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Report to Congressional Requesters

May 2015

ELECTRICITY

Generation Mix Has Shifted, and Growth in Consumption Has Slowed, Affecting System Operations and Prices

Accessible Version

GAO-15-524

GAO Highlights

Highlights of GAO-15-524, a report to congressional requesters

May 2015

ELECTRICITY

Generation Mix Has Shifted, and Growth in Consumption Has Slowed, Affecting System Operations and Prices

Why GAO Did This Study

Electricity in the United States has traditionally been generated largely from coal, natural gas, nuclear, and hydropower energy sources. More recently, various federal and state policies, tax incentives, and research and development efforts have supported the use of renewable energy sources such as wind, solar, and geothermal. In addition, consumption of electricity has been affected by federal efforts to improve energy efficiency, changes in the economy, and other factors.

GAO was asked to provide information on changes in the electricity industry. This report examines what is known about (1) how electricity generation and consumption have changed since 2001 and (2) the implications of these changes on efforts to maintain reliability, and on electricity prices.

GAO analyzed data on electricity generation, consumption, and prices and reviewed literature. GAO also interviewed 21 stakeholders, including government officials, and industry representatives, selected to represent different perspectives and experiences regarding changes in the industry.

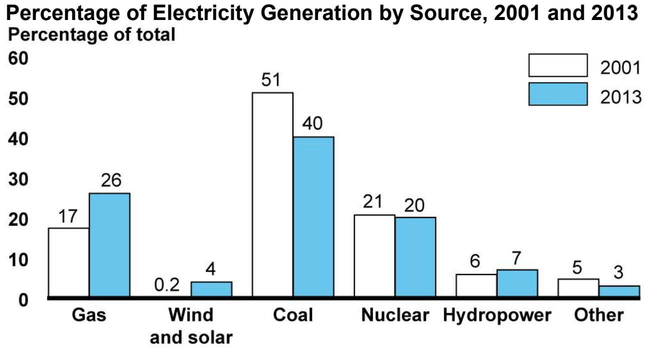
GAO is not making recommendations in this report. The Department of Energy and Federal Energy Regulatory Commission reviewed a draft of this report and provided technical comments that GAO incorporated as appropriate.

View GAO-15-524. For more information, contact Frank Rusco at (202) 512-3841 or ruscof@gao.gov.

What GAO Found

The mix of energy sources for electricity generation has changed, and the growth in electricity consumption has slowed. As shown in the figure below, from 2001 through 2013, natural gas, wind, and solar became larger portions of the nation's electricity generation, and the share of coal has declined. These changes have varied by region. For example, the majority of wind and solar electricity generation is concentrated in a few states—in 2013, California and Arizona accounted for over half of electricity generated at solar power plants. Regarding consumption, national retail sales of electricity grew by over 1 percent per year from 2001 through 2007 and remained largely flat from that time through 2014.

Percentage of Electricity Generation by Source, 2001 and 2013



Source: GAO analysis of SNL Financial data. | GAO-15-524

Note: Other includes biomass, geothermal, oil, and other nonrenewable sources. Numbers may not sum to 100 because of rounding.

The literature GAO reviewed and stakeholders GAO interviewed identified the following implications of these changes:

- **Maintaining Reliability**: System operators, such as utility companies, have taken additional actions to reliably provide electricity to consumers. For example, some regions have experienced challenges in maintaining the delivery of natural gas supplies to power plants. In particular, severe cold weather in the central and eastern U.S. in 2014 led to higher than normal demand for gas for home heating and to generate electricity. Challenges delivering fuel to natural-gas-fueled power plants resulted in outages at some plants. System operators took various steps to limit the effect of this event, including relying on power plants that utilize other fuel sources that were more readily available at the time, such as coal and oil-fueled power plants, and implementing certain emergency procedures.
- **Prices**: Increased gas-fueled generation has influenced electricity prices, with wholesale electricity prices and gas prices generally fluctuating in tandem over the past decade. The effect of the increased use of wind and solar sources on consumer electricity prices depends on specific circumstances. Among other things, it depends on the relative cost of wind and solar compared with other sources, as well as the amount of federal and state financial support for wind and solar development that can offset some of the amount that consumers might otherwise pay. Taken together, the addition of wind and solar sources could have contributed to higher or lower consumer electricity prices at different times and in different regions.

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Abbreviations

EIA	Energy Information Administration
ERCOT	Electric Reliability Council of Texas
DOE	Department of Energy
FERC	Federal Energy Regulatory Commission
ISO	Independent System Operator
ITC	Investment Tax Credit
NERC	North American Electric Reliability Corporation
PTC	Production Tax Credit
RTO	Regional Transmission Organizations
SNL	SNL Financial

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U.S. GOVERNMENT ACCOUNTABILITY OFFICE
441 G St. N.W.
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May 29, 2015

The Honorable Lamar Smith
Chairman
Committee on Science, Space, and Technology
House of Representatives

The Honorable Jeff Sessions
United States Senate

The Honorable Cynthia Lummis
House of Representatives

The Honorable Gary Palmer
House of Representatives

The electricity system is important to the health of the U.S. economy and well-being of Americans. Electricity has traditionally been generated largely from coal, natural gas, nuclear, and hydropower energy sources. More recently, various federal and state policies, tax incentives, and research and development efforts have supported the use of renewable energy sources such as wind, solar, and geothermal, which offer environmental benefits over some traditional sources of electricity, such as fewer emissions of air pollutants. In addition, consumption of electricity has been affected by energy efficiency improvements, changes in the economy, and other factors.

You asked us to provide information on changes in the electricity system. This report examines what is known about (1) how electricity generation and consumption have changed since 2001, and (2) the implications of these changes on efforts to maintain reliability, and on electricity prices.

To conduct this work, we analyzed data on electricity generation, consumption, and prices; reviewed literature, including studies by federal agencies, electricity system operators, and consultants; and summarized the results of interviews with a nonprobability sample of 21 stakeholders. To describe changes in electricity generation, we analyzed data from SNL

Financial (SNL) current as of April 3, 2015.[1] We generally present data on changes from 2001 through 2013 because 2013 is the most recent year for which complete data are available, though in some instances we present more recent data. To describe changes in electricity consumption, we examined data from the Energy Information Administration (EIA) on retail sales of electricity to consumers.[2] We took several steps to assess the reliability of SNL and EIA data. We reviewed relevant documentation, interviewed SNL and EIA representatives, and compared some data elements to those available from other sources. We determined the data were sufficiently reliable for the purposes of this report. To identify implications of changes in electricity generation and consumption, we reviewed literature and interviewed stakeholders. We identified literature by conducting a literature search and obtaining suggestions from the stakeholders we interviewed. Stakeholders included power plant owners, system operators, a state regulator, non-governmental organizations, and federal agencies. We selected stakeholders to represent different perspectives and experiences regarding changes in the industry, and to maintain balance with respect to sources of electricity and stakeholders' roles in the market. Because this was a nonprobability sample, the views of stakeholders we selected are not generalizable to all potential stakeholders, but they illustrate a range of views. Identifying and examining federal agency actions to address the challenges identified were beyond the scope of this review. Appendix I provides additional information on our scope and methodology and appendix II lists the stakeholders we interviewed.

We conducted this performance audit from November 2014 to May 2015 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that

[1]SNL's energy database combines information from multiple sources including the Energy Information Administration, Federal Energy Regulatory Commission, and others. Data used in this report reflect information collected through a variety of means including the EIA-860 form that collects generator-level specific information about existing and planned power plants and the EIA 923 form that collects data on electricity generation and fuel consumption, among other things. Some data are updated annually, but SNL updates others more frequently. As plans may change, actual future retirements and units placed in service may differ from these plans.

[2]EIA is a statistical administration within the Department of Energy that collects, analyzes, and disseminates independent information on energy issues.

the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Background

This section describes (1) electricity generation and consumption in the United States, (2) federal and state actions that have influenced electricity generation and consumption, (3) electricity reliability, and (4) federal and state regulation.

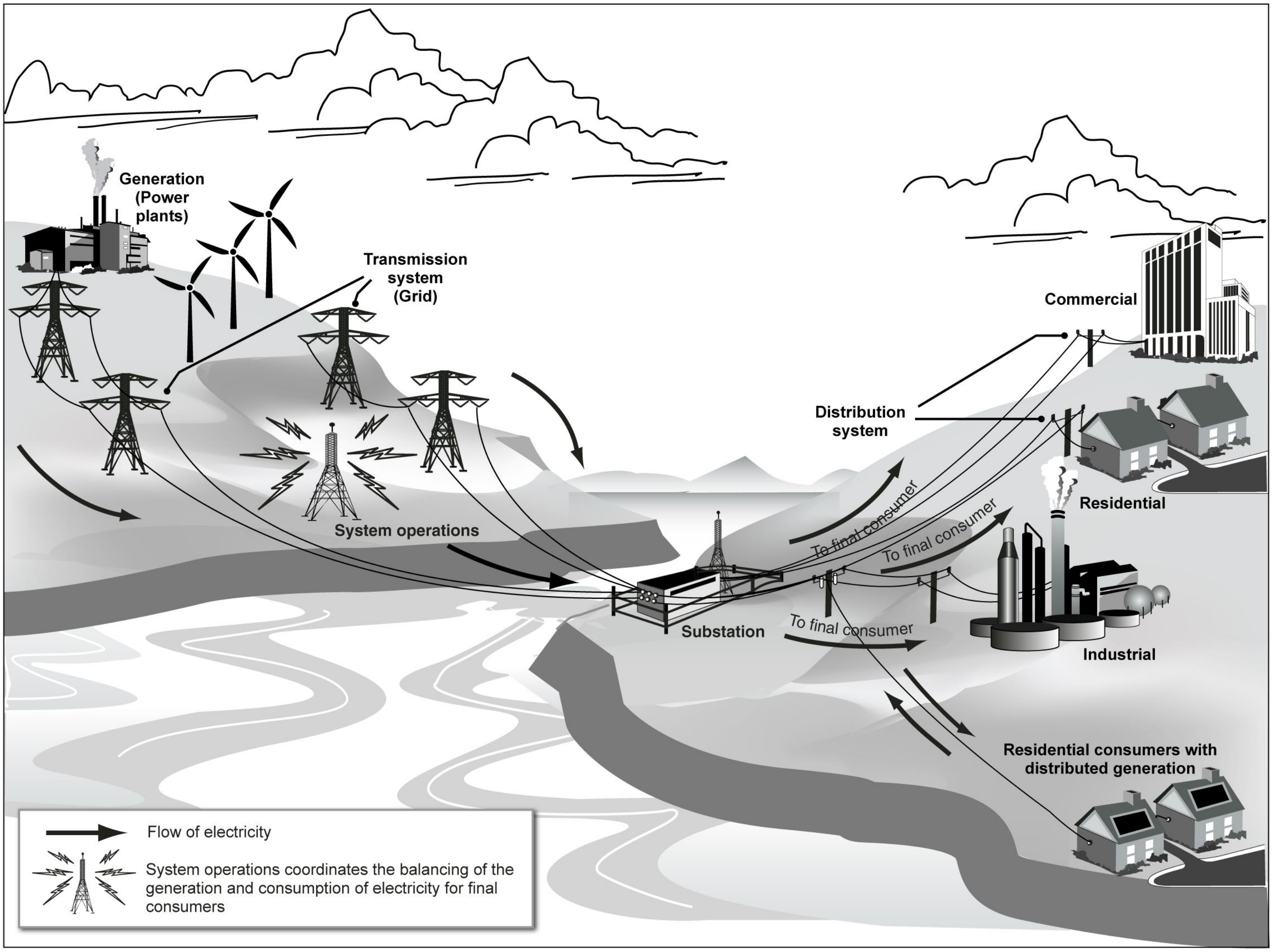
Electricity Generation and Consumption in the United States

The electricity system includes four distinct functions: generation, transmission, distribution, and system operations (see fig. 1). Electricity may be generated at power plants by burning fossil fuels; through nuclear fission; or by harnessing renewable sources such as wind, solar, geothermal energy, or hydropower.[3] Once electricity is generated, it is sent through the electricity grid, which consists of high-voltage, high-capacity transmission systems, to areas where it is transformed to a lower voltage and sent through the local distribution system for use by industrial, commercial, residential, and other consumers.[4] Throughout this process, system operations are managed by a system operator, such as a local utility, that must constantly balance the generation and consumption of electricity. To do so, system operators monitor electricity consumption from a centralized location using computerized systems and send minute-by-minute signals to power plants to adjust their output to match changes in consumption.

[3]Generating capacity is measured in megawatts (MW) and refers to the maximum capability to generate electricity. The amount of electricity that is actually generated is referred to as generation, commonly expressed in megawatt hours (MWh). A megawatt is equal to 1,000,000 watts. One traditional incandescent light bulb consumes about 60 watts, and a comparable compact fluorescent light bulb consumes approximately 15 watts; therefore, 1,000,000 compact fluorescent light bulbs would consume 15 MWh in one hour.

[4]According to EIA: (1) the industrial sector encompasses manufacturing, agriculture, mining, and construction; (2) the commercial sector consists of businesses, institutions, and organizations that provide services such as schools, stores, office buildings, and sports arenas; (3) the residential sector includes households and excludes transportation; and (4) other includes electricity users not captured in the other three categories, including transportation.

Figure 1: Functions of the Electricity System



Source: GAO. | GAO-15-524

The power plants that system operators use to meet this varying demand include plants that provide baseload generation and those that provide peak generation. Plants that provide baseload generation, often called baseload plants, have generally been the most costly to build but have had the lowest hourly operating costs.[5] In general, system operators maximize the amount of electricity supplied by the baseload plants, which are often used continuously for long periods of time. As demand rises through the day and through the year and exceeds the amount of electricity generation that can be delivered from baseload power plants, system operators have generally relied on electricity supplied by plants that provide peak generation, known as "peakers." Peakers are usually less costly to build but more costly to operate.[6] Wind and solar capacity has somewhat different characteristics. Similar to baseload plants in some respects, wind and solar power plants are generally costly to build, but they have near-zero operating costs because they do not have to purchase fuel. However, wind and solar power plants are variable energy sources. That is, the amount of electricity they can generate varies with the amount of wind and sun and generally not at the discretion or request of system operators.

Federal and State Actions That Have Influenced Electricity Generation and Consumption

Various federal and state actions have influenced electricity generation. Regarding federal actions, in April 2015, we found that from fiscal year 2004 through 2013, federal programs aided the development of new electricity-generating capacity through various means, including outlays, loan programs, and tax expenditures.[7] In more recent years, federal actions have been targeted toward renewable sources such as wind and solar, although there has also been federal support for coal, nuclear, and natural gas-fueled generation.[8] For example, two tax credits—the

[5]The types of technologies used to provide baseload generation vary but often include plants using coal, nuclear, hydropower, or combined-cycle natural gas technologies—units that utilize a combustion turbine in conjunction with a steam turbine to produce electricity.

[6]The types of technologies used to provide peaking generation can vary but often include plants using natural gas in combustion turbines.

[7]*Electricity Generation Projects: Additional Data Could Improve Understanding of the Effectiveness of Tax Expenditures*, GAO-15-302 (Washington, D.C.: Apr. 28, 2015). Tax expenditures are tax provisions—including tax deductions and credits—that are exceptions to the normal structure of individual and corporate income tax requirements necessary to collect federal revenue. Tax expenditures can have the same effects on the federal budget as spending programs—namely that the government has less money available to use for other purposes.

[8]The scope of our April 2015 report was limited to supports for the construction of new utility-scale electricity generation projects. For more information on federal supports for energy production and consumption more broadly, see GAO, *Energy Policy: Information on Federal and Other Factors Influencing U.S. Energy Production and Consumption from 2000 through 2013*, GAO-14-836 (Washington, D.C.: Sept. 30, 2014).

