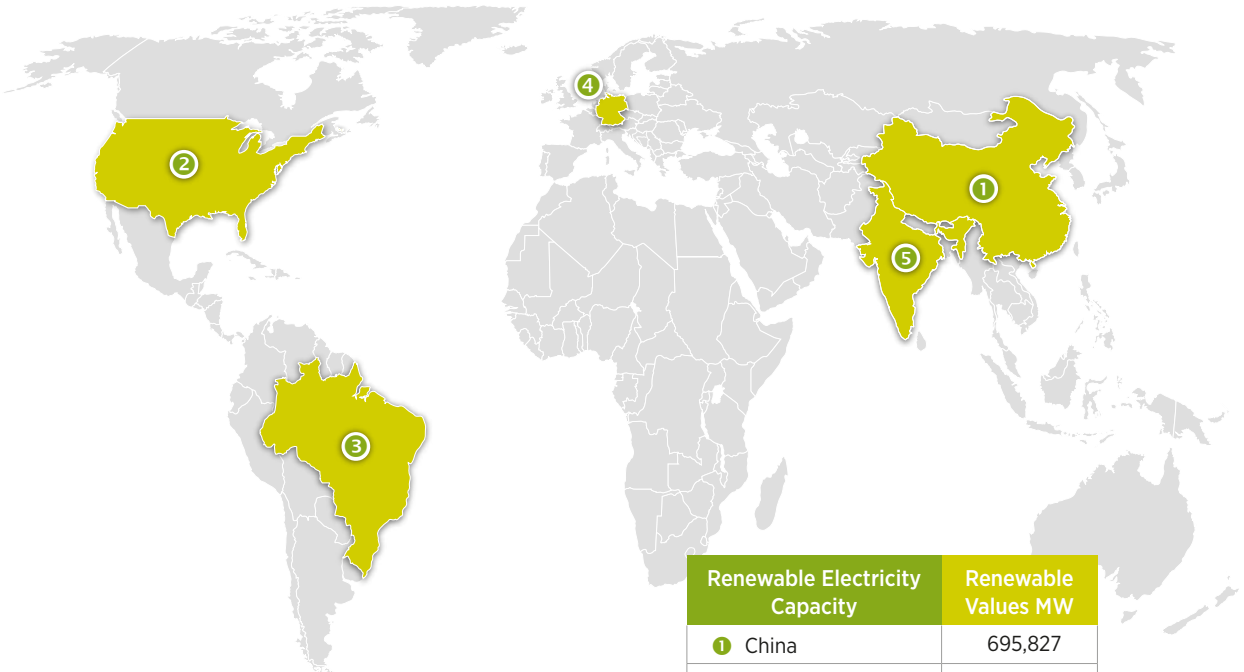
	Hydropower	Solar PV[1]	Biomass Energy	Wind	Geothermal	All Renewables	Renewable Generation (TWh)
2009	17.0%	0.1%	1.4%	1.4%	0.4%	**20.4%**	**3,897**
2010	17.1%	0.2%	1.6%	1.7%	0.3%	**20.9%**	**4,199**
2011	16.8%	0.3%	1.6%	2.1%	0.3%	**21.1%**	**4,402**
2012	17.3%	0.5%	1.8%	2.5%	0.3%	**22.4%**	**4,755**
2013	17.3%	0.6%	1.9%	2.9%	0.3%	**23.0%**	**5,040**
2014	17.4%	0.8%	2.0%	3.2%	0.3%	**23.8%**	**5,329**
2015	17.1%	1.1%	2.0%	3.6%	0.4%	**24.2%**	**5,524**
2016	17.2%	1.3%	2.1%	4.1%	0.4%	**25.1%**	**5,895**
2017	16.7%	1.8%	2.0%	4.7%	0.4%	**25.7%**	**6,189**
2018	16.8%	2.1%	2.2%	4.8%	0.4%	**26.3%**	**6,523**

Sources: IRENA, EIA, LBNL, and SEIA/GTM

Reported values may vary from those included in previous editions of the data book due to a change of sources.

[1] Grid-connected only

Top Countries for Renewable Electricity Installed Capacity (2018)



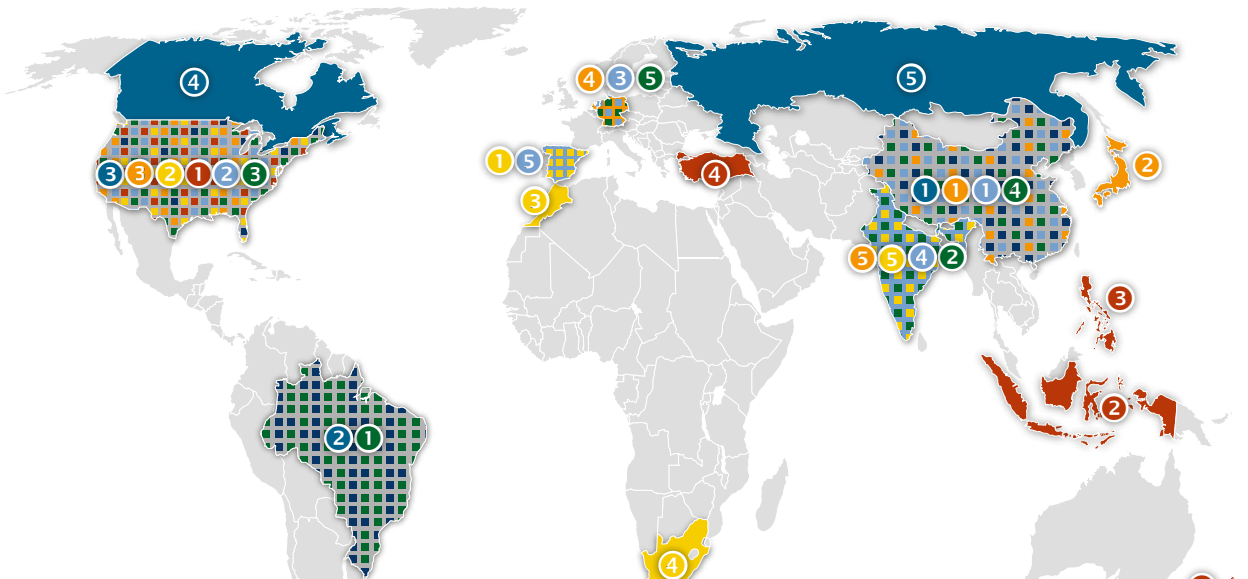
Renewable Electricity Capacity	Renewable Values MW
1 China	695,827
2 United States	249,396
3 Brazil	135,669
4 Germany	119,385
5 India	117,955

Sources: IRENA, EIA, LBNL, and SEIA/GTM

Reported values may vary from those included in previous editions of the data book due to a change of sources.

[1]Grid-connected only

Top Countries for Installed Renewable Electricity Capacity by Technology (2018)



Hydropower	Solar PV[1]	CSP	Geothermal	Wind	Biomass Energy
1 China	1 China	1 Spain	1 United States	1 China	1 Brazil
2 Brazil	2 Japan	2 United States	2 Indonesia	2 United States	2 India
3 United States	3 United States	3 Morocco	3 Philippines	3 Germany	3 United States
4 Canada	4 Germany	4 South Africa	4 Turkey	4 India	4 China
5 Russia Fed	5 India	5 India	5 New Zealand	5 Spain	5 Germany

Sources: IRENA, EIA, LBNL, and SEIA/GTM

[1]Grid-connected only

IV. Wind

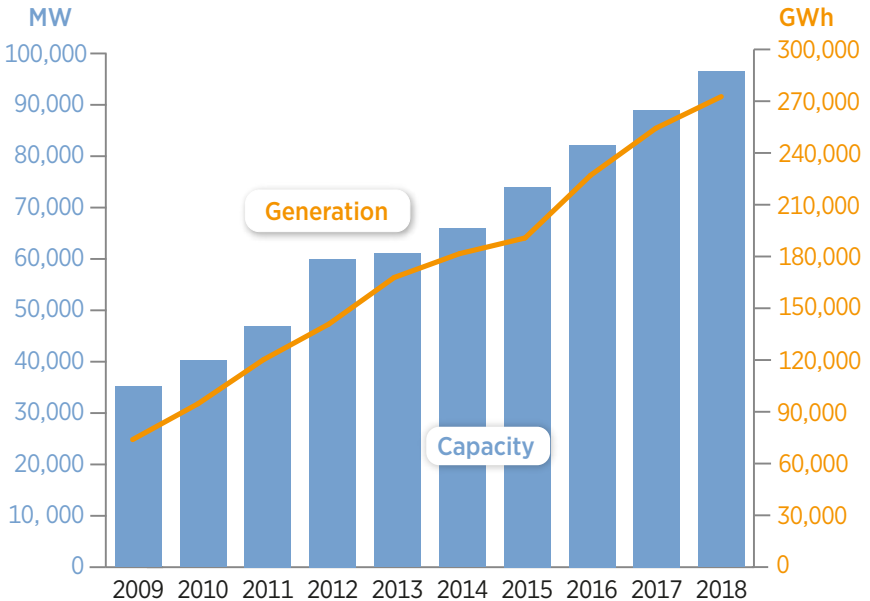
Wind: Summary

- In the United States, cumulative wind capacity grew 8.4% in 2018, compared to 8.3% in 2017. **Nearly 7.5 GW of additional wind capacity**[1] was installed in 2018, leading to a **total capacity of more than 96.4 GW**.
- States with some of the highest cumulative wind capacity also experienced the most growth in capacity in 2018, including Texas (2.3 GW), Iowa (1.1 GW), and Oklahoma (0.6 GW). Colorado (0.6 GW) also saw a large wind capacity increase in 2018.
- **Global cumulative wind capacity reached 564 GW** in 2018.
- **China continued to lead the world in cumulative wind capacity with 184.7 GW**, including almost 18.5 GW of wind capacity additions in 2018.
- Although the 30 MW Block Island Wind Farm in Rhode Island remains the only operational offshore wind project in the United States as of 2018, an additional **25.8 GW of offshore wind capacity was in various planning stages**. These projects are largely on the East Coast (90.8%). The top five states for planned off-shore wind capacity were Massachusetts (9.0 GW), New Jersey (4.2 GW), North Carolina (3.7 GW), Rhode Island (2.0 GW), and Virginia (1.4 GW).[2]
- Globally, off-shore wind installations grew 25.5% from 18.9 GW in 2017 to 23.7 GW in 2018.

[1] Wind *net* capacity increased by 7.5 GW when accounting for retirements and repowering, while 8.2 GW of new wind capacity were installed in the United States in 2018.

[2] These capacities are a combination of specific developer announcements and technical potential estimations for developer-controlled lease areas. For a specific breakdown of developer announcements and technical potential estimates, see the EERE *2018 Offshore Wind Technologies Market Report*.

U.S. Total Installed Wind Electricity Capacity and Generation



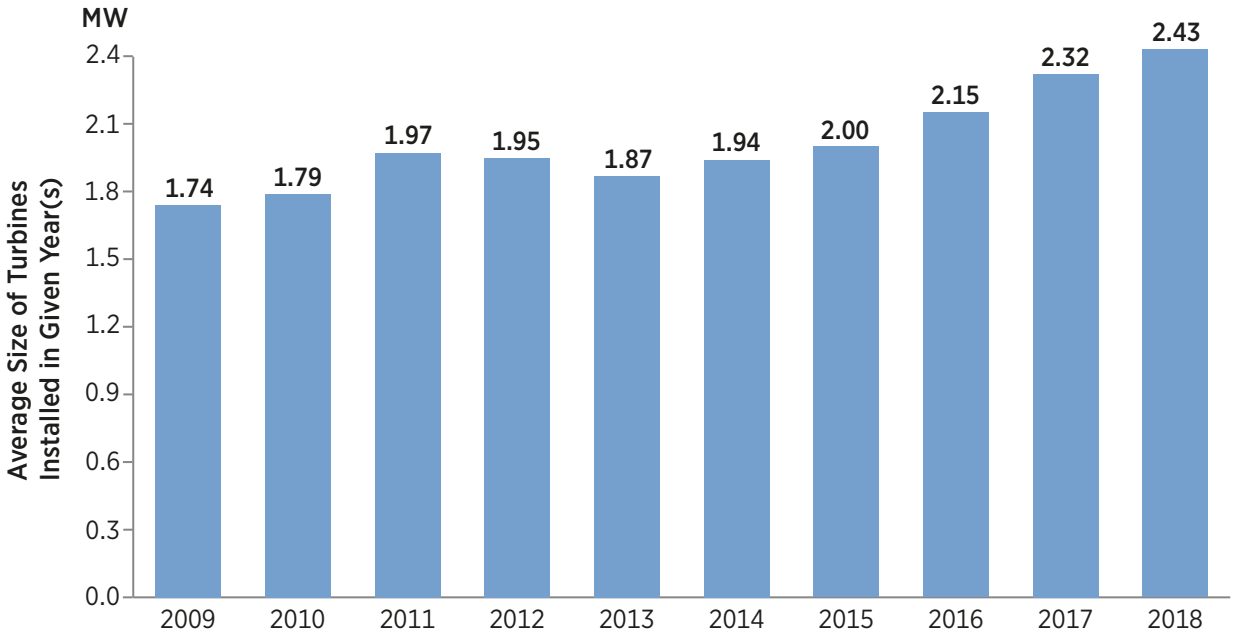
	U.S. Wind Electricity Generation (GWh)	U.S. Wind Electricity Capacity and Percent Increase from Previous Year	
		Total (MW)	% Increase
2009	**73,886**	**35,155**	**39.3%**
2010	**94,652**	**40,271**	**14.6%**
2011	**120,177**	**46,921**	**16.5%**
2012	**140,822**	**60,010**	**27.9%**
2013	**167,840**	**61,115**	**1.8%**
2014	**181,655**	**65,885**	**7.8%**
2015	**190,719**	**74,000**	**12.3%**
2016	**226,993**	**82,151**	**11%**
2017	**254,303**	**88,981**	**8.3%**
2018	**272,650**	**96,442**	**8.4%**

Sources: LBNL Wind Technologies Market Report (capacity data) and EIA (generation data)

LBNL data include installed capacity that are online and installed as of the end of the year. A wind project, or the capacity portion of a wind project, is reported as online when it is delivering electricity to the power grid or ultimate point of delivery. The timing of installation is usually consistent with "commercial operation date" but may differ, and specific criteria are at the discretion of the wind project owner.

Reported values may vary from those included in previous editions of the data book due to retroactive changes in source data.

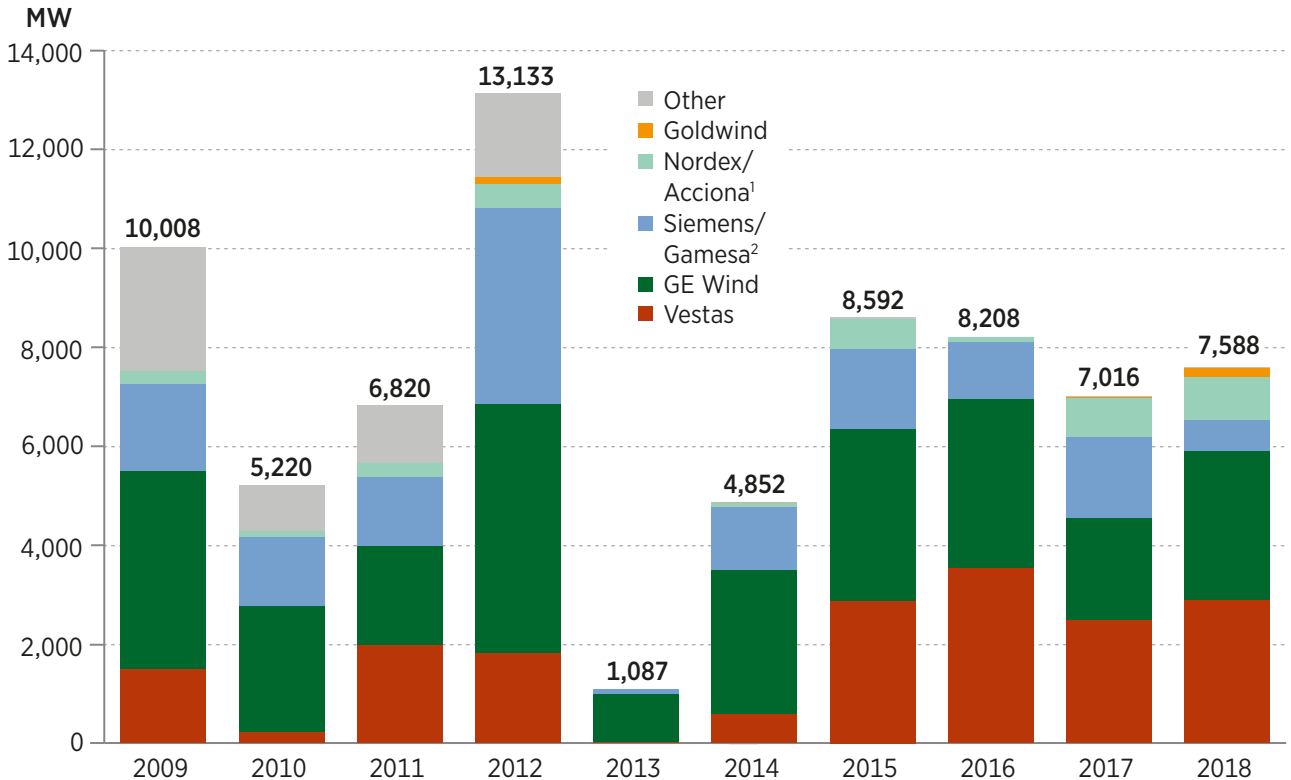
U.S. Average Installed Turbine Size



IV

Source: American Wind Energy Association

U.S. Annual Wind Turbine Installations by Manufacturer



Source: LBNL

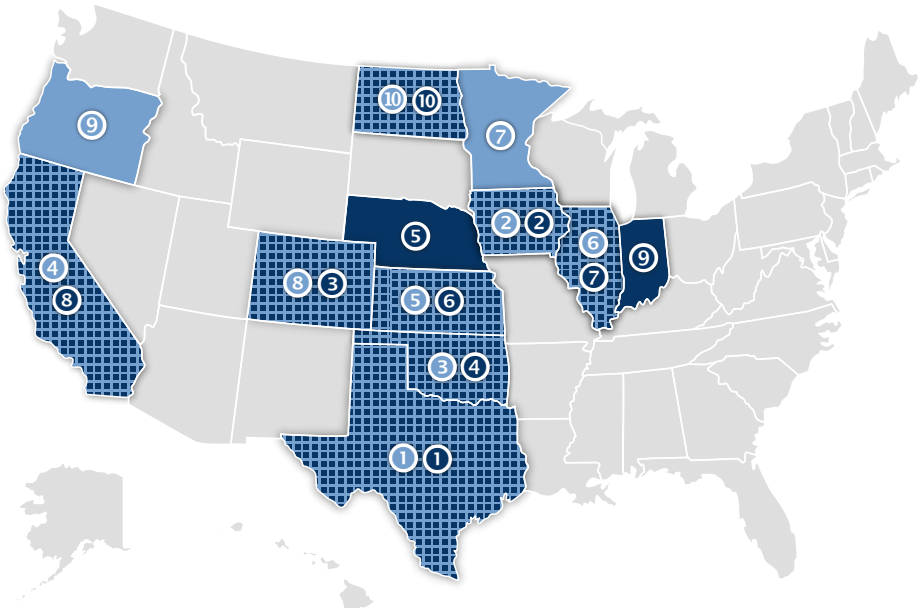
Reported values may vary from those included in previous editions of the data book due to retroactive changes in source data.

More wind turbine manufacturers have been consolidated under Other in this edition of the data book relative to previous editions.

[1] Nordex and Acciona merged in 2018. Historical installations from the two companies have been merged retroactively in the data book.

[2] Siemens and Gamesa merged in 2017. Historical installations from the two companies have been merged retroactively in the data book.

States Leading Wind Electricity Development (2018)

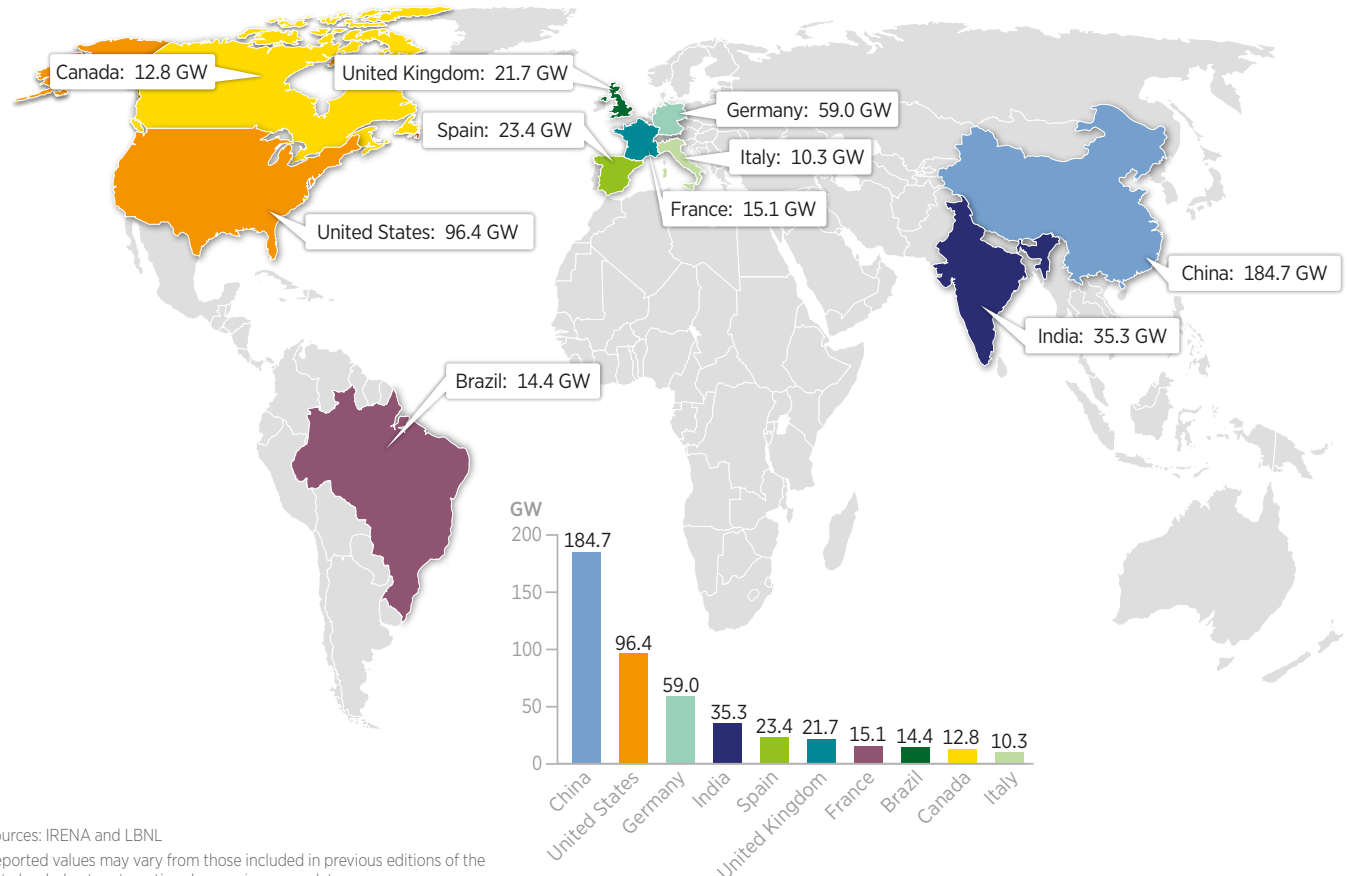


Cumulative Capacity (MW)	
1 Texas	24,896
2 Iowa	8,421
3 Oklahoma	8,072
4 California	5,840
5 Kansas	5,654
6 Illinois	4,861
7 Minnesota	3,779
8 Colorado	3,704
9 Oregon	3,213
10 North Dakota	3,155

Annual Capacity Additions (MW)	
1 Texas	2,296
2 Iowa	1,113
3 Colorado	597
4 Oklahoma	577
5 Nebraska	557
6 Kansas	543
7 Illinois	529
8 California	285
9 Indiana	200
10 North Dakota	159

Source: LBNL

Cumulative Wind Electricity Capacity (2018) – Top 10 Countries

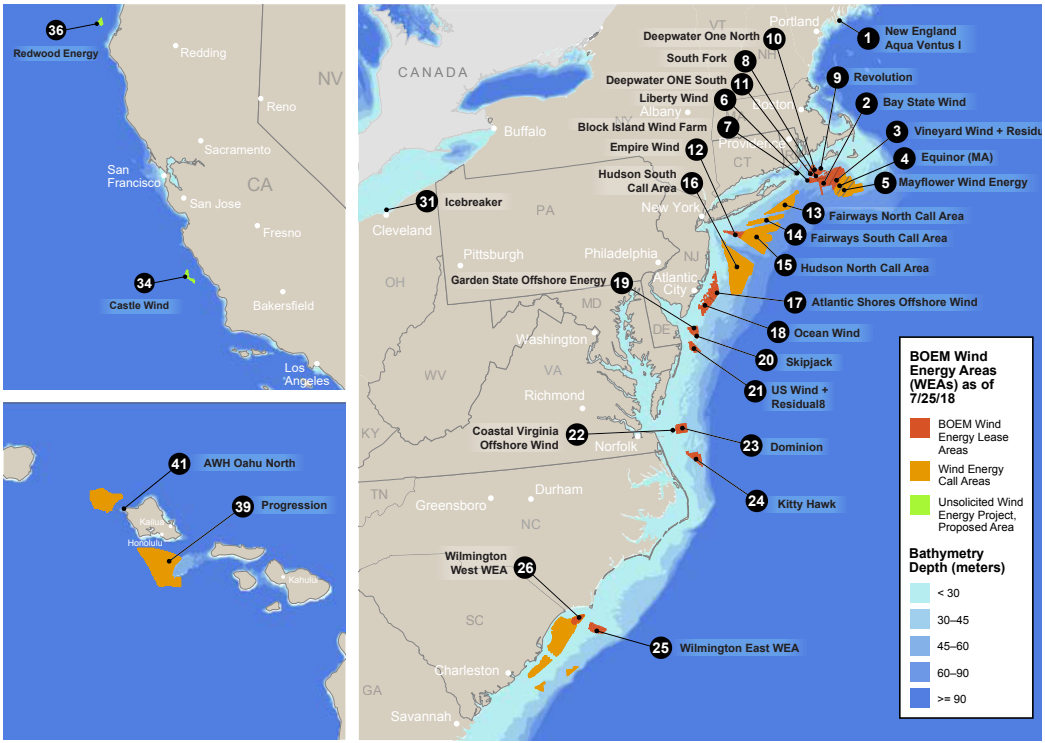


Sources: IRENA and LBNL

Reported values may vary from those included in previous editions of the data book due to retroactive changes in source data.

