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# U.S. Energy in the 21<sup>st</sup> Century: A Primer

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Since the start of the 21<sup>st</sup> century, the U.S. energy system has changed tremendously. Technological advances in energy production have driven changes in energy consumption, and the United States has moved from being a net importer of most forms of energy to a declining importer—and a net exporter in 2019. The United States remains the second largest producer and consumer of energy in the world, behind China.

Overall energy consumption in the United States has held relatively steady since 2000, while the mix of energy sources has changed. Between 2000 and 2019, consumption of natural gas and renewable energy increased, while oil and nuclear power were relatively flat and coal decreased. In the same period, production of oil, natural gas, and renewables increased, while nuclear power was relatively flat and coal decreased. Overall energy production increased by 42% over the same period.

Increases in the production of oil and natural gas are due in part to technological improvements in hydraulic fracturing and horizontal drilling that have facilitated access to resources in unconventional formations (e.g., shale). U.S. oil production (including natural gas liquids and crude oil) and natural gas production hit record highs in 2019. The United States is the largest producer of natural gas, a net exporter, and the largest consumer.

Oil, natural gas, and other liquid fuels depend on a network of over three million miles of pipeline infrastructure. Increases in fuel production led to a realignment of the U.S. pipeline network, which expanded by an additional 58,000 miles of pipeline between 2004 and 2019, as well as the conversion, reversal, and expansion of existing pipelines. The trajectory of future pipeline development is uncertain due to ongoing permit challenges and litigation for current pipeline expansion efforts.

Coal, used primarily for electricity generation, supplied 23% of electricity generation in 2019, while overall consumption declined by 48% since 2007, in the face of increasing competition from natural gas and renewables. Nuclear power faces significant challenges as a future source of electric power generation with more facilities going offline than coming online since 2000.

The electric power industry faces uncertainty over how to address transmission and reliability within an environment of aging infrastructure, potential cybersecurity threats, and continued interest in renewable energy and other low carbon sources of electricity. Reliability and electricity prices are complicated by environmental regulations, the rising availability of natural gas for electricity generation, and the intermittent nature of renewables.

Renewable energy consumption nearly doubled between 2000 and 2019, primarily due to increased use of wind and solar for electric power generation and biofuels for transportation. New electric power capacity additions for wind and solar have exceeded those for coal and natural gas in four of the last five years. Small-scale solar, which is of particular interest because it rarely requires new transmission infrastructure, can be installed in a variety of geographies, and may financially benefit individuals and communities. Renewables also include hydropower, geothermal energy, and other types of biomass. Each energy product (e.g., heat, electricity, and liquid fuels) derived from these sources has a unique market and policy considerations.

Adoption of energy-efficiency technologies in buildings, transportation, and industry may support policy objectives toward energy security and reducing energy consumption (e.g., consumers saving money, avoiding greenhouse gas emissions). Policy options include mandatory efficiency standards and programs encouraging adoption of existing technologies, among others. Resulting changes in energy consumption may also be impacted by changes in demand for energy services.

While a majority of energy production occurs on nonfederal lands, some production occurs on federal lands. In 2019, energy production on federal lands increased for oil and natural gas, with agencies managing numerous leases for renewable energy production (e.g., solar and wind).

Congress has been interested in energy production and consumption for decades. Current topics of concern to Congress include reliability and resilience, infrastructure, efficiency, exports, imports, prices, energy independence, security, and geopolitics, as well as environmental and climate effects. Legislation has been introduced in both houses of Congress to address these issues and others.

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## Introduction: Continued Growth

The United States has been an integral part of the global energy sector for many decades. It is a global leader in energy production, consumption, and technology, and its energy market is highly sophisticated. Its energy prices, for the most part, are determined in the marketplace and rise or fall with changes in supply and demand. The United States is a major producer of all forms of energy—oil, natural gas,<sup>1</sup> coal, nuclear power, and renewable energy.

Since the beginning of the 21<sup>st</sup> century, the U.S. energy sector has transformed from a situation of declining production, especially of oil and natural gas, to one in which the United States is a growing producer. Exports of energy are rising while imports are falling. Prices, technology, and regulations have prompted changes in the energy mix.

This report provides an overview of U.S. energy issues, and it serves as an initial resource document for related information, data, and CRS contacts. The report is organized around the major fuels and energy sources used in the United States. It also highlights the role of the federal government, particularly the use of federal lands in energy production. It does not focus on security, research and development, or environmental issues, although those subjects are also critical to the U.S. energy sector.

## Issues for Congress

### Policy Goals

Energy policy is a perennial concern for Members of Congress. Energy supply and consumption are key drivers of economic activity. There is ongoing debate over U.S. energy policy given the wide range of possible energy sources; their availability in terms of domestic vs. foreign resources, the economic costs and benefits of developing those resources; and the effects (economic, environmental, social, etc.) of their use. Additionally, environmental policy also has an effect on the energy sector, especially fuel use.

The United States has access to a wide range of energy sources, including fossil fuels (e.g., coal, petroleum, and natural gas), nuclear, and renewables (e.g., wind, solar, hydropower, geothermal, biomass). In addition, increases in energy efficiency have allowed the United States to consume less energy over time, extending existing supplies. Different U.S. sectors employ different sources. For example, nuclear energy is used exclusively in electric power generation, along with other sources, while the transportation sector is largely dependent on petroleum in the form of gasoline, diesel fuel, and jet fuel. However, the energy profile has changed dramatically in recent years. Coal had been the predominant fuel for electric power generation for decades, but between 2000 and 2019, natural gas use in power generation grew by 163%. Over the same time, non-hydroelectric renewable energy grew by 495%.<sup>2</sup> There is a growing market for electric passenger vehicles, although they do not yet represent a significant share of transportation energy use.

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<sup>1</sup> Throughout this report, natural gas figures are reported for dry production, with the exception of production on federal lands, which is reported in gross withdrawals. Gross withdrawals include all gases withdrawn from gas, oil, or coalbed wells, including natural gas, natural gas liquids, and nonhydrocarbon gases but excluding lease condensate. Dry production refers more narrowly to natural gas production with gas liquids and nonhydrocarbon gases removed.

<sup>2</sup> U.S. Energy Information Administration (EIA), *Electric Power Annual 2010*, Table 2.1.A, November 2011, and EIA *Electric Power Monthly*, Table 1.1, July 2020.

The shift in energy use over time has led to a decrease in total U.S. energy-related carbon dioxide (CO<sub>2</sub>) emissions. Since peaking in 2007, annual emissions have decreased roughly 2% through the end of 2019.<sup>3</sup> Much of this decrease has been a result of changes in the electricity sector, where coal use has decreased, replaced by lower-carbon natural gas and renewable generation. The economic downturn in 2008–2009 also played a role as energy consumption is correlated with economic activity.

## COVID-19

The COVID-19 pandemic and subsequent response have upended many of the ways that businesses, schools, and households operate day to day. Economic activity, which partly drives energy consumption, has declined. These factors have led to significant shifts in how Americans consume energy. For example, U.S. consumption of petroleum products (including gasoline and diesel fuel) fell by more than 30% from the start of 2020 through mid-March of 2020.<sup>4</sup> Annual petroleum consumption decreased by 12% from 2019 to 2020.<sup>5</sup> EIA projects consumption to remain below 2019 levels in 2021 and fully recover in 2022. Likewise, some areas of the country saw decreases in electricity demand as businesses were shut down in response to COVID-19 mitigation.<sup>6</sup> Across the United States, electricity consumption decreased by 3.8% in 2020, while EIA forecasts an increase of 2.1% in 2021 relative to 2020.<sup>7</sup> It is uncertain whether any of these changes in energy supply and use will continue after the pandemic, or whether the U.S. energy system will return to the trends of previous years.

## Legislation

Energy policy has often been legislated in large bills that deal with a wide variety of issues, with debate spanning several sessions. The Energy Policy Act of 2005 (EPAAct 2005; P.L. 109-58) was a comprehensive general legislation, with provisions and authorizations in almost all areas of energy policy. The Energy Independence and Security Act of 2007 (EISA, P.L. 110-140) set new target fuel economy standards for cars and light trucks, and expanded the Renewable Fuel Standard (RFS). EISA also included energy efficiency standards for appliances and other equipment, and provisions on industrial and building efficiency, which have continued to be of interest to Members.

In the 116<sup>th</sup> Congress, both the House and Senate debated large energy bills. S. 2657, the American Energy Innovation Act of 2020,<sup>8</sup> was considered by the Senate starting March 5, 2020. On March 9, a cloture motion on the bill failed on a 15-73 vote. The bill incorporated language from several energy and mineral bills reported by the Senate Committee on Energy and Natural

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<sup>3</sup> EIA, *U.S. Energy-Related Carbon Dioxide Emissions, 2019*, Washington, DC, September 30, 2020, <https://www.eia.gov/environment/emissions/carbon/>.

<sup>4</sup> Jesse Barnett, *COVID-19 Mitigation Efforts Result in the Lowest U.S. Petroleum Consumption in Decades*, EIA, Washington, DC, April 23, 2020, <https://www.eia.gov/todayinenergy/detail.php?id=43455>.

<sup>5</sup> EIA, *Short-Term Energy Outlook*, March 9, 2021, <https://www.eia.gov/outlooks/steo/>.

<sup>6</sup> April Lee and Jonathan DeVilbiss, *Daily Electricity Demand Impacts from COVID-19 Mitigation Efforts Differ by Region*, EIA, Washington, DC, March 7, 2020, <https://www.eia.gov/todayinenergy/detail.php?id=43636>.