Production Tax Credit (PTC) and the Investment Tax Credit (ITC)—and a related program that provided payments in lieu of these tax credits supported wind and solar electricity by lowering the costs associated with electricity generation and providing an incentive to those firms engaged in the construction and operation of wind and solar projects. The Department of the Treasury estimated that these two tax credits resulted in almost $12 billion in revenue losses for the federal government from fiscal year 2004 through 2013.[9] In addition, the related payment program provided almost $17 billion in outlays from fiscal year 2004 through 2013.[10] EIA recently estimated that wind, solar, and other renewables, accounted for about 72 percent of all electricity-related direct federal financial interventions and subsidies in fiscal year 2013.[11]

Regarding state actions, our April 2015 report found that key state supports aided the development of electricity generation projects—particularly renewable ones—in most states, from fiscal year 2004 through 2013.[12] For example, we found that as of September 2014, 38 states and the District of Columbia had established renewable portfolio

[9]Specifically, the PTC accounted for an estimated $8.1 billion in forgone revenue and, as of the end of 2013, provided an income tax credit of 2.3 cents per kilowatt-hour of electricity produced form wind and certain other renewable sources. Since it was first made available in 1992, the PTC has expired six times—in 1999, 2001, 2003, 2012, 2013, and 2014. Most recently, the PTC was extended for certain qualified facilities for projects that began construction before January 1, 2015. Because the credit is taken over a 10-year period once a project is placed in service, the PTC will continue to result in forgone revenue for years to come. The ITC accounted for an estimated $3.4 billion in forgone revenue and provided an income tax credit up to 30 percent for the development of solar, wind, and certain other renewable projects. The ITC was first established in 1978 at 10 percent of eligible investment costs and was temporarily increased in 2005 to 30 percent for solar and certain other technologies. Subsequent legislation extended the ITC at 30 percent for these technologies through December 31, 2016. After January 1, 2017, the ITC is scheduled to return to 10 percent of eligible investment costs for solar projects.

[10]Section 1603 of the American Recovery and Reinvestment Act of 2009 (Pub. L. No. 111-5, § 1603, 123 Stat. 115, 364 (Feb. 19, 2009)), as amended, allows taxpayers eligible for the PTC or ITC to receive a payment from the Treasury in lieu of a tax credit.

[11]EIA's estimates do not include all subsidies beneficial to energy activities, and were instead limited to activities that provide a financial benefit with an identifiable federal budget effect and that are specifically targeted at energy markets. Further, EIA's estimates do not account for the effectiveness of support programs, which may vary across fuel sources. See EIA, *Direct Federal Financial Interventions and Subsidies in Energy in Fiscal Year 2013* (Washington, D.C.: March 2015).

[12]GAO-15-302.

standards or goals.[13] Such policies mandate or set goals that retail service providers obtain a minimum portion of the electricity they sell from renewable sources, creating additional demand for renewables. Retail service providers meet these requirements in various ways, such as by building renewable generating capacity or purchasing renewable generation from other producers through long-term contracts known as power purchase agreements.

Federal and state activities have also encouraged energy efficiency, which can reduce the consumption of electricity. For example, Treasury estimated that energy-efficiency-related federal tax expenditures, such as for household energy efficiency improvements and the purchase of energy efficient equipment, amounted to over $15 billion in forgone revenue for the federal government from fiscal year 2000 through 2013.[14] State governments have also played an important role in encouraging energy efficiency. According to the American Council for an Energy-Efficient Economy, as of April 2014, 25 states had fully funded policies in place that establish specific energy savings targets that utilities or nonutility program administrators must meet through customer energy efficiency programs. In March 2014, we found that the federal government has also made efforts to facilitate activities that encourage customers to reduce demand when the cost to generate electricity is high, known as demand-response activities.[15] These efforts have included actions to fund the installation of advanced electricity meters that facilitate these demand-response activities, as well as regulatory efforts to encourage demand-response activities.

Electricity Reliability

Electricity reliability—the ability to meet consumers' electricity demand at all times—is influenced by a variety of factors. Since electricity cannot be

[13]This information is derived from our survey of state regulatory commissions and data from the Database of State Incentives for Renewable Energy, which is funded by DOE and others.

[14]Specifically, Treasury estimated that forgone revenue associated with the credit for energy efficiency improvements to existing homes amounted to $10.36 billion, the credit for residential energy efficiency property amounted to $3.08 billion, and the exclusion of utility conservation subsidies amounted to $2.04 billion from fiscal 2000 through 2013.

[15]GAO, *Electricity Markets: Demand-Response Activities Have Increased, but FERC Could Improve Data Collection and Reporting Efforts,* GAO-14-73 (Washington, D.C.: Mar. 27, 2014).

easily and inexpensively stored, electricity generated must be matched with demand, which varies significantly depending on the time of day and year. To maintain a reliable supply of electricity, system operators take steps to ensure that power plants will be available to generate electricity when needed. In doing so, system operators typically ensure available capacity exceeds estimated demand so that any unexpected increases in demand or power plant or transmission outages can be accommodated without consumers losing access to electricity.

Maintaining a reliable supply of electricity is a complex process requiring the system operator to coordinate three broad types of services as follows:

- **Capacity:** Operators procure generating capacity—long-term commitments to have available specific amounts of electricity-generating capacity to ensure that there will be sufficient electricity to reliably meet expected future electricity needs. Procuring capacity may involve operators of power plants committing that existing or new power plants will be available to generate electricity in the future, if needed.

- **Energy:** Operators schedule which power plants will generate electricity throughout the day—referred to as energy scheduling—to maintain the balance of electricity generation and consumption.

- **Ancillary services:** Operators procure several ancillary services to maintain a reliable electricity supply. Ancillary services generally involve resources being available on short notice to increase or decrease their generation or consumption.[16] These and other services are needed to ensure supply and demand remain in balance so that electricity can be delivered within technical standards—for example, at the right voltage and frequency—to keep the grid stable and to protect equipment that needs to operate at specific voltage and frequency levels.

[16]Such ancillary services are often referred to as reserves, and they help ensure that resources are available to increase their output or decrease consumption in the event that a power plant is taken out of service or if consumption is greater than anticipated. There are a range of reserves including “spinning reserves” that are already operating and can quickly increase their generation, and non-spinning reserves that may take more time.

Federal and State Regulation of Electricity

Responsibility for regulating electricity prices is divided between the states and the federal government. Most electricity consumers are served by retail markets that are regulated by the states, generally through state public utility commissions or equivalent organizations. As the primary regulator of retail markets, state commissions approve many aspects of utility operations, such as the siting and construction of new power plants, as well as the prices consumers pay and how those prices are set.[17] Prior to being sold to retail consumers, electricity may be bought, sold, and traded in wholesale electricity markets by a variety of market participants, including companies that own power plants, as well as utilities and other retail service providers that sell electricity directly to retail consumers. Wholesale electricity markets are overseen by the Federal Energy Regulatory Commission (FERC).[18]

During the last 2 decades, some states and the federal government have taken steps to restructure electricity markets with the goal of increasing competition. The electricity industry has historically been characterized by utilities that were integrated and provided the four functions of electricity service—generation, transmission, distribution, and system operations—to all retail consumers in a specified area. In much of the Western, Central, and Southeastern United States, retail electricity delivery continues to operate under this regulatory approach, and these regions are referred to as traditionally regulated regions. In parts of the country where states have taken steps to restructure retail electricity markets, new entities called retail service providers compete with utilities to provide electricity to retail consumers by offering electricity plans with differing

[17]The price consumers pay for electricity is often a combination of rates determined by regulators and prices determined by markets. Rates are generally approved by regulators and set to recover the cost of providing a service plus a rate of return. Prices are market-based, determined based on the interaction of supply and demand. For the purposes of this report, we generally use “prices” to refer to both rates and prices.

[18]FERC oversees wholesale electricity sales and, among other things, has statutory responsibility to ensure that wholesale electricity rates are “just and reasonable” and not “unduly discriminatory or preferential.” FERC is also responsible for regulating transmission of electricity in interstate commerce by privately owned utilities. FERC does not regulate transmission or wholesale electricity sales in most of the state of Texas because Texas’ grid is separate from the rest of the U.S. grid. In addition, FERC does not regulate transmission or wholesale electricity sales in Alaska or Hawaii because of their geographical isolation. Further, FERC does not have jurisdiction over municipal utilities or most electric cooperatives.

prices, terms, and incentives.[19] Beginning in the late 1990s, FERC took a series of steps to restructure wholesale electricity markets, and wholesale electricity prices are now largely determined by the interaction of supply and demand rather than regulation. In addition, FERC encouraged the voluntary creation of new entities called Regional Transmission Organizations (RTO) to manage regional networks of electric transmission lines as system operators—functions that had traditionally been carried out by local utilities.[20]

In addition to its role in regulating aspects of the electricity market, FERC is also responsible for approving and enforcing standards to ensure the reliability of the bulk power system—generally the generation and transmission systems.[21] FERC designated the North American Electric Reliability Corporation (NERC) to develop and enforce these reliability standards, subject to FERC review. These standards outline general requirements for planning and operating the bulk power system to ensure reliability. For example, one reliability standard requires that system planners plan and develop their systems to meet the demand for electricity even if equipment on the bulk power system, such as a single generating unit or transformer, is damaged or otherwise unable to operate.[22]

[19]We use the term retail service provider to encompass regulated utilities providing retail electricity service as well as other qualified providers who may not own generation, transmission, or distribution assets.

[20]RTOs have been created in regions that cover much of California and the eastern United States, except the Southeast. In addition to acting as system operators, these regional transmission organizations have developed organized wholesale markets for buying and selling electricity and other needed services to operate the grid, such as ancillary services.

[21]The bulk power system refers to facilities and control systems necessary for operating the electric transmission network and certain generation facilities needed for reliability.

[22]NERC, *Transmission System Planning Performance Requirements*, Standard TPL-001-4.

The Electricity Generation Mix Has Shifted Toward More Natural Gas, Wind, and Solar Sources, and Growth in Electricity Consumption Has Slowed

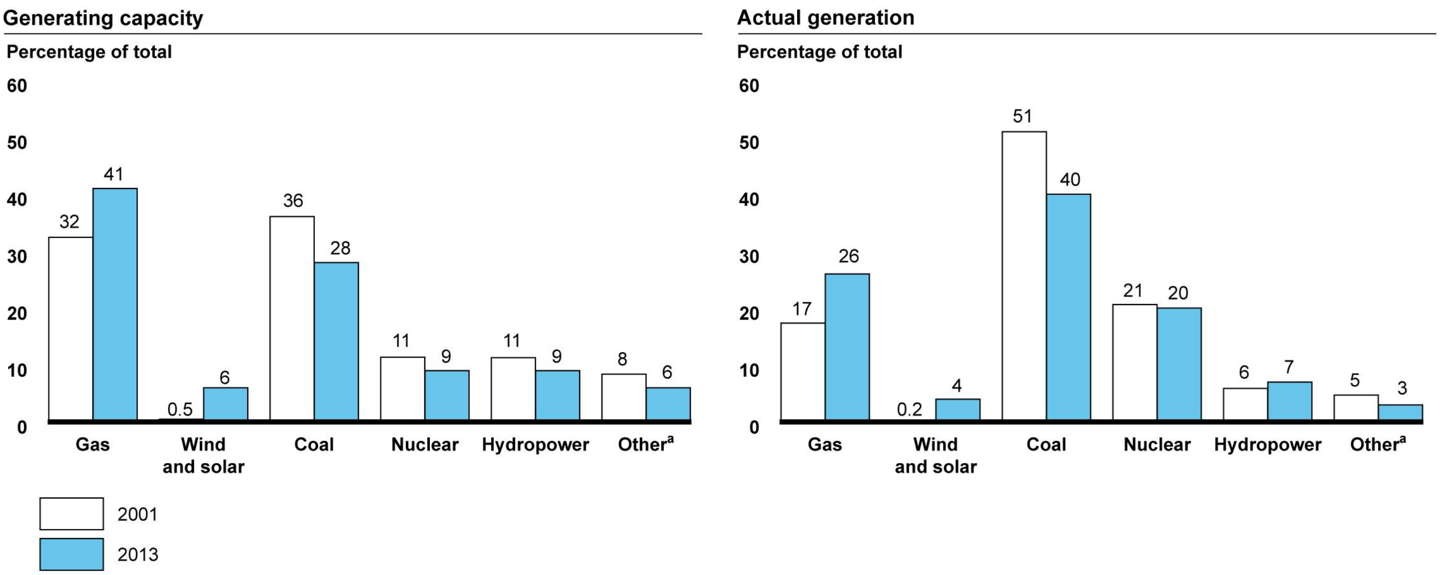
According to our analysis of SNL data, the mix of energy sources used to generate electricity has generally shifted to include more natural gas, wind, and solar, but less coal and nuclear, from 2001 through 2013, though the extent of these changes varied by region. Growth in electricity consumption has generally slowed, with key differences among different types of consumers and regions.

Electricity-Generating Capacity and Actual Generation Have Changed in Several Key Ways

Natural gas, wind, and solar sources provided larger portions of the nation's electricity mix from 2001 through 2013 in terms of both generating capacity and actual generation, while coal and nuclear sources provided smaller portions, according to our analysis of SNL data (see fig. 2).[23] At the time of our analysis, 2013 was the most recent year with complete data for both generating capacity and generation. The growth or decline in specific energy sources varied over this time period and across U.S. regions. (See app. III for additional information on electricity-generating capacity and actual generation by region.) SNL data on power plants under construction and planned for retirement suggest that these recent trends are likely to continue.

[23]SNL data include data on generating units and power plants. (A power plant may have multiple generating units.) All capacity data presented here refer to generating-unit level data. Because of differing data availability, generation data represent a combination of individual data at the unit level (representing about 71 percent of generation in 2013) and at the plant level (representing the remaining 29 percent of generation in 2013). These plant level data were imputed to the unit level based on each generating unit's share of a plant's generating capacity. SNL identifies the primary energy source for each unit using data from the most recent year, and we used this categorization to analyze changes in generating capacity and generation. One shortcoming of this approach is that it misses changes over time in energy sources at units capable of using more than one energy source. See appendix I for additional information on these data.

Figure 2: Share of Electricity-Generating Capacity and Actual Generation in 2001 and 2013 by Source



Source: GAO analysis of SNL Financial data. | GAO-15-524

Notes: Includes generating units identified by their primary energy source in the most recent year at power plants with capacities of at least 1 megawatt that are connected to the grid and intend to sell electricity to retail customers or retail service providers. Generating capacity refers to the maximum capability of a generating unit to generate electricity. Numbers may not sum to 100 due to rounding.

[a]The "other" category includes biomass, geothermal, oil, and other nonrenewable sources.

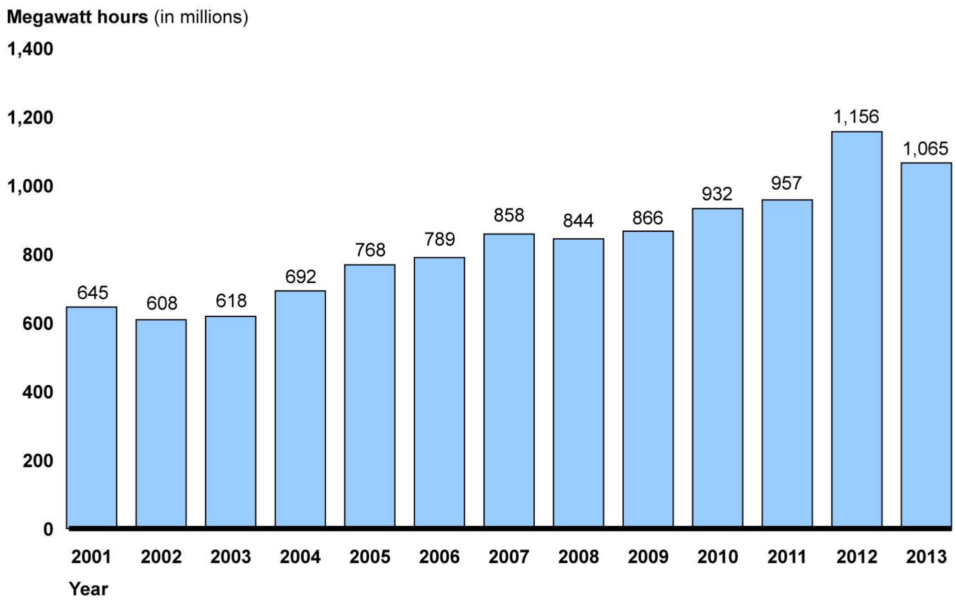
Contribution of Natural Gas Has Increased

Generating capacity and actual generation from natural-gas-fueled power plants increased across the nation from 2001 through 2013, with different regions seeing varying levels of growth, according to our analysis of SNL data. Natural-gas-fueled generating capacity increased by about 181,000 MW during this period, and accounted for 72 percent of the new generating capacity added from all sources.[24] This increase in gas-fueled capacity resulted from the construction of about 270,000 MW during this period offset by a smaller amount of retirements. Regarding actual generation, electricity generated from natural-gas-fueled power plants generally increased throughout this period, with a pronounced jump from 2011 through 2012 when generation increased by about 21 percent (see

[24]This trend continued in 2014 with the addition of approximately 4,000 MW of gas-fueled generating capacity.

fig. 3).[25] The average utilization of natural-gas-fueled capacity—a measure of the intensity with which capacity was operated—varied over this period, declining from about 30 percent in 2001 to a low of about 20 percent in 2003 before generally increasing to about 27 percent in 2013.[26] Increases in gas-fueled capacity and generation led to natural gas accounting for a larger share of the nation's electricity mix, increasing from 17 percent of generation in 2001 to 26 percent in 2013.