Includes offshore wind.

Proposed U.S. Offshore Wind Electricity Projects (2018)

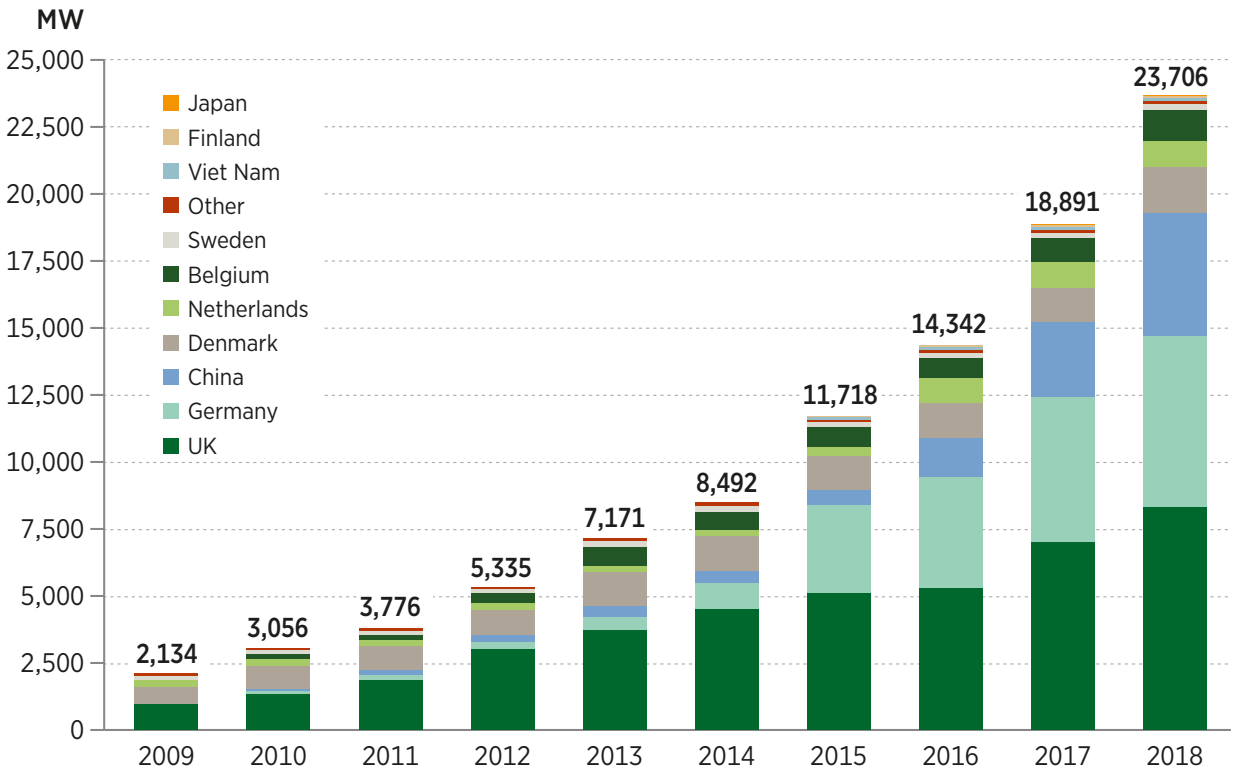


	Project Owner (Project Name)	State	Current Status	Project Capacity (MW)
1	New England Aqua Ventus I	ME	Permitting	12
2	Bay State Wind	MA	Site Control	2,277
3	Vineyard Wind + Residual	MA	Permitting	2,025
4	Equinor (MA)	MA	Site Control	1,564
5	Mayflower Wind Energy	MA	Site Control	1,547
6	Liberty Wind	MA	Site Control	1,607
7	Block Island Wind Farm	RI	Installed	30
8	South Fork	RI	Permitting	130
9	Revolution	RI	Permitting	700
10	Deepwater ONE North	RI	Site Control	355
11	Deepwater ONE South	RI	Site Control	816
12	Empire Wind	NY	Site Control	963
17	Atlantic Shores Offshore Wind	NJ	Site Control	2,226
18	Ocean Wind	NJ	Site Control	1,947
19	Garden State Offshore Energy	DE	Site Control	1,050
20	Skipjack	DE	Permitting	120
21	US Wind + Residual8	MD	Permitting	966
22	Coastal Virginia Offshore Wind	VA	Permitting	12
23	Dominion	VA	Site Control	1,371
24	Kitty Hawk	NC	Site Control	1,485
25	Wilmington East WEA	NC	Unleased	1,623
26	Wilmington West WEA	NC	Unleased	627
31	Icebreaker	OH	Permitting	21
34	Castle Wind	CA	Unsolicited Project Application	1,000
36	Redwood Energy	CA	Unsolicited Project Application	150
38	AWH Oahu South	HI	Unsolicited Project Application	400
39	Progression	HI	Unsolicited Project Application	400
41	AWH Oahu North	HI	Unsolicited Project Application	400

Source: DOE Office of Energy Efficiency and Renewable Energy (EERE)

Planning: begins when developer or regulator agency initiates formal site control process; Site Control: begins when developer obtains development rights to a site; P/PI (Permitting/Procurement Initiated): begins when developer files major permit applications or when the relevant regulatory authority initiates an auction (or other process) to procure energy for the project; P/CA (Permitting/Contract Awarded): begins when the project's permit applications have been approved or when a developer has been selected from the procurement process; Operating: begins when the project has been connected to the power grid and all units are fully commissioned.

Cumulative Offshore Wind Electricity Capacity by Country



Sources: IRENA, EERE, and LBNL.

Previous editions of the data book used offshore wind capacity data from the Global Wind Energy Council (GWEC); beginning this year, the data book uses IRENA for international capacity data.

V. Solar

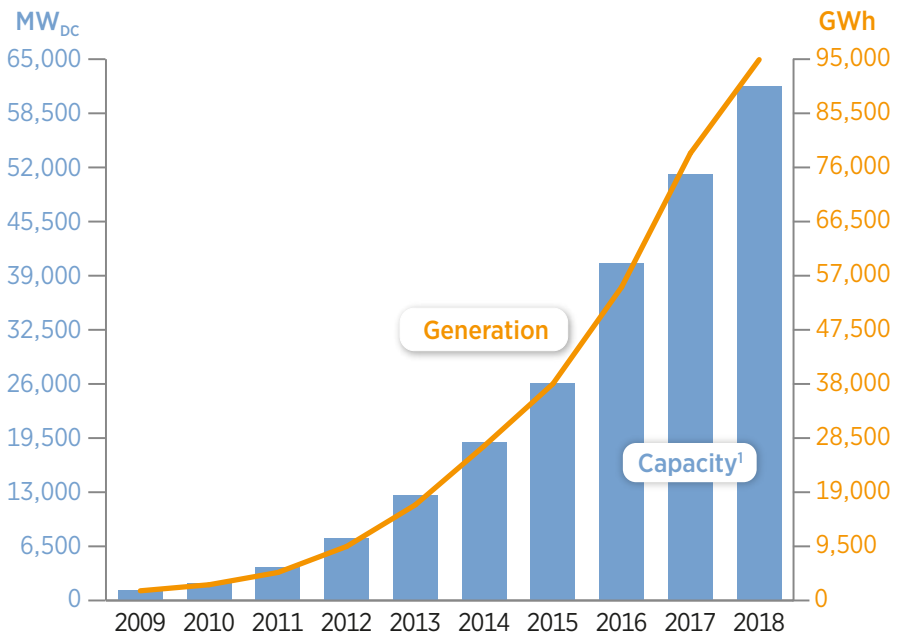
Solar: Summary

- U.S. solar **capacity increased by 19.9%** in 2018, driven by PV capacity growth.
- Consistently high growth rates over the last decade have resulted in a total of **61.8 GW_{DC} (49.4 GW_{AC}) of PV capacity**[1] in the United States by the end of 2018.
- With no new capacity additions in 2018, U.S. **CSP capacity remained at 1,775 MW_{AC}.**
- **U.S. solar generation**—from PV and CSP combined—**totaled more than 98.5 TWh**, which represents approximately **2.3% of total U.S. generation** in 2018.
- Both utility-scale and residential markets have driven PV solar capacity growth in the United States over the last three years. **Distributed PV capacity grew by 22.0%** (4.5 GW) in 2018, and **utility-scale PV capacity grew by 19.6%** (6.1 GW).
- **U.S. Distributed PV generation in 2018 totaled 34.7 TWh, which represents 36.5% of total solar PV generation**.
- Globally, cumulative capacity in 2018 totaled **480.6 GW for PV and 5.5 GW for CSP capacity.**

Sources: EIA, SEIA/GTM, and PVWatts.

[1] While the rest of the data book reports in MW_{AC}, this section reports solar PV capacity in MW_{DC} to conform with solar industry norms. While EIA-860 reports utility-scale solar capacity in MW_{AC}, SEIA/GTM reports small-scale grid-connected PV capacity in MW_{DC}. The solar industry typically reports capacity in MW_{DC}. Based on consultation with developers, SEIA/GTM use an 87% MW_{DC} to MW_{AC} derate factor for installations below 10 MW. The data book uses the 87% derate factor when small-scale capacity figures are added to a cumulative MW_{AC} total. In the solar section of the data book, capacity figures are reported in MW_{DC} to conform with the solar industry standard. To do this, As such, EIA-860 capacity is converted to MW_{DC} assuming an 80% MW_{DC}-to-MW_{AC} derate factor, which is the conservative estimate of converter efficiency used by the EIA. For more information, see "New EIA Data Show Total Grid-Connected Photovoltaic Solar Capacity," October 24, 2012, https://www.eia.gov/todayinenergy/detail.php?id=8510

U.S. PV Electricity Installed Capacity and Generation



	U.S. PV Generation (GWh)	U.S. PV Capacity[1] (MW$_{DC}$) and % Increase from Previous Year	
		PV	Increase
2009	1,699	1,221	–
2010	2,763	2,115	73%
2011	4,915	4,010	90%
2012	9,478	7,531	88%
2013	16,783	12,634	68%
2014	27,112	18,992	50%
2015	38,011	26,079	37%
2016	55,009	40,562	56%
2017	78,491	51,239	26%
2018	94,921	61,776	21%

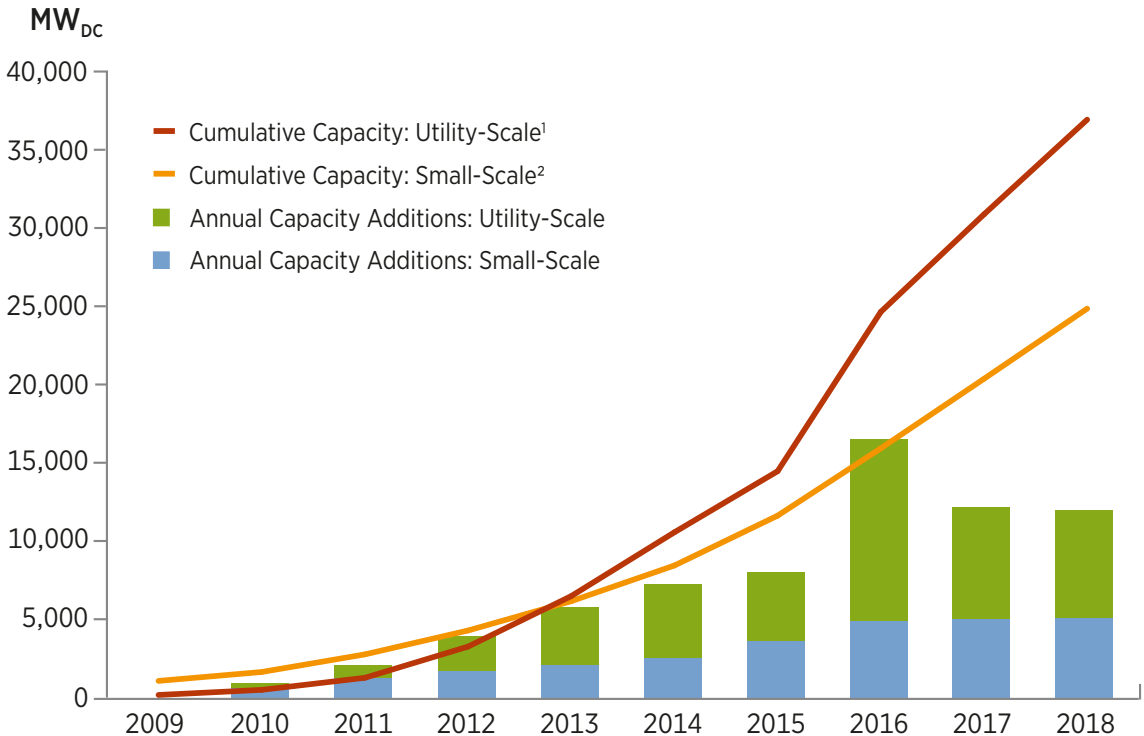
V

Sources: EIA, SEIA/GTM, PVWatts.

PV capacity in this section is reported in MW$_{DC}$.

[1]Grid-connected only; PV capacity in this section is reported in MW$_{DC}$. A de-rate of 80% has been used to convert utility-scale solar from MW$_{AC}$ to MW$_{DC}$.

U.S. PV Cumulative Capacity by Segment



V

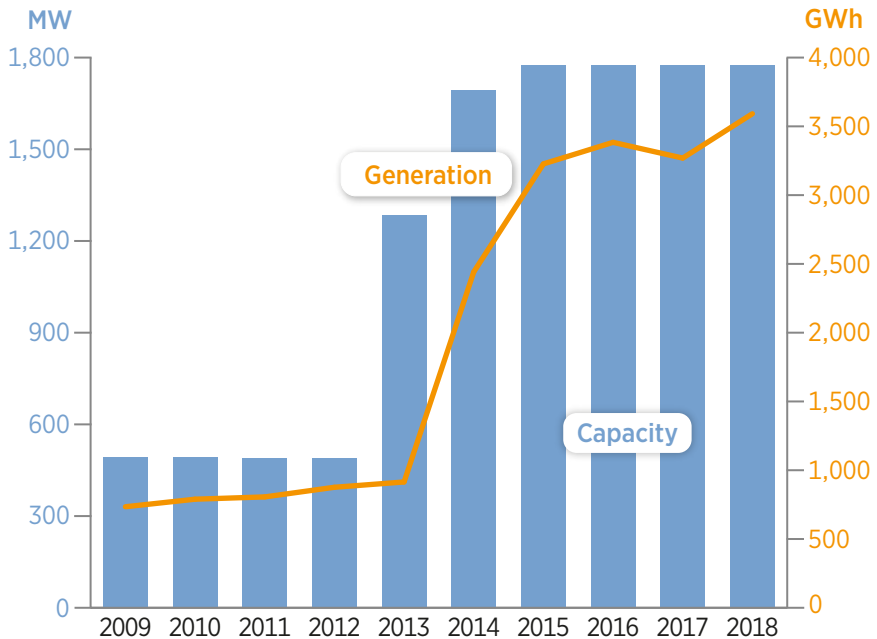
Sources: EIA, SEIA/GTM, and PVWatts.

PV capacity in this section is reported in MW_{DC}.

[1] Utility-scale PV includes generators reported within EIA-860 as larger than 1 MW in size. This includes almost all solar PV generators whose offtaker is a utility or power market. In this section, a de-rate of 80% has been used to convert utility-scale solar from MW_{AC} to. Generation data for utility-scale solar PV is aggregated from the EIA's *Electric Power Monthly* reports.

[2] Small-Scale PV, otherwise known as 'distributed solar PV' capacity data is sourced from the SEIA/GTM *Solar Market Insight 2018 Year-in-Review* report for 'residential', and 'non-residential' installations. This includes rooftop residential and commercial PV, community solar projects, government and nonprofit customers, and other projects where the immediate offtaker of energy is not a utility or power market. Generation data for small-scale solar PV is estimated on a state-level using average capacity factors calculated through PVWatts assuming fixed-tilt roof mounted systems.

U.S. CSP Electricity Installed Capacity and Generation



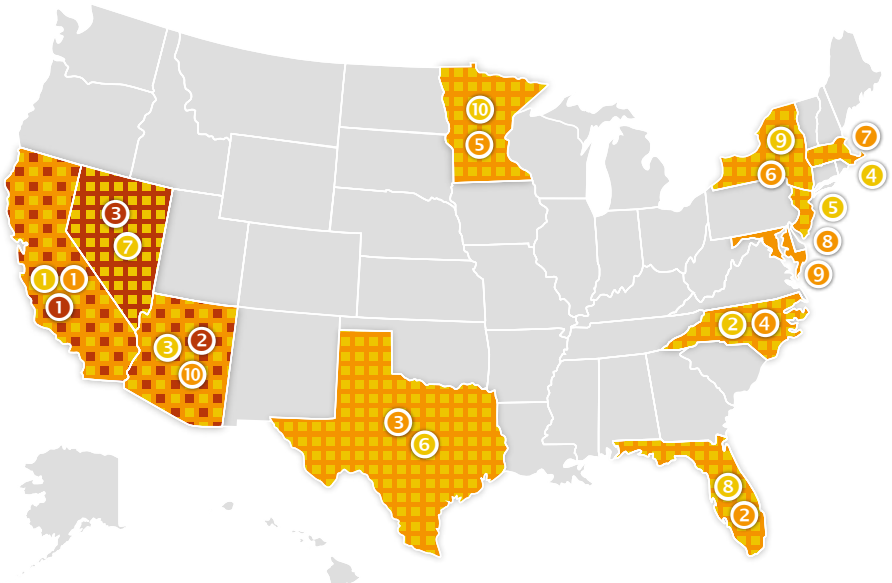
	U.S. CSP Generation (GWh)	U.S. CSP Capacity (MW) and % Increase from Previous Year	
		CSP	Increase
2009	735	491	17%
2010	789	491	0%
2011	806	490	0%
2012	876	490	0%
2013	915	1,285	162%
2014	2,441	1,693	32%
2015	3,227	1,775	5%
2016	3,384	1,775	0%
2017	3,269	1,775	0%
2018	3,592	1,775	0%

V

Source: EIA

CSP capacity is reported in MW_{AC}.

States Leading Solar Electricity Development (2018)



PV Cumulative Capacity[1]	
1 California	22,498
2 North Carolina	5,056
3 Arizona	3,594
4 Massachusetts	3,286
5 New Jersey	3,086
6 Texas	2,847
7 Nevada	2,467
8 Florida	2,056
9 New York	1,828
10 Minnesota	1,531

PV Annual Capacity[1] Additions	
1 California	2,913
2 Florida	1,191
3 Texas	995
4 North Carolina	824
5 Minnesota	574
6 New York	472
7 Massachusetts	413
8 New Jersey	394
9 Maryland	351
10 Arizona	239

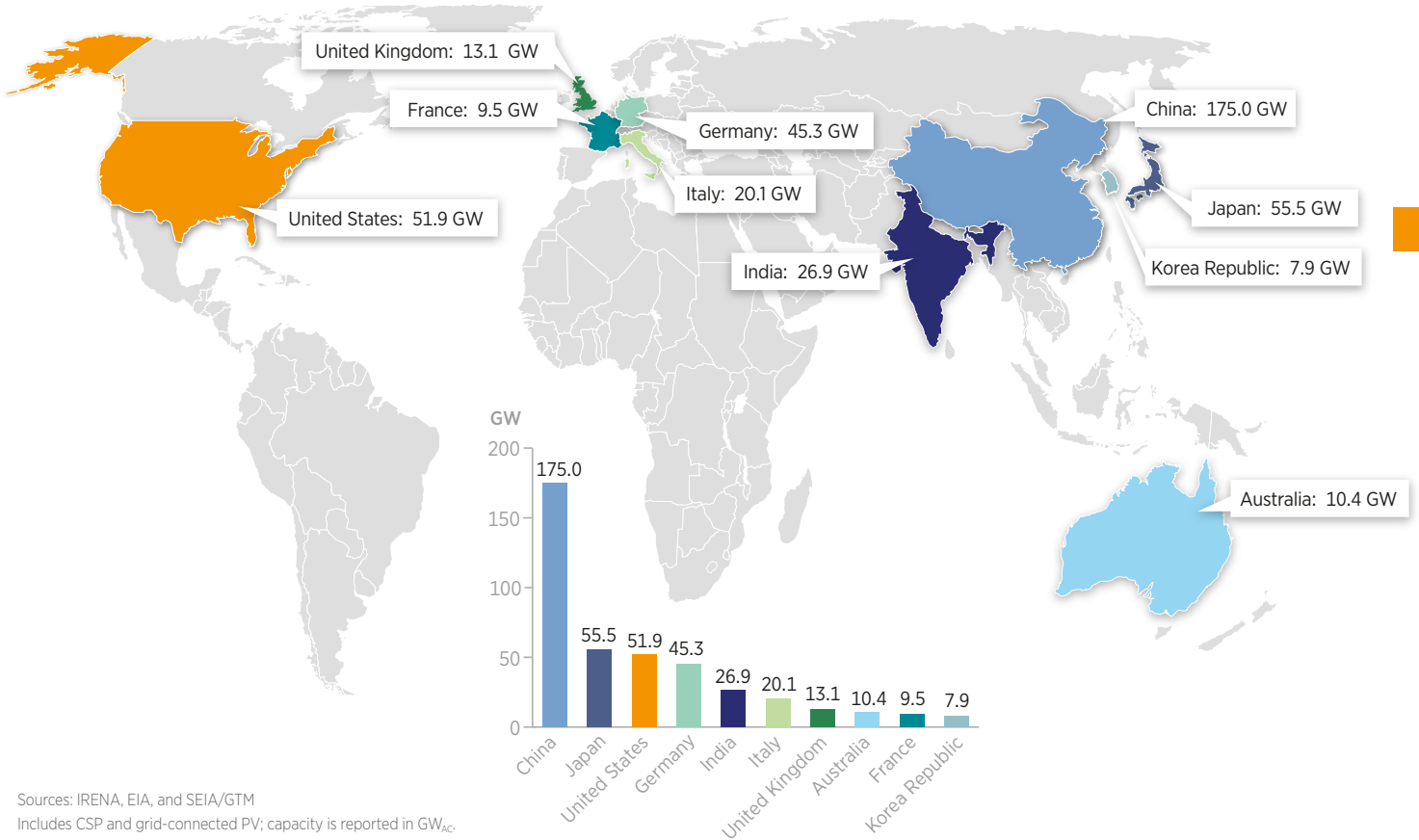
CSP Cumulative Capacity[2]	
1 California	1,294
2 Arizona	280
3 Nevada	201

Sources: EIA, SEIA/GTM

[1] Grid-connected only; capacity is reported in MWDC. A derate factor of 80% has been used to convert utility-scale solar from MW_{AC} to MW_{DC}.