<sup>7</sup> EIA, *Short-Term Energy Outlook*, March 9, 2021, <https://www.eia.gov/outlooks/steo/report/electricity.php>.

<sup>8</sup> The American Energy Innovation Act is an Energy and Natural Resources Committee substitute amendment to S. 2657, the Advanced Geothermal Innovation Leadership (AGILE) Act of 2019, as reported by the committee. For more information on S. 2657, see CRS Report R46372, *Summary and Analysis of S. 2657, the American Energy Innovation Act*, coordinated by Brent D. Yacobucci.

Resources. H.R. 4447, the Clean Economy Jobs and Innovation Act, was passed by the House on September 24, 2020. The bill incorporated language from several energy and mineral bills introduced and/or reported by various House committees. Provisions from S. 2657 and H.R. 4447 were incorporated into the Consolidated Appropriations Act, 2021 (P.L. 116-260). Division Z, the Energy Act of 2020, promotes increased energy efficiency in homes, schools, and federal buildings; expands research and development in nuclear energy, energy storage, electric vehicles, renewable energy, and carbon capture utilization and storage (CCUS); and promotes energy storage development.

## U.S. Energy Profile

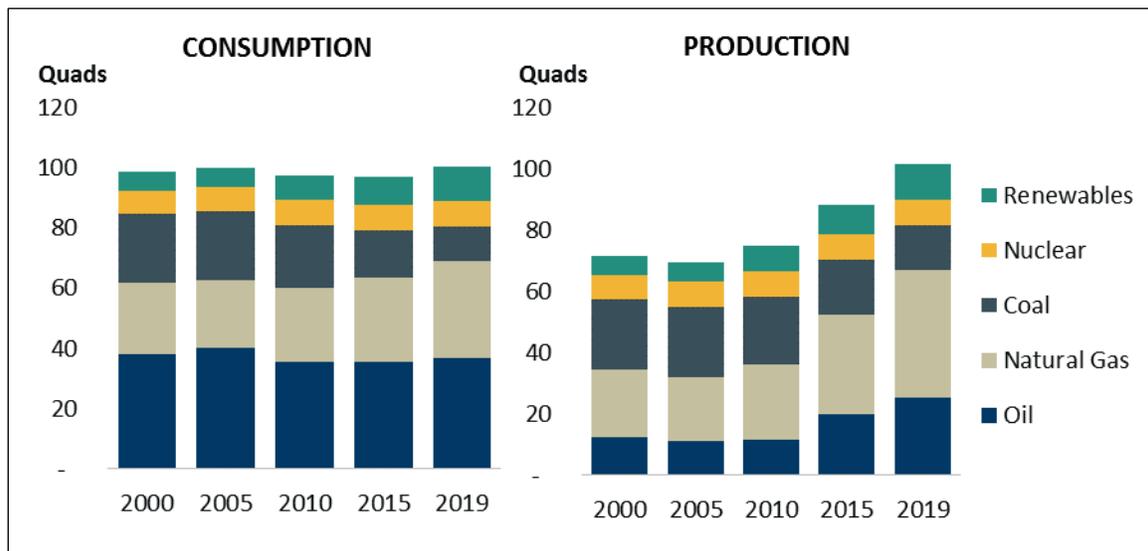
The United States is the second largest producer and consumer of energy in the world, behind China.<sup>9</sup> U.S. primary energy consumption (see **Figure 1**) has held relatively steady since 2000, increasing by 2% by 2019; however, the fuel mix has changed. While oil has remained at almost 40% of the fuel mix, natural gas and renewables have increased in both percentage and absolute terms while coal consumption declined. Nuclear generation has stayed flat.

U.S. energy production between 2000 and 2019 increased 42%, altering the previous position of the United States as a growing importer of energy. (See **Figure 1**.) Oil production has increased by 106% during the time frame, the largest increase of all fuel types. Renewable energy production (including hydropower) has risen the next fastest, growing 91%, followed by natural gas production at 87%. The increase in production of oil and natural gas resources comes from innovations in extraction from *unconventional* (or *tight*) formations, such as shale (see shaded box below, “Unconventional Shale Resources Make the Difference”). Domestic coal production, on the other hand, has declined during the same period by about 37%.

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<sup>9</sup> BP, *Statistical Review of World Energy*, 2020, p. 8.

**Figure I. U.S. Primary Energy Consumption and Production by Fuel 2000-2019**  
Quadrillion Btu (Quads)



**Source:** Data compiled by CRS from U.S. Energy Information Administration (EIA), *Monthly Energy Review*, October 27, 2020, Table I.3, “Primary Energy Consumption by Source”; and EIA, *Monthly Energy Review*, October 27, 2020, Table I.2, “Primary Energy Production by Source.”

**Notes:** Renewables include hydropower, geothermal, solar, wind, and biomass (including biofuels).

The change in the U.S. consumption fuel mix has occurred primarily in the electricity sector where fuel substitutes are more readily available (see “The Electric Power Sector: In Transition”). Electric power generation in 2019 came from coal (23%), natural gas (38%), nuclear (19%), renewables (18%),<sup>10</sup> and petroleum (<1%), according to the U.S. Energy Information Administration (EIA).<sup>11</sup> In 2000, coal accounted for 52% of the electricity fuel mix and natural gas was 16%, nuclear was almost 20%, and renewables were 9%.

Industrial use of energy has also experienced changes in recent years, but not to the same degree as electric power generation. Energy in transportation remains dominated by petroleum, which made up 91% of the fuel used in transportation in 2019, compared to 97% in 2000.<sup>12</sup>

### Unconventional Shale Resources Make the Difference

The United States saw a rise in natural gas and oil production starting in 2006 and 2008, respectively, driven mainly by technology improvements—especially in hydraulic fracturing and directional drilling—which have enabled the extraction of oil and gas from unconventional shale formations. The United States has been the world’s largest producer of natural gas since 2009 and of petroleum liquids since 2014, according to the BP Statistical Review of World Energy 2020. Production from shale formations comprised 75% of U.S. natural gas production in 2019 and 48% of oil production. The contribution of unconventional shale resources to both oil and natural gas U.S. production is expected to grow.

Determination of whether a formation is unconventional or conventional depends on its geology. Unconventional formations typically are fine-grained, organic-rich, sedimentary formations—usually shales and similar rocks. These

<sup>10</sup> In this report, renewables refer to hydropower, biofuels, wood biomass, wind, waste, solar, and geothermal energy.

<sup>11</sup> Data for 2000-2010 from EIA, *Electric Power Annual 2010*, Table 2.1.A, November 2011; and data for 2011-2019 from EIA, *Electric Power Monthly*, Table 1.1, July 2020.

<sup>12</sup> EIA, *Monthly Energy Review*, October 27, 2020, Table 2.5, “Transportation Sector Energy Consumption.”

unconventional formations are both the source of and the reservoir for oil and natural gas, unlike conventional petroleum reservoirs, which trap oil and gas that have migrated to the reservoir from a different source.

The Society of Petroleum Engineers describes “unconventional resources” as petroleum accumulations that are pervasive throughout a large area and are not significantly affected by pressure exerted by water (hydrodynamic influences); they are also called “continuous-type deposits” or “tight formations.”<sup>13</sup> Although the unconventional formations may be as porous as other sedimentary reservoir rocks, their extremely small pore sizes and lack of permeability (i.e., connectivity between the pores) means that the oil and gas are not recoverable through conventional means of extraction. Instead, hydraulic fracturing technology combined with horizontal drilling creates new fractures, or extends existing fractures, enhancing permeability and enabling the oil and gas to flow to the well and up to the surface.

In contrast, conventional oil and natural gas deposits formed as hydrocarbons migrated from organic-rich source rocks into porous and permeable reservoir rocks, such as sandstones and carbonates. The hydrocarbons remained in the reservoir rocks because they are trapped beneath an impermeable *cap-rock* (such as shale). The trapped oil and gas can flow into a well drilled through the cap-rock and into the reservoir rock under natural pressure, or by using conventional enhancement techniques such as flooding the reservoir with water. Conventional enhancement techniques such as water flooding are ineffective in unconventional shale formations because of their low permeability.

## Crude Oil and Petroleum Products: Increased Production and Exports<sup>14</sup>

Access to crude oil and petroleum products (e.g., gasoline, diesel fuel, heating oil, and jet fuel) at reasonable prices has been an element of U.S. energy, national security, and economic policy for decades. Geopolitical events, along with domestic price and allocation control policies, in the 1970s resulted in reduced U.S. access to world oil supplies, rapidly escalating prices, mandatory rationing, and localized shortages. Combined with an outlook at that time for increasing U.S. oil demand, decreasing domestic production, and high import dependency, these circumstances facilitated enactment of landmark legislation such as the Energy Policy and Conservation Act (EPCA, P.L. 94-163) in 1975.<sup>15</sup> EPCA policies that have affected the oil sector include the Strategic Petroleum Reserve (SPR),<sup>16</sup> which still exists, and a crude oil export prohibition that was repealed in 2015.<sup>17</sup>

Petroleum product consumption in the United States, which has been relatively stable since 2000, was approximately 19.4 million barrels per day (bpd) during 2019, roughly 20% of global demand and more than any other country. The transportation sector, which accounts for approximately 70% of U.S. petroleum consumption, is largely dependent on oil.