Figure 3: Electricity Generated from Gas-Fueled Power Plants, 2001 through 2013



Source: GAO analysis of SNL Financial data. | GAO-15-524

Note: Includes generation from units identified by their primary energy source in the most recent year at power plants with capacities of at least 1 megawatt that are connected to the grid and intend to sell electricity to retail consumers or retail service providers.

All but one region of the country experienced increases in the amount of electricity generated from natural gas over this period. Specifically, electricity generated from natural gas declined in Alaska and increased in

[25]Preliminary data from EIA suggest that electricity generated from natural gas declined by 0.3 percent in 2014. (See EIA, *Monthly Energy Review*, March 27, 2015.)

[26]Data on utilization presented in this report are the capacity-weighted annual average capacity factor—the ratio of actual electricity generation to the maximum potential to generate electricity.

the rest of the United States, ranging from an increase of 5 percent in Texas to almost 200 percent in some regions in the East. In some regions, natural gas became an increasingly significant energy source in the generation mix. For example, in New England, natural gas increased from 31 percent of the region's electricity generation in 2001 to 42 percent in 2013. According to EIA, lower natural gas prices, regional environmental initiatives, and other factors have contributed to increases in gas-fueled electricity generation.[27]

As the use of natural gas to generate electricity has increased since 2001, the mix of technologies used in gas-fueled power plants has also changed. Specifically, combined-cycle plants, which use a combustion turbine in conjunction with a steam turbine to generate electricity, have become an increasingly common technology for generating electricity—growing from 7 percent of total electricity generation in 2001 to 23 percent in 2013, according to SNL data (increasing from 42 percent of electricity generated from gas in 2001 to 86 percent in 2013).[28] Though more expensive to build initially, such plants are more fuel-efficient than simpler combustion turbine plant designs. This efficiency can make it economically feasible to generate electricity with natural gas for sustained periods. As a result, these plants can be economically operated like traditional baseload generation such as coal and nuclear plants, which often run continuously for long periods of time. Trends in the utilization of combined-cycle and other gas-fueled power plants differed over this period. Utilization decreased for all gas-fueled capacity in the early 2000s, but while it has increased since 2003 for combined-cycle capacity (from 34 percent in 2003 to almost 44 percent in 2013), utilization has declined somewhat for other gas-fueled technologies (from 12 percent in 2003 to 8 percent in 2013).

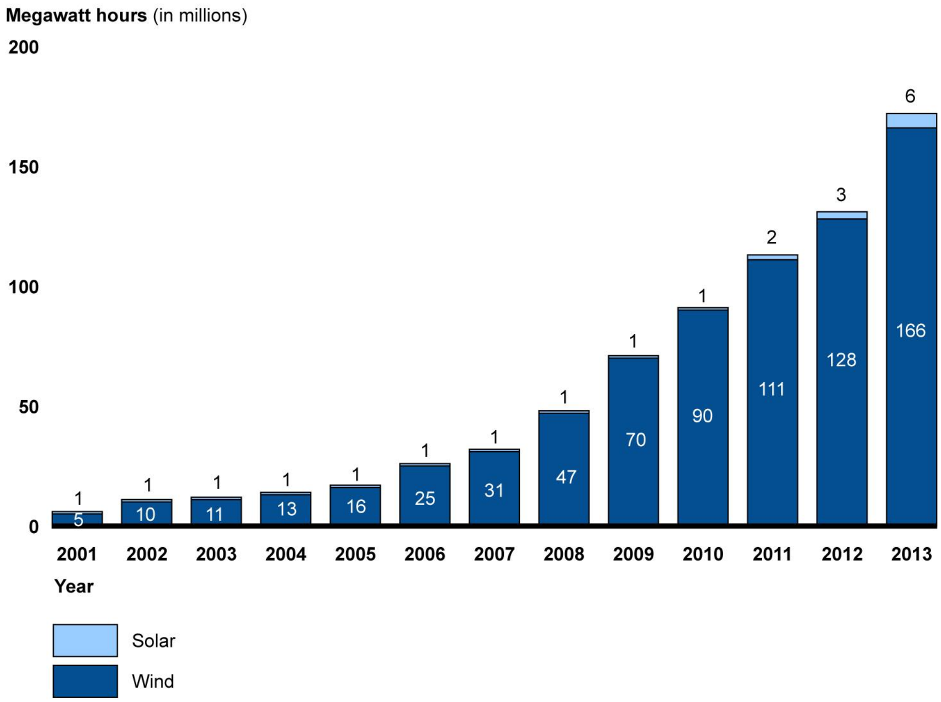
[27]See, for example, EIA, *Today in Energy: Northeast grows increasingly reliant on natural gas for power generation* (Washington, D.C.: November 12, 2013).

[28]Combined-cycle plants use two processes to produce electricity, one of which involves combustion and the other which is thermoelectric. In this type of plant, electricity is first generated by a simple cycle turbine that turns a generator directly as a result of burning fuel in the turbine—similar to jet engines used in aircraft. Such combined-cycle plants also use the heat produced by the simple cycle turbine that would otherwise be released to the atmosphere to heat water to produce steam which turns a steam turbine connected to a generator to produce electricity.

Contribution of Wind and Solar Have Increased

Generating capacity and actual generation from wind and, to a lesser extent, solar power plants increased from 2001 through 2013, with most of the increase occurring since 2007. (See fig. 4.) We have previously found that various federal and state actions have contributed to increases in wind and solar power plant capacity, including financial supports and state renewable portfolio standards.[29] These increases led to wind and, to a lesser extent, solar accounting for a larger share of the nation's energy mix, increasing from just over 0 percent of electricity generation in 2001 to 4 percent in 2013.

Figure 4: Electricity Generated from Wind and Solar Power Plants, 2001 through 2013



Source: GAO analysis of SNL Financial data. | GAO-15-524

Note: Includes generation from units identified by their primary energy source in the most recent year at power plants with capacities of at least 1 megawatt that are connected to the grid and intend to sell electricity to retail consumers or retail service providers.

[29] See GAO-15-302; GAO-14-836; *Wind Energy: Additional Actions Could Help Ensure Effective Use of Federal Financial Support,* GAO-13-136 (Washington, D.C.: Mar. 11, 2013); and *Solar Energy: Federal Initiatives Overlap but Take Measures to Avoid Duplication,* GAO-12-843 (Washington, D.C.: Aug. 30, 2012).

Regarding wind, generating capacity increased about sixteen fold over this period, with 57,000 MW of capacity added from 2001 through 2013 and wind's share of total generating capacity increasing from just over 0 percent in 2001 to 5.4 percent in 2013.[30] However, these plants operate less intensively than some other sources because wind power plants only generate electricity when the wind is blowing. As such, wind's share of the nation's actual generation increased from just over 0 percent in 2001 to about 4 percent in 2013. Generation from wind increased by over 160 million MWh from 2001 through 2013, the second largest increase in actual generation of all energy sources after natural gas. Most of this increase, 136 million MWh (or 84 percent of the total increase), occurred since 2007. The average utilization of wind power plants fluctuated over this period between 26 and 33 percent.

Electricity generated from wind is concentrated in a few states; as shown in table 1, 74 percent of total electricity generated from wind came from 10 states in 2013. In addition, wind can contribute a substantial portion of generation in some areas. For example, in the Upper Midwest region of the country, including states such as Minnesota and Iowa, about 14 percent of the region's electricity came from wind power plants. In addition, representatives from one utility told us they have had hours where 60 percent of the electricity produced on their system came from wind sources, and their system has experienced longer periods with over 50 percent wind generation. By contrast, other regions of the country, such as the southeastern United States, produced less than 1 percent of their total electricity from wind in 2013.

[30]This trend continued in 2014 with the addition of about 5,000 MW of wind generating capacity.

Table 1: Electricity Generation from Wind Power Plants and Percentage of National Wind Electricity Generation in 2013 for the Top 10 States

States	Generation (megawatt hours in thousands)	Percentage of National Wind Electricity Generation	Cumulative Percentage of National Wind Electricity Generation
Texas	35,852	22%	22%
Iowa	15,456	9%	31%
California	11,988	7%	38%
Oklahoma	10,928	7%	45%
Illinois	9,618	6%	50%
Kansas	9,433	6%	56%
Minnesota	8,256	5%	61%
Oregon	7,456	4%	66%
Colorado	7,120	4%	70%
Washington	7,004	4%	74%

Source: GAO analysis of SNL Financial Data. | GAO-15-524

Note: The cumulative percentage column shows the total percentage of a given state and all higher ranking states. For example, the cumulative percentage for the number 5 ranked state, Illinois, is 50 percent and is based on the sum of the top five states' wind power plant generation in 2013 divided by total generation from all wind power plants in 2013. The table includes generation from units identified by their primary energy source in the most recent year at power plants with capacities of at least 1 megawatt that are connected to the grid and intend to sell electricity to retail consumers or retail service providers. Numbers may not sum due to rounding.

Distributed solar generation has also increased

Data on solar generating capacity and actual generation do not include distributed solar installations, such as capacity installed on household or commercial rooftops—known as distributed generation. Data from an industry association show that distributed solar generating capacity has increased to reach over 8,500 MW as of the end of 2014—compared to about 10,000 MW that was installed at larger solar power plants based on SNL data that we reviewed.[a] The electricity generated at such distributed generation sites is not generally measured or managed by the system operator. Nonetheless, it can be a significant portion of the generation mix in some regions. For example, according to the largest utility in Hawaii, solar systems had been installed on 12 percent of residential consumer sites in Hawaii as of the end of 2014, and on the island of Oahu, this capacity was equivalent to about 25 percent of the island's peak electricity needs.

Source: GAO. | GAO-15-524

[a]See Greentech Media and Solar Energy Industries Association, *Solar Market Insight Report 2014 Q4* (Mar. 4, 2015). In addition, since 2010, EIA has collected data on solar and other generating capacity that is "net metered"—when consumers can use electricity they generate that is in excess of their consumption at some times to offset consumption at other times. Though these data have limitations, they suggest that distributed net-metered solar capacity has been a large portion of total solar capacity.

Regarding solar, generating capacity increased by about 7,000 MW, or about eighteen-fold, from 2001 through 2013 at larger power plants with capacities of at least 1 MW. This trend accelerated in 2014 with the addition of over 3,000 MW of solar generating capacity, and total solar generating capacity reached about 10,000 MW. Regarding actual generation, electricity generated at large solar power plants increased about 7 fold—by about 5 million MWh—from 2001 through 2013. The average utilization of solar power plants fluctuated over this period between 16 percent and 25 percent. Despite the growth in solar capacity and generation, large solar power plant generation contributed less than 0.2 percent of total electricity generation nationwide in 2013.[31] More so than wind generation, generation from solar power plants was concentrated in a small number of states. For example, California and Arizona accounted for over half of electricity generation from large solar power plants in 2013.

Contribution of Coal Has Declined

Generating capacity and actual generation from coal-fueled power plants declined from 2001 through 2013 as plants retired and in some cases, witnessed changes in their usage patterns, according to our analysis of SNL data. Coal-fueled electricity-generating capacity was stable for most of this period, but declined over the last couple years as aging plants retired and little new capacity was added. Specifically, from 2001 through 2013, about 29,500 MW of coal-fueled generating capacity retired, with about 75 percent of those retirements occurring from 2009 through 2013.[32] In our October 2012 and August 2014 reports, we found that a

[31]Preliminary estimates from EIA suggest that solar accounted for over 0.4 percent of electricity generation in 2014. (See EIA, *Monthly Energy Review* (Mar. 26, 2015).)

[32]This trend continued in 2014 with the retirement of about 3,700 MW of coal-fueled generating capacity.

number of factors have contributed to companies retiring coal-fueled power plants, including comparatively low natural-gas prices, the potential need to invest in new equipment to comply with environmental regulations, increasing prices for coal, and low expected growth in demand for electricity.[33] We found that the facilities that power companies have retired or plan to retire are generally older, smaller, and more polluting, and some had not been used extensively.

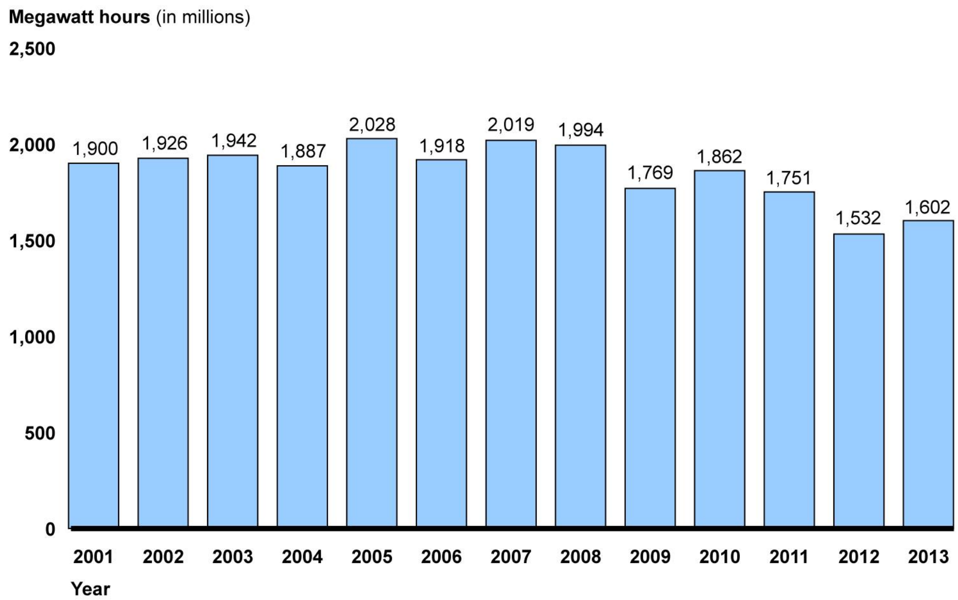
Actual generation from coal declined—in particular since 2008—as natural gas prices fell and made coal-fueled power plants comparatively less competitive (see fig 5). Generation from coal declined in most regions of the country. Several regions, such as New England, experienced large decreases as they shifted away from coal. As coal-fueled generation has declined, coal-fueled power plants have, in general, been utilized less intensively. The average utilization of coal-fueled capacity fluctuated around 70 percent from 2001 through 2008 and then began a general decline to about 59 percent in 2013. For example, representatives from the system operator ISO New England told us that their region no longer regularly uses its coal-fueled power plants to generate baseload electricity.[34] Instead, representatives told us that these plants are more often used to generate electricity during peak periods or when other resources are not available.[35] Retirements of some coal-fueled power plants and the decrease in usage among others led to coal accounting for a smaller share of the nation's generating capacity and generation.

[33]GAO, *Electricity: Significant Changes Are Expected in Coal-Fueled Generation, but Coal is Likely to Remain a Key Fuel Source*, GAO-13-72 (Washington, D.C.: Oct. 29, 2012); and *EPA Regulations and Electricity: Update on Agencies' Monitoring Efforts and Coal-Fueled Generating Unit Retirements,* GAO-14-672 (Washington, D.C.: Aug. 15, 2014).

[34]ISO New England serves Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont.

[35]ISO New England representatives also noted that the region's oil plants provided similar support during the summer and winter months.

Figure 5: Change in Electricity Generated from Coal-Fueled Power Plants, 2001 through 2013



Source: GAO analysis of SNL Financial data. | GAO-15-524

Note: Includes generation from units identified by their primary energy source in the most recent year at power plants with generating capacities of at least 1 megawatt that are connected to the grid and intend to sell electricity to retail customers or retail service providers.