[2] CSP capacity is reported in MW_{AC}.

Cumulative Solar Electricity Capacity (2018) – Top 10 Countries



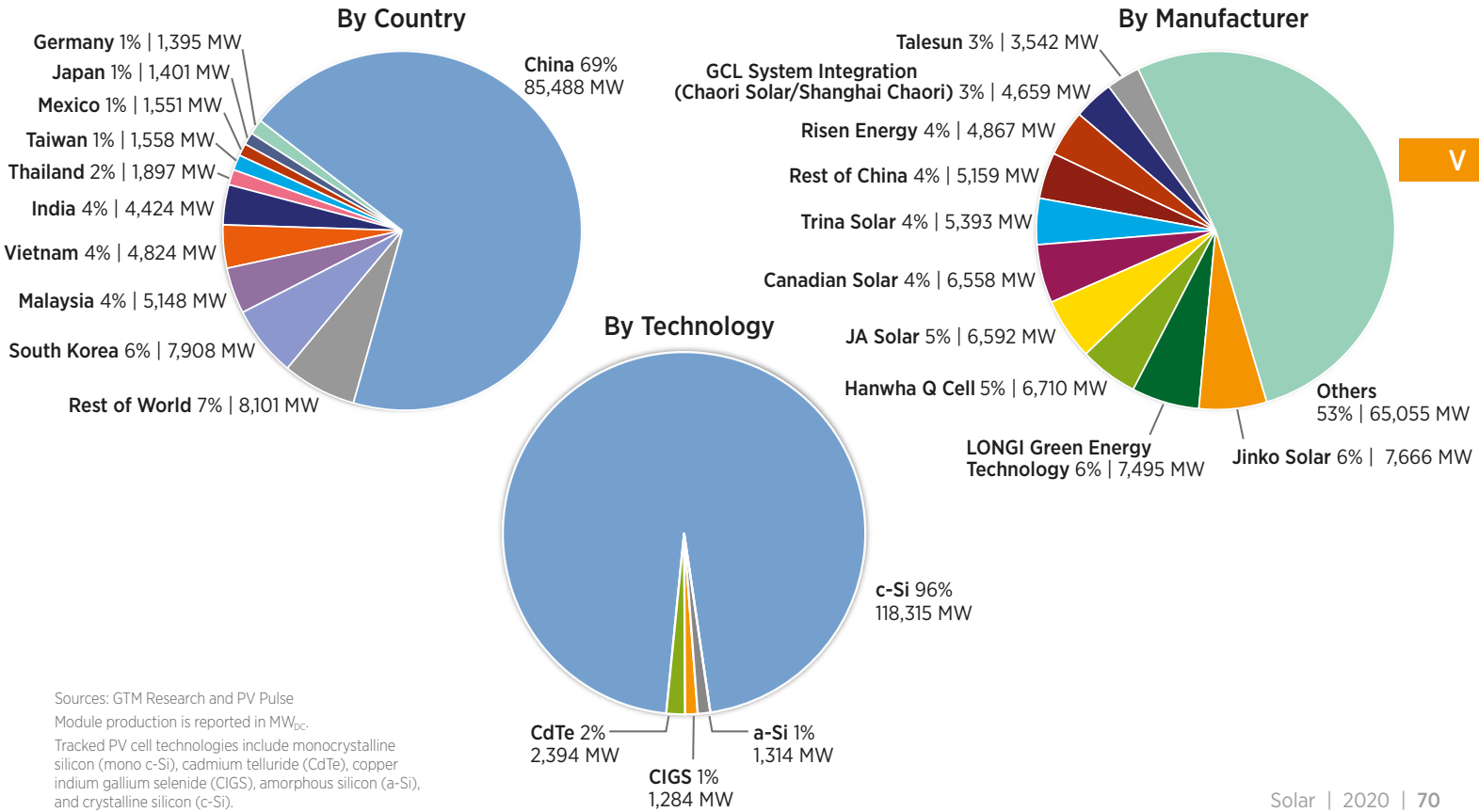
Sources: IRENA, EIA, and SEIA/GTM

Includes CSP and grid-connected PV; capacity is reported in GW_{AC}.

Previous editions of the data book used REN21 for global capacity data; beginning this year the data book uses IRENA for international capacity data.

Global Photovoltaic Manufacturing (2018)

Global Solar Module Production (2018): 123,695 MW



Sources: GTM Research and PV Pulse

Module production is reported in MW_{DC}.

Tracked PV cell technologies include monocrystalline silicon (mono c-Si), cadmium telluride (CdTe), copper indium gallium selenide (CIGS), amorphous silicon (a-Si), and crystalline silicon (c-Si).

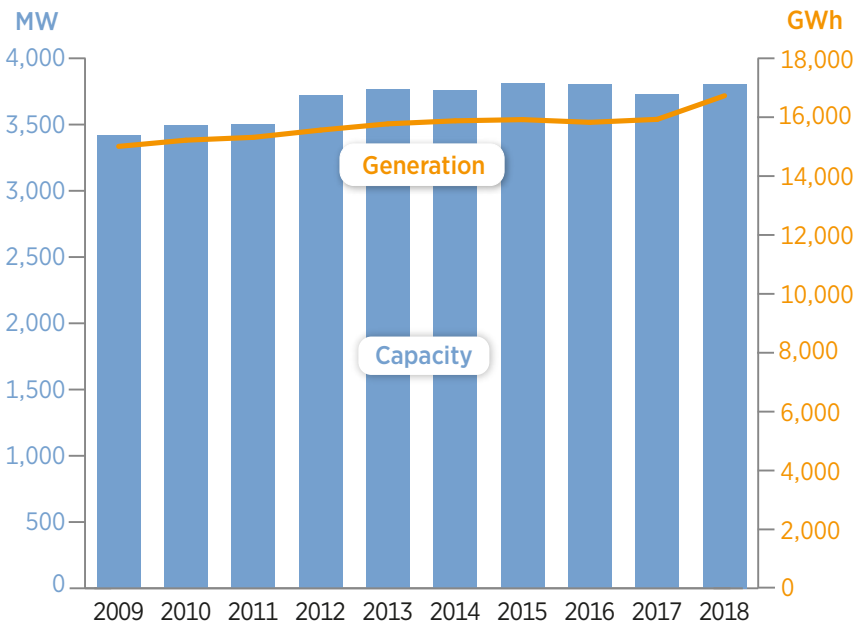
VI. Geothermal

Geothermal: Summary

- U.S. geothermal capacity has slowly increased since 2009, with a 2.0% growth in capacity (73.6 MW) in 2018. **Geothermal generation increased by 0.3%** (40.3 MWh) **in 2018**.
- **The United States continued to lead the world in geothermal electricity capacity** (more than 3.8 GW) **and generation** (more than 16.0 TWh), with most of the capacity being located in California and Nevada.
- **The U.S. Department of Energy (DOE) Frontier Observatory for Research in Geothermal Energy (FORGE), located in Milford, Utah and led by the University of Utah's Energy and Geoscience Institute, is the first dedicated field site of its kinds for testing targeted enhanced geothermal systems (EGS) research and development**. The Utah FORGE site Phase 2 activities have focused on building the necessary Phase 3 infrastructure, confirmatory reservoir testing, as well as high-resolution data collection, analysis, and modeling.
- FORGE Phase 3 will involve full implementation of the Utah FORGE laboratory, with comprehensive infrastructure supporting site monitoring, drilling, reservoir stimulation and testing, as well as competitive research and development over five years.
- **Phase 3 activities at the Utah FORGE site are anticipated to start in the first half of 2020 and will include drilling the first full-sized EGS well, as well as releasing research and development solicitations**.

Sources: EIA, and EERE

U.S. Geothermal Electricity Capacity and Generation

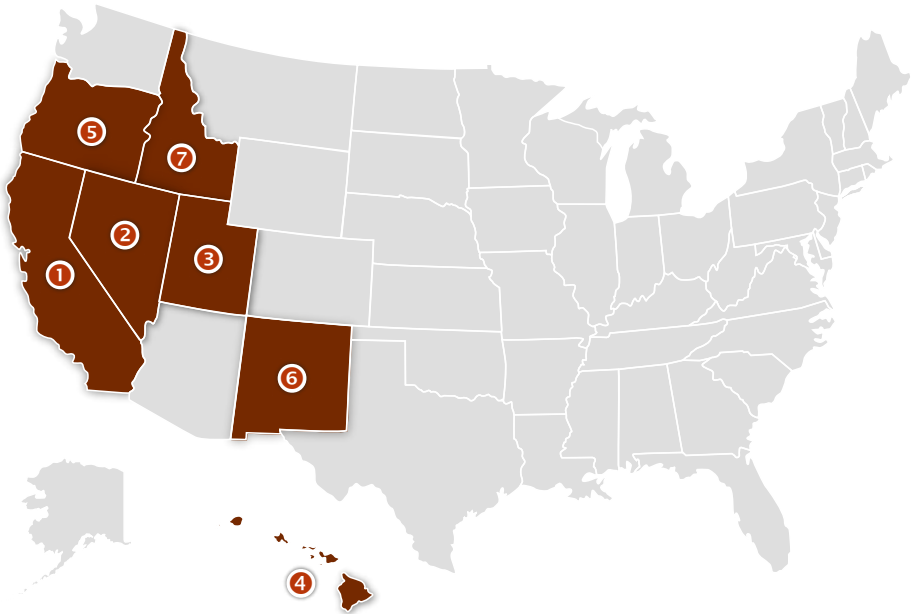


	U.S. Geothermal Electricity Generation (GWh)	U.S. Geothermal Electricity Capacity and % Increase from Previous Year	
		Total (MW)	% Increase
2009	15,009	3,421	3.5%
2010	15,219	3,498	2.3%
2011	15,316	3,500	0.1%
2012	15,562	3,724	6.4%
2013	15,775	3,765	1.1%
2014	15,877	3,757	-0.2%
2015	15,918	3,812	1.5%
2016	15,826	3,805	-0.2%
2017	15,927	3,732	-1.9%
2018	15,967	3,806	2%

VI

Source: EIA

Cumulative State Geothermal Electricity Development (2018)

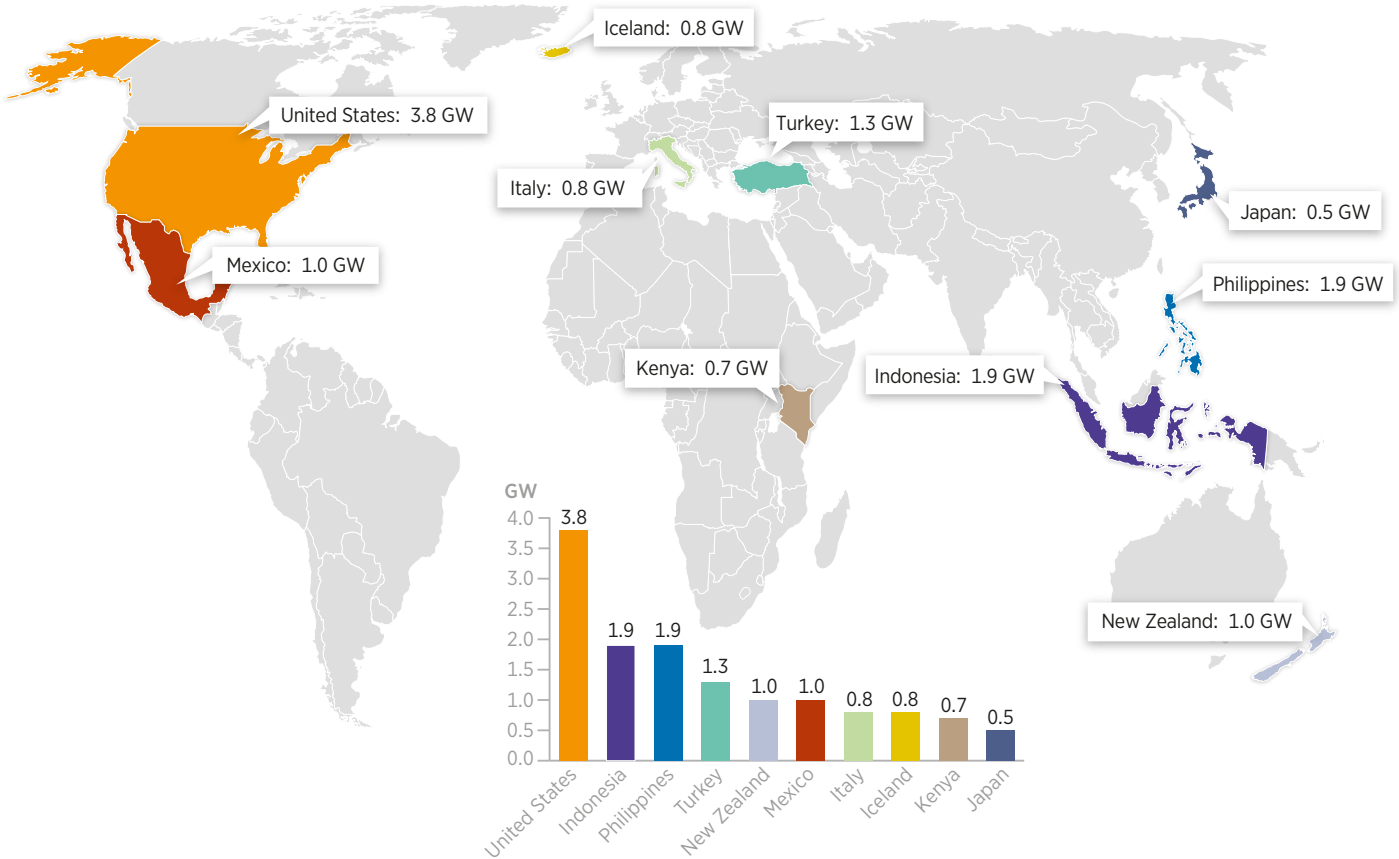


Total Installed Capacity (MW)	
1 California	2792
2 Nevada	805
3 Utah	84
4 Hawaii	51
5 Oregon	37
6 New Mexico	19
7 Idaho	18

VI

Source: EIA

Cumulative Geothermal Electricity Capacity (2018) – Top 10 Countries



Sources: EIA and IRENA

Previous editions of the data book used REN21 for global capacity data; beginning this year the data book uses IRENA for international capacity data.

VII. Biomass Energy

Biomass Energy: Summary

- In 2018, U.S. biomass energy electricity[1] **capacity decreased by 2.3% from 15.9 GW to 15.6 GW**.

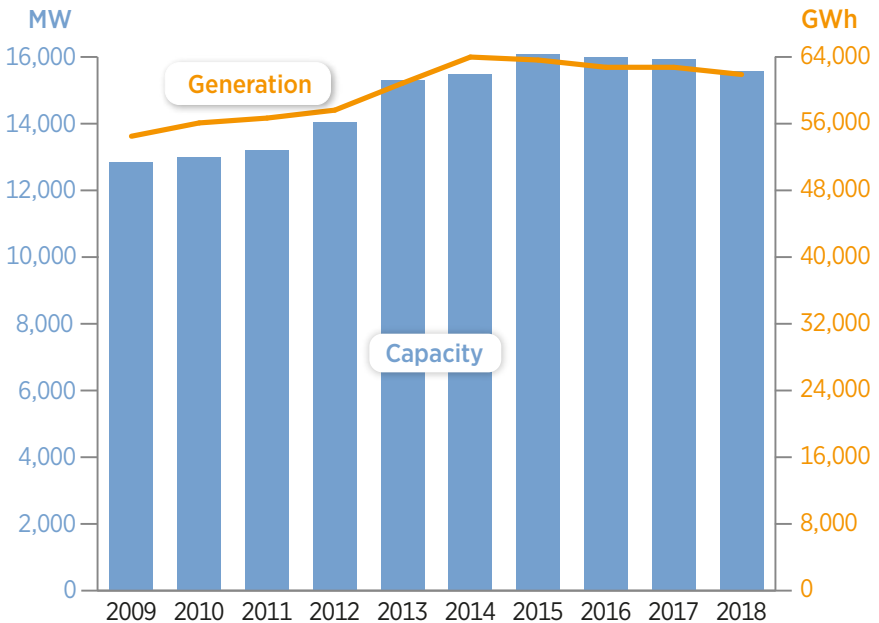
- In 2018, biomass energy electricity generation was 61.9 TWh, accounting for **almost 8.3% of all renewable energy generated in the United States** (741.6 TWh) and more than 1.4% of total U.S. electricity generation from all sources (4,209 TWh).

- The top five states for biomass energy capacity in 2018 were Florida (1.4 GW), California (1.4 GW), Virginia (1.0 GW), Georgia (1.0 GW), and Maine (0.8 GW).

VII

[1] Biomass energy electricity comes primarily from wood and agricultural residues that are burned as fuel for cogeneration of electricity and heat in the industrial sector, such as in the pulp and paper industry.

U.S. Biomass Energy Electricity Capacity and Generation



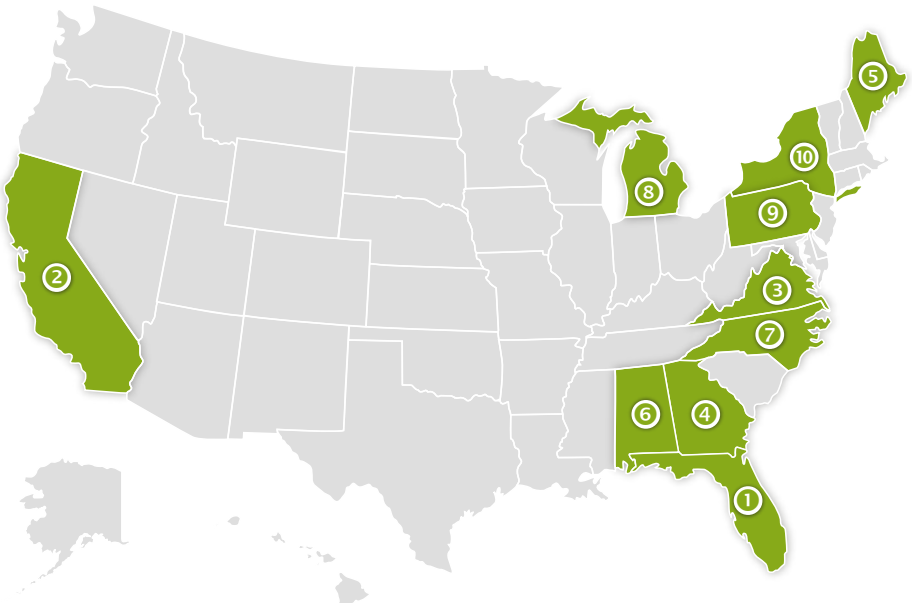
	U.S. Biomass Energy Generation (GWh)	U.S. Biomass Energy Capacity and % Change from Previous Year	
		Total (MW)	% Change
2009	**54,493**	**12,836**	**2.8%**
2010	**56,089**	**12,992**	**1.2%**
2011	**56,671**	**13,207**	**1.6%**
2012	**57,622**	**14,047**	**6.4%**
2013	**60,858**	**15,309**	**9%**
2014	**63,989**	**15,483**	**1.1%**
2015	**63,632**	**16,100**	**4.0%**
2016	**62,760**	**15,993**	**-0.7%**
2017	**62,762**	**15,928**	**-0.4%**
2018	**61,901**	**15,563**	**-2.3%**

VII

Source: EIA

Reported values may vary from those included in previous editions of the data book due to retroactive changes in source data.

States Leading Biomass Energy Electricity Installed Capacity (2018)



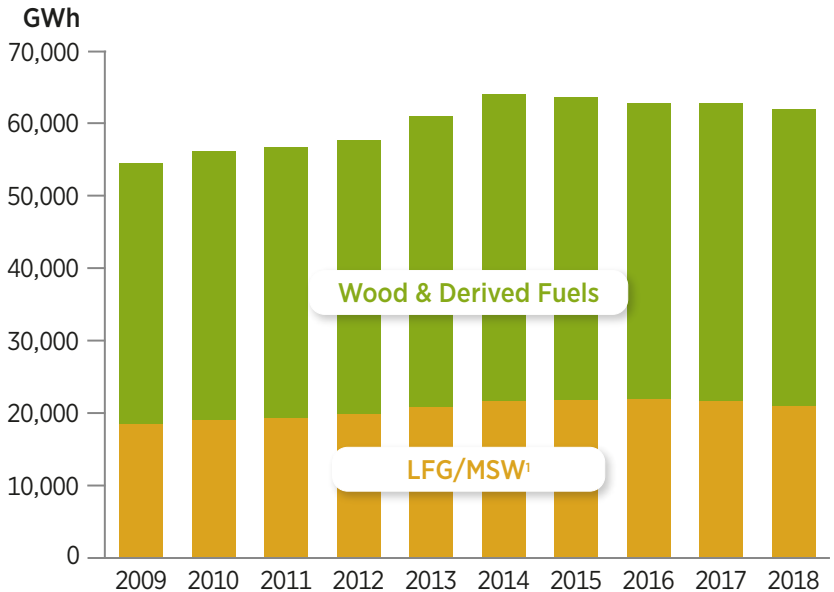
Total Installed Capacity (MW)	
1 Florida	1,416
2 California	1,394
3 Virginia	1,018
4 Georgia	1,007
5 Maine	769
6 Alabama	666
7 North Carolina	633
8 Michigan	616
9 Pennsylvania	601
10 New York	586

VII

Source: EIA

Reported values may vary from those included in previous editions of the data book due to retroactive changes in source data.

U.S. Biomass Energy Electricity Generation Sources



	LFG/ MSW[1] (GWh)	Wood and Derived Fuel (GWh)	Total
2009	18,443	36,050	54,493
2010	18,917	37,172	56,089
2011	19,222	37,449	56,671
2012	19,823	37,799	57,622
2013	20,831	40,028	60,858
2014	21,650	42,340	63,989
2015	21,703	41,929	63,632
2016	21,813	40,947	62,761
2017	21,610	41,152	62,762
2018	20,896	41,005	61,901

VII

Source: EIA

Reported values may vary from those included in previous editions of the data book due to retroactive changes in source data.

LFG = landfill gas; MWS = municipal solid waste.

[1] Includes biogenic municipal solid waste, landfill gas, sludge waste, agricultural byproducts, and other biomass energy. In previous editions of the data book, "other" was reported separately.

VIII. Hydropower

Hydropower: Summary

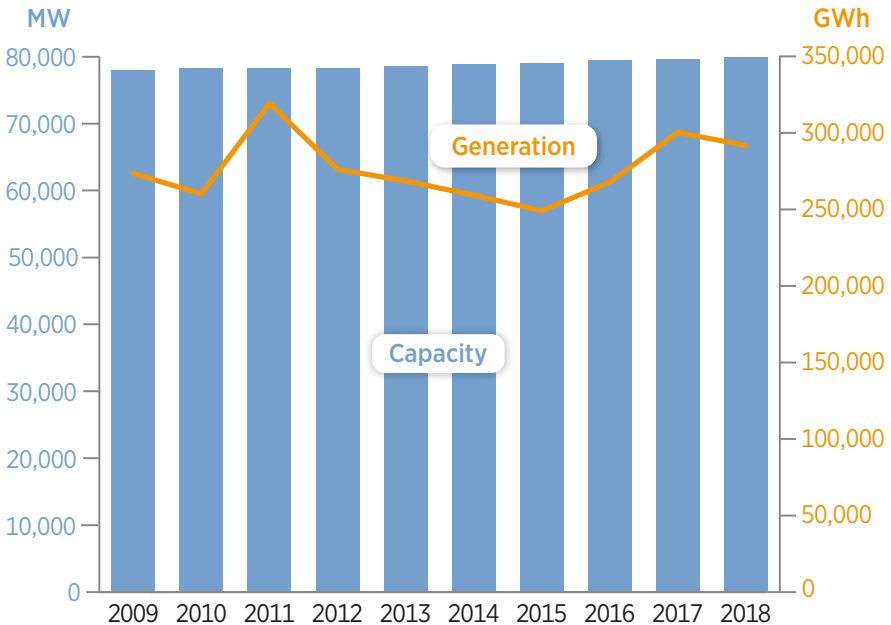
- While installed U.S. hydropower capacity remained stable in 2018 at 79.9 GW, **generation decreased by 2.6% from 300.3 TWh to 292.5 TWh**.
- Hydropower, primarily from large-scale plants, remained **the largest source of renewable electricity generation** in 2018, accounting for **6.6% of U.S. total electricity generation** and **39.0% of U.S. renewable electricity generation**.
- Hydropower capacity continued to be concentrated in the West, led by Washington (21.3 GW), California (10.1 GW), and Oregon (8.5 GW).[1]
- Globally, with a cumulative installed capacity of 1.2 TW, hydropower provided **63.9%** (4,168 TWh) **of global renewable generation**.