Notable changes in the U.S. oil sector since 2000 include a doubling of crude oil production, expansion of U.S. refining capacity, and nearly balanced petroleum trade (imports minus exports; see **Figure 3**). Oil production in the United States for 2019 was larger than any other country. U.S.-based oil refining capacity increased by 17% and these assets are generally recognized as

<sup>13</sup> Society of Petroleum Engineers, *Glossary of Terms Used in Petroleum Reserves/Resources Definition*, [http://www.spe.org/industry/docs/GlossaryPetroleumReserves-ResourcesDefinitions\\_2005.pdf](http://www.spe.org/industry/docs/GlossaryPetroleumReserves-ResourcesDefinitions_2005.pdf).

<sup>14</sup> Phillip Brown, CRS Specialist in Energy Policy, is the author of this section.

<sup>15</sup> EPCA, as amended, is available at 42 U.S.C. §6201 et seq.

<sup>16</sup> For additional information, see CRS Report R42460, *The Strategic Petroleum Reserve: Authorization, Operation, and Drawdown Policy*, by Robert Pirog.

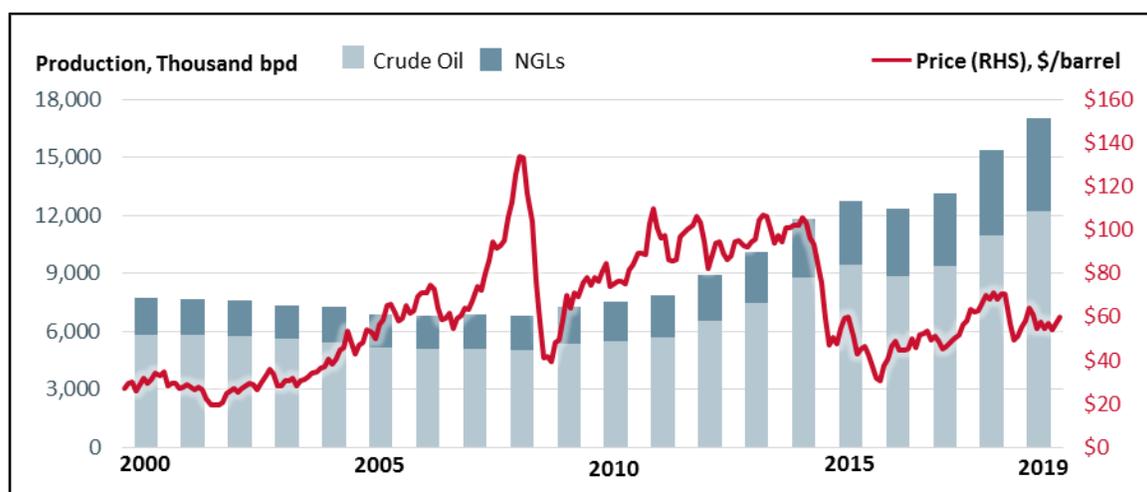
<sup>17</sup> For additional information, see CRS Report R44403, *Crude Oil Exports and Related Provisions in P.L. 114-113: In Brief*, by Phillip Brown, John Frittelli, and Molly F. Sherlock.

some of the most sophisticated and cost-competitive in the world. Annualized petroleum exports—crude oil and products—from the United States increased by a factor of eight over the last 20 years. These developments have affected global oil supply and prices, and at times have been leveraged to impose economic sanctions on certain oil producing countries with the goal of achieving foreign policy objectives.<sup>18</sup>

## Crude Oil and Natural Gas Liquids Production

Approximately 12.2 million bpd of crude oil was produced in the United States during 2019, the highest annual level in the history of the sector. Combined with 4.8 million bpd of natural gas liquids (NGLs; see the “Natural Gas Liquids” section, below), total production during the year was nearly 17 million bpd for these petroleum liquids (see **Figure 2**).<sup>19</sup> Oil production in the United States had been in general decline for nearly 40 years (1970-2008). However, this downward trend reversed, primarily through the application of horizontal drilling and hydraulic fracturing technology to access tight oil (see shaded box on “Unconventional Shale Resources Make the Difference” above). Between 2008 and 2019, annual production of U.S. tight oil increased by more than 7 million bpd. Tight oil represented the largest portion of domestic production volume in 2019.<sup>20</sup>

**Figure 2. U.S. Crude Oil Production, NGL Production, and WTI Spot Price**  
Calendar Years 2000-2019



**Source:** CRS analysis of U.S. Energy Information Administration oil production, NGL production, and price data.

**Notes:** Production numbers represent annual averages. Prices reflect calendar monthly averages. WTI = West Texas Intermediate. Bpd = barrels per day. NGLs = Natural Gas Liquids. RHS = Right Hand Side.

<sup>18</sup> For additional information, see CRS Report R46213, *Oil Market Effects from U.S. Economic Sanctions: Iran, Russia, Venezuela*, by Phillip Brown.

<sup>19</sup> For additional information about NGLs, see CRS Report R45398, *Natural Gas Liquids: The Unknown Hydrocarbons*, by Michael Ratner.

<sup>20</sup> EIA, *Tight Oil Production Estimates by Play*, at <https://www.eia.gov/energyexplained/oil-and-petroleum-products/data/US-tight-oil-production.xlsx>, accessed August 27, 2020.

## Oil Transportation and Storage

Produced and imported crude oil is moved using various transportation modes (e.g., pipeline, rail, barge, tanker, and truck) and is delivered to either oil refineries or commercial storage facilities located throughout the United States.<sup>21</sup> The majority of U.S. storage capacity is located in the Gulf Coast region and the Midwest region, which includes more than 75 million barrels of storage capacity in Cushing, OK.<sup>22</sup> Cushing is the pricing location for West Texas Intermediate (WTI) oil futures contracts that are frequently reported by news media. Most crude oil—both domestically produced and imported—is delivered to refineries using pipeline infrastructure. While relatively small volumes of crude oil are transported using the rail system, the rapid growth of this transportation mode between 2011 and 2014 resulted in increased congressional interest and oversight of crude oil movements by rail.<sup>23</sup>

## Oil Refining

Refineries convert crude oil into various intermediate and finished products (e.g., gasoline, diesel fuel, jet fuel, heating oil, marine fuel, and asphalt), some of which are blended with other petroleum liquids. Since 2000, the number of operable refineries in the United States declined by 15%, while operable capacity increased by 17%. As of January 1, 2020, 135 refineries located in 30 U.S. states and the Virgin Islands have capacity to process nearly 19 million barrels of crude oil per calendar day.<sup>24</sup> During 2019, U.S. refineries processed nearly 17 million bpd.<sup>25</sup> Approximately 45% of U.S. refining capacity is located along the Gulf Coast areas of Texas and Louisiana. Petroleum products from refineries are stored, blended, transported by various modes, and ultimately delivered and sold to consumers.

Many U.S. refineries have technically sophisticated configurations and equipment that allow for upgrading low-quality crude oils with high sulfur content into high-value, low-sulfur petroleum products. U.S. refineries have also enjoyed an operational cost benefit in the form of relatively low-cost natural gas, uses for which include process heat and sulfur removal. These configuration and cost advantages contribute to the U.S. refining sector being globally competitive.

## Petroleum Trade

U.S. petroleum trade balances—imports and exports—since 2000 have changed from being a large net importer to being nearly balanced in 2019 (see **Figure 3**). This trade balance shift is the result of increased petroleum product exports combined with increasing crude oil exports enabled by legislation enacted in 2015 (P.L. 114-113) that repealed crude oil export restrictions.<sup>26</sup> While

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<sup>21</sup> For information about crude oil transportation modes, see EIA, *Refinery Receipts of Crude Oil by Method of Transportation*, at [https://www.eia.gov/dnav/pet/pet\\_pnp\\_caprec\\_dcu\\_nus\\_a.htm](https://www.eia.gov/dnav/pet/pet_pnp_caprec_dcu_nus_a.htm), accessed September 14, 2020.

<sup>22</sup> EIA, *Working and Net Available Shell Storage Capacity*, at <https://www.eia.gov/petroleum/storagecapacity/>, accessed December 11, 2020.

<sup>23</sup> For additional information, see CRS Report R43390, *U.S. Rail Transportation of Crude Oil: Background and Issues for Congress*, by John Frittelli et al.