Contribution of Nuclear Has Declined

Generating capacity and actual generation from nuclear power plants both increased from 2001 through 2013, but the share of nuclear in the national electricity mix declined because other sources increased by a larger amount, according to our analysis of SNL data. No new nuclear power plants were built during this period, and four nuclear power plants retired in the last 2 years, accounting for about 4,200 MW of capacity.[36] However, nuclear generating capacity increased by 5 percent from 2001 through 2013 because of capacity increases at some existing plants as owners upgraded equipment or undertook other changes. Regarding

[36]In 2013 and 2014, four nuclear power plants with five nuclear generating units retired. Specifically, in 2013, three plants with four nuclear generating units retired: Kewaunee (574 MW) in Wisconsin, Crystal River Nuclear Unit 3 (877 MW) in Florida, and San Onofre Nuclear Generating Station, Units 2 and 3 in California (1,070 and 1,080 MW, respectively). In December 2014, the Vermont Yankee plant in Vermont (604 MW) retired. These retirements are not reflected in the 2013 capacity numbers presented above because all of the plants were operating during part of 2013.

actual generation, electricity generated at nuclear power plants increased by 3 percent. The average utilization of nuclear power plants fluctuated around 90 percent throughout this period. Since nuclear plants tend to be larger capacity plants that run continuously for long periods of time, the retirement of a single plant can have significant effects on a regional power system. For example, representatives at ISO New England said that the Vermont Yankee nuclear power plant, which retired in December 2014, had generated about 5 percent of total electricity generation in their region in 2014. Since nuclear generating capacity and generation did not increase as much as gas, wind, and solar, nuclear accounted for a slightly smaller share of the national electricity mix, decreasing from 21 percent of generation in 2001 to 20 percent in 2013.

Contributions of Other Sources Has Varied

The contributions of other energy sources to the nation's energy mix have also changed according to our analysis of SNL data, as follows:

- **Hydropower:** Generating capacity and actual generation from hydropower plants increased from 2001 through 2013, by 3,600 MW and 68 million MWh respectively.[37] Generation from hydropower plants varies from year to year based on a region's weather, particularly the amount of rain or snow, according to EIA. The western region generates more electricity from hydropower than any other region and accounted for 57 percent (about 39 million MWh) of the increase in generation during this period. The average utilization of hydropower capacity fluctuated between 28 percent and 38 percent throughout this period. While hydropower generating capacity increased in absolute terms through new construction and increases in capacity at existing hydropower plants, its share of capacity declined because hydropower generating capacity did not increase as much as other sources, such as natural gas and wind.

- **Other sources:** Generating capacity and actual generation from other sources—including oil, biomass, and geothermal together—declined overall from 2001 through 2013. This decline was primarily driven by declines in oil-fueled power plants, where generation declined by over 80 percent and average utilization declined over the period. Two regions, New England and Florida, accounted for a large portion of the decline in oil-fueled power plant generation. Although oil was a relatively small portion of overall generation in the beginning of the

[37]Hydropower sources include conventional hydropower plants and pumped storage.

period, its share of generation declined further as oil prices rose in the mid-2000s. Generating capacity and actual generation from biomass, geothermal, and other sources increased overall from 2001 through 2013. These changes had little effect on the overall national electricity generation mix, as these other sources represent a small and stable portion of generation—about 2 percent of the national total in both 2001 and 2013.

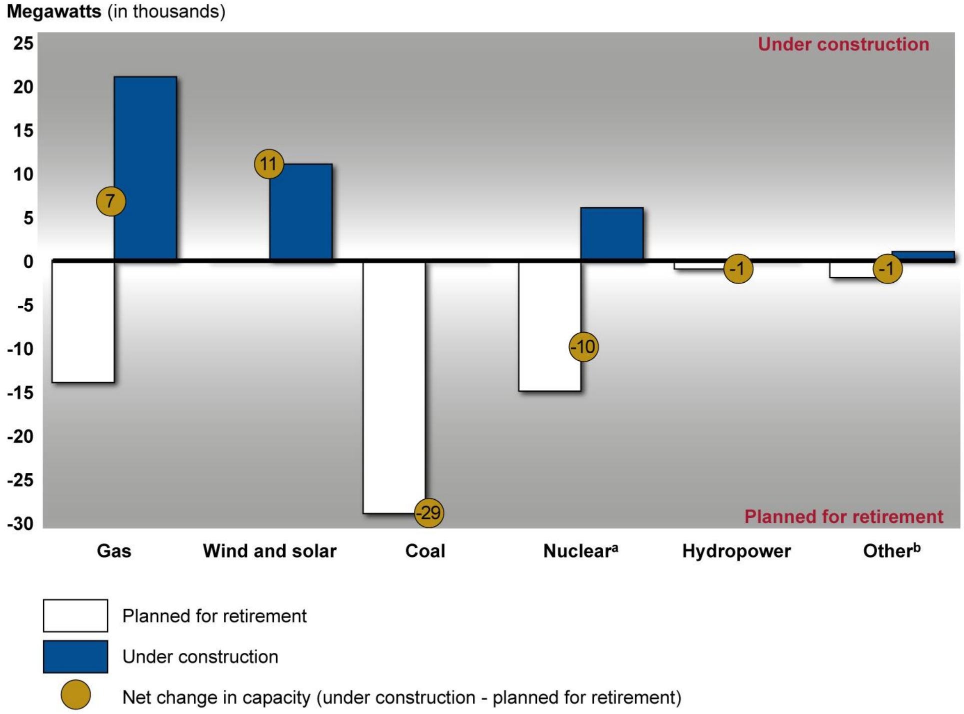
Generating Capacity under Construction and Planned for Retirement Suggest Trends May Continue

Our analysis of SNL data on generating capacity currently under construction and companies' plans to retire generating capacity suggests that these general changes in the electricity generation mix are likely to continue.[38] Figure 6 shows the amount of generating capacity under construction, the amount planned for retirement from 2015 through 2025, and the net change (capacity under construction minus planned for retirement), and highlights that natural gas, wind, and solar capacity may continue to increase. There is no coal capacity under construction, and while about 6,000 MW of nuclear capacity is under construction, more nuclear capacity (about 15,000 MW) is planned for retirement than is under construction.[39] These data do not include capacity that is in pre-construction-planning stages or that has not formally announced retirement.

[38]These data reflect information available through SNL as of April 3, 2015, and include units with announced retirement dates from 2015 through 2025 and units that are currently under construction. These data may not reflect all plans, particularly for later years.

[39]Planned retirements for nuclear plants included officially announced retirements as well as plants in which the license to operate is set to expire. This license expiration date may not reflect an actual intent to retire the plant, it can indicate that the request for a license renewal has either not yet been submitted for an extension, or that the license renewal request has not yet been approved by the Nuclear Regulatory Commission.

Figure 6: Electricity-Generating Capacity under Construction and Planned for Retirement from 2015–2025 by Source



Source: GAO analysis of SNL Financial data. | GAO-15-524

Notes: Includes generating units identified by their primary energy source in the most recent year at power plants with capacities of at least 1 megawatt that are connected to the grid and intend to sell electricity to retail customers or retail service providers. Capacity under construction refers to all capacity under construction, and capacity planned for retirement refers to capacity with planned retirement dates from 2015–2025. Generating capacity refers to the maximum capability of a generating unit to generate electricity. Capacity under construction minus capacity planned for retirement may not equal net change due to rounding.

[a]Planned retirements for nuclear plants included officially announced retirements as well as plants in which the license to operate is set to expire. This license expiration date may not reflect an actual intent to retire the plant; it can indicate that the request for a license renewal has either not yet been submitted for an extension or that the license renewal request has not yet been approved by the Nuclear Regulatory Commission.

[b]The "other" category includes biomass, geothermal, oil, and other nonrenewable sources. The majority of the change in this category is from planned retirements of oil-fueled power plants.

Growth in Electricity Consumption Slowed

Continuing a long-term trend, growth in electricity consumption slowed from 2001 through 2014. According to EIA data on annual national electricity retail sales—a proxy for end-use consumption—the rate of growth of electricity consumption has slowed in each decade since the 1950s, from growing almost 9 percent per year in the 1950s, to over 2 percent per year in the 1980s and 1990s. This decreasing growth trend continued in the 2000s, with electricity retail sales growing by over 1 percent per year from 2001 through 2007, and fluctuating, but remaining largely flat from that time through 2014.[40]

These overall trends mask differences in consumption patterns for different types of consumers, in different regions, and during peak periods of consumption. Regarding consumers, industrial electricity consumption has decreased since 2001, while commercial and residential consumption have increased. Specifically, industrial consumption decreased by 4 percent over the period from 2001 through 2014, and the sector's share of total electricity consumption declined from 29 percent to 26 percent. Meanwhile, residential electricity consumption increased 17 percent, and commercial consumption increased 25 percent over this period. Regarding regional differences, consumption patterns have varied across the country. For example, consumption declined by almost 5 percent in the Northeast (Mid-Atlantic and New England states) since the recession of 2007 and through 2014, while it increased by over 9 percent in the West South Central states of Texas, Louisiana, Oklahoma and Arkansas over that same period. (See app. IV for additional information on consumption by consumer type and region.)

In contrast to the slowdown in the growth of overall electricity consumption, peak consumption has, in some cases, increased. Peak consumption refers to the level of electricity consumed when the overall system usage is at its highest, such as during hot days when air conditioning usage is high.[41] Changes in peak consumption levels have, in some instances, differed from changes in total consumption over the course of a year. For example, in New England, while overall consumption has declined, peak consumption has risen according to EIA.

[40]2014 data are preliminary estimates.

[41]Peak consumption, as used here, is the maximum level of demand over a specified period of time, and is measured in megawatts.

According to literature we reviewed, the following factors have contributed to these changes in electricity consumption:

Distributed generation and electricity consumption data

Growth in distributed generation such as rooftop solar may have also contributed to changes shown in EIA's data on retail electricity sales. Households and commercial facilities that generate some of their own electricity displace some electricity sales. Therefore, actual electricity consumption may be higher than suggested by retail electricity sales data. According to EIA, this effect is difficult to measure because data on electricity generated from distributed generation sources are not readily available.

Source: GAO. | GAO-15-524

- **Changes in the economy:** Changes in electricity consumption are often closely linked to the economy, according to EIA.[42] In this regard, the economic recession from late 2007 through 2009 was associated with a large drop in electricity consumption in the industrial sector. Since many industrial operations operate more evenly throughout the year, declines in industrial operations could lead to reduced electricity consumption throughout the year.

- **Efficiency improvements:** Overall improvements in the efficiency of technologies powered by electricity—such as household appliances and others—have slowed the growth of electricity consumption, according to EIA.[43] For example, according to EIA, a new refrigerator purchased today uses less than a third as much electricity as one purchased in the late 1970s, despite the larger size of today's refrigerators.[44]

- **Changes in the uses of electricity:** Consumer uses of electricity have changed over the last decades, affecting the nature of electricity consumption. For example, the growing use of computers and home entertainment devices has increased the use of electricity. In addition, air conditioning has become more widely used in U.S. households. As a result, a heat wave—often associated with peak levels of electricity consumption—may lead to more electricity consumption during peak periods than in the past.

- **Demand-response activities:** Another factor that may have affected consumption trends, particularly peak consumption, is the increasing use of demand-response activities—steps taken to encourage consumers to reduce consumption during periods of high demand when the costs to generate electricity are high. For example, system operators may call on industrial consumers to reduce their electricity usage during periods of high demand in exchange for a payment or

[42]EIA, *Today in Energy: U.S. economy and electricity demand growth are linked, but relationship is changing* (Mar. 22, 2013).

[43]EIA, *Annual Energy Outlook 2014*, DOE/EIA-0383 (Washington, D.C.: April 2014).

[44]EIA, *Today in Energy* (Mar. 22, 2013).

other financial incentive. In March 2014, we cited FERC data suggesting that the extent of demand-response activities had increased overall—more than doubling from 2005 to reach about 8.5 percent of potential reduction in peak consumption in 2011.[45]

Changes in Generation and Consumption Require System Operators to Take Additional Actions to Maintain Reliability and Affect Electricity Prices to Varying Extents

According to literature we reviewed and stakeholders we interviewed, changes in electricity generation and consumption have required system operators to take additional actions to maintain reliability. Changes in generation and consumption, together with additional actions system operators have taken to maintain reliability, have affected consumer electricity prices to varying extents, though the net effect on prices is unclear.

Changes in Generation and Consumption Require System Operators to Take Additional Actions to Maintain Reliability

According to several stakeholders we interviewed and literature we reviewed,[46] changes in generation and consumption have led system operators to take additional actions to reliably provide electricity to consumers, as follows:

- **Increased reliance on natural gas:** The increased reliance on natural gas to generate electricity in some regions of the country has sometimes required system operators to take additional actions to maintain reliability. Although all fuel-based electricity generation can face fuel supply challenges, natural-gas-fueled power plants face different challenges than sources such as coal, oil, and nuclear. For

[45]The potential to reduce peak electricity consumption describes the capability of consumers participating in demand-response programs to reduce their electricity use, an action that, in turn, may reduce the system's peak electricity consumption. These data reflect the 59 percent of utilities and other entities responding to FERC's survey, rather than the extent of demand-response throughout the United States. See GAO-14-73.

[46]We spoke with 21 stakeholders selected to represent a cross section of the electricity industry and reviewed relevant literature. Throughout the report we use the indefinite quantifier, "several" when three or more stakeholder and literature sources combined supported a particular idea or statement.

example, natural gas is not easily stored on site, so the ability of a natural-gas-fueled power plant to generate electricity generally depends on the real-time delivery of natural gas through a network of pipelines. Some regions have recently experienced challenges in maintaining the delivery of natural gas supplies to power plants. For example, in January 2014, a severe cold weather event know as a "polar vortex" affected much of the central and eastern United States, causing significant outages at plants using various fuel sources and leading to higher than normal demand for natural gas for both electricity generation and home heating. According to FERC, there were no widespread electricity outages. However, challenges delivering fuel to natural-gas-fueled power plants posed significant concerns and resulted in outages at some natural-gas-fueled power plants. System operators took various steps to limit the effect of this event, including relying on power plants that utilize other fuel sources that were more readily available at that time, such as coal and oil, issuing public appeals for conservation, utilizing demand-response resources, and implementing certain emergency procedures. Going forward, several stakeholders raised concerns about the sufficiency of natural gas pipeline capacity in some regions to meet potential greater future needs. However, FERC has reported that actions taken since the 2013–2014 winter—including improved communications between the electricity and natural gas industries and additional cold-weather preparation—led to better operational performance during the 2014–2015 winter, which also presented extremely challenging cold-weather conditions.[47] In addition, a recent Department of Energy (DOE) study suggests that the future needs for interstate natural gas pipelines may be modest relative to the historical level of pipeline capacity additions.[48]

- **Increased use of wind and solar:** The increased use of wind and solar to generate electricity has increased operational uncertainty, which has required system operators to take additional actions to maintain reliability. The electricity that wind and solar power plants provide is variable—that is, the amount of electricity they generate varies with the availability of the wind and sun at a given point in time

[47]FERC, *2014 State of the Markets* (Washington, D.C.: Mar. 19, 2015).

[48]DOE, *Natural Gas Infrastructure Implications of Increased Demand from the Electric Power Sector* (Feb. 2015).

Effects of distributed generation on system operations to maintain reliability

The addition of distributed generation such as rooftop solar can present unique challenges that system operators must manage to maintain reliability. Several stakeholders told us that because distributed generation occurs behind a consumer's meter, such as at an individual residence or business, changes in generation are not visible to or controllable by the system operator without the installation of specialized technology.

Regarding the lack of visibility, increases in distributed generation would be seen by the system operator as decreases in demand, since the electricity generated is used on-site and displaces electricity that would have been provided through the grid. Because system operators only see the net effect of these changes, it is more difficult for them to understand and predict demand.

Regarding lack of control, if distributed generation results in more electricity than customers can use on site, electricity flows can exceed equipment technical specifications, which could require equipment upgrades. Additionally, if there is more distributed generation than can be used by all customers, the imbalance of supply and demand could put the stability of the grid at risk.

Accommodating increased distributed generation may therefore require system operators to, among other things, use models to predict distributed generation patterns or install advanced controls to make distributed generation visible to and controllable by the utility in order to maintain electric reliability.