Source: EIA

Reported values may vary from those included in previous editions of the data book due to retroactive changes by the EIA.

[1] Pumped-hydro storage is excluded from renewable capacity and generation metrics unless specifically mentioned, as the quantity and source of the electricity powering pumps is indistinguishable. Pumped-hydro storage is also referred to in Section XII.

U.S. Hydropower Electricity Capacity and Generation

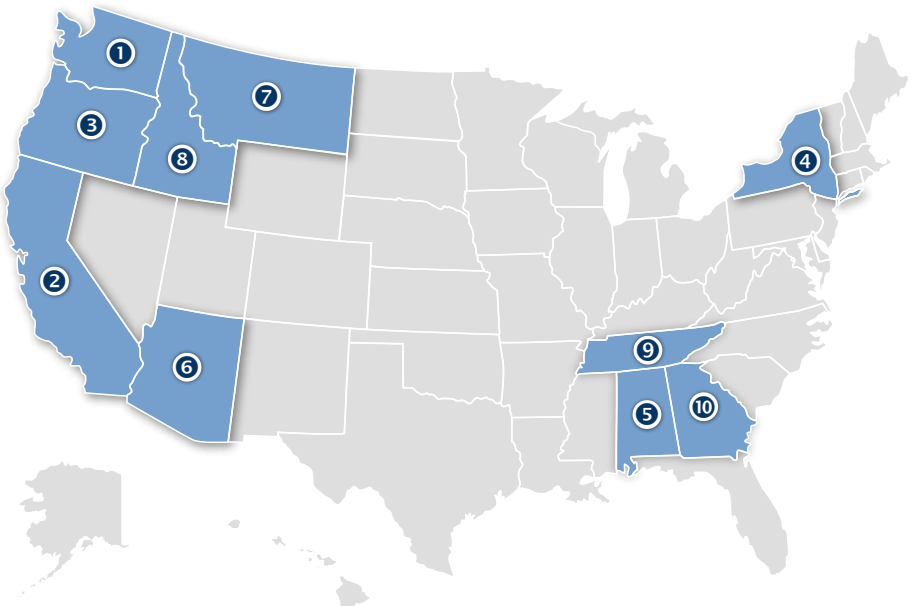


	U.S. Hydropower Generation (GWh)	U.S. Hydropower Capacity and % Increase from Previous Year	
		Total (MW)	% Increase
2009	**273,445**	**77,910**	**0.3%**
2010	**260,203**	**78,204**	**0.4%**
2011	**319,355**	**78,194**	**0.0%**
2012	**276,240**	**78,241**	**0.1%**
2013	**268,565**	**78,581**	**0.4%**
2014	**259,367**	**78,793**	**0.3%**
2015	**249,080**	**78,957**	**0.2%**
2016	**267,812**	**79,376**	**0.5%**
2017	**300,333**	**79,594**	**0.3%**
2018	**292,524**	**79,912**	**0.4%**

VIII

Source: EIA
Capacity and generation figures exclude pumped-storage hydropower.
Reported values may vary from those included in previous editions of the data book due to retroactive changes in source data.

States Leading Hydropower Electricity Installed Capacity (2018)



Total Installed Capacity (MW)	
1 Washington	21,272
2 California	10,068
3 Oregon	8,452
4 New York	4,692
5 Alabama	3,319
6 Arizona	2,718
7 Montana	2,703
8 Idaho	2,687
9 Tennessee	2,522
10 Georgia	1,963

VIII

Source: EIA
Capacity and generation figures exclude pumped-storage hydropower.

IX. Marine and Hydrokinetic Power

Marine and Hydrokinetic Power: Summary

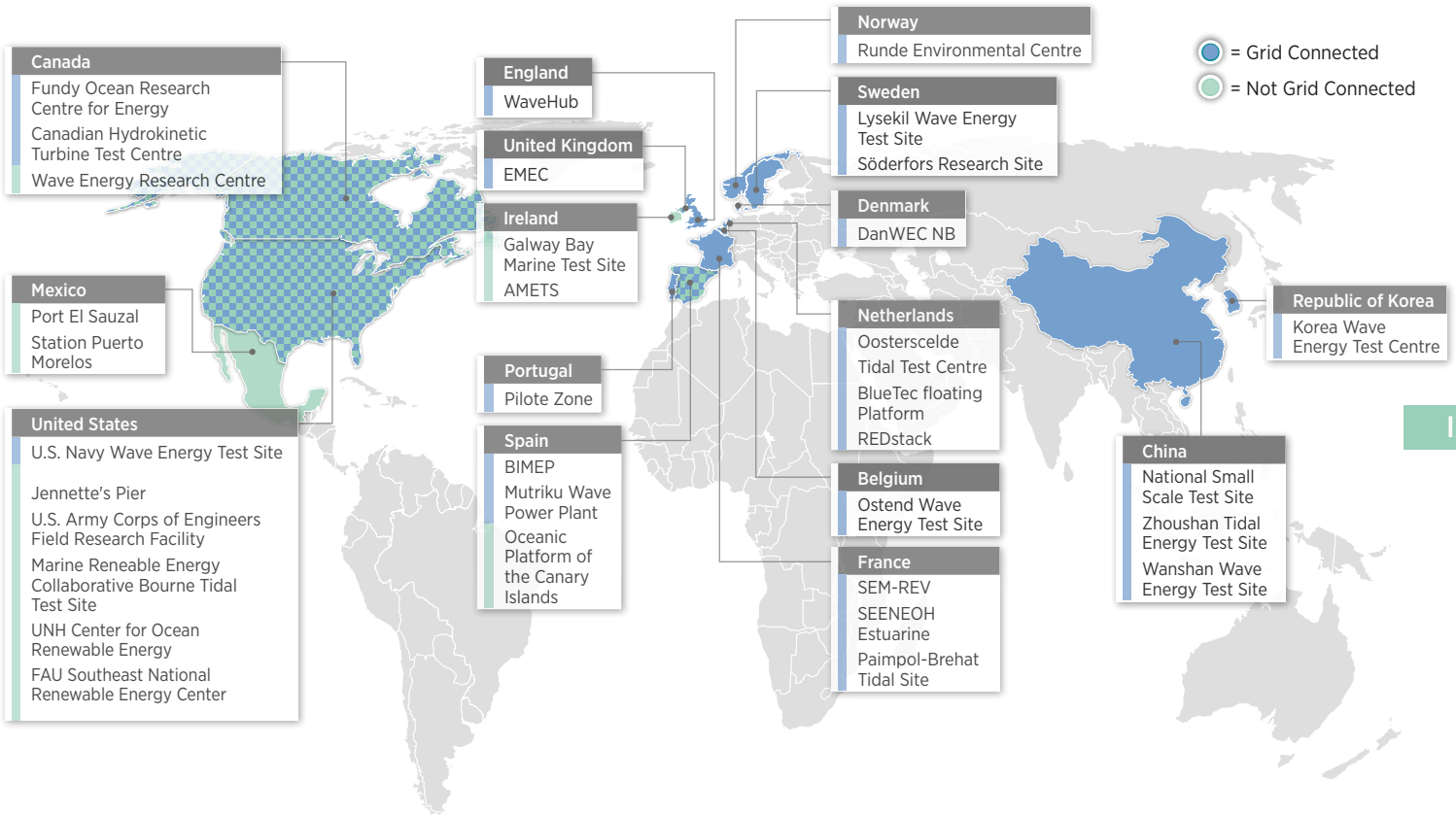
- Most marine and hydrokinetic power projects worldwide continue to be in a **pilot deployment and test-site state**. Technology development activity is **concentrated in North America and Europe**, followed by Oceana and Asia. Specifically, pilot deployments are concentrated in the United Kingdom (36%) and the United States (16%).

- As of 2018, two hydrokinetic projects were licensed in the United States: Verdant Power's Roosevelt Island Tidal Energy facility in New York (1.05 MW) and Ocean Renewable Power Company's TidGen Power System in in Cobscook Bay, Maine (0.3 MW).

- Additional small-scale testing units were deployed in the United States in 2018, including the University of New Hampshire's Living Bridge Project, which deployed a 25 kW cross-flow vertical axis tidal turbine beneath a bridge, and the BOLT Lifesaver point-absorber device in Hawaii which includes several 10 kW capacity units.

Source: Ocean Energy Systems

Global Marine and Hydrokinetic Power – Examples of Open Sea Test Sites



IX

Sources: Ocean Energy Systems and, EERE

Information about these and additional projects can be found in the EERE Marine and Hydrokinetic Technology Database at http://en.openei.org/wiki/Marine_and_Hydrokinetic_Technology_Database.

X. Energy Storage

Energy Storage: Summary – United States

- The United States had 2.7 GW of cumulative electrochemical, electromechanical, and thermal storage[1] capacity as of 2018. Pumped-storage hydropower capacity is still far larger than other storage technologies, with a cumulative installed capacity of 21.6 GW.

- U.S. electrochemical, electromechanical, and thermal storage cumulative installed capacity expanded by 10.8% in 2018, up from a 5.7% increase in 2017.

- In 2018, **all new storage installations in the United States were electrochemical** (263.7 MW). There were no new electromechanical, thermal storage, or pumped-storage hydropower projects were completed in 2018.

- **Since 2009, 52.9% of new storage capacity in the United States has been electrochemical** (1.4 GW)**, 39.7% has been thermal** (1.1 GW)**, and 7.4% has been electromechanical** (0.2 GW).

Sources: DOE-OE Global Energy Storage Database and EIA

Pumped-storage hydropower is excluded from capacity metrics unless specifically mentioned.

Previous editions of the data book exclusively used data from the DOE-OE Global Energy Storage Database. This year's edition utilizes domestic capacity data from EIA Form-860 for domestic storage larger than 1 MW in size, smaller resources and international storage is taken from the Global Energy Storage Database.

[1] Electrochemical storage devices include lead-acid batteries, lithium-ion batteries, metal-air batteries, nickel-based batteries, sodium-based batteries, and flow batteries. Electromechanical storage devices include flywheels, compressed air technologies, and gravitational storage. Thermal storage in this data book includes only those technologies that store thermal energy and converts this energy to electricity. Typically, thermal storage is used with CSP, but these projects are only included in this section if they use a conduit, such as molten salt, to continue providing power without the presence of solar radiation.

Energy Storage: Summary - United States (continued)

- Cumulative electrochemical battery capacity in the United States grew from 66 MW in 2009 to 1,368 MW in 2018, which corresponds with a CAGR of 40.1%.

- The **average duration** of utility-owned electrochemical batteries installed in the United States in 2018 was **3.15 hours** with an average capacity of 6.9 MW.

- **Cumulative renewable-paired storage[1] has grown** from 68.8 MW in 2009 to 1.4 GW in 2018, **accounting for 53.3% of installed electrochemical, electromechanical, and thermal storage installed capacity in the United States** in 2018.

- Renewable-paired storage capacity in the United States expanded by 5.6% (76 MW) in 2018, up from a 2.4% (32 MW) increase in 2017.

Sources: DOE-OE Global Energy Storage Database and EIA

Pumped-storage hydropower is excluded from capacity metrics unless specifically mentioned.

[1]Renewable-paired storage systems are those flagged within the DOE Global Energy Storage Database as being connected to on-site renewable generation, or that are marked as providing 'onsite renewable generation shifting', 'renewables capacity firming', or 'renewables energy time shifting' in the EIA 860 form.

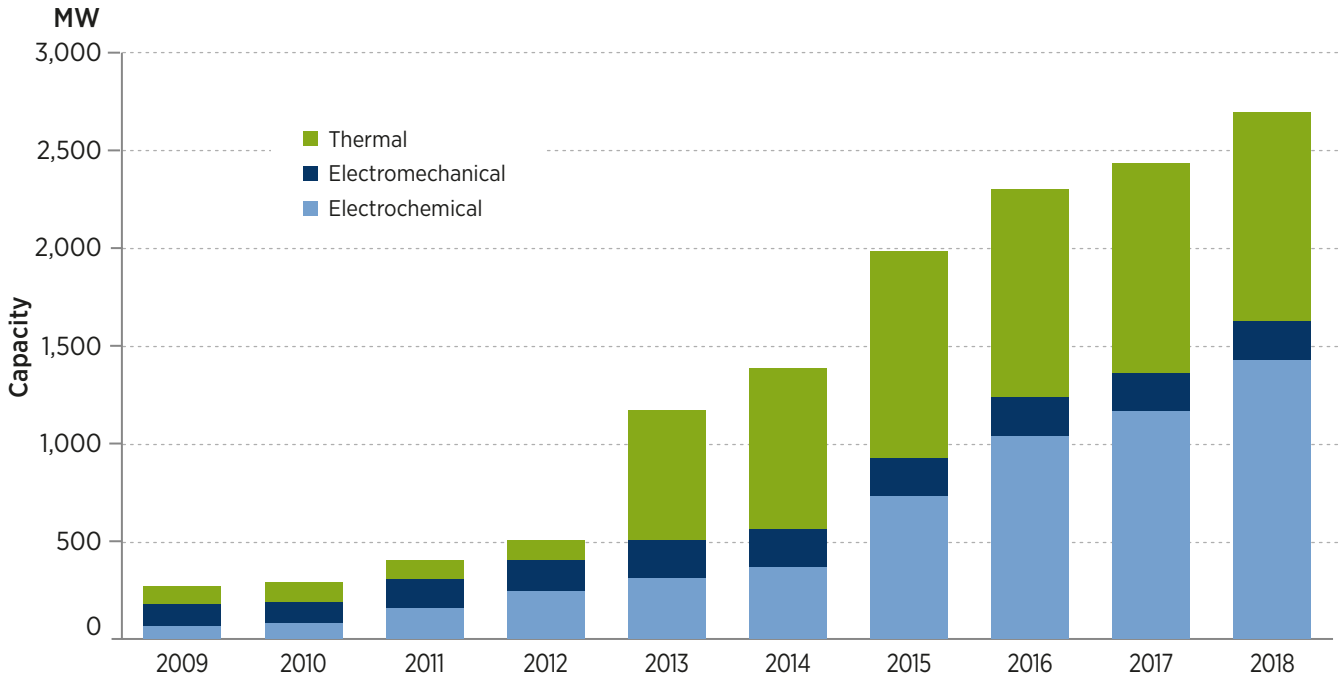
Energy Storage: Summary - Global (continued)

- Pumped-hydro storage was the largest contributor to global energy storage cumulative capacity as of 2018, with 146.9 GW. 1.7 GW of new capacity was installed globally in 2018.
- **In 2018, 51.7% of new storage capacity installed globally was thermal** (3.3 GW), **44.7% was electrochemical** (2.8 GW), **and 3.2% was electromechanical** (0.2 GW).
- **Since 2009, electrochemical systems have accounted for 61.6% of all storage projects in the world**, or 655 out of 1,064 total projects.
- The United States led the world in electrochemical, electromechanical, and thermal storage cumulative installed capacity in 2018 with 2.7 GW, followed by Spain (1.1 GW) and South Africa (405 MW).

X

Sources: DOE-OE Global Energy Storage Database and EIA
Pumped-storage hydropower is excluded from capacity metrics unless specifically mentioned.

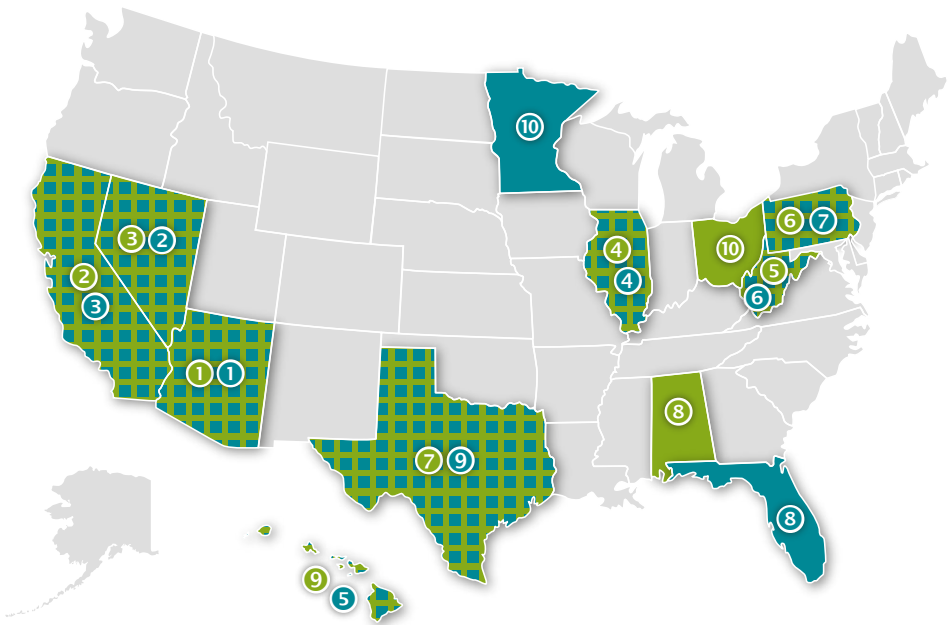
U.S. Energy Storage Cumulative Capacity



X

Sources: DOE-OE Global Energy Storage Database and EIA
Reported values may vary from those included in previous editions of the data book due to a change of sources.
For utility-owned storage systems in the United States the EIA 860 form is used to calculate installed capacity.
Pumped-hydro storage is excluded from capacity metrics unless specifically mentioned.

States Leading Energy Storage Development (2018)



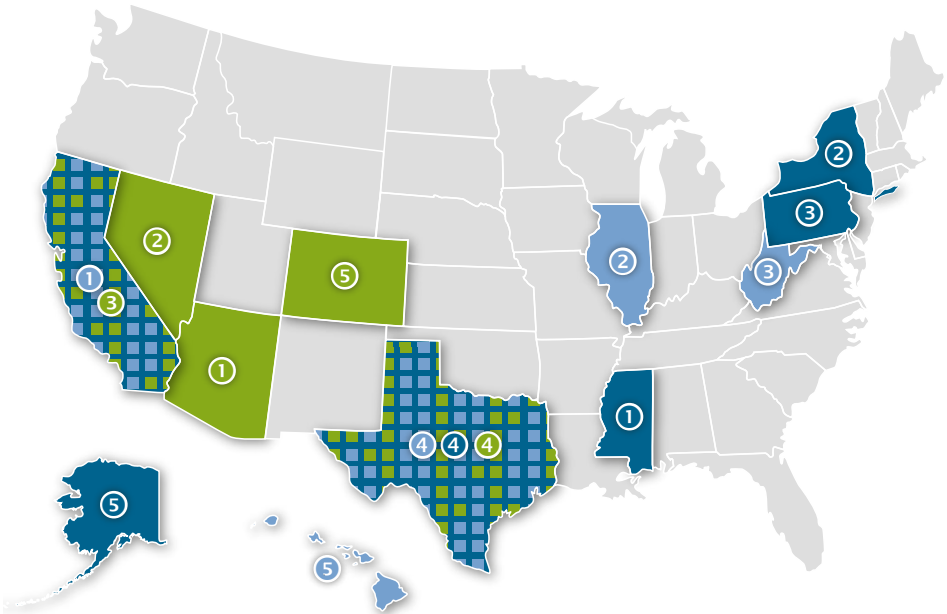
Cumulative Storage Capacity (MW)	
1 Arizona	605
2 California	543
3 Nevada	299
4 Illinois	277
5 West Virginia	130
6 Pennsylvania	127
7 Texas	126
8 Alabama	111
9 Hawaii	104
10 Ohio	91

Cumulative Renewable-Paired Storage Capacity (MW)	
1 Arizona	570
2 Nevada	299
3 California	281
4 Illinois	83
5 Hawaii	69
6 West Virginia	32
7 Pennsylvania	15
8 Florida	14
9 Texas	14
10 Minnesota	12

X

Sources: DOE-OE Global Energy Storage Database and EIA
Pumped-hydro storage is excluded from capacity metrics unless specifically mentioned.

States Leading Energy Storage Development by Technology (2018)



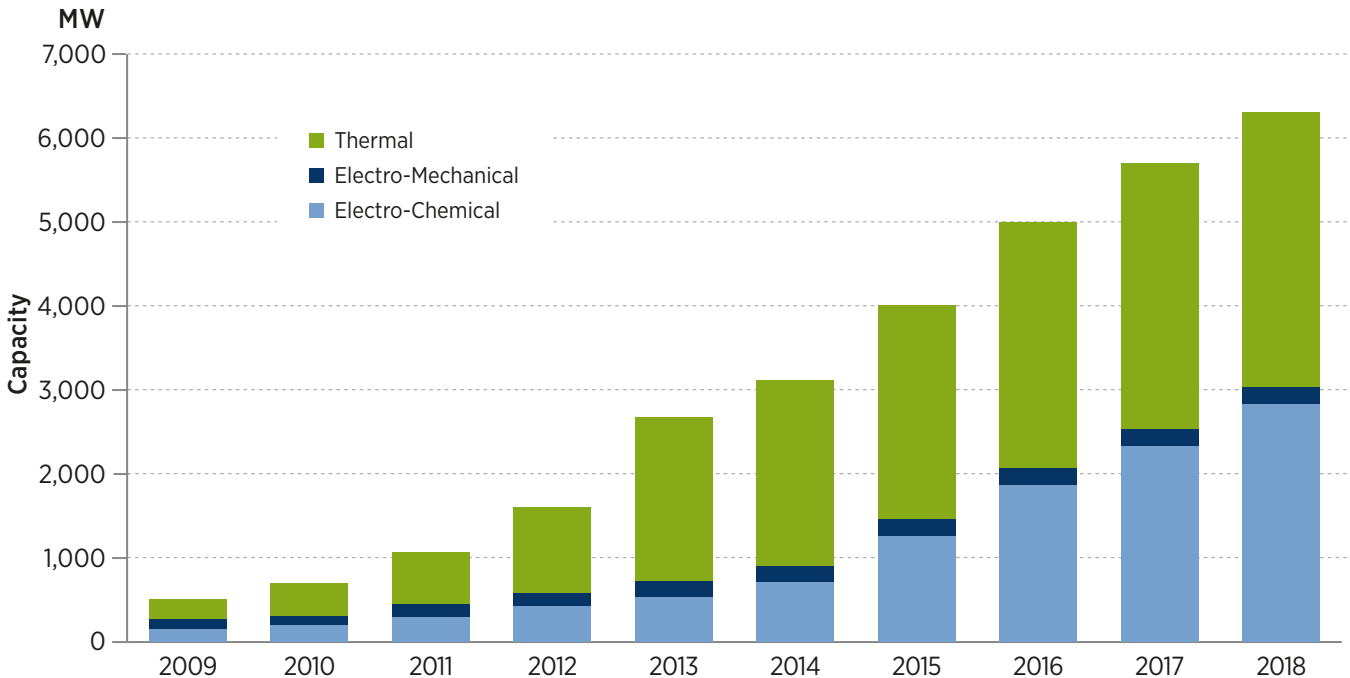
Electrochemical: Cumulative Storage Capacity (MW)	
1 California	378
2 Illinois	277
3 West Virginia	130
4 Texas	107
5 Hawaii	101

Electromechanical: Cumulative Storage Capacity (MW)	
1 Alabama	110
2 New York	40
3 Pennsylvania	40
4 Texas	5
5 Alaska	4

Thermal: Cumulative Storage Capacity (MW)	
1 Arizona	563
2 Nevada	299
3 California	165
4 Texas	14
5 Colorado	7

Sources: DOE-OE Global Energy Storage Database and EIA
Pumped-hydro storage is excluded from capacity metrics unless specifically mentioned.