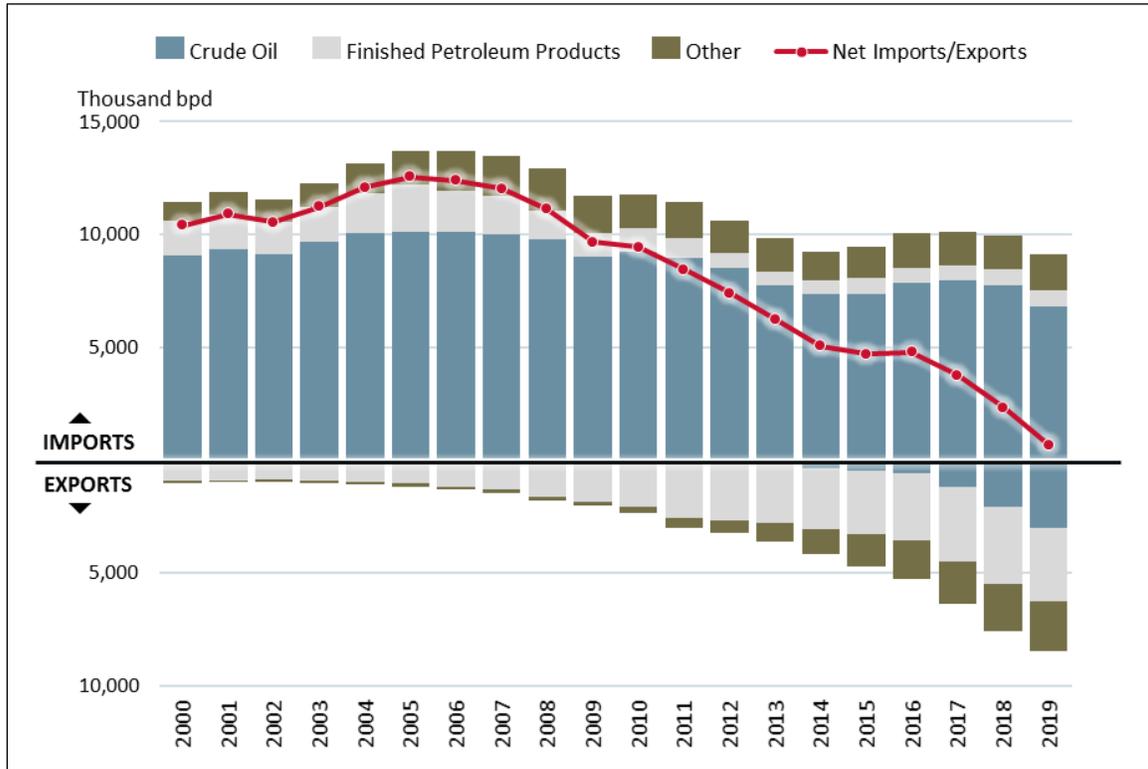
<sup>24</sup> EIA, *Refinery Capacity Report*, June 22, 2020, at <https://www.eia.gov/petroleum/refinerycapacity/>. Refining capacity is also reported in barrels per stream day, which represents maximum oil input without any downtime. Additional information is available at <https://www.eia.gov/tools/glossary/index.php?id=b>.

<sup>25</sup> EIA, *Refinery Utilization and Capacity*, at [https://www.eia.gov/dnav/pet/pet\\_pnp\\_unc\\_dcu\\_nus\\_a.htm](https://www.eia.gov/dnav/pet/pet_pnp_unc_dcu_nus_a.htm), accessed September 15, 2020.

<sup>26</sup> For additional information about repeal of the U.S. crude oil export prohibition, see CRS Report R44403, *Crude Oil Exports and Related Provisions in P.L. 114-113: In Brief*, by Phillip Brown, John Frittelli, and Molly F. Sherlock. For

overall petroleum trade is approaching a balanced level, the United States continues to be one of the largest crude oil importing countries and remains integrated with the global petroleum market.<sup>27</sup> This import trend could continue should sophisticated U.S. refiners choose to source crude oil with quality characteristics that support optimized refining operations and petroleum product yields.

**Figure 3. U.S. Petroleum Imports, Exports, and Trade Balance**  
Calendar Years 2000-2019



**Source:** CRS analysis of U.S. Energy Information Administration petroleum import and export data.

**Notes:** “Other” includes hydrocarbon gas liquids, oxygenates, renewable fuels, blending components, and unfinished oils. Bpd = barrels per day.

## Oil and Petroleum Product Prices

Crude oil (see **Figure 2**) and petroleum product prices can exhibit volatile and erratic movements. A myriad of factors (e.g., global economic growth, Organization of the Petroleum Exporting Countries production policies and compliance, geopolitical events, and natural disasters) can affect petroleum market supply and demand balances, storage levels, futures prices, and ultimately the price of physical oil commodities.<sup>28</sup> Oil market characteristics—generally inelastic

additional information about the U.S. crude oil export debate, see CRS Report R43442, *U.S. Crude Oil Export Policy: Background and Considerations*, by Phillip Brown et al.

<sup>27</sup> In 2019, the United States was the second largest crude oil importing country. China was the largest. For additional information, see EIA, *China’s Crude Oil Imports Surpassed 10 Million Barrels per Day in 2019*, March 23, 2020.

<sup>28</sup> For additional information, see EIA, “What Drives Crude Oil Prices?” at <https://www.eia.gov/finance/markets/crudeoil/>, accessed September 15, 2020.

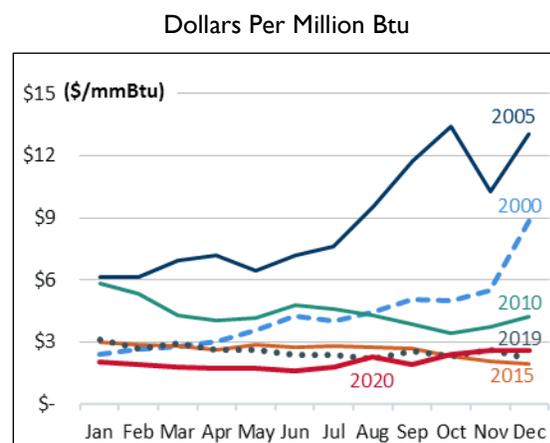
supply and demand in the short term—can contribute to market conditions that could result in volatile price movements (both up and down) when supply and demand are imbalanced by as little as 1% to 2% for a brief or sustained period. Apart from a release of SPR crude oil to address supply disruptions and associated economic dislocations, non-emergency statutory authorities that could quickly affect global oil markets and prices are limited. Congressional interest in statutory and legislative options tends to increase when crude oil and petroleum product (e.g., gasoline) prices are deemed either too low for producers or too high for consumers.<sup>29</sup>

## Natural Gas: The United States Is a Global Player<sup>30</sup>

The United States became a net exporter of natural gas in 2017, the first time since 1957. The United States is the third largest overall exporter of natural gas, and a growing liquefied natural gas (LNG) exporter, with seven terminals in operation.<sup>31</sup> The United States continues to import natural gas from Canada to balance its markets. Since prices peaked in the mid-2000s (\$12.69 per million British thermal unit (Btu); see **Figure 4**),<sup>32</sup> domestic gas production has risen significantly. (See “U.S. Supply,” below.) Improvements in technologies such as hydraulic fracturing and horizontal drilling made the development of unconventional natural gas resources such as shale and other lower-permeability rock formations possible.<sup>33</sup> Improved efficiency has lowered production costs, making shale gas (see shaded box on “Unconventional Shale Resources Make the Difference” above) economically competitive at almost any price and enabling large-scale exports.

As U.S. production increased and prices fell, U.S. consumption of natural gas grew, rising over 31% from 2000 to 2019. (See “U.S. Consumption,” below.) The rise in consumption, though, did not keep pace with production, so companies turned to exports, first by pipeline to Mexico and

**Figure 4. Monthly U.S. Natural Gas Prices, 2000-2020**



**Source:** CRS analysis of U.S. Energy Information Administration, *Natural Gas Spot and Futures Prices (NYMEX)*, updated November 25, 2020, [http://www.eia.gov/dnav/ng/ng\\_pri\\_fut\\_s1\\_m.htm](http://www.eia.gov/dnav/ng/ng_pri_fut_s1_m.htm).

**Notes:** Prices are spot prices and in nominal dollars.

<sup>29</sup> During periods of low oil prices, policy options such as acquiring oil for the SPR, loans and loan guarantees, and imposing trade tariffs have been explored. For additional information, see CRS Insight IN11246, *Low Oil Prices and U.S. Oil Producers: Policy Considerations*, by Phillip Brown and Michael Ratner. During periods of high oil and petroleum product prices, legislation such as the No Oil Producing and Exporting Cartels (NOPEC) Act has been introduced and debated. For additional information, see CRS In Focus IF11186, *No Oil Producing and Exporting Cartels (NOPEC) Act of 2019*, by Phillip Brown.

<sup>30</sup> Michael Ratner, CRS Specialist in Energy Policy, is the author of this section.

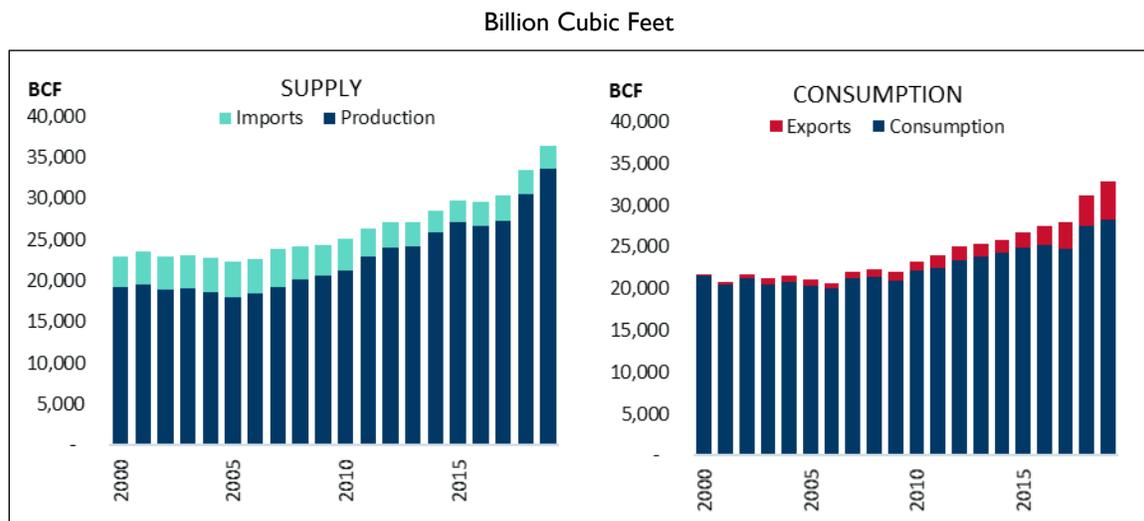
<sup>31</sup> Liquefied natural gas (LNG) is primarily methane that has been cooled to negative 260 degrees Fahrenheit. When natural gas is cooled to this temperature its volume contracts by 600 times, making it economical to transport on a ship.