Source: GAO. | GAO-15-524

and cannot generally be increased by the system operator. Among other things, system operators modulate the operation of traditional power plants—referred to as ramping and cycling—to offset fluctuations in wind and solar electricity generation throughout the day. Because these fluctuations are largely weather-based, several system operators told us they have had to develop forecasting tools to be able to predict wind and solar output in order to effectively schedule other sources to generate electricity when wind and solar sources are not available. According to several stakeholders and literature, the addition of large amounts of wind and solar could require system operators to procure additional ancillary services—commitments from resources to increase or decrease their generation or consumption on short notice to better accommodate unexpected deviations in forecasted output—and invest in upgrades to the transmission system, including new transmission lines. Overall, according to a recent DOE report, wind variability has had a minimal and manageable effect on electricity reliability.[49]

- **Power plant retirements:** The retirement of coal, nuclear, and other power plants may require system operators to take additional actions to maintain reliability. As we found in 2012, in some cases, the retirement of individual plants can contribute to reliability challenges.[50] To address the retirement of power plants, system operators may need to rely on new power plants, utilize more costly existing power plants more often, or invest in upgrades to transmission lines to transfer power from other locations to areas where it is needed, among other things. These actions can take time to complete.[51] For example, according to documentation from ISO New England, up to 8,300 MW of older coal and oil-fueled power plants are considered at risk for retirement by 2020. Although coal and oil-fueled power plants generated only about 7 percent of electricity in ISO New England during 2014, these power plants play more significant roles in generating electricity on peak demand days and have helped system operators maintain grid reliability during challenging periods such as

[49]DOE, *Wind Vision: A New Era for Wind Power in the United States*, DOE/G0-102015-4557 (March 2015).

[50]GAO-12-635.

[51]In some cases, system operators can enter into contractual arrangements to keep a power plant needed for reliability from retiring until solutions are in place to address related reliability concerns.

the polar vortex. According to ISO New England's system plan, preserving the reliable operation of the system will become increasingly challenging as a result of expected retirements, and the region is in a precarious position for the next several winters as retirements continue and actions to address retirements—such as investments in the addition of new transmission and power plants—are years away from completion.[52]

- **Changes in electricity consumption.** Changes in electricity consumption may require system operators to take additional actions to maintain reliability both in the long and short-term. Over the long-term, system operators need to ensure they have sufficient generating and transmission capacity to meet forecasted consumer electricity needs. This means that a system operator may need to continually add more transmission or generation capacity when peak demand is rising, even if average consumption is stable or declining. In the short-term, system operators may need to take actions to increase or decrease the use of power plants and demand-response resources to address deviations between forecasted and actual consumption. According to NERC, the electricity industry faces several challenges in forecasting electricity consumption, because conservation programs, distributed generation, and other changes in electricity consumption have increased the uncertainty of traditional forecasting methods used in long-term and short-term planning.

The degree to which system operators have had to take additional actions to maintain reliability in response to changes in generation and consumption varies regionally based on the extent of these changes and other characteristics. For example, the extent to which system operators manage the grid in response to wind and solar growth will depend on factors such as the relative amount of generation from wind and solar power plants compared to traditional power plants, the size of a region's grid and how interconnected it is with neighboring grids, and other factors. In this regard, representatives of Midcontinent Independent System Operator said they have been able to reliably accommodate larger amounts of wind generation without major operational challenges or the need for significant additional ancillary services because the large size of their grid and its extensive connections to neighboring grids provide a broad base of power plants that system operators can use to balance

[52] ISO New England, *2014 Regional System Plan* (Nov. 6, 2014).

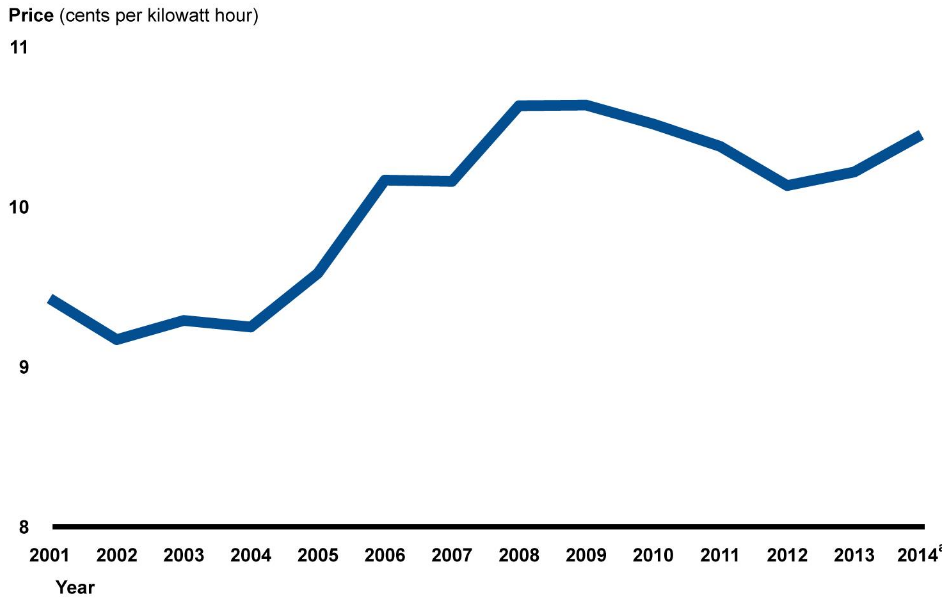
variations in the output of wind power plants.[53] In contrast, according to literature we reviewed and representatives of the largest utility in Hawaii, while that state has been able to reliably integrate high levels of wind and solar, its isolated island grids means it has no neighboring grids to turn to for balancing variations in the output of wind and solar electricity generation. Therefore, system operators there have fewer backup resources to turn to in the event of an unexpected change in wind and solar output than system operators managing larger, more integrated grids.

Changes in Generation and Consumption Influence Electricity Prices, but the Net Effect Is Unclear

Changes in generation and consumption, together with associated actions system operators have taken to maintain reliability, have influenced consumer electricity prices in complex, interrelated, and sometimes contradictory ways, and the net effect of these changes on consumer prices is unclear, based on our review of literature and discussions with stakeholders. National average real consumer electricity prices were nearly 11 percent higher in 2014 than 2001, but prices over this period fell in 5 years, rose in 6 years, and were relatively stable in 2 years (see fig.7). Prices and trends vary by consumer type and region. (App. V provides additional information on prices by consumer type and region.)

[53]The Midcontinent Independent System Operator is a regional transmission organization that coordinates the markets and the movement of wholesale electricity. It operates in all or parts of the following U.S. states: Arkansas, Illinois, Indiana, Iowa, Kentucky, Louisiana, Michigan, Minnesota, Mississippi, Missouri, Montana, North Dakota, South Dakota, Texas, and Wisconsin.

Figure 7: U.S. Real Average Annual Retail Electricity Price, 2001–2014



Source: GAO analysis of Energy Information Administration data. | GAO-15-524

Note: Prices were converted to 2014 dollars using the gross domestic product deflator.

[a]2014 data are preliminary.

Several stakeholders we interviewed and literature we reviewed highlighted several ways changes in generation and consumption, together with associated actions system operators have taken to maintain reliability, have influenced electricity prices. In many cases, these changes in generation and consumption affect prices at the wholesale level. The extent to which and how quickly such wholesale price changes flow through to retail consumer prices depends on a region's regulatory structure, individual retail contracts, consumer type, and other factors. A complete assessment of these factors and their net effect was outside the scope of this report. Nevertheless, literature and stakeholders highlighted the following ways changes have influenced prices:

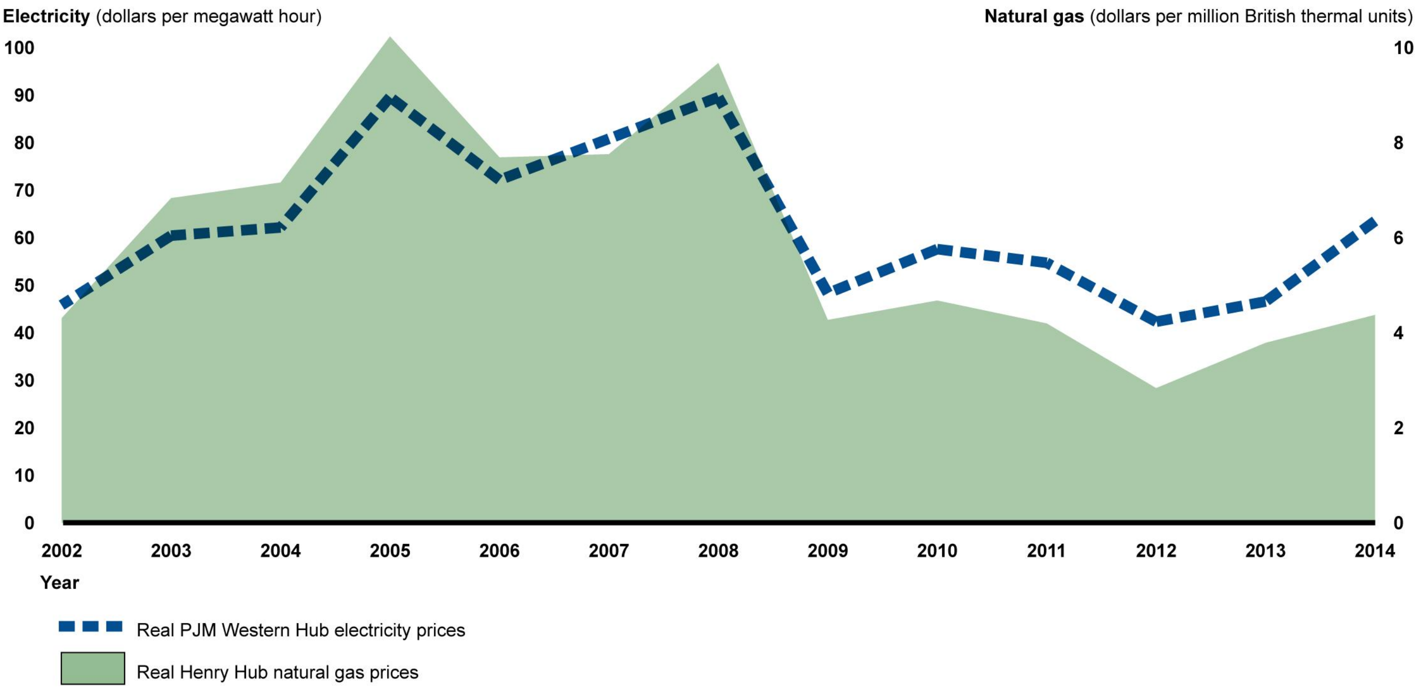
- **Wholesale electricity prices and natural gas prices have tended to move in tandem.** Increases in gas-fueled generation have influenced electricity prices, and average annual prices of natural gas and wholesale electricity—electricity for resale—at key hubs have generally moved in tandem since 2002, the earliest year for which data are available.[54] (Fig. 8 shows real annual average natural gas prices and electricity prices at a key wholesale gas hub and a key electricity hub.[55]) Specifically, natural gas prices more than doubled from 2002 to a peak in 2005, declined somewhat, and peaked again in 2008. According to EIA, these increases in prices were initially due to increasing demand for natural gas and hurricanes that disrupted Gulf Coast natural gas production, among other factors. Natural gas prices dropped in 2009 and have remained low since—the result of lower demand due to the economic recession and increasing natural gas production from development of shale gas resources, among other factors. These changing natural gas prices generally contributed first to higher and then lower wholesale electricity prices since 2002. Additionally, as discussed previously, pipeline constraints and competing demands have affected the delivery of natural gas in some regions. This situation has influenced natural gas and wholesale electricity prices during the winter months. For example, during January 2014, the month a polar vortex occurred, monthly natural gas and wholesale electricity prices in New England—a region heavily dependent on natural gas for generating electricity—reached their highest levels, according to available historical data.[56] Prices moderated the following winter, with January 2015 wholesale electricity prices in New England around 60 percent lower than prices the previous January. More generally, FERC reported that wholesale electricity prices were more moderate in January and February 2015 compared to January and February 2014, helped by more stable and less volatile natural gas prices.

[54]We analyzed real average annual natural gas and wholesale electricity prices. PJM Western Hub electricity prices are day-ahead and were available in SNL starting in 2002.

[55]Prices at other wholesale electricity hubs we analyzed generally follow a similar pattern.

[56]Average day-ahead prices for natural gas in January 2014 at the Algonquin Gate—a key natural gas hub in New England—reached over $25 per million British thermal units. This is the highest monthly price reported by SNL, which has historical data available since 2002. Average, monthly, day-ahead wholesale electricity prices in ISO New England are available from SNL since March 2003. Based on these data, the highest monthly price occurred in all hubs in New England in January 2014.

Figure 8: Real Annual Average Henry Hub Natural Gas Prices and PJM Western Hub Wholesale Electricity Prices, 2002–2014



Source: GAO analysis of SNL Financial and Energy Information Administration data. | GAO-15-524

Note: Henry Hub is a key hub in Louisiana often used as a benchmark for U.S. natural gas prices. PJM is a major grid operator in the Mid-Atlantic region of the United States. PJM's Western Hub is often used as a benchmark for electricity prices in that region. Prices were converted to 2014 dollars using the gross domestic product deflator.

The effect of additional wind- and solar-electricity generation on consumer prices varies. The effect of the increased use of wind and solar sources on consumer electricity prices varies regionally and over time, depending on the relative cost of procuring wind and solar compared with other sources, and the relative costs of integrating wind and solar into the electricity grid. First, as with the addition of other new power plants, if the cost of procuring electricity from wind or solar power plants is higher than the cost of procuring electricity from other sources, the increased use of wind or solar would generally be expected to contribute to higher electricity prices. Alternately, if the cost is lower, the increased use of wind and solar would generally be

Negative wholesale electricity prices

In some instances, wholesale electricity markets experience negative prices—that is, power plant owners paying consumers to take their electricity. For example, owners of certain power plants are sometimes unwilling or unable to reduce their generation even if there is little or no demand for the electricity they generate. This can be the case for owners of wind plants, which may receive $23 per MWh of electricity generated from the federal Production Tax Credit, sometimes making it economically beneficial for these wind plants to pay consumers to take their electricity so they can continue to receive the credit. It can also be the case for power plants that are costly to shut down and restart, such as nuclear plants. Owners of these power plants may be willing to accept negative prices for a short time in order to avoid the cost of shutting the plant down.

Our analysis of available hourly data at electricity hubs within U.S. regional transmission organizations indicates that negative prices occurred on average 0.7 percent of the time from 2005 through 2014.[a] Specific trends in instances of negative prices varied by electricity hub, and the annual percent of negative prices varied across the hubs, ranging from 0 percent to 9.8 percent over that time period. In most cases, any payment consumers might receive as a result of these negative prices is more than offset by the cost of purchasing electricity in other hours. However, negative prices could affect the profitability of individual power plants in areas where negative prices occur.

Source: GAO. | GAO-15-524

[a]Our analysis examined hourly “real-time” electricity prices—electricity for delivery in the next hour—at market hubs. There are a variety of other prices that we did not examine. See appendix I for additional information on our analysis.

expected to contribute to lower prices.[57] These relative costs vary regionally and over time based on, among other things, what alternative power plants exist in a region, the cost of those alternatives, and the amount of federal and state financial support for wind and solar development. For example, according to a DOE study published in 2014, the average cost of procuring electricity from wind power plants was lower than the cost of purchasing electricity through the wholesale markets in 2005—a time of high natural gas and wholesale electricity prices.[58] Conversely, in 2009, after the price of natural gas and wholesale electricity had dropped, the average cost of procuring electricity from wind power plants was higher than the cost of purchasing electricity through the wholesale markets. Some of the costs of wind and solar projects are paid for by taxpayers, which can offset the prices that some retail consumers may have otherwise had to pay for electricity generated from wind and solar. According to this DOE study, prices for procuring wind have been lower as a result of federal and, in some cases, state tax incentives. Second, as with the addition of other new power plants, the effect of new wind and solar sources on consumer prices also depends on the relative costs of any transmission and ancillary services system operators determine are needed to reliably integrate wind and solar sources into the grid. To the extent that additional ancillary services and transmission upgrades are needed, these costs may be passed on to consumers, contributing to higher electricity prices. For example, Texas recently completed a significant transmission project primarily designed to move electricity generated by wind power plants in remote parts of the state to population centers, such as Dallas and Austin. The project has cost close to $7 billion, which will be recovered from Texas electricity consumers through retail electricity prices. Traditional power plants also face grid integration costs. Taken all together, the addition of wind and solar sources could have contributed to higher or lower consumer electricity prices at different times and in different regions.