Global Energy Storage Capacity



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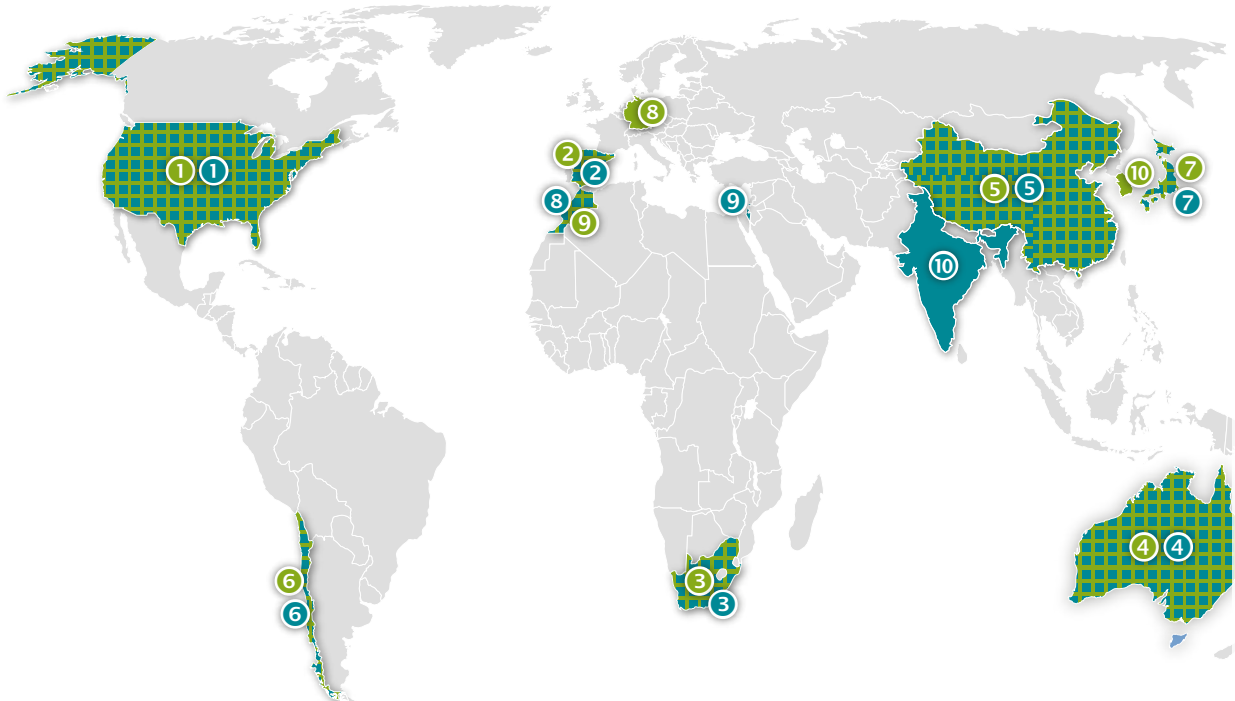
Sources: DOE-OE Global Energy Storage Database and EIA
Pumped-hydro storage is excluded from capacity metrics unless specifically mentioned.

Top Countries for Energy Storage Installed Capacity (2018)



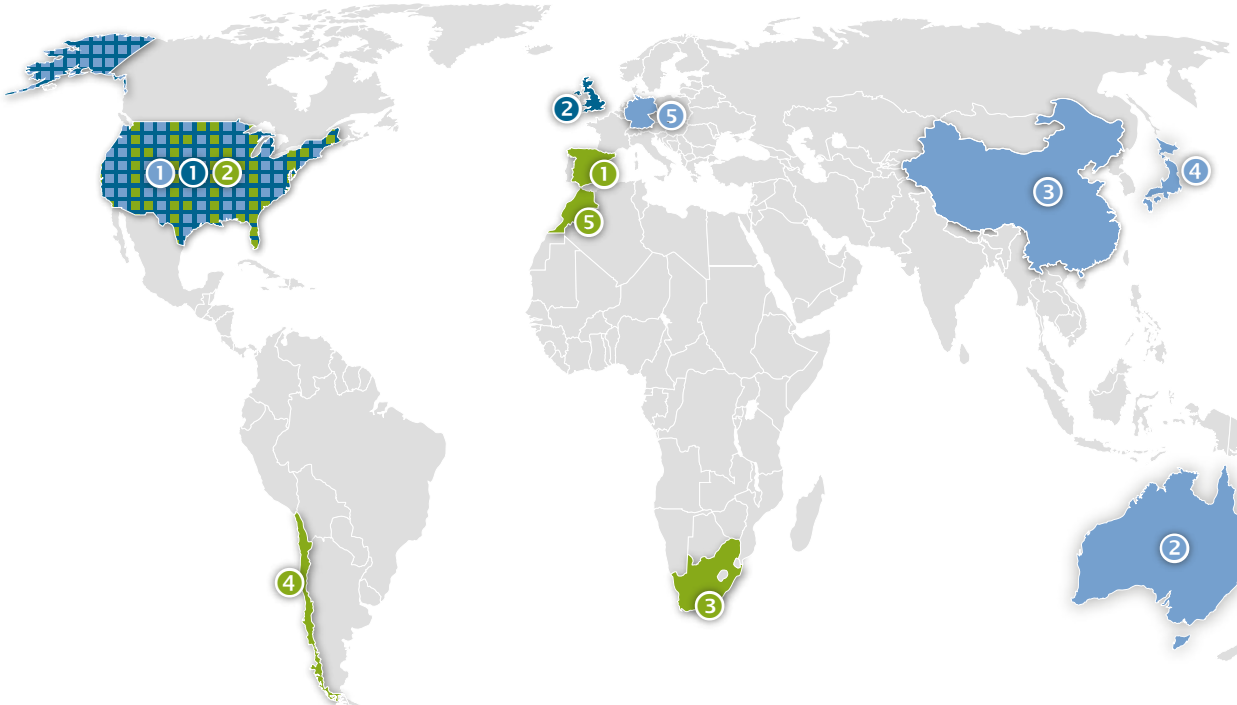
Cumulative Storage Capacity (MW)	
1 United States	2,697
2 Spain	1,139
3 South Africa	405
4 Australia	295
5 China	254
6 Chile	253
7 Japan	237
8 Germany	218
9 Morocco	161
10 South Korea	147

Cumulative Renewable-Paired Storage Capacity (MW)	
1 United States	1,441
2 Spain	1,133
3 South Africa	405
4 Australia	262
5 China	239
6 Chile	221
7 Japan	166
8 Morocco	161
9 Israel	121
10 India	101

Sources: DOE-OE Global Energy Storage Database and EIA

Pumped-hydro storage is excluded from capacity metrics unless specifically mentioned.

Top Countries for Energy Storage Installed Capacity by Technology (2018)



Electrochemical: Cumulative Storage Capacity (MW)	
1 United States	1,427
2 Australia	291
3 China	242
4 Japan	237
5 Germany	217

Electromechanical: Cumulative Storage Capacity (MW)	
1 United States	199
2 United Kingdom	5

Thermal: Cumulative Storage Capacity (MW)	
1 Spain	1,131
2 United States	1,071
3 South Africa	405
4 Chile	221
5 Morocco	161

Sources: DOE-OE Global Energy Storage Database and EIA
Pumped-hydro storage is excluded from capacity metrics unless specifically mentioned.

XI. Hydrogen and Fuel Cells

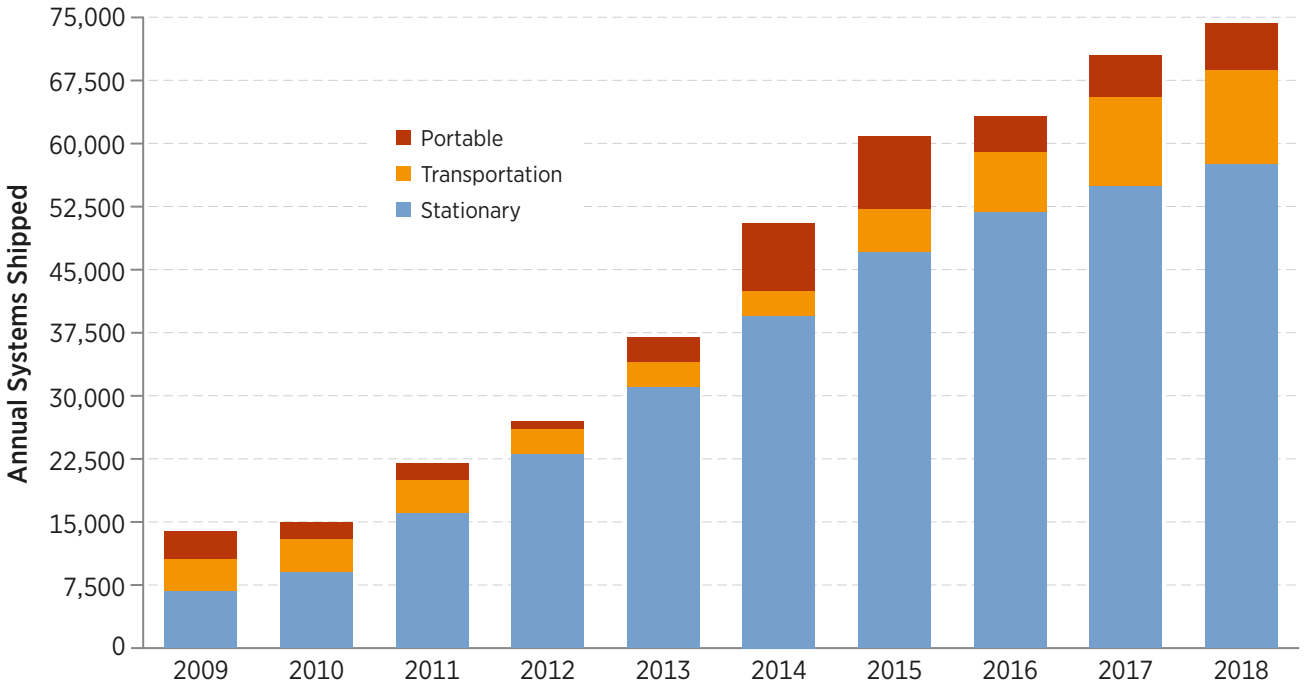
Hydrogen and Fuel Cells: Summary

- In 2018, **global fuel cell shipments by rated power totaled more than 803.1 MW, a 21.9% increase** from 2017 (658.6 MW). Most of the growth in 2018 was due to transportation fuel cell shipments.
- Global stationary fuel cell shipments for both backup and prime power (less than 1kW to multi-megawatts) totaled more than 239.8 MW in 2018—a 7.9% increase over 2017 (222.3 MW).
- Of the **46 hydrogen stations** available in the United States by the end of 2018, **41 were** available as commercial retail fueling stations **in California.**
- Hydrogen fueling stations represented 0.2% of the alternative fueling stations in the United States at the end of 2018.[1]
- More than 23,000 forklifts and nearly 6,000 fuel cell cars were adopted within the United States by the end of 2018.
- **North America led the world in fuel cell adoptions by rated power** in 2018, **accounting for 51.7% (415.0 MW) of the global total**, followed by Asia at 42.7% (343.3 MW) and Europe at 5.4% (43.4 MW).

Sources: EERE and E4Tech

[1] Alternative fueling stations include biofuel, ethanol, natural gas and electric charging stations.

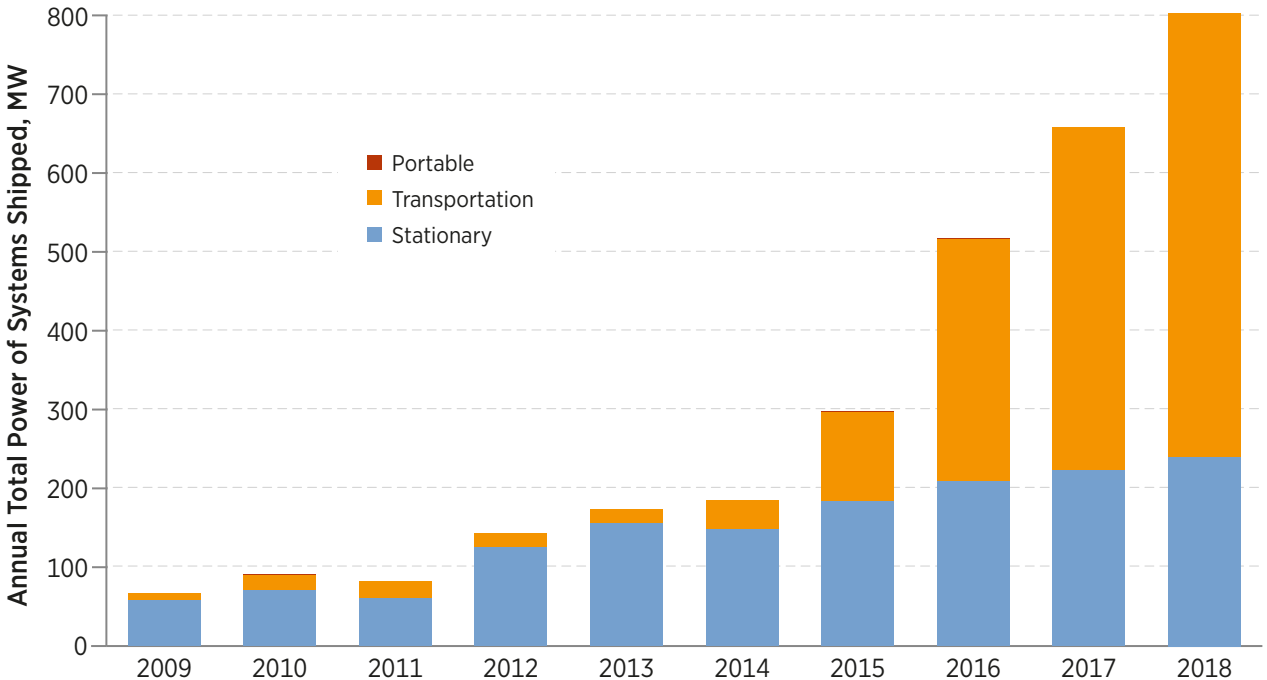
Annual Total Number of Fuel Cell Systems Adopted by Application, World Markets



XI

Sources: EERE, Navigant Research (2008-2013), and E4tech (2014-2018)
Reported values may vary from those included in previous editions of the data book due to retroactive changes in source data.

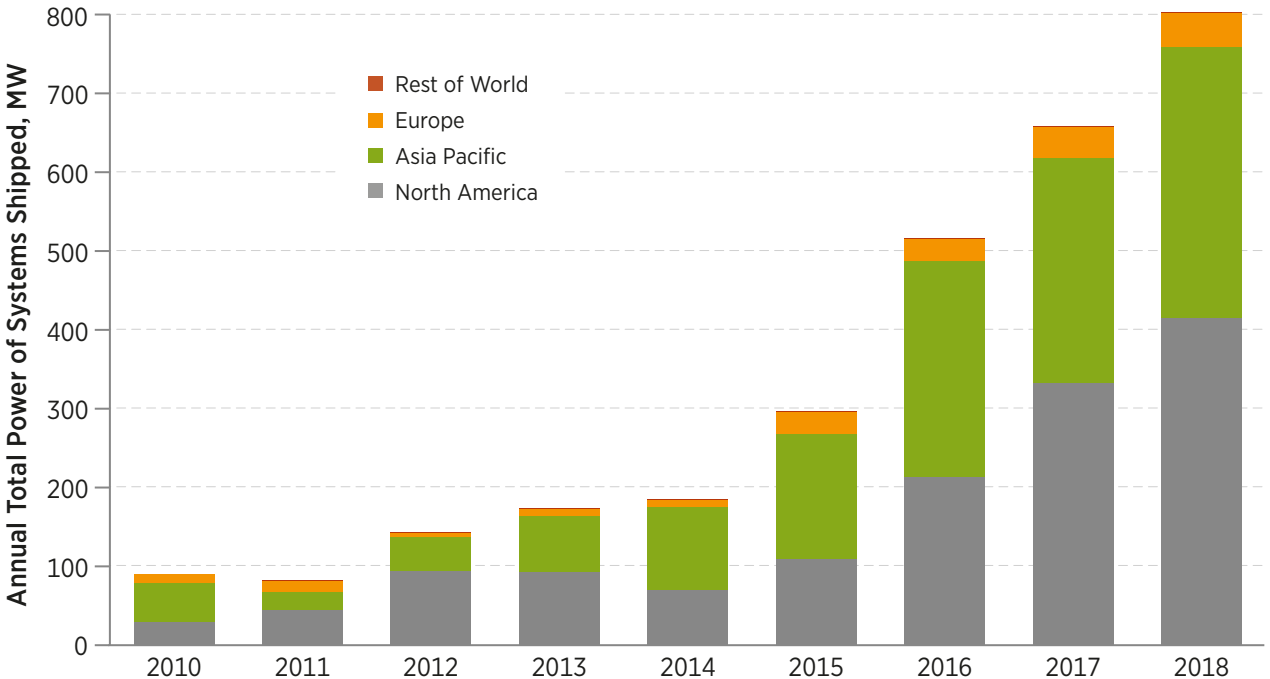
Annual Rated Power of Fuel Cell Systems Adopted by Application, World Markets



XI

Sources: EERE, Navigant Research (2008-2013), and E4tech (2014-2018)
Reported values may vary from those included in previous editions of the data book due to retroactive changes in source data.

Annual Rated Power of Fuel Cell Systems Adopted by Region, World Markets



XI

Sources: EERE, Navigant Research (2008-2013), and E4tech (2014-2018)
Reported values may vary from those included in previous editions of the data book due to retroactive changes in source data.

XII. Plug-In Electric Vehicles

Plug-In Electric Vehicles: Summary

- Almost 361,000 plug-in electric vehicles (PEV) were sold in the United States in 2018, an increase of 84.7% since 2017 (196,000). **Plug-in hybrid electric vehicles (PHEV) and battery electric vehicles (BEV) accounted for 33.9% and 66.1% of the annual sales for all plug-in vehicles** respectively.

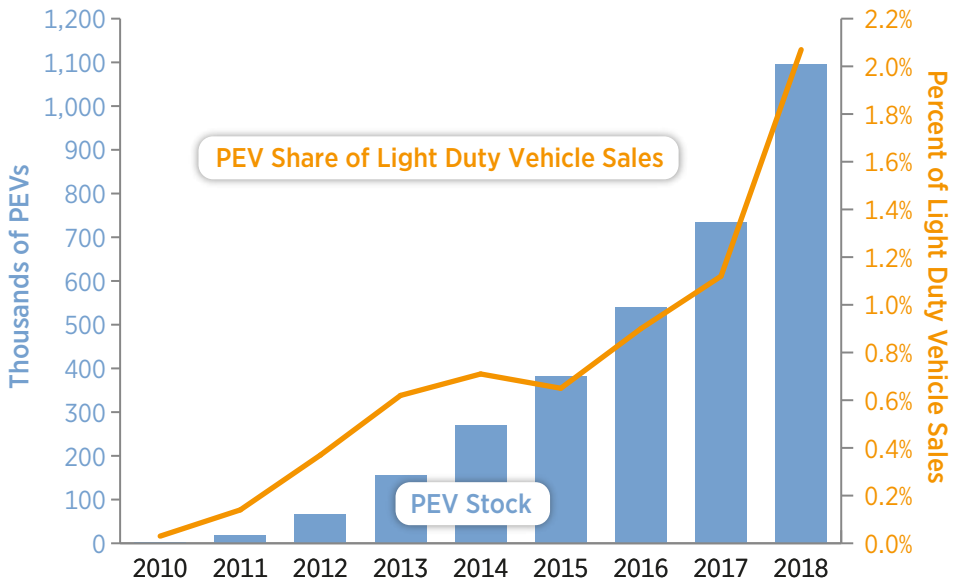
- Fourty-seven different PEV models were actively selling in the U.S. market in 2018, compared to 43 in 2017. These models covered various vehicle sizes from two-seaters to standard SUVs.

- **The share of plug-in electric vehicles sales to total light-duty vehicle sales grew to 2.1% in 2018**—up from 1.1% in 2017.

- In 2018, the largest manufacturer of plug-in electric vehicles by total volume of sales was Tesla with 53.0% of total sales (192,000 vehicles), followed by GM with 10.1% (37,000) and Toyota with 7.6% (28,000).

- **The top 10 selling models accounted for more than 84.6% of the PEV market**. The top selling model in 2018 was Tesla Model 3 with 38.7% of the total annual sales, followed by Prius PHEV (7.6%), Tesla Model X (7.2%), Tesla Model S (7.1%), and Honda Clarity Plug In (5.1%).

U.S. PEV Stock and Share of Light Duty Vehicle Sales



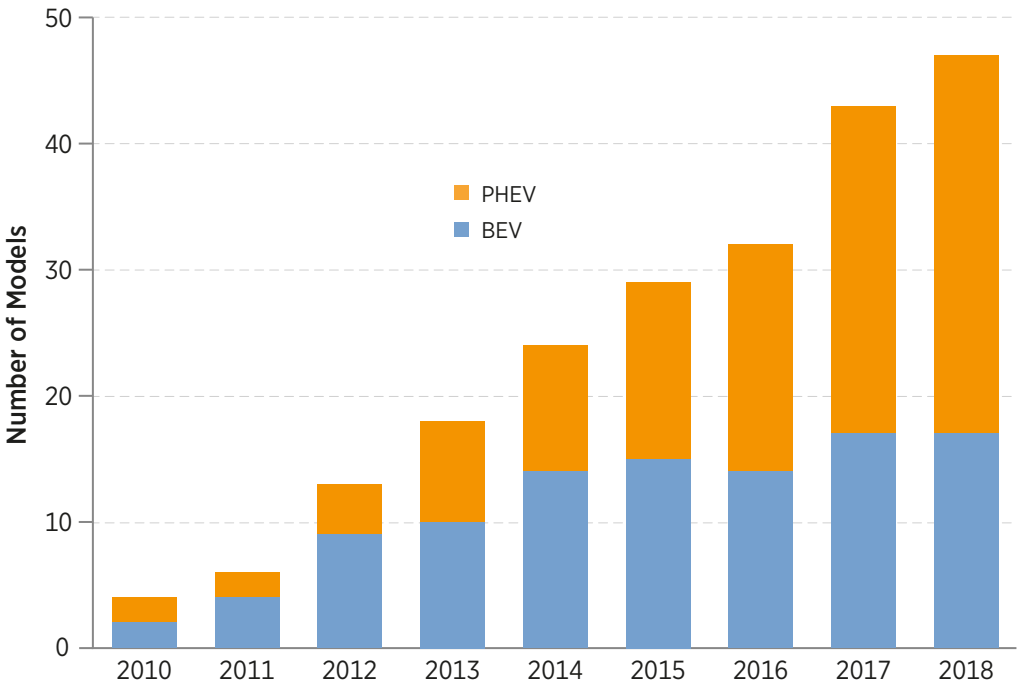
	Estimated PEV Stock (thousands)	PEV Share of Light Duty Vehicle Sales
2010	2	0.0%
2011	18	0.1%
2012	66	0.4%
2013	156	0.6%
2014	270	0.7%
2015	381	0.7%
2016	539	0.9%
2017	734	1.2%
2018	1,096	2.1%

XII

Source: Argonne National Laboratory

Note: PEV stock is equal to the cumulative sum of annual plug-in vehicle sales indexed to the NHTSA Vehicle Survivability and Travel Mileage Schedules

Number of Available PEV Models in the United States

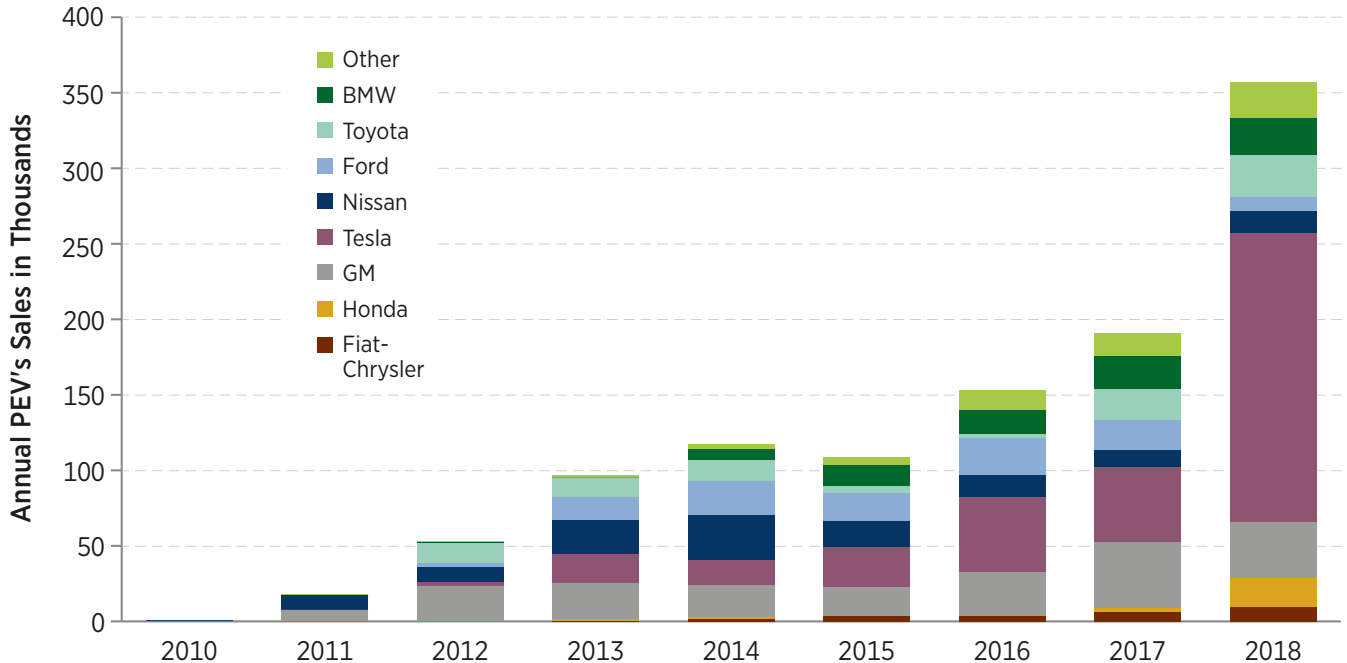


	Available Models	
	BEV	PHEV
2010	2	2
2011	4	2
2012	9	4
2013	10	8
2014	14	10
2015	15	14
2016	14	18
2017	17	26
2018	17	30

XII

Source: Oak Ridge National Laboratory and Argonne National Laboratory
Reported values may vary from those included in previous editions of the data book due to retroactive changes in source data.