<sup>32</sup> June 2008. Compare to previous price peak of \$13.42 per million British thermal unit in October 2005. U.S. Energy Information Administration (EIA), *Natural Gas Spot and Futures Prices (NYMEX)*, updated September 16, 2020, [http://www.eia.gov/dnav/ng/ng\\_pri\\_fut\\_s1\\_m.htm](http://www.eia.gov/dnav/ng/ng_pri_fut_s1_m.htm).

<sup>33</sup> Federal Energy Regulatory Commission, “Energy Primer: A Handbook of Energy Market Basics,” July 2015, p. 10.

then as LNG to other parts of the world. (See “U.S. Exports,” below.) As shown in **Figure 5**, domestic production and imports (supply) of natural gas were greater than consumption and exports (demand) in 2019. The differential is made up in part by increasing amounts of natural gas held in storage.

**Figure 5. U.S. Natural Gas Supply and Demand, 2000-2019**



**Source:** CRS analysis of U.S. Energy Information Administration, <http://www.eia.gov/naturalgas/data.cfm>.

**Notes:** Difference between the two columns for a given year in each chart is the volume of natural gas held in storage.

## U.S. Supply

The United States is the world’s largest producer of natural gas. Since 2005, U.S. natural gas production rose every year until 2016, even as prices declined. Production resumed growing in 2017 and 2018, and reached a new high in 2019 of 33,657 billion cubic feet (BCF). The increase in natural gas production between 2005 and 2019 is mostly attributed to the development of shale gas resources, specifically in the Marcellus and Utica formations in the northeastern United States. Overall, shale gas production accounted for 75% of total U.S. natural gas production in 2019; the Marcellus and Utica formations accounted for 43% of the U.S. shale gas production.

## U.S. Consumption

The United States is the largest consumer of natural gas in the world, using about 28,000 BCF in 2019. Electric power generation made up 40% of U.S. natural gas consumption in 2019; industrial use accounted for 30%, residential use for 18%, and commercial use for 12%. (See **Figure 6**.) Low natural gas prices, due to the growth of domestic gas resources, contributed to a significant rise in the use of natural gas for electric power generation. Additionally, some federal and state policies promote the use of fuels with lower greenhouse gas (GHG) emissions.

Consumption of natural gas for power generation grew nearly 117% between 2000 and 2019,<sup>34</sup> and is expected to continue to grow through 2050.<sup>35</sup>

The U.S. industrial sector increased its consumption of natural gas by 3% between 2000 and 2019;<sup>36</sup> the sector is expected to account for the largest share of growth in natural gas consumption through 2050.<sup>37</sup> As the United States continues to expand its natural gas resource base, the industrial sector will see a wider array of fuel and feedstock choices, and manufacturing industries could also experience further growth.<sup>38</sup>

## U.S. Exports<sup>39</sup>

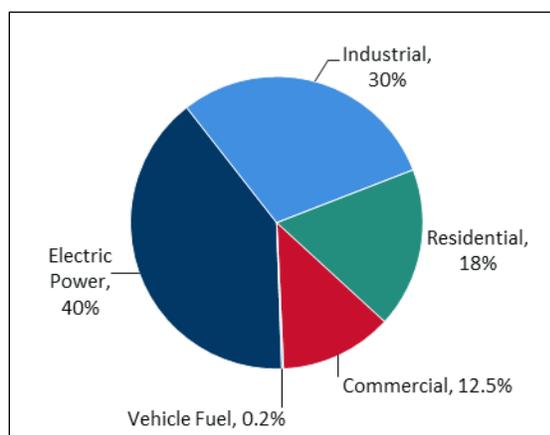
Between 2000 and 2008, the United States prepared to increase imports of LNG based on forecasts of growing consumption and flat supply, and companies began constructing LNG import terminals. However, the rise in natural gas prices gave the industry incentive to bring more domestic gas to market, reducing the need for import terminals. Imports in 2017 were 40% below their peak in 2007.

Because of increased U.S. natural gas production, there was a push for modification and expansion of existing LNG import terminals for export, as well as construction of new terminals, in order to expand U.S. export capacity. The first LNG shipments from the lower 48 occurred in February 2016 from the Sabine Pass LNG Terminal in Louisiana.<sup>40</sup>

## Natural Gas Liquids

Most oil and gas wells produce a variety of hydrocarbons, including natural gas, oil, and natural gas liquids (NGLs),<sup>41</sup> as well as other gases and liquids (e.g., nitrogen, hydrogen sulfide, and

**Figure 6. U.S. Natural Gas Consumption by Sector, 2019**



**Source:** CRS analysis of U.S. Energy Information Administration, *Natural Gas Consumption by End Use*, updated August 31, 2020, [http://www.eia.gov/dnav/ng/ng\\_cons\\_sum\\_dcu\\_nus\\_a.htm](http://www.eia.gov/dnav/ng/ng_cons_sum_dcu_nus_a.htm). Numbers do not sum to 100% due to rounding.

<sup>34</sup> EIA, *Natural Gas Consumption by End Use*, updated February 26, 2021, [https://www.eia.gov/dnav/ng/ng\\_cons\\_sum\\_dcu\\_nus\\_a.htm](https://www.eia.gov/dnav/ng/ng_cons_sum_dcu_nus_a.htm).

<sup>35</sup> Based on EIA's reference case in the *Annual Energy Outlook 2020*, January 29, 2020, <https://www.eia.gov/outlooks/aeo/>.

<sup>36</sup> EIA, *Natural Gas Consumption by End Use*, accessed August 31, 2020, [https://www.eia.gov/dnav/ng/ng\\_cons\\_sum\\_dcu\\_nus\\_a.htm](https://www.eia.gov/dnav/ng/ng_cons_sum_dcu_nus_a.htm).

<sup>37</sup> Based on EIA's reference case in the *Annual Energy Outlook 2020*, January 29, 2020, <https://www.eia.gov/outlooks/aeo/>.

<sup>38</sup> *Ibid.*, p. 131.

<sup>39</sup> For additional information on U.S. LNG exports, see CRS Report R42074, *U.S. Natural Gas Exports: New Opportunities, Uncertain Outcomes*, by Michael Ratner et al., and CRS In Focus IF10878, *U.S. LNG Trade Rising, But No Domestic Shipping*, by Michael Ratner and John Frittelli.

<sup>40</sup> The United States has exported LNG from Alaska since 1969.

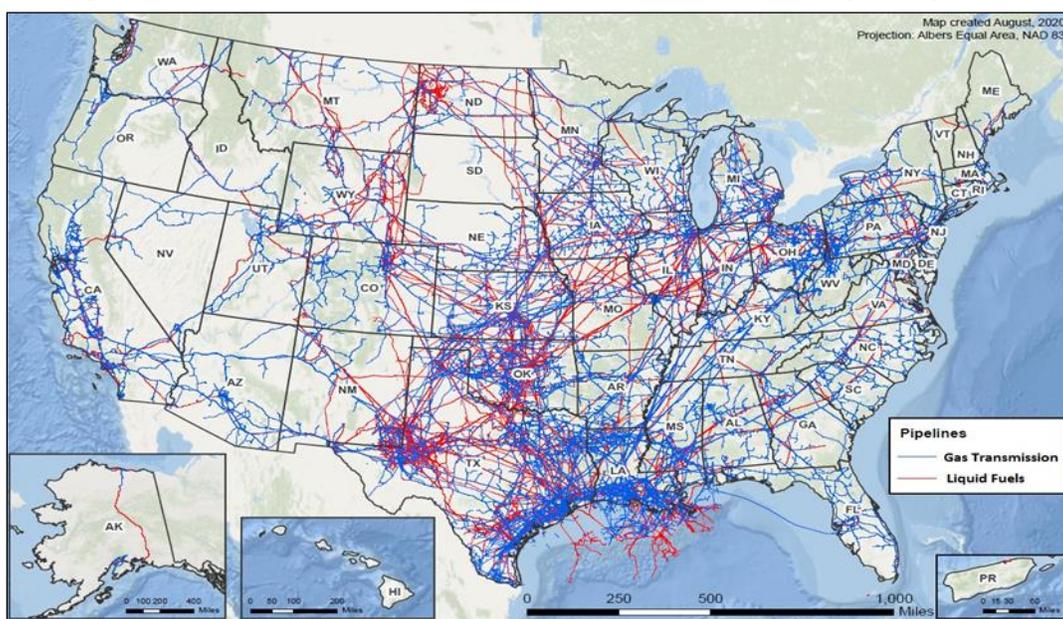
<sup>41</sup> NGL is a general term for all liquid products separated from the natural gas stream at a gas processing plant and

water) and particulate matter. NGLs have taken on a greater prominence as the price for “dry” gas<sup>42</sup> dropped, primarily because of the increase in natural gas supply. In response to the price drop, the natural gas industry produced more “wet” gas<sup>43</sup> in order to bolster the value it receives per well. Historically, individual NGL products prices, except for ethane, have been linked to oil prices. When oil prices were high relative to dry gas, it drove an increase of wet gas production, thereby maintaining production of dry gas as a “byproduct” despite its low price.