[57]Additionally, the use of wind and solar power plants may displace higher cost power plants, which can benefit consumers by lowering wholesale market prices. Generally, those resources that displace the most expensive power plants provide the most value to the grid.

[58]DOE, *2013 Wind Technologies Market Report* (August 2014). This report compared generation-weighted average, levelized prices from a sample of long-term wind power purchase agreements in the year the agreements were executed to an annual range of wholesale electricity prices.

Financial viability of baseload power plants

Lower utilization and lower electricity prices have affected the financial viability of some power plants that have traditionally operated as baseload plants in restructured regions, according several stakeholders we interviewed and literature we reviewed. In some instances, baseload plants have been utilized less often in recent years as natural gas-fueled plants have become more cost competitive and the levels of wind and solar generation have increased. Additionally, lower annual wholesale electricity prices starting in 2009 have reduced the revenue power plants earn when they are operating. According to several stakeholders and literature, these factors have sometimes made it difficult for baseload power plants to recover their costs and earn a profit. These difficulties can be exacerbated if additional investment is needed to continue to operate the power plant, for example, the installation of pollution controls to comply with environmental regulations. Some baseload coal and nuclear plants have retired in recent years, with these factors reportedly influencing their decision. For example, Entergy retired its 604 MW Vermont Yankee nuclear plant in 2014, which company financial filings attributed to sustained low natural gas and wholesale electricity prices and high power plant costs, among other factors. According to several stakeholders and literature, if plant utilization and wholesale prices remain low, owners could choose to retire more unprofitable plants in the future, which could raise reliability and price concerns.

Source: GAO. | GAO-15-524

- **The effect of retirements on prices may vary.** The effect of power plant retirements on prices may vary, depending on the cost of the retiring power plant compared to the costs of existing power plants and power plants built to replace retiring power plants, among other things.[59] If retiring plants are less expensive than existing and replacement power plants, their retirement would generally be expected to raise prices. For example, according to EIA, after the initial shutdown of San Onofre Nuclear Generation Station in 2012—a large nuclear power plant in Southern California that produced low-cost electricity—prices in Southern California increased in 2012 and 2013, a change that EIA said is likely attributable in part to the need for more expensive generation in that region to fill the shortage from San Onofre's closure.[60] Alternately, if retiring power plants are replaced by power plants with similar or lower costs, prices could remain unchanged or decline in some hours. The relative cost of retiring and new power plants depends on the specific circumstances of the retiring and potential replacement plants, and may change over time with changing fuel prices and other market factors.

- **Lower electricity consumption could reduce prices.** Lower consumption of electricity—whether in all hours or, particularly, at peak times—can lower the price of electricity in wholesale markets, a decline that may translate into lower prices for retail consumers. Electricity consumption could decline in a given hour, for example, because of demand-response activities in which consumers reduce their electricity consumption in response to prices or other incentives. Electricity consumption could also decline over a longer time period—for example because of reduced consumption due to a slowdown in economic growth or increased adoption of energy efficient technologies. These declines in consumption could lower prices in some or all hours by reducing use of the highest cost plants. According to PJM Interconnection, demand-response activities served

[59]Various factors influence prices in this context. For example, while replacement power plants can influence the degree to which a power plant's retirement influences electricity prices, replacement power plants may not be immediately available. Additionally, retiring power plants may be replaced by power plants using a different fuel source, and the increasing demand for the replacement fuel source could affect prices.

[60]See EIA, *Today in Energy: Extended Nuclear Plant Outages Raise Southern California Wholesale Power Prices* (Mar. 26, 2013). After initially shutting down San Onofre Nuclear Generating station in January 2012, Southern California Edison announced in June 2013 plans to permanently retire the plant.

as an alternative to generating additional electricity during a heat wave in 2012, which lowered prices.

Agency Comments

We provided drafts of this product to DOE and FERC for review and comment. The agencies provided technical comments on early or final drafts, which we incorporated as appropriate.

As agreed with your offices, unless you publicly announce the contents of this report earlier, we plan no further distribution until 30 days from the report date. At that time, we will send copies to the appropriate congressional committees, the Secretary of Energy, the Chairman of FERC, and other interested parties. In addition, the report will be available at no charge on the GAO website at http://www.gao.gov.

If you or your staff members have any questions about this report, please contact me at (202) 512-3841 or ruscof@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. GAO staff who made key contributions to this report are listed in appendix VI.

Frank Rusco
Director, Natural Resources and Environment

Appendix I: Scope and Methodology

This report examines changes in electricity markets. Our objectives were to describe what is known about (1) how electricity generation and consumption have changed since 2001, and (2) the implications of these changes on efforts to maintain reliability, and on electricity prices. To conduct this work, we analyzed data on electricity generation and consumption; reviewed literature, including studies by federal agencies, electricity grid operators, and consultants; and summarized the results of interviews with a nonprobability sample of 21 stakeholders.

To describe changes in electricity generation, we primarily used data from SNL Financial (SNL), current as of April 3, 2015.[1] We generally present data on changes from 2001 through 2013 because 2013 is the most recent year for which complete data are available, though in some instances we present more recent data. We obtained SNL data on power plants with capacities of at least 1 megawatt that are connected to the grid and intend to sell electricity to retail customers or retail service providers. We used the SNL-identified primary energy source for the most recent year for each generating unit at a given power plant and used data for each generating unit for our calculations, where available.[2] We used these generating unit level data to calculate total generating capacity and percentage of total generating capacity for each year from 2001 through 2014 (the most recent year with complete data).

We calculated similar totals and percentages for actual generation for each year from 2001 through 2013 (the most recent year with complete data). However, some power plants provide generation data at the more detailed generating unit level, while others only provide data for the entire

[1]SNL's energy database combines information from multiple sources including EIA, FERC, and others. Data used in this report reflect information collected through a variety of means including the EIA-860 form that collects generator-level specific information about existing and planned power plants and the EIA 923 form that collects data on electric generation and fuel consumption, among other things. Some data are updated annually, but SNL updates others more frequently. As plans may change, actual future retirements and units placed in service may differ from these plans.

[2]For combined-cycle plants, SNL data classified the generating units of combined-cycle plants driven by waste heat as "other nonrenewable" since the primary energy source of the individual unit was waste heat. For the purposes of this report, we reclassified these "other nonrenewable" units at combined-cycle plants to be the primary fuel type of the plant. For example, in a combined-cycle gas plant where one unit burned natural gas and produced waste heat that a second unit then converted into electricity, that second unit was reclassified as a gas unit since combustion of gas was the underlying source of the waste heat.

plant.[3] Where available, we used the generating unit data for our actual generation calculations, and this unit data accounted for 71 percent of total generation in 2013. When generating unit data were not available, we identified the total actual generation for the year at a given plant and divided it among the units based on share of total generating capacity for each generating unit. These plant level data accounted for the remaining 29 percent of actual generation in 2013. This approach implicitly assumes that all units at a given plant are used with the same intensity to generate electricity, an assumption that may not be appropriate on average. To examine changes in the intensity with which power plants are operated, or their utilization, we analyzed annual capacity factor data—the ratio of actual generation to the maximum potential to generate electricity.

To describe changes in electricity consumption and electricity prices, we examined EIA data on retail sales of electricity to consumers. Retail electricity prices can be difficult to determine, according to EIA, as they depend on a customer's rate structure, which can differ from utility to utility. EIA does not directly collect data on retail electricity rates. However, using data collected on revenues and electricity sold, EIA calculates average retail revenue per kilowatt hour as a proxy for retail electricity prices.

To determine the frequency that negative prices occurred in markets of regional transmission organizations, we analyzed price data from hubs at each of the seven regional transmission organizations.[4] The number of hubs and starting-time periods for the data varied with each regional transmission organization. We obtained hourly wholesale electricity prices

[3]Since some power plants have generating units that use different energy sources, relying on plant level data is less precise than data based on generating units.

[4]Specifically, we analyzed the following hourly prices at the following hubs: California Independent System Operator, hour ahead prices at ZP26, NP15, and SP15; Electric Reliability Council of Texas, real time settlement price points at HB Houston, HB North, HB South, and HB West; ISO New England real time prices at Internal Hub, Connecticut, Maine, Northeastern Massachusetts, New Hampshire, Southeastern Massachusetts, Rhode Island, Vermont, and Western/Central Massachusetts; Midcontinent Independent System Operator real time prices at Arkansas, Illinois, Indiana, Louisiana, Michigan, Minnesota, and Texas; New York Independent System Operator real time prices at West, Genesee, Central, North, Mohawk Valley, Capital, Hudson Valley, Millwood, Dunwoodie, New York City, and Long Island; PJM Interconnection real time prices at AEP GEN, AEP-Dayton, ATSIGEN, CHICAGOGEN, Chicago, Dominion, Eastern, N. Illinois, New Jersey, Ohio, WESTINT, and Western; Southwest Power Pool real time prices at North and South.

from SNL for each regional transmission organization and calculated the number and percentage of occurrences of negative prices in each.

We took several steps to assess the reliability of SNL and EIA data. We reviewed relevant documentation, interviewed EIA and SNL representatives, and compared some data elements to those available from other sources. We determined the data were sufficiently reliable for the purposes of this report.

To identify the implications of changes, we reviewed literature and interviewed stakeholders. We identified literature by conducting a literature search and obtaining suggestions from the stakeholders we interviewed. Specifically, we searched sources including Proquest Environmental Science Professional, PolicyFile, Web of Science, and the web sites of system operators and federal agencies from December through March 2015. Stakeholders included power plant owners, grid operators, a state regulator, non-governmental organizations, and federal agencies. We identified stakeholders through our research and analysis of changes in generation and consumption, using our past work, and by considering the suggestions of other stakeholders. We selected stakeholders to represent different perspectives and experiences regarding changes in the industry, and to maintain balance with respect to sources of electricity and stakeholders' roles in the market. Because this was a nonprobability sample, the views of stakeholders we selected are not generalizable to all potential stakeholders, but they illustrate a range of views. Throughout the report we use the indefinite quantifier, "several" when three or more stakeholder and literature sources combined supported a particular idea or statement. Identifying and examining federal agency actions to address the challenges identified was beyond the scope of this review.

We conducted this performance audit from November 2014 to May 2015 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

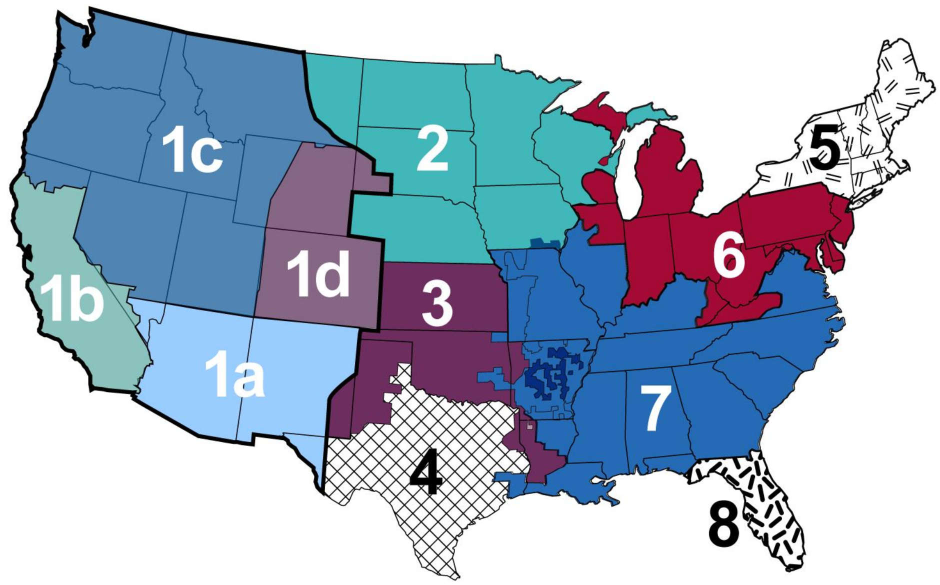
Appendix II: Stakeholders Interviewed

1. American Electric Power
2. American Public Power Association
3. American Wind Energy Association
4. California Independent System Operator
5. Calpine
6. Colorado Public Utilities Commission
7. Department of Energy and the Energy Information Administration
8. Edison Electric Institute
9. Electric Reliability Council of Texas
10. Exelon
11. Federal Energy Regulatory Commission
12. Hawaiian Electric Company
13. Interstate Natural Gas Association of America
14. ISO New England
15. Midcontinent Independent System Operator
16. National Association of Regulatory Utility Commissioners
17. National Renewable Energy Laboratory
18. North American Electric Reliability Corporation
19. PJM Interconnection
20. Solar Energy Industries Association
21. Xcel Energy

Appendix III: Additional Information on Electricity-Generating Capacity and Actual Generation

Figure 9 shows the territories of eight regional reliability entities that set and enforce reliability standards for the electricity industry and four sub-regions for the Western Electricity Coordinating Council. Table 2 provides generating capacity and annual generation by source in these regions as well as Alaska and Hawaii for select years.

Figure 9: Regional Electricity Reliability Entities and Select Sub-Regions



Region
1-Western Electricity Coordinating Council 1a-Arizona, New Mexico, and Southern Nevada Power Area 1b-California-Mexico Power Area 1c-Northwest Power Pool Area 1d-Rocky Mountain Power Area
2-Midwest Reliability Organization
3-Southwest Power Pool Regional Entity[a]
4-Texas Reliability Entity
5-Northeast Power Coordinating Council
6-ReliabilityFirst Corporation
7-SERC Reliability Corporation[a]
8-Florida Reliability Coordinating Council

Sources: GAO analysis of SNL Financial information, and Map Resources (map). | GAO-15-524

Note: This figure shows the territories of the regional reliability entities that set and enforce reliability standards for the electricity industry.

[a]There is an area of overlap between the Southwest Power Pool Regional Entity and SERC Reliability Corporation. For example, some generating unit owners participate in one region and their associated transmission system owner in another. Generating capacity and generation are accounted for in the region where the generation owner participates.