U.S. Annual PEV Sales by Manufacturer



XII

Source: Argonne National Laboratory

The "Other" category includes Audi, Hyundai, Kia, Mercedes-Benz, Mitsubishi, Subaru, Tata, and Volvo

XIII. Renewable and Alternative Fuels

Renewable and Alternative Fuels: Summary

- U.S. ethanol production grew by 0.8% from 15.9 billion gallons in 2017 to 16.1 billion gallons in 2018.
- Globally, ethanol production increased by 6.6%— from 26.8 billion gallons in 2017 to 28.6 billion gallons in 2018.
- In 2018, ethanol and gasoline prices increased by 9.0% (to $2.92 per gallon) and 16.1% (to $2.74 per gallon), respectively.
- In 2018, **the United States produced 56.4% of the world's ethanol**,[1] followed by Brazil (27.8%), the European Union (5.0%), China (4.1%), and Canada (1.7%).
- In the United States, the primary types of alternative fueling stations[2] **were electric charging stations, which comprised 75.2% of the total number of alternative fueling stations**, followed by ethanol (11.1%), propane (3.0%), and compressed natural gas (3.0%).

XIII

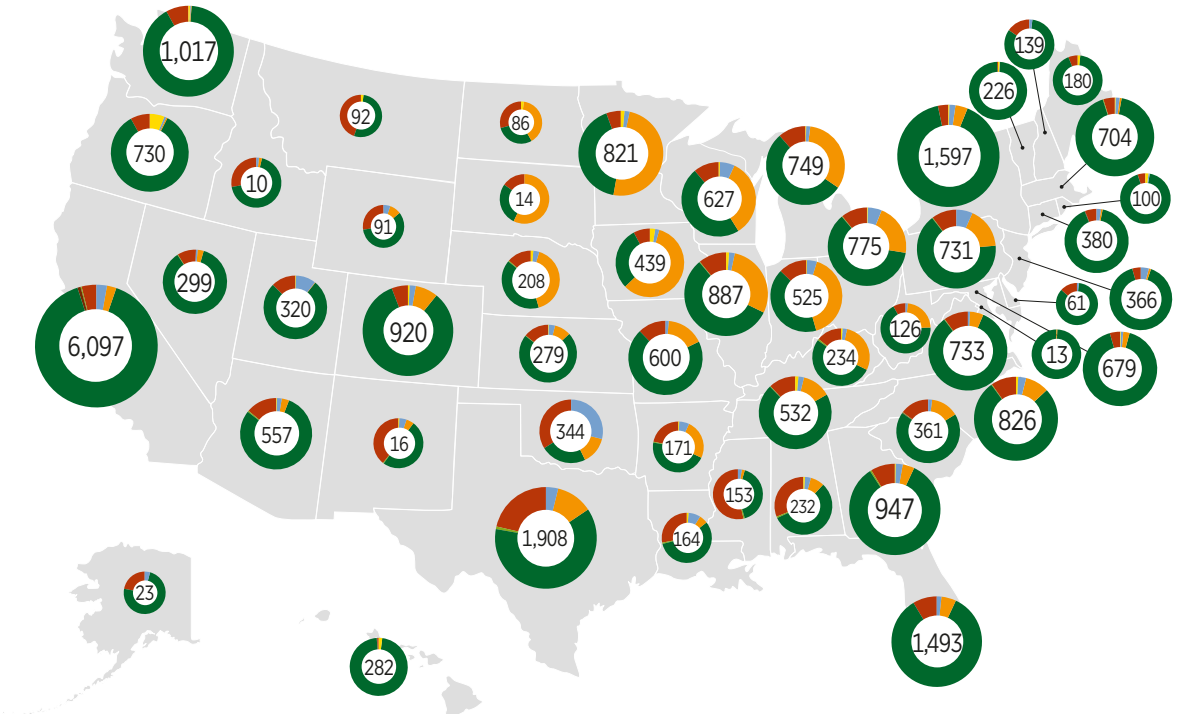
Sources: EERE Alternative Fuels Data Center and REN21

[1] The renewable fuel standard (RFS) in the United States sets targets that limit the amount of renewable fuel (including corn ethanol) and increase levels of cellulosic and advanced biofuels (including cellulosic ethanol). Achieving substantial growth in the ethanol market size is challenging given that gasoline in the United States is generally sold as a 10% ethanol (E10) and that ethanol production volumes above that level would need to enter the E15 or E85 markets.

[2] Alternative fueling stations include electric charging stations, as well as hydrogen, propane, biodiesel, ethanol, and natural gas fueling stations.

- Excluding electric charging stations, **the top state in the United States for alternative fueling stations was Texas with 719 stations**, followed by California (630), Minnesota (385), and Illinois (385).
- The states with the most EV charging stations in 2018 were California (5,467 stations), New York (1,427), Florida (1,261), Texas (1,189), and Washington (922).

Renewable and Alternative Fueling Stations by State (2018)



Breakdown of Stations by State

- B20 (20% biodiesel)
- CNG (compressed natural gas)
- E85 (85% ethanol)
- Electric[1]
- Hydrogen
- LNG (liquefied natural gas)
- Propane

Total Renewable and Alternative Fueling Stations by State

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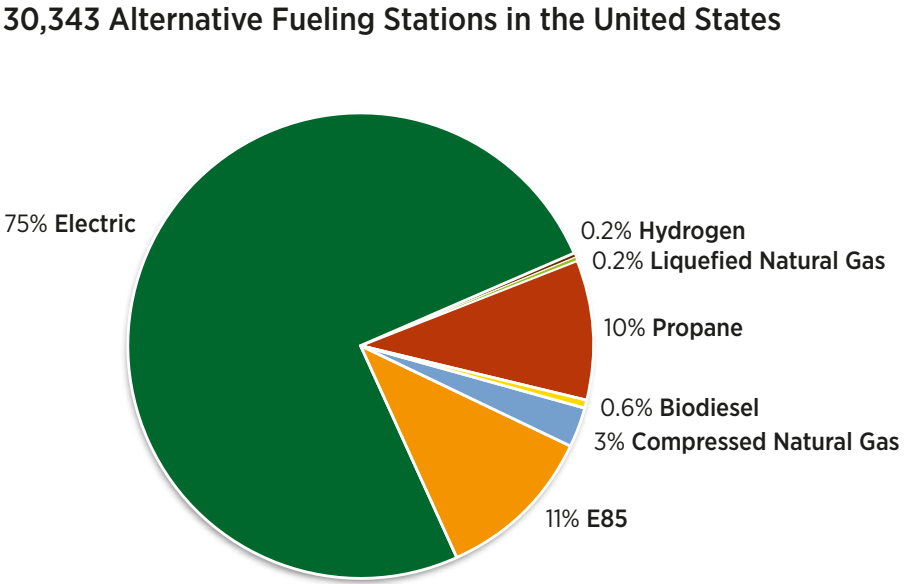
Source: EERE Alternative Fuels Data Center

For the full list of fueling station counts, see "Alternative Fueling Station Counts by State" at http://www.afdc.energy.gov/afdc/fuels/stations_counts.html.

[1]Public and private electric vehicle charging stations; there were more than 65,000 charging outlets in 2018.

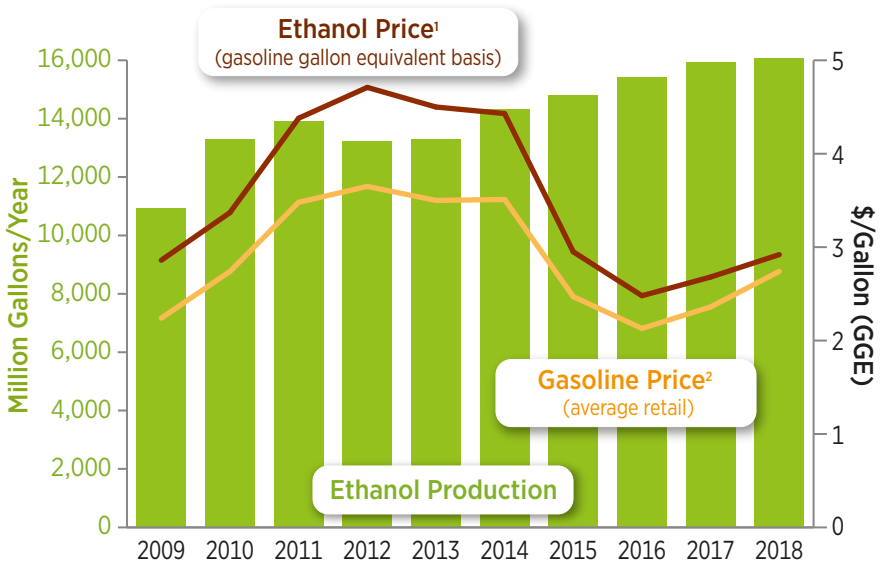
Renewable and Alternative Fueling Stations by Type (2018)



XIII

Source: EERE Alternative Fuels Data Center

U.S. Corn Ethanol Production and Prices



	Ethanol Price[1] (gasoline gallon equivalent basis, $/gallon)	Gasoline Price[2] (average retail, $/gallon)	Ethanol Production (million gallons/ year)
2009	$2.86	$2.24	10,938
2010	$3.37	$2.74	13,298
2011	$4.38	$3.48	13,929
2012	$4.71	$3.65	13,218
2013	$4.50	$3.50	13,293
2014	$4.43	$3.51	14,313
2015	$2.95	$2.47	14,806
2016	$2.48	$2.13	15,413
2017	$2.68	$2.36	15,936
2018	$2.92	$2.74	16,061

XIII

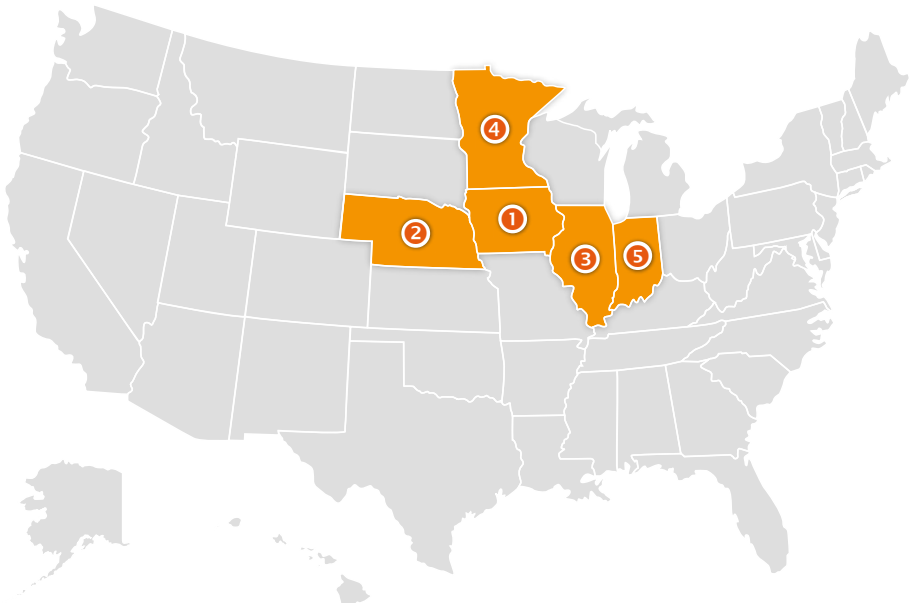
Sources: Renewable Fuels Association (RFA) and EERE

Reported values may vary from those included in previous editions of the data book due to retroactive changes in data sources.

[1] Ethanol price is based on the average retail price for E85 fuel blend, inclusive of taxes.

[2] Gasoline price is based on the average retail price for E10, inclusive of taxes.

U.S. Corn Ethanol Production Capacity (2018)



Top Five States for U.S. Ethanol (operating) Production Capacity in 2018 (millions of gallons/year)	
1 Iowa	4,328
2 Nebraska	2,239
3 Illinois	1,787
4 Minnesota	1,297
5 Indiana	1,198

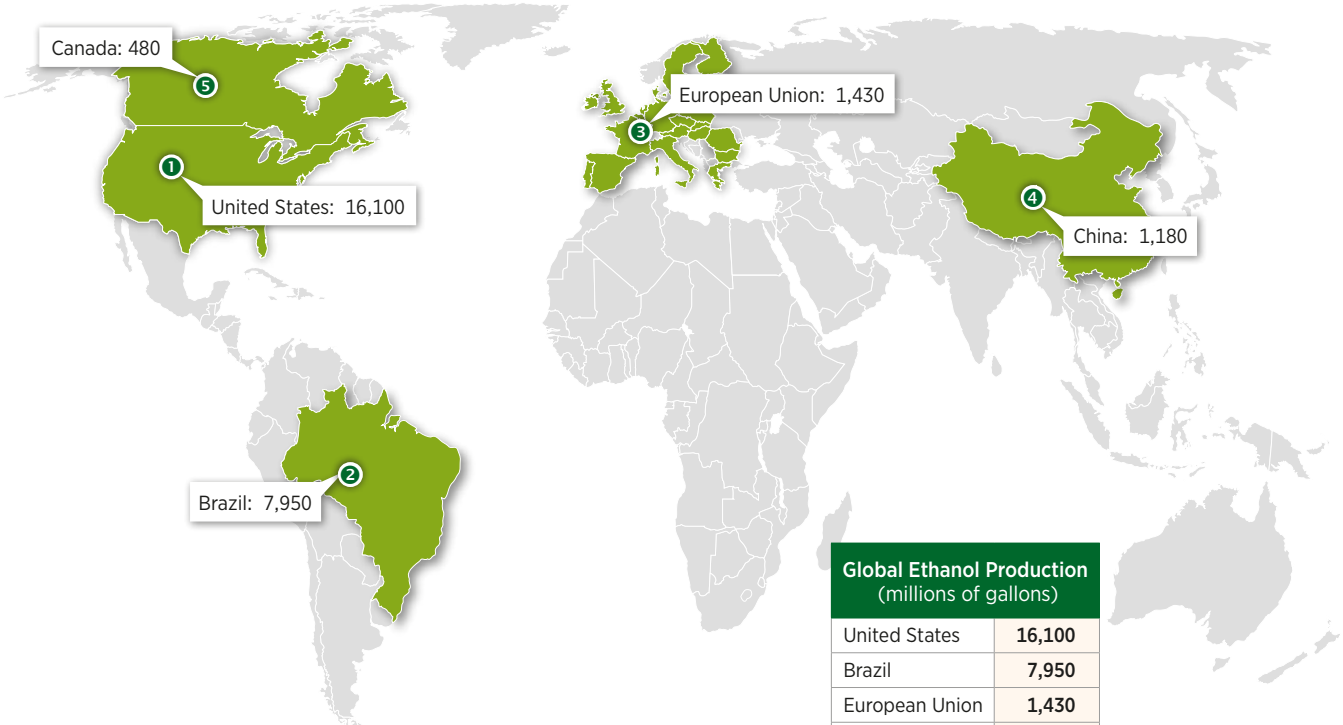
XIII

Source: RFA

No sugarcane ethanol is currently produced in the United States.

Global Ethanol Production (2018)

Top Five Regions (2018) **Ethanol Production** (millions of gallons)



Global Ethanol Production (millions of gallons)	
United States	**16,100**
Brazil	**7,950**
European Union	**1,430**
China	**1,180**
Canada	**480**

XIII

Source: RFA

Ethanol produced from various feedstocks.

Biodiesel: Summary

- **U.S. biodiesel production decreased** for the second year in a row **to 2.58 billion gallons** (2.72 billion gasoline gallons equivalent) in 2018—down from 2.63 billion gallons in 2017, a 1.9% decrease.[1]

- **Global biodiesel production grew by 11.7%** in 2018, to 9.06 billion gallons from 8.11 billion gallons in 2017.

- In 2018, **the United States continued to lead the world in biodiesel production**, followed by Brazil (1.43 billion gallons), Indonesia (1.06 billion gallons), Germany (0.92 billion gallons), and Argentina (0.74 billion gallons).

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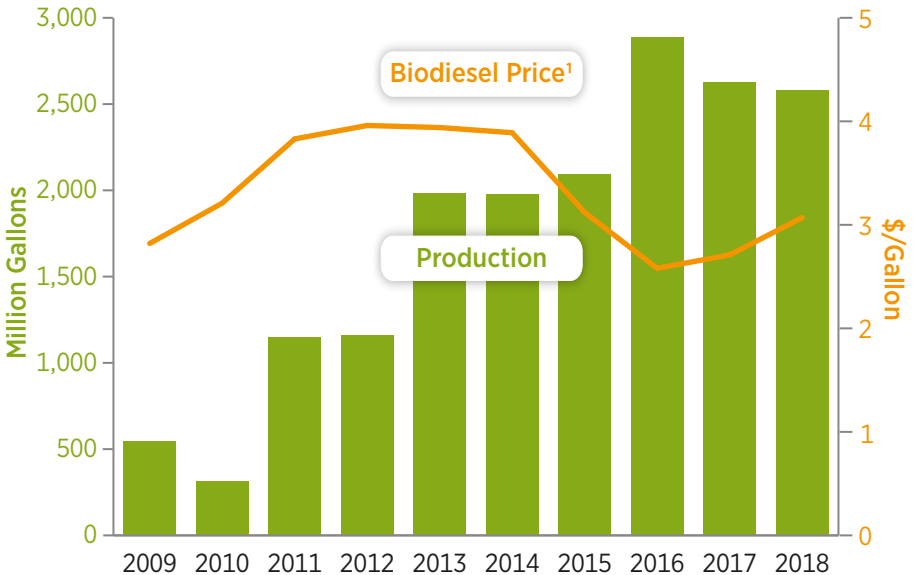
[1]Reported values may vary from those included in previous editions of the data book due to retroactive changes in source data. The conversion rate is based on an unweighted average of B100 and B20 conversion rates.

U.S. Biodiesel Production and Price



	Biodiesel Price¹ (gasoline gallon equivalent basis) ($ per gallon)	Total U.S. Production (million gallons)
2009	**2.82**	**545**
2010	**3.21**	**315**
2011	**3.83**	**1,147**
2012	**3.96**	**1,160**
2013	**3.94**	**1,985**
2014	**3.89**	**1,976**
2015	**3.12**	**2,093**
2016	**2.58**	**2,890**
2017	**2.71**	**2,630**
2018	**3.07**	**2,580**

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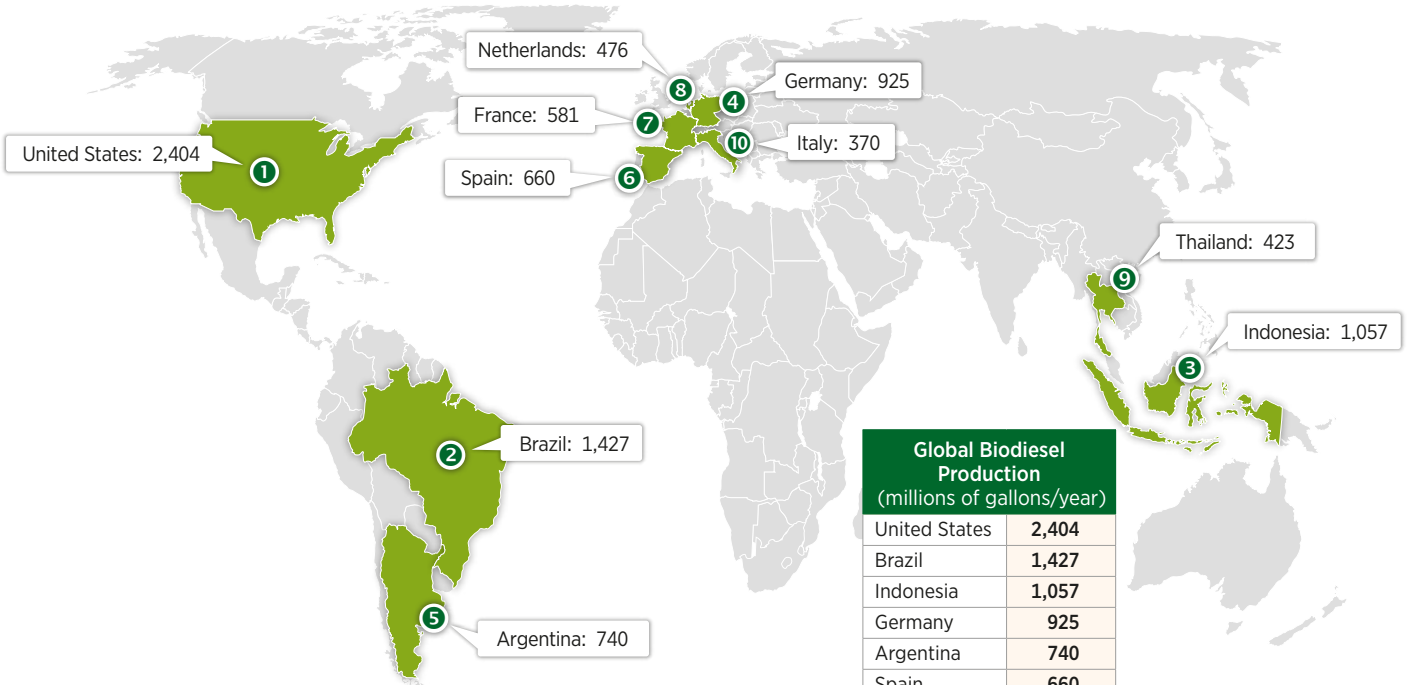
Sources: EERE; Production data are from http://biodiesel.org/.
Reported values may vary from those included in previous editions of the data book due to retroactive changes in source data.
Ethanol produced from various feedstocks.
¹Biodiesel price is an unweighted average of prices for B20 and B99-B100

Global Biodiesel Production (2018) – Top 10 Countries



Global Biodiesel Production (millions of gallons/year)	
United States	**2,404**
Brazil	**1,427**
Indonesia	**1,057**
Germany	**925**
Argentina	**740**
Spain	**660**
France	**581**
Netherlands	**476**
Thailand	**423**
Italy	**370**

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Source: REN21

XIV. Clean Energy Investments

Clean Energy Investment: Summary

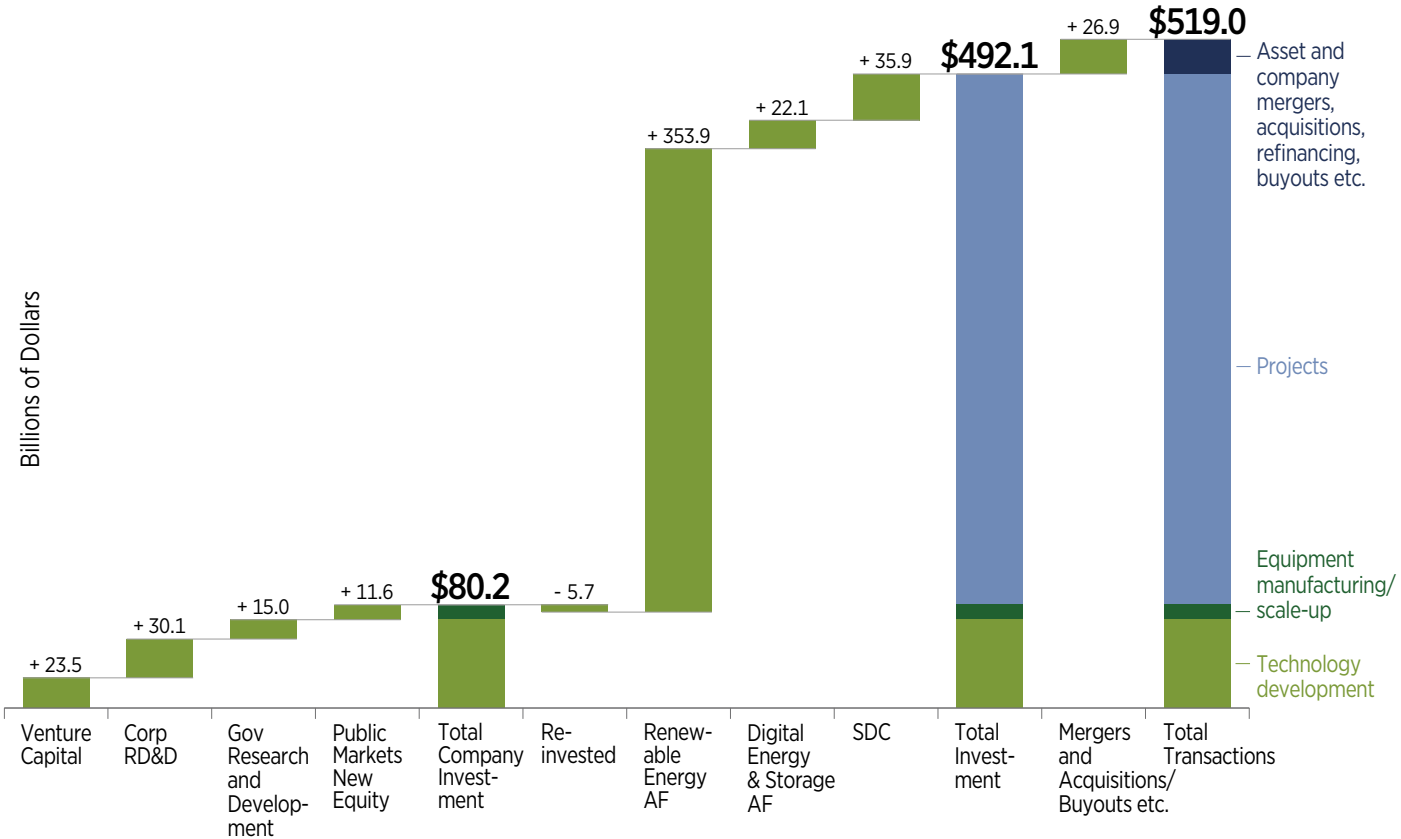
- **Global investment in clean energy in 2018 decreased by 11.0%** from 2017 to $287.8 billion (down from $324.7 billion in 2017).
- New investment in clean energy in the United States remained stable between 2017 ($48.8 billion) and 2018 ($48.6 billion). The **U.S. share of global investment grew to 16.9%** in 2018—up from 15.0% in 2017.
- Worldwide, **wind and solar continued to experience the highest levels of new investment** of all renewable technologies in 2018 (91.3% of all asset classes). However, global investment in solar decreased by 22.6% in 2018, to $134.5 billion (representing 46.8% of total global clean energy investments). Global investment in wind slightly decreased (0.1%) in 2018, to $128.1 billion (representing 44.5% of total global clean energy investments).
- Globally, **new venture capital and private equity investment in clean energy grew by 8.7%** to $10.0 billion in 2018—up from $9.2 billion in 2017.
- Government **research and development (R&D) expenditures grew to $15.0 billion** in 2018, compared to $14.5 billion in 2017. Corporate R&D expenditures grew by 15.8% to $30.1 billion in 2018.