## Pipelines: The Backbone of U.S. Oil and Gas Supply<sup>44</sup>

The U.S. pipeline network is integral to the nation’s energy supply and provides vital links to other critical infrastructure, such as power plants, refineries, airports, and military bases. These pipelines are geographically widespread, running alternately through remote and densely populated regions—from Arctic Alaska to the Gulf of Mexico and nearly everywhere in between. The siting of interstate natural gas pipelines and U.S. pipeline border crossings is under federal jurisdiction. The siting of all other pipelines, including interstate crude oil and refined products pipelines, is under the jurisdiction of the states—although individual projects may still require federal approval for specific segments, such as water crossings or routes through federal lands.

**Figure 7. U.S. Natural Gas Transmission and Hazardous Liquid Pipelines**



**Source:** National Pipeline Mapping System, “Gas Transmission and Hazardous Liquid Pipelines,” August 5, 2020, [https://www.npms.phmsa.dot.gov/Documents/NPMS\\_Pipelines\\_Map.pdf](https://www.npms.phmsa.dot.gov/Documents/NPMS_Pipelines_Map.pdf).

includes ethane, propane, butane, and pentanes. When NGLs are present with methane, which is the primary component of natural gas, the natural gas is referred to as either “hot” or “wet” gas. Once the NGLs are removed from the methane the natural gas is referred to as “dry” gas, which is what most consumers use.

<sup>42</sup> Natural gas without associated liquids.

<sup>43</sup> Natural gas with associated liquids.

<sup>44</sup> Paul Parfomak, CRS Specialist in Energy Policy, is the author of this section.

**Notes:** Hazardous liquids primarily include crude oil, gasoline, jet fuel, diesel fuel, home heating oil, propane, and butane. Other hazardous liquids transported by pipeline include anhydrous ammonia, carbon dioxide, kerosene, liquefied ethylene, and some petrochemical feedstocks.

The U.S. pipeline network spans over three million miles, transporting natural gas, crude oil, refined products, and other liquid fuels (**Table 1**). Of the nation’s approximately 500,000 miles of long-distance transmission pipeline, roughly 220,000 miles carry hazardous liquids—including crude oil and refined petroleum products, along with other products. The natural gas transmission network consists of around 300,000 miles of pipeline. These natural gas lines feed around 2.3 million miles of regional pipelines in some 1,500 local distribution networks which serve nearly 70 million customers.<sup>45</sup> They also connect to seven large liquefied natural gas (LNG) marine terminals on the Atlantic and Gulf coasts used for import and export. The gas network also contains nearly 250,000 miles of onshore and offshore field and gathering pipeline, which connect extraction wells to processing facilities.<sup>46</sup> Natural gas pipelines also connect to 162 active LNG storage sites, as well as over 400 underground storage facilities, both of which can augment pipeline gas supplies during peak demand periods.<sup>47</sup>

**Table 1. U.S. Hazardous Liquid and Natural Gas Pipeline Mileage, 2019**

Category	Miles
Hazardous Liquids (crude oil, refined products, etc.)	219,746
Natural Gas Gathering	246,000
Natural Gas Transmission	302,249
Natural Gas Distribution Mains and Service Lines	2,262,397
<b>TOTAL</b>	<b>3,030,392</b>

**Source:** PHMSA, “Annual Report Mileage Summary Statistics,” web tables, September 1, 2020, accessible at <https://www.phmsa.dot.gov/data-and-statistics/pipeline/annual-report-mileage-summary-statistics>; and “Gathering Pipelines FAQs,” web page, <https://www.phmsa.dot.gov/faqs/gathering-pipelines-faqs>.

**Notes:** Hazardous liquid mileage includes federally-regulated hazardous liquid gathering pipelines.

The oil pipeline infrastructure of the United States is fully integrated with that of Canada. Six major pipeline systems link oil-producing regions, refineries, and intermediate storage and transportation hubs in both countries. Although Canada-U.S. cross-border oil pipelines have been in place since the 1950s, pipeline capacity from Canada to the United States experienced a period of rapid growth between 2010 and 2015. During this time several cross-border pipelines were constructed and others were rebuilt or significantly expanded to provide increased takeaway capacity from the growing crude oil production in the Canadian oil sands. By comparison, U.S. liquid fuel pipeline connections to Mexico are limited, with several small-diameter pipelines between the two countries used primarily for U.S. refined product exports. Unlike oil, which is readily moved by vessels, railcars, and trucks, natural gas is transported among the United States, Canada, and Mexico almost entirely by pipeline. There are over 50 individual gas pipelines

<sup>45</sup> Pipeline and Hazardous Materials Safety Administration (PHMSA), “Annual Report Mileage for Gas Distribution Systems,” web table, February 1, 2021, <https://www.phmsa.dot.gov/data-and-statistics/pipeline/annual-report-mileage-gas-distribution-systems>.

<sup>46</sup> Only 7% of onshore gathering lines are currently under federal regulation, so the total mileage of U.S. gathering lines is not known precisely. Few state agencies collect this information. The Pipeline and Hazardous Materials Safety Administration estimates that there are approximately 240,000 miles onshore in addition to approximately 6,000 miles offshore.

<sup>47</sup> PHMSA, “Liquefied Natural Gas (LNG) Facilities and Total Storage Capacities,” web table, February 1, 2021, <https://www.phmsa.dot.gov/data-and-statistics/pipeline/liquefied-natural-gas-lng-facilities-and-total-storage-capacities>.

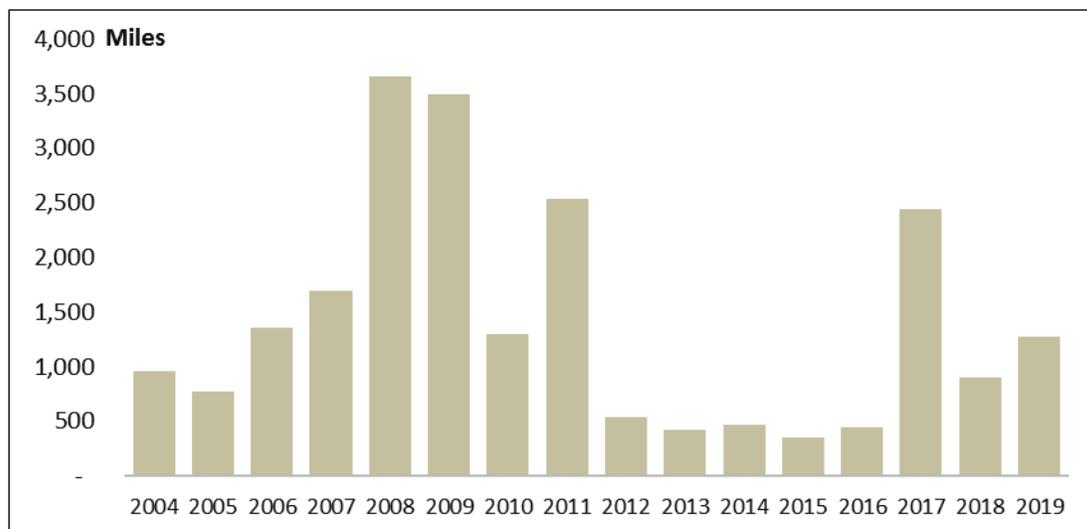
linking the United States and its neighbors at 24 border crossings to Canada and 19 border crossings to Mexico.

## Pipeline Network Expansion from the Shale Boom

The rapid growth of U.S. natural gas and crude oil production from shale in the mid-2000s has led to a corresponding realignment and expansion of the nation’s pipeline system. Developers and operators have invested billions of dollars to connect major new production regions, such as the Marcellus (Pennsylvania) and Bakken (North Dakota) shale basins, to traditional oil and gas markets. They have converted, reversed, and expanded existing pipelines; added relatively short laterals to supply new wholesale customers; and developed entirely new, long-haul pipelines to fundamentally reconfigure oil and natural gas flows throughout North America.

Between 2004 and 2019, developers added over 58,000 miles of hazardous liquids transmission pipeline in the United States, an increase of 35% in total reported mileage, not counting the expansion of capacity on existing pipelines.<sup>48</sup> During the same period, total mileage for U.S. natural gas transmission remained flat, in part due to retirements and conversions (i.e., to ship crude oil), but there were major investments to expand the capacity of existing lines and to construct major new connections to key markets. Altogether, developers expanded or constructed over 37,000 miles of interstate natural gas transmission between 2004 and 2019, most of it in the years immediately after the initial commercialization of shale gas resources (**Figure 8**).

**Figure 8. Annual U.S. Natural Gas Transmission Capacity Expansion and New Construction**  
Pipeline mileage



**Source:** CRS analysis of U.S. Energy Information Administration (EIA), “U.S. Natural Gas Pipeline Projects,” online spreadsheet, accessed September 9, 2020, <https://www.eia.gov/naturalgas/pipelines/EIA-NaturalGasPipelineProjects.xlsx>. EIA’s figures are based on its analysis of regulatory filings and industry reports.

**Notes:** Capacity expansion may include adding a parallel line, increasing pipeline diameter, or adding additional compressor stations along its route to increase carrying capacity.

<sup>48</sup> PHMSA, “Annual Report Mileage for Hazardous Liquid or Carbon Dioxide Systems,” web table, February 1, 2021, <https://www.phmsa.dot.gov/data-and-statistics/pipeline/annual-report-mileage-hazardous-liquid-or-carbon-dioxide-systems>.