Table 2: Electricity-Generating Capacity and Actual Generation by Regional Reliability Entities and Select Sub-Regions and Source, Select Years

	Generating capacity (Megawatts)			**Actual generation** (Megawatt hours)	
	2001	**2013**	**2014**	**2001**	**2013**
Alaska Systems Coordinating Council	2,238	2,770	2,828	6,857,547	5,539,284
Coal	110	213	216	438,373	633,138
Gas	1,103	1,292	1,336	4,278,373	2,598,541
Hydropower	393	451	470	1,236,663	1,389,353
Nuclear	—	—	—	—	—
Solar	—	—	—	—	—
Wind	2	59	59	951	73,520
Other[a]	630	755	747	903,188	844,733
Florida Reliability Coordinating Council	44,358	62,876	61,857	185,697,736	208,557,784
Coal	10,652	9,352	9,344	64,356,592	45,002,299
Gas	15,731	37,832	38,962	46,225,629	126,964,015
Hydropower	62	55	55	72,524	254,211
Nuclear	3,992	4,516	3,665	31,583,220	26,525,855
Solar	—	75	75	—	105,845
Wind	—	—	—	—	—
Other[a]	13,922	11,047	9,756	43,459,771	9,705,560
Hawaiian Islands Coordinating Council	2,303	2,796	2,809	10,256,177	10,245,387
Coal	202	180	180	1,572,953	1,374,963
Gas	—	—	—	—	—
Hydropower	24	25	25	98,198	78,295
Nuclear	—	—	—	—	—
Solar	—	27	39	—	17,418
Wind	11	217	217	2,122	503,312
Other[a]	2,065	2,347	2,347	8,582,904	8,271,399
Midwest Reliability Organization	43,426	62,567	63,513	188,621,111	222,077,896
Coal	24,274	25,194	25,239	143,841,097	140,074,657
Gas	7,848	15,460	15,569	4,925,321	11,657,402
Hydropower	3,103	3,078	3,050	9,050,062	9,560,246
Nuclear	4,026	4,113	3,611	27,267,808	24,627,348
Solar	—	6	6	—	—
Wind	643	10,620	11,915	1,357,190	31,964,534

	Generating capacity (Megawatts)			Actual generation (Megawatt hours)	
	2001	2013	2014	2001	2013
Other[a]	3,532	4,095	4,124	2,179,633	4,193,709
Northeast Power Coordinating Council	68,218	81,239	81,804	258,890,952	257,674,989
Coal	6,454	4,568	4,497	41,244,470	11,047,738
Gas	26,547	37,953	38,467	80,012,894	108,700,274
Hydropower	8,929	9,657	9,672	28,636,305	34,810,969
Nuclear	9,498	9,942	10,111	73,834,919	81,938,883
Solar	—	243	434	—	135,852
Wind	48	2,448	2,571	27,532	5,402,856
Other[a]	16,742	16,429	16,052	35,134,833	15,638,417
ReliabilityFirst Corporation	211,145	239,330	236,286	945,900,643	928,118,290
Coal	109,101	101,248	97,873	612,759,284	481,767,976
Gas	46,079	73,060	73,060	48,650,270	124,240,421
Hydropower	6,394	7,034	7,054	9,971,592	13,297,101
Nuclear	32,499	34,144	34,138	252,454,921	270,277,700
Solar	—	596	684	—	605,287
Wind	67	8,503	8,972	14,207	20,807,519
Other[a]	17,005	14,745	14,506	22,050,368	17,122,286
SERC Reliability Corporation	227,607	291,675	290,826	993,556,048	1,085,235,067
Coal	97,099	98,459	96,055	576,743,267	453,440,506
Gas	63,612	118,256	119,667	89,722,317	259,404,488
Hydropower	20,904	23,300	23,298	36,406,905	55,768,724
Nuclear	34,466	36,114	36,055	263,336,195	282,359,477
Solar	—	562	860	—	244,061
Wind	2	3,302	3,302	—	9,711,887
Other[a]	11,524	11,684	11,588	27,347,364	24,305,923
Southwest Power Pool Regional Entity	49,172	68,112	68,219	190,881,582	224,303,232
Coal	19,790	22,337	22,276	126,345,671	130,793,911
Gas	23,196	33,387	33,121	45,643,603	56,457,296
Hydropower	2,721	2,807	2,851	4,967,164	4,963,352
Nuclear	1,194	1,205	1,205	10,346,573	7,168,301
Solar	—	55	63	—	117,409
Wind	192	6,137	6,664	—	21,222,890
Other[a]	2,080	2,184	2,040	3,578,571	3,580,073

	Generating capacity (Megawatts)			Actual generation (Megawatt hours)	
	2001	2013	2014	2001	2013
Texas Reliability Entity	75,996	96,734	100,357	303,121,716	354,201,523
Coal	15,766	20,358	20,311	109,950,185	123,373,495
Gas	53,540	58,833	60,882	151,742,875	158,864,340
Hydropower	478	471	472	677,564	258,816
Nuclear	4,737	5,020	5,020	38,162,859	38,314,996
Solar	—	136	202	—	144,720
Wind	848	11,212	12,751	469,092	31,873,580
Other[a]	628	704	720	2,119,141	1,371,576
Western Electricity Coordinating Council Sub-Regions	152,666	219,664	219,630	623,312,059	732,760,758
Arizona, New Mexico, Southern Nevada Power Area	24,978	44,029	43,550	132,647,947	165,776,790
Coal	9,902	10,741	10,185	71,949,708	69,330,603
Gas	8,089	23,681	23,542	23,516,778	53,298,953
Hydropower	2,904	2,953	2,949	8,011,598	6,134,868
Nuclear	3,754	3,937	3,937	28,768,475	31,431,080
Solar	1	1,045	1,267	171	1,273,454
Wind	1	935	935	—	2,077,624
Other[a]	327	737	735	401,216	2,230,207
California-Mexico Power Area	58,581	85,549	84,588	224,063,305	214,879,200
Coal	3,636	2,124	2,124	25,974,063	13,316,627
Gas	30,004	47,423	45,816	113,700,771	116,113,217
Hydropower	14,601	13,816	13,849	25,603,558	24,519,367
Nuclear	4,324	4,390	2,240	33,293,817	17,911,943
Solar	390	4,257	6,810	842,647	3,363,722
Wind	1,539	9,113	9,347	3,193,963	18,966,270
Other[a]	4,088	4,426	4,403	21,454,487	20,688,055
Northwest Power Pool Power Area	55,930	69,566	70,797	197,455,878	275,973,524
Coal	11,649	12,216	12,241	73,737,104	80,187,510
Gas	6,522	12,809	13,718	25,799,861	36,926,514
Hydropower	35,240	35,639	35,654	85,018,547	127,887,335
Nuclear	1,141	1,144	1,141	7,995,920	8,460,890
Solar	—	43	43	—	25,241
Wind	423	6,143	6,433	274,534	16,259,033

	Generating capacity (Megawatts)			Actual generation (Megawatt hours)	
	2001	2013	2014	2001	2013
Other[a]	956	1,573	1,567	4,629,912	6,227,002
Rocky Mountain Power Area	13,176	20,520	20,695	69,144,929	76,131,244
Coal	6,867	8,063	7,959	50,599,848	51,879,203
Gas	2,740	6,187	6,202	10,351,588	9,776,289
Hydropower	3,248	3,304	3,303	7,747,789	6,614,025
Nuclear	—	—	—	—	—
Solar	—	122	128	—	242,034
Wind	38	2,428	2,688	117,535	7,438,202
Other[a]	283	415	415	328,169	181,491

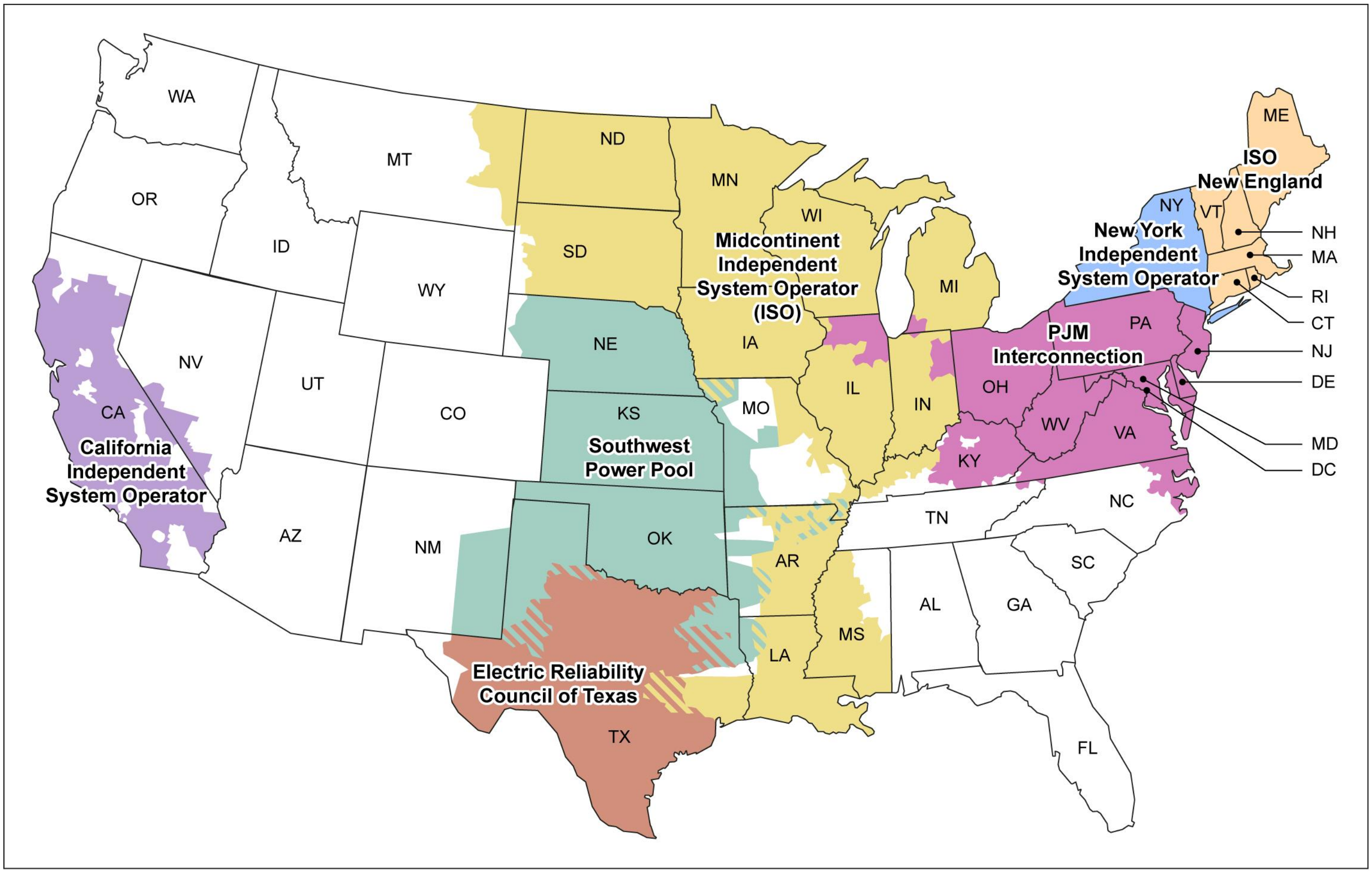
Source: GAO analysis of SNL Financial Data. | GAO-15-524

Notes: Includes generating units identified by their primary energy source in the most recent year at power plants with generating capacities of at least 1 megawatt that are connected to the grid and intend to sell electricity to retail customers or retail service providers. Generating capacity refers to the maximum capability of a facility to generate electricity. This table presents generating capacity and generation by the territories of the eight regional reliability entities that set and enforce reliability standards for the electricity industry, as well as the subregions of the Western Electricity Coordinating Council reliability entity and Alaska and Hawaii. Totals by source may not add up to regional totals due to rounding.

[a]The “other” category includes biomass, geothermal, oil, and other nonrenewable sources.

Regional Transmission Organizations (RTO) manage regional networks of electric transmission lines as system operators, including operating organized markets for buying and selling electricity and other needed services to operate the grid, such as ancillary services. Figure 10 shows the RTOs in the United States, and table 3 provides generating capacity and actual generation by source for each RTO and generating capacity and actual generation by source outside of RTO regions.

Figure 10: United States Regional Transmission Organizations (RTO)



Sources: ISO/Regional Transmission Organization Council (data); Map Resources (map). | GAO-15-524

Note: This graphic reflects RTO borders based on available information as of February 2014, but these borders may change as territory is added or subtracted from RTO regions. The transmission grid that the Electric Reliability Council of Texas (ERCOT) administers is located solely within the state of Texas and constitutes a separate grid from the two other main grids in the continental United States. As a result, ERCOT is largely unregulated by FERC and is instead subject to oversight by the Public Utility Commission of Texas. ERCOT performs similar functions as the RTOs in this map, including managing Texas's transmission system and overseeing wholesale sales of electricity.

Table 3: Electricity-Generating Capacity and Actual Generation by Regional Transmission Organization (RTO) and Source, Select Years

	Generating capacity (Megawatts)			**Actual generation** (Megawatt hours)	
RTO	**2001**	**2013**	**2014**	**2001**	**2013**
California Independent System Operator	53,048	76,659	76,109	234,542,241	222,125,622
Coal	3,636	2,124	2,124	25,974,063	13,316,627
Gas	25,685	40,722	39,694	102,141,788	101,645,137
Hydropower	10,028	9,016	9,048	20,080,610	18,146,664
Nuclear	8,078	8,327	6,177	62,062,292	49,343,023
Solar	388	4,080	6,442	840,150	2,988,588
Wind	1,539	8,440	8,674	3,193,963	17,441,469
Other[a]	3,695	3,951	3,951	20,249,375	19,244,114
Electric Reliability Council of Texas	76,076	96,900	100,523	303,434,765	354,258,731
Coal	15,766	20,358	20,311	109,950,185	123,373,495
Gas	53,540	58,919	60,968	151,742,875	158,873,050
Hydropower	558	551	552	990,613	307,314
Nuclear	4,737	5,020	5,020	38,162,859	38,314,996
Solar	—	136	202	—	144,720
Wind	848	11,212	12,751	469,092	31,873,580
Other[a]	628	704	720	2,119,141	1,371,576
ISO New England	29,787	37,736	37,584	111,187,396	116,820,604
Coal	2,759	2,363	2,359	20,649,885	6,260,600
Gas	9,219	15,616	15,658	29,064,055	52,400,155
Hydropower	3,439	3,784	3,795	4,572,402	8,870,883
Nuclear	4,389	4,651	4,661	33,435,663	37,183,277
Solar	—	188	369	—	70,134
Wind	2	812	824	12,133	1,873,989
Other[a]	9,979	10,323	9,919	23,453,257	10,161,565
Midcontinent Independent System Operator, Inc.	152,894	198,687	198,422	655,730,265	721,842,066
Coal	75,333	78,751	78,518	441,827,469	428,021,841
Gas	50,430	78,162	77,187	87,509,440	128,031,153
Hydropower	4,429	4,508	4,480	11,544,291	10,109,527
Nuclear	12,940	13,784	13,276	95,760,372	96,671,165
Solar	—	55	96	—	8,073
Wind	672	13,711	15,095	1,357,592	39,601,257
Other[a]	9,090	9,717	9,770	17,731,100	19,399,050

RTO	Generating capacity (Megawatts) 2001	2013	2014	Actual generation (Megawatt hours) 2001	2013
New York Independent System Operator	38,432	43,504	44,219	147,703,557	140,854,385
Coal	3,694	2,205	2,138	20,594,585	4,787,138
Gas	17,328	22,336	22,809	50,948,839	56,300,119
Hydropower	5,491	5,873	5,877	24,063,903	25,940,086
Nuclear	5,110	5,291	5,449	40,399,256	44,755,606
Solar	—	55	65	—	65,718
Wind	47	1,636	1,747	15,399	3,528,867
Other[a]	6,763	6,106	6,134	11,681,575	5,476,851
PJM Interconnection	182,213	210,245	208,422	820,446,739	823,309,873
Coal	86,311	80,124	77,019	487,014,941	377,731,154
Gas	38,183	65,600	67,087	40,233,407	124,152,098
Hydropower	7,231	8,463	8,475	9,989,205	14,595,705
Nuclear	33,025	34,713	34,571	259,287,812	277,021,558
Solar	—	579	689	—	614,103
Wind	34	6,059	6,161	11,175	14,991,863
Other[a]	17,427	14,706	14,420	23,910,198	14,203,391
Southwest Power Pool	51,020	70,021	70,384	204,458,085	243,177,493
Coal	21,806	24,706	24,670	139,479,731	147,707,494
Gas	21,513	30,267	30,077	38,177,148	48,086,616
Hydropower	2,804	2,905	2,952	5,101,378	5,366,847
Nuclear	2,462	2,449	2,450	19,072,682	14,033,668
Solar	—	55	63	—	117,409
Wind	195	7,373	8,048	2,630	25,613,231
Other[a]	2,240	2,266	2,124	2,624,516	2,252,228
Non-RTO[b]	293,659	394,012	392,464	1,229,592,522	1,406,325,435
Coal	106,196	104,422	101,361	654,021,756	501,024,276
Gas	69,112	154,550	156,861	144,752,726	395,513,420
Hydropower	65,021	67,489	67,524	141,156,066	202,199,636
Nuclear	28,891	30,290	29,518	218,863,771	231,693,180
Solar	3	2,019	2,683	2,668	2,266,298
Wind	478	11,874	12,553	395,142	31,376,971
Other[a]	23,958	23,368	21,964	70,400,394	42,251,654

Source: GAO analysis of SNL Financial Data. | GAO-15-524

Notes: Includes generating units identified by their primary energy source in the most recent year at power plants with generating capacities of at least 1 megawatt that are connected to the grid and intend to sell electricity to retail customers or retail service providers. Generating capacity refers to the maximum capability of a facility to generate electricity. Totals by source may not add up to regional totals due to rounding.

[a]The “other” category includes biomass, geothermal, oil, and other nonrenewable sources.

[b]Non-RTO include capacity outside of any RTO territory.

Table 4 provides annual generating capacity and generation by regulatory status and source for select years.