XIV

Source: Bloomberg New Energy Finance (BNEF)

Reported values may vary from those included in previous versions of the *Renewable Energy Data Book* due to retroactive changes in source data.

Clean Energy Investment Types and Flows (2018) – Global

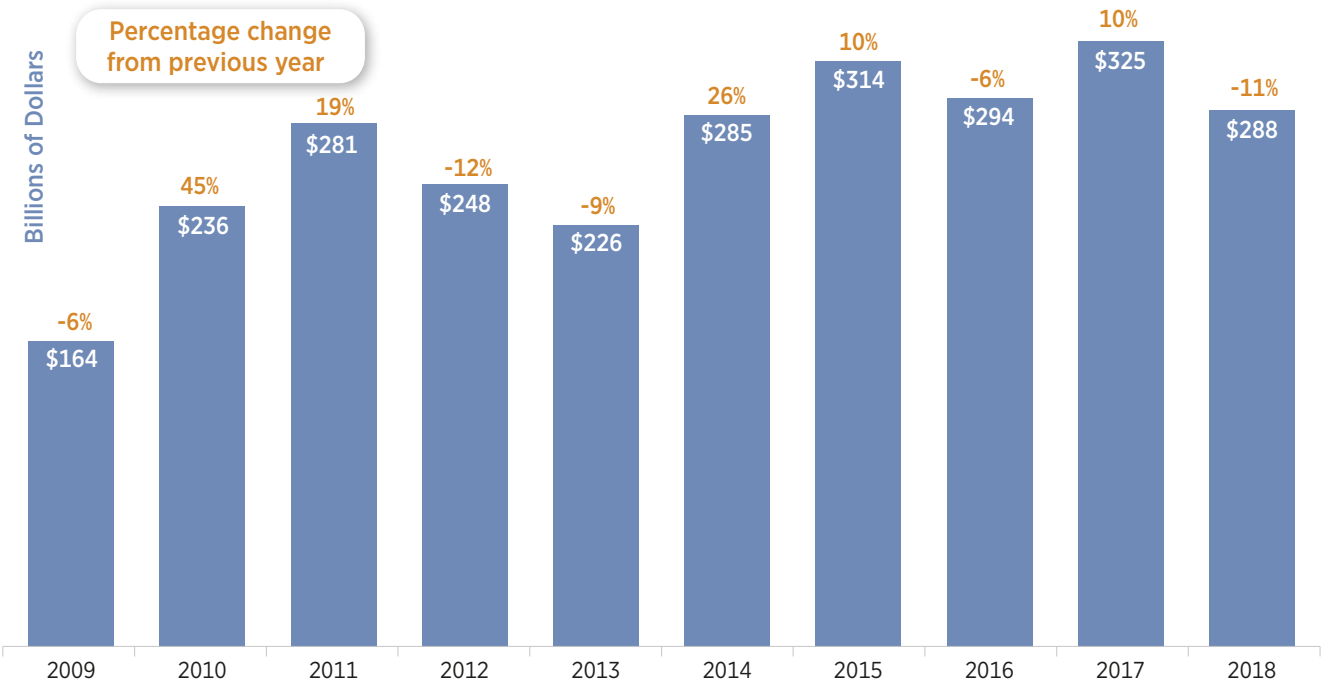


Source: BNEF

Total values include estimates for undisclosed deals.

AF = asset finance; RD&D = research, development, and demonstration; SDC = small distributed capacity.

New Investment in Clean Energy – Global



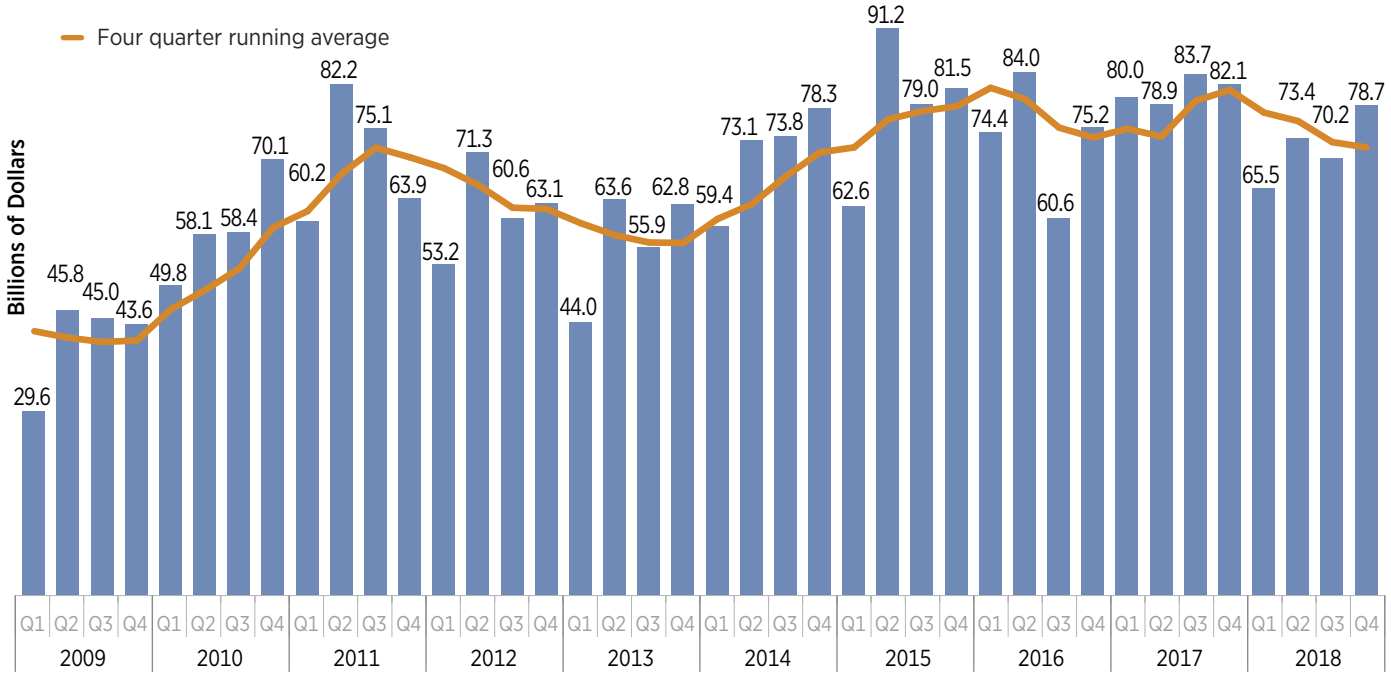
XIV

Source: BNEF

Reported values may vary from those included in previous editions of the data book due to retroactive changes in source data.

Total values include estimates for undisclosed deals, corporate and government R&D, and energy-smart technology spending (not reported in quarterly statistics). Energy-smart technologies include digital energy, smart grids, power storage, hydrogen and fuel cells, advanced transportation, and energy efficiency on both the demand side and the supply side.

New Investment in Clean Energy – Global

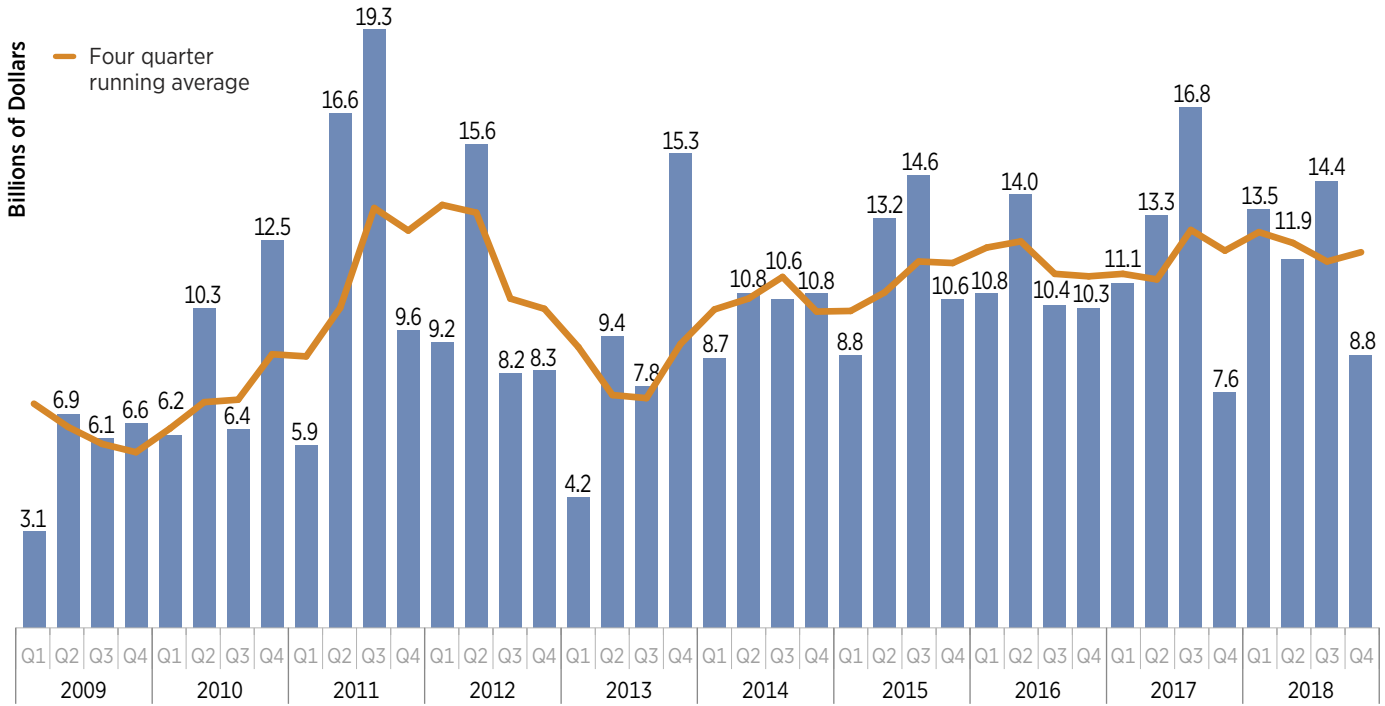


XIV

Source: BNEF

Reported values may vary from those included in previous editions of the data book due to retroactive changes in source data.

New Investment in Clean Energy – United States

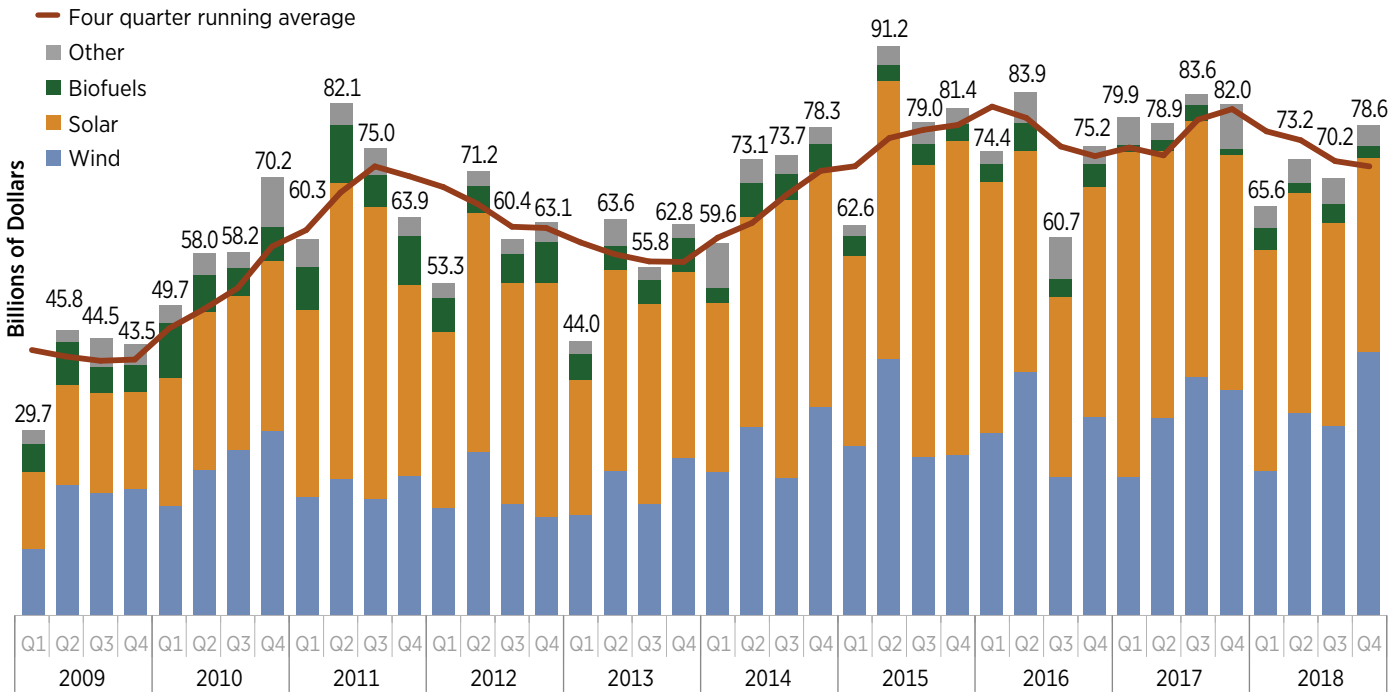


XIV

Source: BNEF

Reported values may vary from those included in previous editions of the data book due to retroactive changes in source data.

New Investment in Clean Energy by Technology – Global

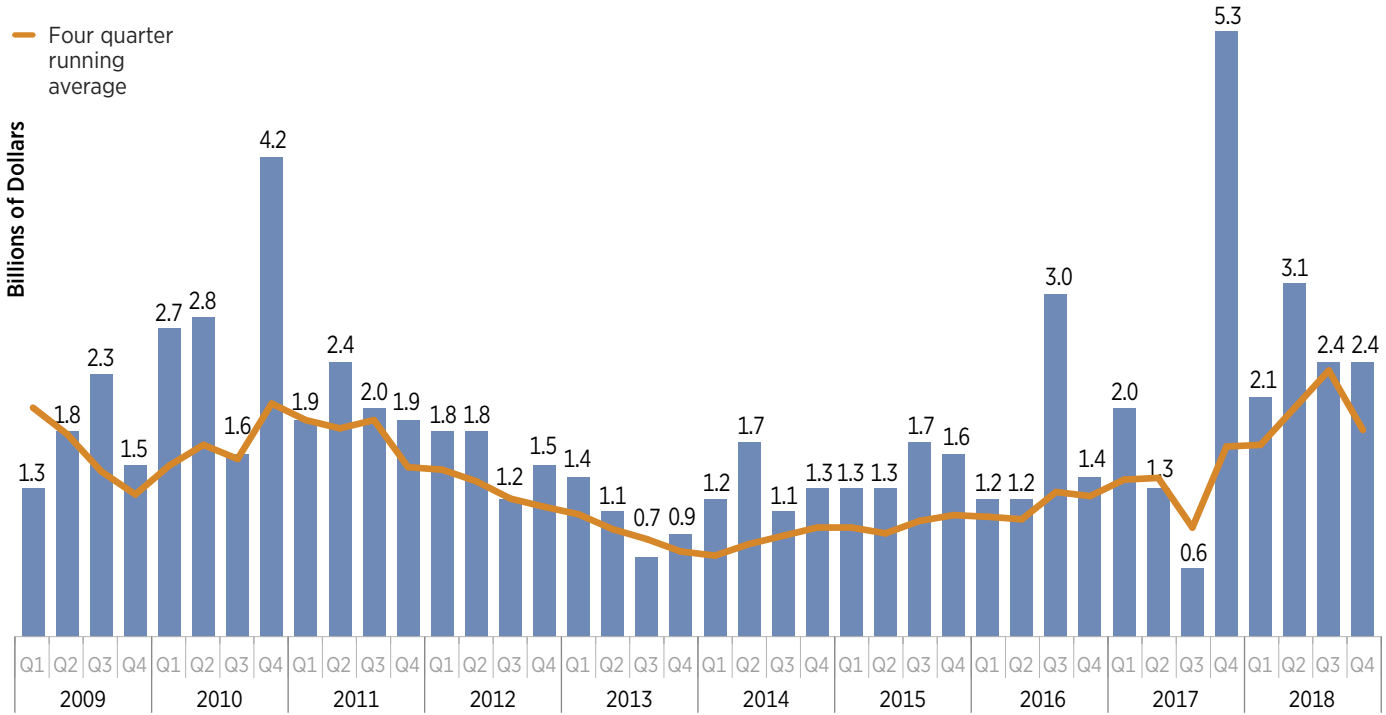


XIV

Source: BNEF

Reported values may vary from those included in previous editions of the data book due to retroactive changes in source data.

Venture Capital and Private Equity New Investment in Clean Energy – Global

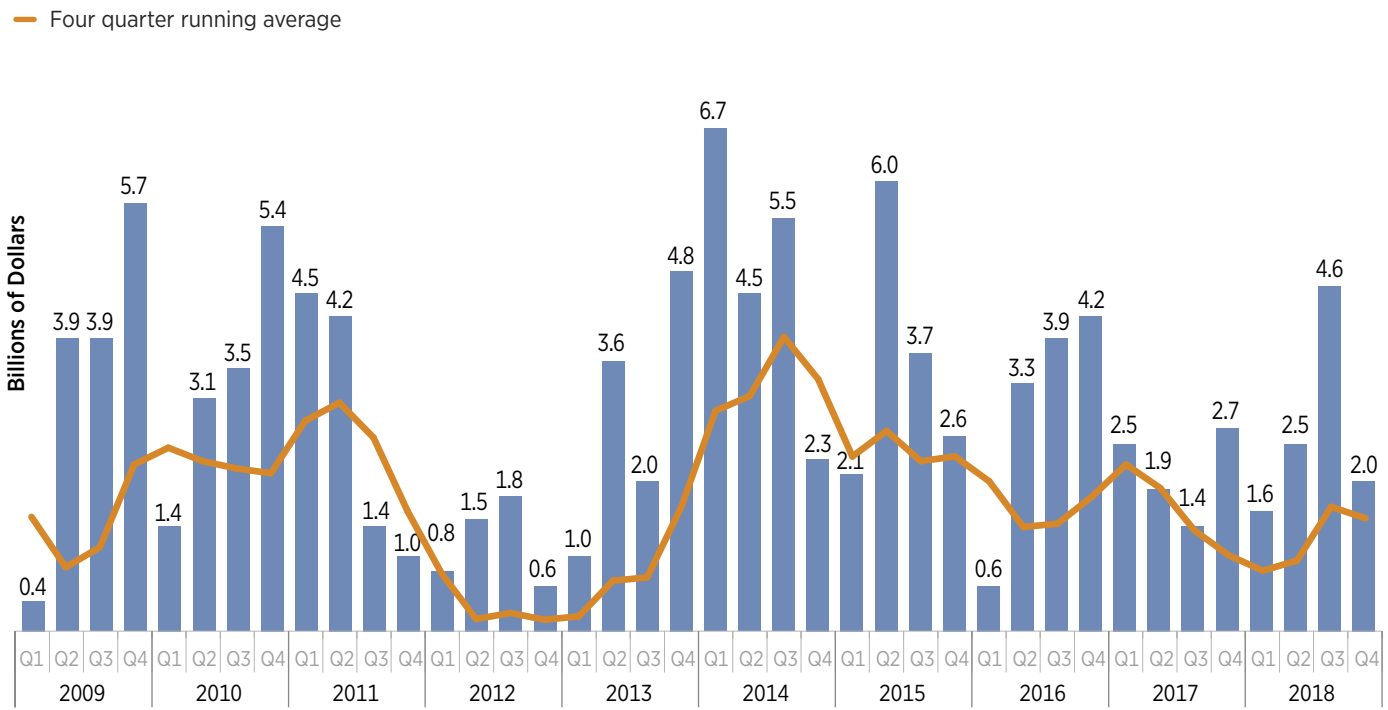


XIV

Source: BNEF

Reported values may vary from those included in previous editions of the data book due to retroactive changes in source data.