Although changes in the U.S. economy due to the COVID-19 pandemic have temporarily disrupted global and domestic demand for gas, if long-term trends continue, some industry analysts expect continued expansion of U.S. gas pipeline infrastructure. A 2018 analysis by the INGAA Foundation, a pipeline industry research organization, projected the need for approximately 26,000 miles (1,400 miles annually) of new natural gas transmission pipeline between 2018 and 2035; in 2018, INGAA reported that total capital expenditure for these projects may range from \$154 billion to \$190 billion.<sup>49</sup>

## **Challenges to Pipeline Network Expansion**

Over the last decade, proposals for new oil and natural gas transmission pipelines at both the federal and state levels have been subjected to greater public scrutiny and have become increasingly controversial. Many pipeline permit applications have faced significant challenges in permit application review and are the subject of protracted litigation. Pipeline proponents have based their support primarily on increasing the diversity of the U.S. energy supply and on expected economic benefits, including oil and gas production jobs and near-term job creation associated with pipeline construction and operation. Opponents, primarily environmental groups and affected communities along pipeline routes, have objected to these projects principally on the grounds that pipeline development has negative environmental impacts, disproportionately impacts disadvantaged communities, and promotes continued U.S. dependency on fossil fuels. As a result, major pipeline projects, especially natural gas projects in the Northeast and Mid-Atlantic, have been denied permits or have been cancelled by their developers due to regulatory uncertainty, cost overruns, and unfavorable economics. Others, such as the Dakota Access Pipeline, have been constructed but continue to be subject to permit challenges and litigation, with uncertain prospects for continued operations. These complexities, and the potential for changing environmental policies to address the climate impacts of fossil fuels, make the trajectory for future pipeline development uncertain.

## **Coal: Still Declining<sup>50</sup>**

The Trump Administration had made it clear that it would have liked to help revive the U.S. coal industry, which has been in decline for decades in part because of other fuels' technological improvements and more competitive prices. The Trump Administration rolled back or initiated reversing several coal-related regulations that were finalized under the Obama Administration. This effort coincided with the emergence of three of the largest coal producers from Chapter 11 bankruptcy, higher coal prices, lower inventories, and higher natural gas prices—factors that could lead to coal being more competitive as a fuel source for electricity generation. Coal will likely remain an essential component in the U.S. energy supply picture, but how big a role it will play is an open question, particularly under the Biden Administration, which may seek to reverse actions taken by the prior administration.

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<sup>49</sup> INGAA Foundation, "North American Midstream Infrastructure Through 2035: Significant Development Continues," June 18, 2018, p. 48. The INGAA Foundation is affiliated with the Interstate Natural Gas Association of America (INGAA), the interstate gas pipeline industry trade association.

<sup>50</sup> Brandon Tracy, CRS Analyst in Energy Policy, and Michael Ratner, CRS Specialist in Energy Policy, are the authors of this section.

## Coal Reserves and Production

The United States has the largest coal reserves and resources in the world.<sup>51</sup> EIA estimated in 2019 that there were about 14 billion short tons of recoverable domestic coal reserves, down from 15 billion short tons in 2018 and 18 billion short tons in 2000. The total demonstrated U.S. reserve base (DRB) in 2019 was estimated at about 472 billion short tons, down from 499 billion short tons in 2000.<sup>52</sup> According to the National Mining Association, the federal government owns about one-third of U.S. domestic reserves.<sup>53</sup>

EIA statistics show that more than half of U.S. coal reserves are located in the West, with Montana and Wyoming together accounting for 42%. The top five producing states—Wyoming, West Virginia, Pennsylvania, Illinois, and Kentucky—account for over 71% of U.S. coal production.

Even though U.S. coal production reached its highest level of production in 2008 (1.17 billion short tons) and remained strong until 2014 (at or near 1 billion short tons per year up to 2014), coal is losing its share of overall U.S. energy production and consumption, primarily to natural gas in electricity generation. Coal production has declined since 2014, dropping 29% between 2014 and 2019 (see **Table 2**). EIA projections show coal production over 600 million short tons in 2021.<sup>54</sup> The softening of demand for coal has been attributed to utilities opting for low-cost natural gas, declining costs for renewable energy options, increasing regulatory costs associated with coal-fired power plants, a warmer-than-usual winter heating season in 2019 (which resulted in high coal inventories), and lower demand for U.S. coal exports (see **Table 2**). In 2018, coal exports rebounded significantly, up from 60.3 million short tons in 2016 to 115.6 million short tons. Higher demand from Asian countries, particularly India, for U.S. coal fueled this uptick. The EIA projects long-term demand growth in the Asian coal market, but long-term penetration of U.S. coal exports into this market remains uncertain.<sup>55</sup>

Coal mining employment declined from 169,300 in 1985 to 71,500 in 2000 (a 57% decline), then rose to a recent high of 86,100 in 2010 before falling to 52,804 in 2019.<sup>56</sup> A similar pattern was true for the number of coal mines, as the vast majority of the decline occurred between 1985 and 2000, when the number of coal mines fell by 55% (from 3,355 to 1,513) before declining further by 56% from 2000 to 2019 (from 1,513 to 669). The number of coal mining firms has decreased in the United States, while the size of the average mine and output per mine and per worker have increased.

## Coal Consumption

Coal consumption in the United States was consistently near or over 1 billion short tons per year from 2000 (peaking in 2007 at 1.128 billion short tons) until 2012, when demand fell below 900

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<sup>51</sup> BP, *Statistical Review of World Energy*, London, June 2020, p. 44. For something to be categorized a reserve, it must be reasonably certain that it can be recovered in the future from known resources under existing economic and operating conditions. It must also be able to reach a market. Reserves are a subset of resources, which is a broader estimation.

<sup>52</sup> EIA, *Annual Coal Report 2019*, Washington, DC, October 2020, p. 25, <https://www.eia.gov/coal/annual/pdf/acr.pdf>.

<sup>53</sup> National Mining Association, *2010 Coal Producers Survey*, May 2011. This is the latest available report.

<sup>54</sup> EIA, *Annual Energy Outlook 2021*, Washington, DC, February 3, 2021, <https://www.eia.gov/outlooks/aeo/>. Based on EIA's reference case scenario.

<sup>55</sup> EIA, *Quarterly Coal Report*, October-December 2017, April 2018, p. 11.

<sup>56</sup> EIA, *Annual Coal Report 2019*, Washington, DC, October 2020, p. 30, <https://www.eia.gov/coal/annual/pdf/acr.pdf>.

million short tons (pre-1990 levels). As shown in **Table 2**, consumption has declined further since 2012, reaching 587 million short tons in 2019. The EIA projects annual coal consumption to be below 600 million short tons through 2050. Power generation is the primary market for coal, accounting for over 90% of total consumption. With the retirement of many coal-fired power plants and the building of new gas-fired plants, accompanied by lower demand for electricity, there has been a structural shift in demand for U.S. coal. A structural shift would mean long-term reduced capacity for coal-fired electric generation.<sup>57</sup> Thus, coal could likely be a smaller portion of total U.S. energy consumption for years to come. As noted earlier, in 2016, natural gas overtook coal as the number one energy source for power generation.

## Coal Exports

One of the big questions for the industry is how to penetrate the overseas coal market, particularly for steam coal,<sup>58</sup> to compensate for declining domestic demand. EIA forecasts coal exports to decline to 74 million short tons in 2021, before rising to nearly 100 million short tons in total out to 2050.<sup>59</sup> Exports to the Asian market are expected to increase, but there are potential bottlenecks such as infrastructure (e.g., port development and transportation) that could slow export growth.

**Table 2. U.S. Coal Production, Consumption, and Exports, 2000-2019**

(million short tons)

Year	Total Production	Total Consumption	Total Exports
2000	1,073.6	1,084.1	58.5
2001	1,127.7	1,060.1	48.7
2002	1,094.3	1,066.4	39.6
2003	1,071.8	1,094.9	43.0
2004	1,112.1	1,107.3	48.0
2005	1,131.5	1,126.0	49.9
2006	1,162.8	1,112.3	49.6
2007	1,146.6	1,128.0	59.2
2008	1,171.8	1,120.5	81.5
2009	1,075.0	997.5	59.1
2010	1,084.4	1,048.5	81.7
2011	1,095.6	1,002.9	107.3
2012	1,016.5	889.2	125.7
2013	984.8	924.4	117.7
2014	1,000.0	917.7	97.3

<sup>57</sup> The costs of modernizing older power plants to meet new regulatory requirements can be relatively high. When the cost of upgrades to meet new environmental requirements is considered along with (perhaps increasing) operation and maintenance expenses, many older coal power plants are likely to face retirement. The EIA projects many more U.S. coal-fired plants to be retired and replaced with natural gas and renewable energy facilities as coal plants become too expensive to maintain or upgrade.

<sup>58</sup> Steam coal is used to generate steam for electrical power plants, while metallurgical coal is used for steel production.

<sup>59</sup> EIA, *Annual Energy Outlook 2020*, Washington, DC, February 3, 2021, <https://www.eia.gov/outlooks/aeo/>. Based on EIA's reference case scenario.

Year	Total Production	Total Consumption	Total Exports
2015	896.9	798.1	74.0
2016	728.4	731.1	60.3
2017	774.1	716.9	96.9
2018	756.2	688.1	116.2
2019	706.3	586.5	93.8

**Source:** EIA, *Monthly Energy Review*, February 2021, Table 6.1, <https://www.eia.gov/totalenergy/data/monthly/pdf/mer.pdf>.