Table 4: Electricity-Generating Capacity and Actual Generation by Regulatory Status and Source, Select Years

	Generating capacity (Megawatts)			**Actual generation** (Megawatt hours)	
Year	**2001**	**2013**	**2014**	**2001**	**2013**
Regulated	438,271	523,040	518,718	2,016,452,753	2,029,177,778
Coal	200,162	203,153	199,869	1,218,880,147	1,056,681,680
Gas	112,732	184,863	186,986	221,377,161	404,426,452
Hydropower	38,683	39,767	39,802	81,528,835	100,040,542
Nuclear	56,359	59,283	56,337	436,537,110	427,050,499
Solar	3	504	590	2,668	652,841
Wind	112	8,503	9,674	239,259	24,636,277
Other[a]	30,219	26,967	25,462	57,887,573	15,689,487
Merchant	438,858	604,724	609,410	1,690,642,817	1,999,536,432
Coal	115,339	111,900	108,631	680,632,468	545,540,946
Gas	172,279	281,310	283,356	423,193,117	660,575,297
Hydropower	60,318	62,821	62,901	135,969,634	185,496,120
Nuclear	43,272	45,242	44,785	330,507,597	361,965,974
Solar	388	6,663	10,019	840,150	5,622,203
Wind	3,702	52,614	56,179	5,217,867	141,664,949
Other[a]	43,561	44,174	43,539	114,281,985	98,670,943
Total	877,129	1,127,764	1,128,128	3,707,095,570	4,028,714,210
Coal	315,501	315,052	308,500	1,899,512,616	1,602,222,625
Gas	285,011	466,173	470,342	644,570,279	1,065,001,749
Hydropower	99,001	102,588	102,702	217,498,468	285,536,662
Nuclear	99,631	104,524	101,122	767,044,707	789,016,473
Solar	391	7,168	10,609	842,818	6,275,044
Wind	3,814	61,117	65,852	5,457,125	166,301,227
Other[a]	73,780	71,141	69,001	172,169,557	114,360,430

Source: GAO analysis of SNL Financial Data. | GAO-15-524

Notes: Includes generating units identified by their primary energy source in the most recent year at power plants with generating capacities of at least 1 megawatt that are connected to the grid and intend to sell electricity to retail customers or retail service providers. Generating capacity refers to the maximum capability of a facility to generate electricity. A plant is considered regulated if at least one of a power plant's owners has its rate base regulated by the Public Utility Commission or municipal rate-setting authority for the state in which the plant is located. Merchant plants are plants in which no plant owner has its rate base regulated by a state Public Utility Commission or municipal rate-setting authority. Totals by source may not add up to regulatory status totals due to rounding.

[a]The "other" category includes biomass, geothermal, oil, and other nonrenewable sources.

Table 5 provides generating capacity additions and retirements by source.

Table 5: Electricity-Generating Capacity Additions and Retirements by Source, Actual (2001–2014) and Under Construction and Planned (2015–2025)

Thousand megawatts

	Additions		Retirements	
Source	**Actual**	**Under Construction**	**Actual**	**Planned**[a]
Coal	23	0	33	29
Gas	278	21	51	14
Hydropower	2	0	1	1
Nuclear	0	6	4	15
Solar	10	2	0	0
Wind	63	8	0	0
Other[b]	9	1	15	2

Source: GAO analysis of SNL Financial Data. | GAO-15-524

Notes: Includes generating units identified by their primary energy source in the most recent year at power plants with capacities of at least 1 megawatt that are connected to the grid and intend to sell electricity to retail customers or retail service providers. Under construction includes units that have begun construction and does not include proposed units that are in earlier stages of planning.

[a]Planned retirements includes all announced retirements that have been scheduled from 2015 to 2025. Planned retirements for nuclear plants included officially announced retirements as well as plants in which the license to operate is set to expire. This license expiration date may not reflect an actual intent to retire the plant, it can indicate that the request for a license renewal has either not yet been submitted for an extension, or that the license renewal request has not yet been approved by the Nuclear Regulatory Commission.

[b]The “other” category includes biomass, geothermal, oil, and other nonrenewable sources.

Appendix IV: Additional Information on Electricity Consumption

Table 6 below shows retail electricity sales—a proxy for electricity consumption—by consumer type, and table 7 shows retail electricity sales by region.

Table 6: Retail Electricity Sales by Consumer Type, 2001–2014

Million megawatt hours

Year	Residential	Commercial	Industrial	Other
2001	1,202	1,083	997	113
2002	1,265	1,104	990	106
2003	1,276	1,199	1,012	7
2004	1,292	1,230	1,018	7
2005	1,359	1,266	1,019	8
2006	1,352	1,300	1,011	7
2007	1,392	1,336	1,028	8
2008	1,381	1,336	1,010	8
2009	1,365	1,307	917	8
2010	1,446	1,330	971	8
2011	1,423	1,328	991	8
2012	1,375	1,327	986	7
2013	1,395	1,344	978	8
2014[a]	1,405	1,356	959	8

Source: GAO analysis of Energy Information Administration data. | GAO-15-524

Note: According to the Energy Information Administration (EIA), (1) industrial consumers encompass manufacturing, agriculture, mining, and construction; (2) commercial consumers consist of businesses, institutions, and organizations that provide services, such as schools, stores, office buildings, and sports arenas; (3) residential consumers include households and exclude transportation; and (4) other consumers include those not captured in the other three categories, including transportation.

[a]2014 data are preliminary.

Table 7: Retail Electricity Sales by Census Region, 2001–2014

Million megawatt hours

Year	Midwest	Northeast	South	West	Total
2001	810	471	1,504	609	3,394
2002	825	482	1,561	598	3,465
2003	826	484	1,570	614	3,494
2004	832	491	1,592	632	3,547
2005	869	508	1,638	646	3,661
2006	860	493	1,648	670	3,670
2007	888	510	1,682	685	3,765
2008	878	498	1,667	691	3,734
2009	825	479	1,618	675	3,597
2010	871	496	1,713	675	3,755
2011	871	491	1,700	688	3,750
2012	869	483	1,657	686	3,695
2013	867	490	1,677	691	3,725
2014[a]	861	485	1,695	686	3,728

Source: GAO analysis of Energy Information Administration data. | GAO-15-524

Note: The U.S. Census Bureau divides the United States into four regions. Each region includes several states: Midwest region (Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin), Northeast region (Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont), South region (Alabama, Arkansas, Delaware, District of Columbia, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, and West Virginia), West region (Alaska, Arizona, California, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming). Regional sales may not sum to total because of rounding.

[a]2014 data are preliminary.

Appendix V: Additional Information on Electricity Prices

Table 8 shows average retail revenue per kilowatt hour—a proxy for electricity prices—by consumer type, and table 9 shows average retail revenue per kilowatt hour by region.

Table 8: Real Retail Average Electricity Revenue per Kilowatt Hour by Consumer Type, 2001–2014

2014 year cents per kilowatt hour

Year	Residential	Commercial	Industrial	Other	U.S. Average
2001	11.1	10.2	6.5	9.3	9.4
2002	10.8	10.0	6.2	8.6	9.2
2003	10.9	10.0	6.4	9.4	9.3
2004	10.9	9.9	6.4	8.7	9.3
2005	11.1	10.2	6.7	10.1	9.6
2006	11.9	10.8	7.0	10.9	10.2
2007	11.9	10.7	7.1	10.8	10.2
2008	12.3	11.2	7.6	11.7	10.6
2009	12.5	11.0	7.4	11.5	10.6
2010	12.3	10.9	7.2	11.3	10.5
2011	12.3	10.7	7.1	11.0	10.4
2012	12.2	10.4	6.9	10.5	10.1
2013	12.3	10.4	6.9	10.7	10.2
2014[a]	12.5	10.7	7.0	10.3	10.4

Source: GAO analysis of Energy Information Administration data. | GAO-15-524

Note: Values were converted to 2014 dollars using the gross domestic product deflator. According to the Energy Information Administration (EIA), (1) industrial consumers encompass manufacturing, agriculture, mining, and construction; (2) commercial consumers consist of businesses, institutions, and organizations that provide services, such as schools, stores, office buildings, and sports arenas; (3) residential consumers include households and exclude transportation; and (4) other consumers include those not captured in the other three categories, including transportation.

[a]2014 data are preliminary.

Table 9: Real Retail Average Electricity Revenue per Kilowatt Hour by Census Region, 2001–2014

2014 year cents per kilowatt hour

Year	Midwest	Northeast	South	West	U.S. Average
2001	8.2	13.0	8.5	10.8	9.4
2002	8.1	12.3	8.0	11.2	9.2
2003	8.0	12.7	8.3	10.9	9.3
2004	7.9	12.6	8.4	10.5	9.3
2005	7.9	13.3	8.9	10.5	9.6
2006	8.2	14.4	9.6	11.0	10.2
2007	8.5	14.5	9.5	10.8	10.2
2008	8.8	15.2	10.1	10.9	10.6
2009	9.2	14.7	10.0	11.1	10.6
2010	9.3	14.9	9.7	11.0	10.5
2011	9.3	14.3	9.6	10.9	10.4
2012	9.3	13.5	9.2	11.1	10.1
2013	9.4	13.4	9.2	11.3	10.2
2014[a]	9.5	13.9	9.4	11.7	10.4

Source: GAO analysis of Energy Information Administration data. | GAO-15-524

Notes: Values were converted to 2014 dollars using the gross domestic product deflator. The U.S. Census Bureau divides the United States into four regions. Each region includes several states: Midwest region (Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin), Northeast region (Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont), South region (Alabama, Arkansas, Delaware, District of Columbia, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, and West Virginia), West region (Alaska, Arizona, California, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming).

[a]2014 data are preliminary.

Appendix VI: GAO Contact and Staff Acknowledgments

GAO Contact

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Staff Acknowledgments

In addition to the individual named above, Jon Ludwigson (Assistant Director), Eric Charles, Philip Farah, Quindi Franco, Cindy Gilbert, Paige Gilbreath, Michael Kendix, Armetha Liles, Alison O'Neill, MaryLynn Sergent, Maria Stattel, and Barbara Timmerman made key contributions to this report.

Appendix VII: Accessible Data

Data Table for Highlights Figure: Percentage of Electricity Generation by Source, 2001 and 2013

Percentage of total

	2001	2013
Gas	17.3578	26
Wind and solar	0.2	4
Coal	50.9682	40
Nuclear	20.6085	20
Hydropower	5.8792	7
Other	4.726	3

Source: GAO analysis of SNL Financial data. | GAO-15-524

Note: Other includes biomass, geothermal, oil, and other nonrenewable sources. Numbers may not sum to 100 because of rounding.

Data Tables for Figure 2: Share of Electricity-Generating Capacity and Actual Generation in 2001 and 2013 by Source

Generating capacity – Percentage of total

	2001	2013
Gas	32.4168	41
Wind and solar	0.5	6
Coal	36.0674	28
Nuclear	11.3784	9
Hydropower	11.2938	9
Other [Note A]	8.3957	6

Actual generation – Percentage of total

	2001	2013
Gas	17.3578	26
Wind and solar	0.2	4
Coal	50.9682	40
Nuclear	20.6085	20
Hydropower	5.8792	7
Other [Note A]	4.726	3

Source: GAO analysis of SNL Financial data. | GAO-15-524

Notes: Includes generating units identified by their primary energy source in the most recent year at power plants with capacities of at least 1 megawatt that are connected to the grid and intend to sell electricity to retail customers or retail service providers. Generating capacity refers to the maximum capability of a generating unit to generate electricity. Numbers may not sum to 100 due to rounding.

[a]The “other” category includes biomass, geothermal, oil, and other nonrenewable sources.

Data Table for Figure 3: Electricity Generated from Gas-Fueled Power Plants, 2001 through 2013

Year	Megawatt hours (in millions)
2001	645
2002	608
2003	618
2004	692
2005	768
2006	789
2007	858
2008	844
2009	866
2010	932
2011	957
2012	1156
2013	1065

Source: GAO analysis of SNL Financial data. | GAO-15-524

Note: Includes generation from units identified by their primary energy source in the most recent year at power plants with capacities of at least 1 megawatt that are connected to the grid and intend to sell electricity to retail consumers or retail service providers.

Data Table for Figure 4: Electricity Generated from Wind and Solar Power Plants, 2001 through 2013

Megawatt hours (in millions)

Year	Wind	Solar
2001	5	1
2002	10	1
2003	11	1
2004	13	1
2005	16	1
2006	25	1
2007	31	1
2008	47	1
2009	70	1
2010	90	1
2011	111	2
2012	128	3

Year	Wind	Solar
2013	166	6

Source: GAO analysis of SNL Financial data. | GAO-15-524

Note: Includes generation from units identified by their primary energy source in the most recent year at power plants with capacities of at least 1 megawatt that are connected to the grid and intend to sell electricity to retail consumers or retail service providers.

Data Table for Figure 5: Change in Electricity Generated from Coal-Fueled Power Plants, 2001 through 2013

Year	Megawatt hours (in millions)
2001	1900
2002	1926
2003	1942
2004	1887
2005	2028
2006	1918
2007	2019
2008	1994
2009	1769
2010	1862
2011	1751
2012	1532
2013	1602

Source: GAO analysis of SNL Financial data. | GAO-15-524

Note: Includes generation from units identified by their primary energy source in the most recent year at power plants with generating capacities of at least 1 megawatt that are connected to the grid and intend to sell electricity to retail customers or retail service providers.

Data Table for Figure 6: Electricity-Generating Capacity under Construction and Planned for Retirement from 2015–2025 by Source

Megawatts (in thousands)

	Planned for retirement	Under construction	Net change in capacity (under construction – planned for retirement)
Gas	-14	21	7
Wind and solar	0	11	11
Coal	-29	0	-29
Nuclear [Note A]	-15	6	-10

Hydropower	-1	0	-1
Other [Note B]	-2	1	-1

Source: GAO analysis of SNL Financial data. | GAO-15-524

Notes: Includes generating units identified by their primary energy source in the most recent year at power plants with capacities of at least 1 megawatt that are connected to the grid and intend to sell electricity to retail customers or retail service providers. Capacity under construction refers to all capacity under construction, and capacity planned for retirement refers to capacity with planned retirement dates from 2015–2025. Generating capacity refers to the maximum capability of a generating unit to generate electricity. Capacity under construction minus capacity planned for retirement may not equal net change due to rounding.

[a]Planned retirements for nuclear plants included officially announced retirements as well as plants in which the license to operate is set to expire. This license expiration date may not reflect an actual intent to retire the plant; it can indicate that the request for a license renewal has either not yet been submitted for an extension or that the license renewal request has not yet been approved by the Nuclear Regulatory Commission.

[b]The “other” category includes biomass, geothermal, oil, and other nonrenewable sources. The majority of the change in this category is from planned retirements of oil-fueled power plants.

Data Table for Figure 7: U.S. Real Average Annual Retail Electricity Price, 2001–2014

Year	Price (cents per kilowatt hour)
2001	9.427
2002	9.17
2003	9.29
2004	9.249
2005	9.585
2006	10.167
2007	10.159
2008	10.632
2009	10.636
2010	10.518
2011	10.378
2012	10.133
2013	10.218
"2014 [Note A]	10.45

Source: GAO analysis of Energy Information Administration data. | |GAO-15-524

Note: Prices were converted to 2014 dollars using the gross domestic product deflator.

[a]2014 data are preliminary.

Data Table for Figure 8: Real Annual Average Henry Hub Natural Gas Prices and PJM Western Hub Wholesale Electricity Prices, 2002–2014

Year	Real PJM Western Hub electricity prices (dollars per megawatt hour)	Real Henry Hub natural gas prices (dollars per million British thermal units)
2002	45.8067	4.3048
2003	60.4112	6.8305
2004	62.1304	7.1584
2005	89.5494	10.2322
2006	72.1313	7.68809
2007	80.8017	7.75547
2008	89.5319	9.67186
2009	48.2912	4.26739
2010	57.5725	4.67575
2011	54.7008	4.19331
2012	42.299	2.83199
2013	46.5498	3.78484
2014	63.4827	4.373

Source: GAO analysis of SNL Financial and Energy Information Administration data. | GAO-15-524

Note: Henry Hub is a key hub in Louisiana often used as a benchmark for U.S. natural gas prices. PJM is a major grid operator in the Mid-Atlantic region of the United States. PJM's Western Hub is often used as a benchmark for electricity prices in that region. Prices were converted to 2014 dollars using the gross domestic product deflator.

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