Public Market New Investment in Clean Energy – Global

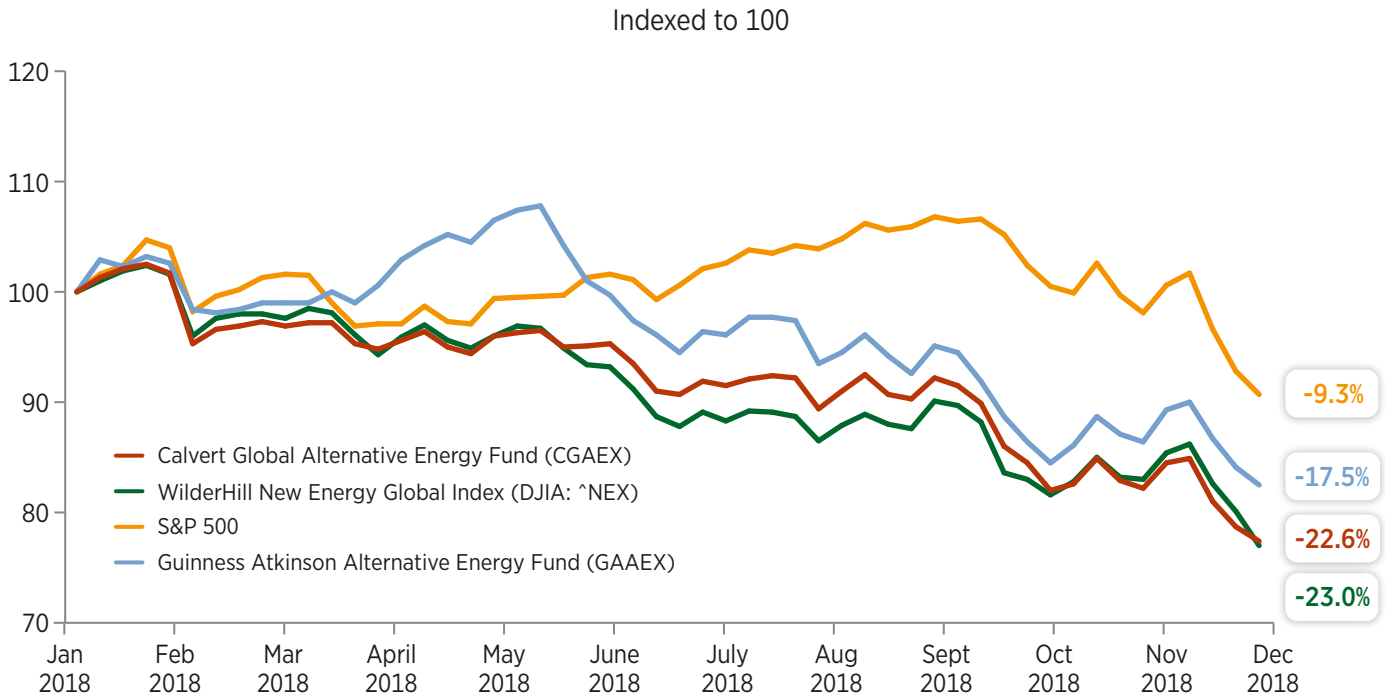


XIV

Source: BNEF

Reported values may vary from those included in previous editions of the data book due to retroactive changes in source data.

Public Renewable Energy Index Performance (2018)



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Source: Alpha Vantage

XV. Voluntary Renewable Electricity Market in the United States

Voluntary Renewable Electricity Market: Summary

- In 2018, almost **6.3 million customers procured 134.3 million MWh of renewable energy through green power markets**, up from 5.5 million customers and 110.3 million MWh in 2017.
- **Voluntary renewable energy accounts for 3% of total U.S. retail electricity sales and constitutes 28% of U.S. non-hydropower renewable generation**.[1]
- In 2018, the **most voluntary sales were through unbundled RECs (47.1%), while the most customers were part of community choice aggregation (CCA) programs (53.7%)**.
- Over 1.7 million customers procured 25 million MWh of renewable energy through competitive suppliers in 2018. **Competitive supplier green power sales grew by 38% from 2017 to 2018**, largely due to increased green power sales by a single large supplier.
- About 275 offtakers procured about 23.5 million MWh of green power through power purchase agreements (PPAs) in 2018. PPA green power sales grew by about 19% from 2017 to 2018.

Source: Heeter and O'Shughnessy

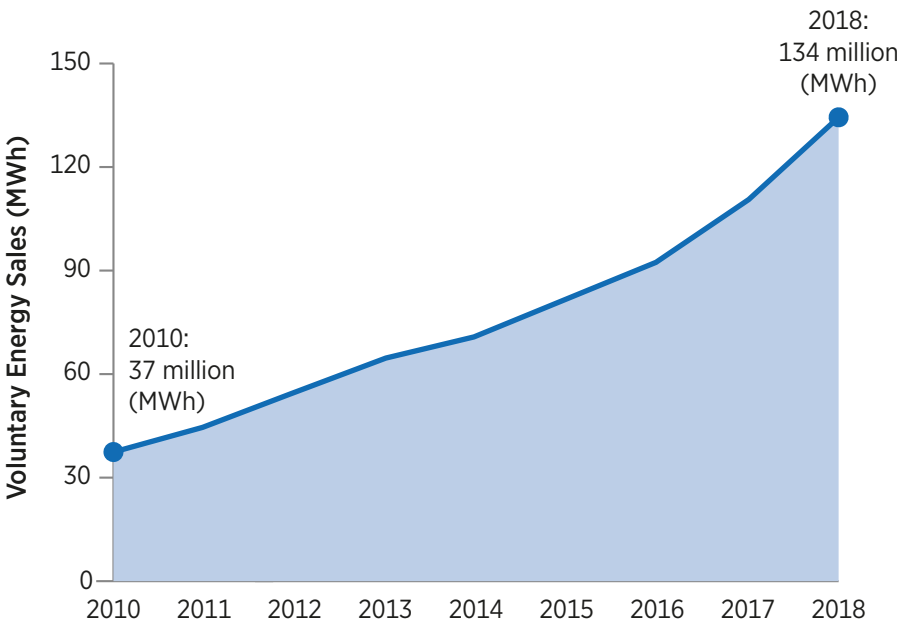
[1] Voluntary Renewable Energy is that purchased voluntarily by retail electricity customers in excess of state renewable energy mandates.

- Almost **966,000 customers procured about 9.6 million MWh of renewable energy through utility green pricing programs in 2018**. Utility green pricing sales grew by about 8% from 2017 to 2018.
- In 2018, 3.4 million MWh of renewable energy was contracted through utilities in the form of bilateral contracts (two-thirds) and green tariffs (one-third).
- **CCA green power sales grew by 7%** from 2017 to 2018, reaching about 3.4 million customers and 9.5 million MWh of renewable energy sales through CCAs in 2018.
- **Almost 209,000 customers procured about 63.2 million MWh of renewable energy through unbundled RECs in 2018**. Unbundled REC sales grew by about 22% from 2017 to 2018.
- **While growing, community solar represents a relatively small share of total U.S. solar capacity, representing 2.2% (1.4 GW_{DC}) of cumulative installed PV capacity (61.8 GW_{DC}).**[1]

Source: Heeter and O'Shaughnessy

[1] Only including community solar programs where program participants maintain ownership of RECs, or RECs are retired on the customers behalf.

U.S. Cumulative Voluntary Sales and Customers

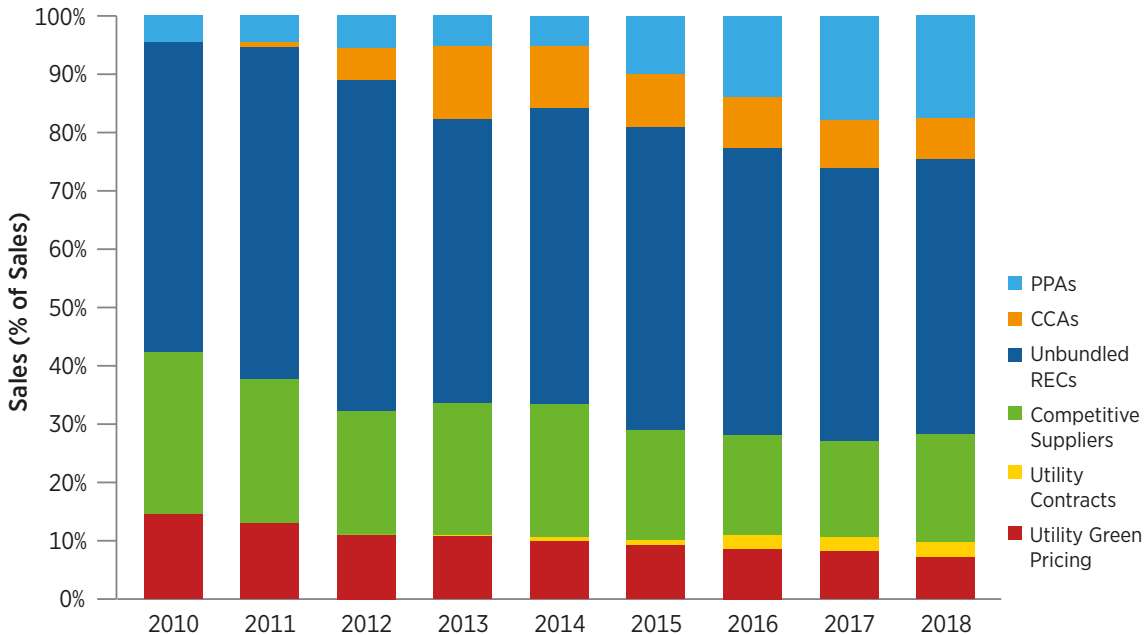


	Sales (Million MWh)	Customers (Thousands)
2010	**37.3**	**1,830**
2011	**44.6**	**1,910**
2012	**54.7**	**2,464**
2013	**64.5**	**4,601**
2014	**71.0**	**4,116**
2015	**81.7**	**3,745**
2016	**92.6**	**5,537**
2017	**110.3**	**5,473**
2018	**134.3**	**6,298**

XV

Source: Heeter and O'Shughnessy

Share of U.S. Voluntary Sales by Mechanism



Source: Heeter and O'Shughnessy

Utility Green Pricing programs involve customers opting into a rate that specifically supplies RE. *Utility Contracts* involve large customers procuring RE directly from the utility through a bilateral contract. *Competitive Suppliers* can offer RE in restructured markets. *Unbundled REC Purchases* involve a third-party selling the environmental attributes of RE generation separate from the actual power generated. *Community Choice Aggregation* involves an aggregated pool of customers switching from an incumbent electricity supplier to an alternative supplier. *Power Purchase Agreements (PPAs)* involve customers purchasing RE from a non-utility provider.

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U.S. Voluntary Sales by Mechanism

	Community choice aggregation (Million MWh)	Community solar (Million MWh)	Competitive suppliers (Million MWh)	Power purchase agreements (Million MWh)	Unbundled RECs (Million MWh)	Utility green pricing (Million MWh)	Utility renewable contracts (Million MWh)	Total (Million MWh)
2010	0.0	0.0	10.4	1.7	19.8	5.4	0.0	37.3
2011	0.3	0.0	11.0	2.1	25.4	5.8	0.0	44.6
2012	3.0	0.0	11.6	3.1	31.0	6.0	0.0	54.7
2013	8.1	0.0	14.5	3.4	31.4	6.9	0.2	64.5
2014	7.7	0.0	16.2	3.6	36.0	7.0	0.5	71.0
2015	7.4	0.0	15.4	8.2	42.5	7.5	0.7	81.7
2016	8.1	0.0	16.0	12.9	45.5	8.0	2.1	92.6
2017	8.9	0.1	18.1	19.8	51.7	8.9	2.8	110.3
2018	9.5	0.1	25.0	23.5	63.2	9.7	3.3	134.3

- annual decrease | annual increase +

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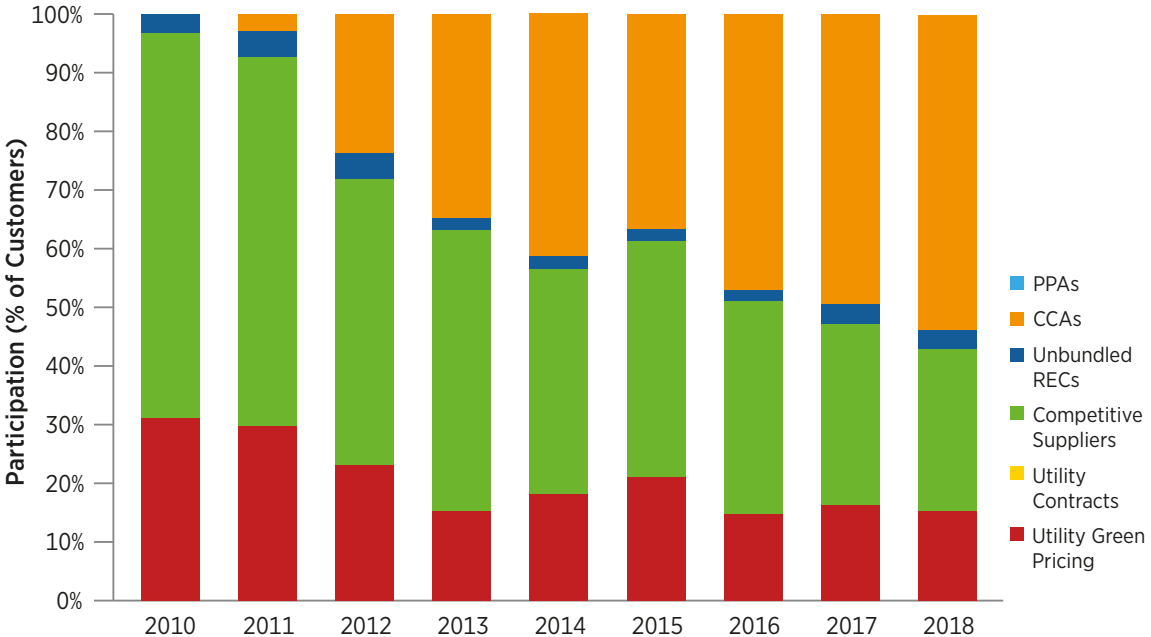
Source: Heeter and O'Shughnessy

Share of U.S. Voluntary Customers by Mechanism



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Source: Heeter and O'Shughnessy

U.S. Voluntary Customers by Mechanism

	Community choice aggregation (Thousand Customers)	Community solar (Thousand Customers)	Competitive suppliers (Thousand Customers)	Power purchase agreements (Thousand Customers)	Unbundled RECs (Thousand Customers)	Utility green pricing (Thousand Customers)	Total (Thousand Customers)
2010	0.4	0.0	1,200	0.0	60	570	1,830.4
2011	55	0.0	1,200	0.1	85	570	1,910.1
2012	584	0.0	1,200	0.1	110	570	2,464.1
2013	1,600	0.0	2,200	0.2	95	706	4,601.2
2014	1,700	0.0	1,584	0.2	89	743	4,116.2
2015	1,380	0.0	1,506	0.2	70	789	3,745.2
2016	2,600	1.5	2,011	0.2	108	816	5,536.7
2017	2,700	4.7	1,691	0.2	192	885	5,473.0
2018	3,382	6.0	1,735	0.3	209	966	6,298.3

- annual decrease | annual increase +

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Source: Heeter and O'Shughnessy

XVI. Glossary

Glossary

Alternating Current (AC)

An electrical current that periodically reverses the directional flow of electrons. The electric grid infrastructure, including most conventional and renewable utilityscale generation sources (other than solar photovoltaics [PV]) operates in AC. PV systems must use an inverter to convert DC into AC in order to operate within the grid. For the purpose of this report, an overall DC-to-AC de-rate factor of 0.80 was assumed.

Asset Financing

Using balance sheet assets (such as accounts receivable, short-term investments or inventory) to obtain a loan or borrow money—the borrower provides a security interest in the assets to the lender. This differs from traditional financing methods, such as issuing debt or equity securities, as the company simply pledges some of its assets in exchange for a quick cash loan.

B20

A fuel containing a mixture of 20% biodiesel and 80% petrodiesel.

Baseload Capacity

The generating equipment normally operated to serve loads on an around-the-clock basis.

Biodiesel

Any liquid biofuel suitable as a diesel fuel substitute or diesel fuel additive or extender. Biodiesel fuels are typically made from oils such as those derived from soybeans, rapeseed, or sunflowers, or from animal tallow. Biodiesel can also be made from hydrocarbons derived from agricultural products such as rice hulls.

Biofuels

Liquid fuels and blending components produced from biomass energy (plant) feedstocks, used primarily for transportation.

Biomass Energy

Organic non-fossil material of biological origin.

British Thermal Unit (Btu)

The quantity of heat required to increase the temperature of 1 pound of liquid water by 1 degree Fahrenheit at the temperature at which water has its greatest density (approximately 39 degrees Fahrenheit).

Capacity Factor

The ratio of the electrical energy produced by a generating unit for a given period of time to the electrical energy that could have been produced at continuous full power operation during the same period.

Community Solar

Community solar is a solar power installation that provides proportional output and financial payoff to individual members of a community.

Compound Annual Growth Rate

The year-over-year growth rate applied during a multiple-year period. The formula for calculating CAGR is (Current Value/Base Value)^(1/# of years) - 1.

Concentrating Solar Power (CSP)

A solar energy conversion system characterized by the optical concentration of solar rays through an arrangement of mirrors to heat working fluid to a high temperature. CSP (but not solar thermal power) may also refer to a system that focuses solar rays on a PV cell to increase conversion efficiency.

Crude Oil

A mixture of hydrocarbons that exists in liquid phase in natural underground reservoirs and remains liquid at atmospheric pressure after passing through surface separating facilities.

Digital Energy

The integration of digital communication technologies into energy systems, especially the electrical grid. Smart meters, along with other digital communication devices embedded in electrical transmission and distribution systems, allow for a two-way flow of information between utilities and their customers as well as greater digital control of the electrical grid, a concept known as the Smart Grid.

Direct Current (DC)

An electrical current that has unidirectional flow. DC is the type of electrical current often seen in batteries and PV cells. PV modules are commonly rated under standardized testing conditions in terms of DC output. For the purpose of this report, an overall DC-to-AC de-rate factor of 0.77 was assumed.

E85

A fuel containing a mixture of 85% ethanol and 15% gasoline.

Ethanol

A clear, colorless, flammable oxygenated hydrocarbon. Ethanol is typically produced chemically from ethylene or biologically from fermentation of various sugars from carbohydrates found in agricultural crops and cellulosic residues from crops or wood. It is used in the United States as a gasoline octane enhancer and oxygenate (blended up to 10% concentration). Ethanol can also be used in high concentrations (E85) in vehicles designed for its use.

Federal Energy Regulatory Commission (FERC)

The U.S. federal agency with jurisdiction over interstate electricity sales, wholesale electric rates, hydroelectric licensing, some natural gas pricing, oil pipeline rates, and gas pipeline certification. FERC is an independent regulatory agency within DOE and is the successor to the Federal Power Commission.

Flexible-Fuel Vehicles

Vehicles that can operate on (1) alternative fuels (such as E85), (2) 100% petroleum-based fuels, or (3) any mixture of an alternative fuel (or fuels) and a petroleum-based fuel. Flexible-fuel vehicles have a single fuel system to handle alternative and petroleum-based fuels.

Fuel Cell

A device that produces electricity by converting the chemical energy of a fuel (e.g., hydrogen) directly into electrical energy. Fuel cells differ from conventional electrical cells in that the active materials such as fuel and oxygen are not contained within the cell but are supplied from outside. It does not contain an intermediate heat cycle as do most other electrical generation techniques.

Gasoline Gallon Equivalent (GGE)

The amount of alternative fuel it takes to equal the energy content of one liquid gallon of gasoline. GGE allows consumers to compare the energy content of competing fuels against a commonly known fuel—gasoline.

Generation
The total amount of electric energy produced by generating units and measured at the generating terminal in kilowatt-hours (kWh) or megawatt-hours (MWh).

Geothermal Energy
The heat that is extracted from hot water or steam that is mined from geothermal reservoirs in the Earth's crust. Water or steam can be used as a working fluid for geothermal heat pumps, water heating, or electricity generation and then is injected back into the Earth.

Geothermal (Ground Source) Heat Pump
A heat pump in which the refrigerant exchanges heat (in a heat exchanger) with a fluid circulating through an earth connection medium (ground or ground water). The fluid is contained in a variety of loop (pipe) configurations depending on the temperature of the ground and the ground area available. Loops may be installed horizontally or vertically in the ground or submersed in a body of water.

Gigawatt (GW)
One billion watts or 1,000 MW or 1 million kW.

Gigawatt-hour (GWh)
One billion watt-hours.

Incremental Capacity
Capacity added on an annual basis.

Insolation
The amount of radiation from the sun received at the surface of the Earth in a particular geographic location or region.

Kilowatt (kW)
One thousand watts.

Kilowatt-hour (kWh)
A measure of electrical energy defined as a unit of work or energy, measured as 1 kW (1,000 watts) of power expended for 1 hour. One kWh is equivalent to 3,412 Btu.

Landfill Gas
Gas that is generated by decomposition of organic material at landfill disposal sites. The average composition of landfill gas is approximately 50% methane and 50% carbon dioxide and water vapor by volume. The methane in landfill gas may be vented, flared, or combusted to generate electricity or useful thermal energy on-site or injected into a pipeline for combustion off site.

Megawatt (MW)
One million watts of electricity.

Megawatt-hour (MWh)
One thousand kilowatt-hours or 1 million watt-hours.

Mergers and Acquisitions
A general term used to refer to the consolidation of companies. A merger is a combination of two companies to form a new company, while an acquisition is the purchase of one company by another in which no new company is formed.

Municipal Solid Waste (MSW)
Residential solid waste and some nonhazardous commercial, institutional, and industrial wastes.

Nameplate Capacity
The maximum rated output of a generator under specific conditions designated by the manufacturer. Nameplate capacity is usually indicated in units of kilovolt-amperes (kVA) and in kW on a nameplate physically attached to the generator.

Non-Powered Dam Project
A dam that does not produce electricity and provides a variety of services ranging from water supply to inland navigation.

Ocean Energy
Energy conversion technologies that harness the energy in tides, waves, and thermal gradients in the oceans.

Petroleum
A broadly defined class of liquid hydrocarbon mixtures. Included are crude oil, lease condensate, unfinished oils, refined products obtained from the processing of crude oil, and natural gas plant liquids.

Photovoltaic (PV) Cell
PV cells convert incident light directly into electricity (DC). An electronic device consisting of layers of semiconductor materials fabricated to form a junction (adjacent layers of materials with different electronic characteristics) and electrical contacts.

Private Equity
Equity capital that is not quoted on a public exchange. Private equity consists of investors and funds that make investments directly into private companies or conduct buyouts of public companies that result in a delisting of public equity. Capital for private equity is raised from retail and institutional investors and can be used to fund new technologies, expand working capital within an owned company, make acquisitions, or strengthen a balance sheet.

Pumped-Storage Hydroelectric Plant
A plant that usually generates electric energy during peak load periods by using water previously pumped into an elevated storage reservoir during off-peak periods when excess generating capacity is available to do so.

Renewable Energy Resources
Energy resources that are naturally replenishing but flow-limited. They are virtually inexhaustible in duration but limited in the amount of energy that is available per unit of time. Renewable energy resources include biomass energy, hydropower, geothermal, solar, wind, and ocean energy.

Solar Thermal Collector
A device designed to receive solar radiation and convert it to thermal energy. Normally, a solar thermal collector includes a frame, glazing, and an absorber, together with appropriate insulation. The heat collected by the solar collector may be used immediately or stored for later use. Solar collectors are used for space heating; domestic hot water heating; and heating swimming pools, hot tubs, or spas.

Venture Capital
Money provided by investors to startup firms and small businesses with perceived long-term growth potential. This is a very important source of funding for startups that do not have access to capital markets. It typically entails high risk for the investor, but it has the potential for above-average returns.

Wind Energy
Kinetic energy present in wind motion that can be converted to mechanical energy for driving pumps, mills, and electric power generators.

Principal Data Sets

DATA PROVIDER	Data Set/Report	Geographic Scope	Technologies Addressed	Date Available/ Accessed
Argonne National Laboratory	EV Technology Markets & Policy Work	United States	electric vehicles	November 2019
Bloomberg New Energy Finance (BNEF)	Global Trends in Clean Energy Investment			December 2019
Energy Information Administration (EIA)	Form 860[1]	United States	Biomass energy, coal, geothermal, hydropower, natural gas, nuclear, petroleum, solar, and wind	December 2019
	Monthly Energy Review[2]	United States		December 2019
	Electric Power Monthly	United States		December 2019
International Renewable Energy Agency	*Renewable Energy Statistics 2019*	Global	Biomass energy, Geothermal, Hydropower, Solar, and Wind	September 2019
Lawrence Berkeley National Laboratory	2018 Wind Technologies Market Report	United States	Wind	September 2019
National Renewable Energy Laboratory (Heeter and O'Shuaghnessy)	State of the Voluntary Green Power Market	United States	Voluntary procurement of RE	October 2019
Renewable Fuels Association (RFA)	*2018 Ethanol Industry Outlook*	United States	Ethanol	October 2019
Sandia National Laboratory	*DOE-OE Global Energy Storage Database*	Global	Storage	December 2019
Solar Energy Industries Association and GTM Research (SEIA/GTM)	*2018 Solar Industry Year in Review*	United States	Distributed solar	November 2019

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[1] Includes installed capacity, planned capacity additions, and planned capacity retirements.
[2] Includes production and consumption by end-use sector.

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