**Notes:** Coal production in 2008, 1,171.8 short tons, was its peak level.

Several key factors are likely to influence how much coal will be exported from the United States in the future, one of which is whether new export terminals are built, particularly for coal from the Powder River Basin (PRB) in Wyoming and Montana. Another major factor is the level of global demand for metallurgical (met) coal, which is used to make steel. Historically, met coal has been the primary coal exported by the United States, accounting for 90% of exports in 2019.<sup>60</sup> Some PRB coal is exported from Canadian terminals at Roberts Bank (near Vancouver, British Columbia) and Ridley Terminal at Prince Rupert, British Columbia. PRB coal is transported to both facilities for export via railway.

PRB coal producers have sought to export via the Pacific Northwest to supply growing Asian market, without success. Three port terminal projects for exporting coal in Washington and Oregon had permit applications before the U.S. Army Corps of Engineers (the Corps), although none have advanced.<sup>61</sup> Two projects, the Gateway Pacific Terminal and Coyote Island Terminal projects, have been cancelled due to permit denials.<sup>62</sup> Washington State's Department of Ecology, in its final environmental impact statement, rejected the application for a Clean Water Act Certification (for water pollution discharges) for the Millennium Bulk Terminal. Millennium Bulk Terminal filed an appeal with the state's Pollution Control Hearing Board, but on August 15, 2018, the Board upheld the Department of Ecology's decision in a Summary Judgment.<sup>63</sup> In addition, the State of Washington denied the Millennium project a permit to build on state land.<sup>64</sup>

<sup>60</sup> U.S. Energy Information Administration, *Coal Data Browser*, Washington, DC, <https://www.eia.gov/coal/data/browser/>.

<sup>61</sup> A permit from the Corps is needed for any project that discharges dredge or fill material in waters of the United States or wetlands, pursuant to provisions in Section 404 of Clean Water Act; and for the construction of any structure in, over, or under navigable waterways of the United States, including excavation, dredging, or deposition of these materials in these waters, pursuant to Section 10 of the Rivers and Harbors Act of 1899. The proposed projects in Washington and Oregon will involve such activities and must obtain either or both a Section 404 and Section 10 permit from the Corps, before the project can proceed. Discussion of the Corps permit requirements is beyond the scope of this report.

<sup>62</sup> Gateway Pacific Terminal Project at Cherry Point Proposal, Project Update: On February 7, 2017, the applicant withdrew all permit applications, State of Washington, Department of Ecology, <http://www.ecy.wa.gov> and George Plaven, "Port of Morrow Agree to Withdraw Coyote Island Terminal Application," *East Oregonian*, November 10, 2016, online edition. The Oregon Department of State Lands rejected a key permit to build in the river in 2014.

<sup>63</sup> State of Washington Environmental and Land Use Hearings Office, PCHB No. 17-090, Millennium Bulk Terminals-Longview. LLC v. State of Washington, Department of Ecology, et al., August 15, 2018.

<sup>64</sup> Natasha Geiling, "Washington State Denies Lease Permit for Proposed Coal Export Terminal," January 4, 2017, <http://thinkprogress.org>.

## U.S. Coal-Producing Industry

The U.S. coal industry is highly concentrated, with a handful of major producers operating primarily in five states—Wyoming, West Virginia, Pennsylvania, Illinois, and Kentucky, in order of volume. In 2019, the top five coal mining companies were responsible for 51% of U.S. coal production, led by Peabody Energy Corp., with 19.6%, and Arch Coal, Inc., with 12.4% (see **Table 3**). Other major producers include the Navajo Nation, Murray Energy Corp., and Alliance Resources.

Three of the top five coal producers filed for Chapter 11 bankruptcy protection between 2015 and 2016: Alpha Natural Resources, LCC (August 2015), Arch Coal (February 2016), and Peabody Energy Corp. (April 2016). Other major producers, such as Patriot Coal, Walter Energy, James River Coal, Armstrong Energy, and FirstEnergy Solutions have filed as well. All told, over 50 coal producers have filed for bankruptcy since 2015, with more than \$19.3 billion in debt being reorganized. The top-two largest producers, both of which filed for bankruptcy, accounted for nearly 33% of U.S. coal production in 2016.

Arch Coal, ANR Inc.,<sup>65</sup> and Peabody Energy have emerged from Chapter 11 bankruptcy with plans to move forward, all three shedding substantial debt. Opponents are critical of the plans and of the long-term viability and reliability of the U.S. coal industry.<sup>66</sup> Major challenges for the U.S. coal industry will be to get the level of financing needed for new or expanded projects and to become profitable.

**Table 3. Leading U.S. Coal Producers and Percentage of U.S. Coal Production for 2000, 2010, and 2019**

2019		2010		2000	
Producer	Percent of Total	Producer	Percent of Total	Producer	Percent of Total
Peabody Energy Corp.	19.6	Peabody Coal Co.	17.7	Peabody Coal Co.	13.1
Arch Coal, Inc.	12.4	Arch Coal, Inc.	16.0	Arch Coal, Inc.	10.1
Navajo Nation	6.7	Cloud Peak Energy	8.6	Kennecott Energy	9.9
Murray Energy Corp.	6.5	Alpha Natural Resources	7.4	CONSOL Energy, Inc.	6.9
Alliance Resource Partners	5.7	CONSOL Energy, Inc.	5.7	RAG	5.9

**Source:** U.S. Energy Information Administration (EIA), *Annual Coal Report 2019*, released October 5, 2020, <https://www.eia.gov/coal/annual/>. EIA, *Annual Coal Report 2010*. EIA, *Coal Industry Annual 2000*.

<sup>65</sup> Alpha Natural Resources, LLC emerged from bankruptcy as two distinct entities: ANR, Inc. and Contura Energy Inc.

<sup>66</sup> Heather Richards, “Does the Sale of Contura Coal Mines Herald a Change in the Northeast Wyoming? Depends on Who You Ask,” *Casper Star Tribune*, December 16, 2017, online, [https://trib.com/business/energy/does-the-sale-of-contura-coal-mines-herald-a-change/article\\_2322fa81-d1b7-5c0b-8de9-d048156fa255.html](https://trib.com/business/energy/does-the-sale-of-contura-coal-mines-herald-a-change/article_2322fa81-d1b7-5c0b-8de9-d048156fa255.html).

## The Electric Power Sector: In Transition<sup>67</sup>

The electric power industry is in the process of transition. The electricity infrastructure of the United States is aging, and uncertainty exists around how best to modernize the grid and what technologies and fuels will be used to produce electricity in the future. Unresolved questions about electricity transmission and reliability of the grid also are arising due to potential cybersecurity threats as well as continuing interest in harnessing renewable energy and other low carbon sources of electricity. Concerns about reliability and electricity prices are complicated by uncertainty about environmental regulations and the rising production of electric power from natural gas—whose lifecycle emissions some have suggested may have to be addressed to meet potential mid-century net-zero climate goals.<sup>68</sup> Congress has played a role already in this transition (e.g., with tax credits for renewable energy), and may continue to be faced with policy issues regarding the modernization of this industry. States have also played major roles in this area through renewable portfolio standards/renewable electricity standards (RPS/RES),<sup>69</sup> and regional emissions trading programs, such as the Regional Greenhouse Gas Initiative (RGGI), among other programs.<sup>70</sup>

### Supply and Demand

The U.S. electric power sector consists of all the power plants generating electricity, together with the transmission and distribution lines, and their associated transformers and substations which bring power to end-use customers. Electricity must be available upon demand, is rarely stored in bulk, and is generally consumed as soon as it is produced. Approximately two-thirds of U.S. electricity consumers live in regions of the country that are served by competitive wholesale electricity markets, where utilities compete to supply electricity to consumers generally at the lowest cost (considering reliability and environmental concerns). The remaining third of consumers are served by electric utilities that operate under what is called the “traditional model,” where rates for electricity are established by a state regulatory body based on the utility’s cost of providing electric power to customers (i.e., its cost-of-service).<sup>71</sup>

Electric power generation in the United States is currently dominated by the use of combustible fossil fuels, such as natural gas and coal. These fuels are burned to produce steam in boilers that turn steam turbine-generators or, in the case of natural gas, burned directly in a combustion turbine to produce electricity. Another major source of electricity is nuclear power (see “Nuclear Power: An Industry Facing Stress”), which uses heat from the fission of radioactive elements to produce steam to turn a generator. Electricity can also be generated mechanically by wind turbines and hydropower, or by solar photovoltaic panels (PV) which convert light directly into electricity. Geothermal energy power plants use underground heat to generate steam to run steam

<sup>67</sup> Richard Campbell, CRS Specialist in Energy Policy, is the author of this section.

<sup>68</sup> For example, the Center of Climate and Energy Solutions suggested: “In order to achieve mid-century net-zero climate goals, natural gas plants (new and existing) will need to employ carbon capture, utilization, and storage capabilities (or corresponding sequestration-based offsets) before 2050.” Center for Climate and Energy Solutions, *Natural Gas*, 2020, <https://www.c2es.org/content/natural-gas/>.

<sup>69</sup> CRS Report R45913, *Electricity Portfolio Standards: Background, Design Elements, and Policy Considerations*, by Ashley J. Lawson.

<sup>70</sup> CRS Report R41836, *The Regional Greenhouse Gas Initiative: Background, Impacts, and Selected Issues*, by Jonathan L. Ramseur.

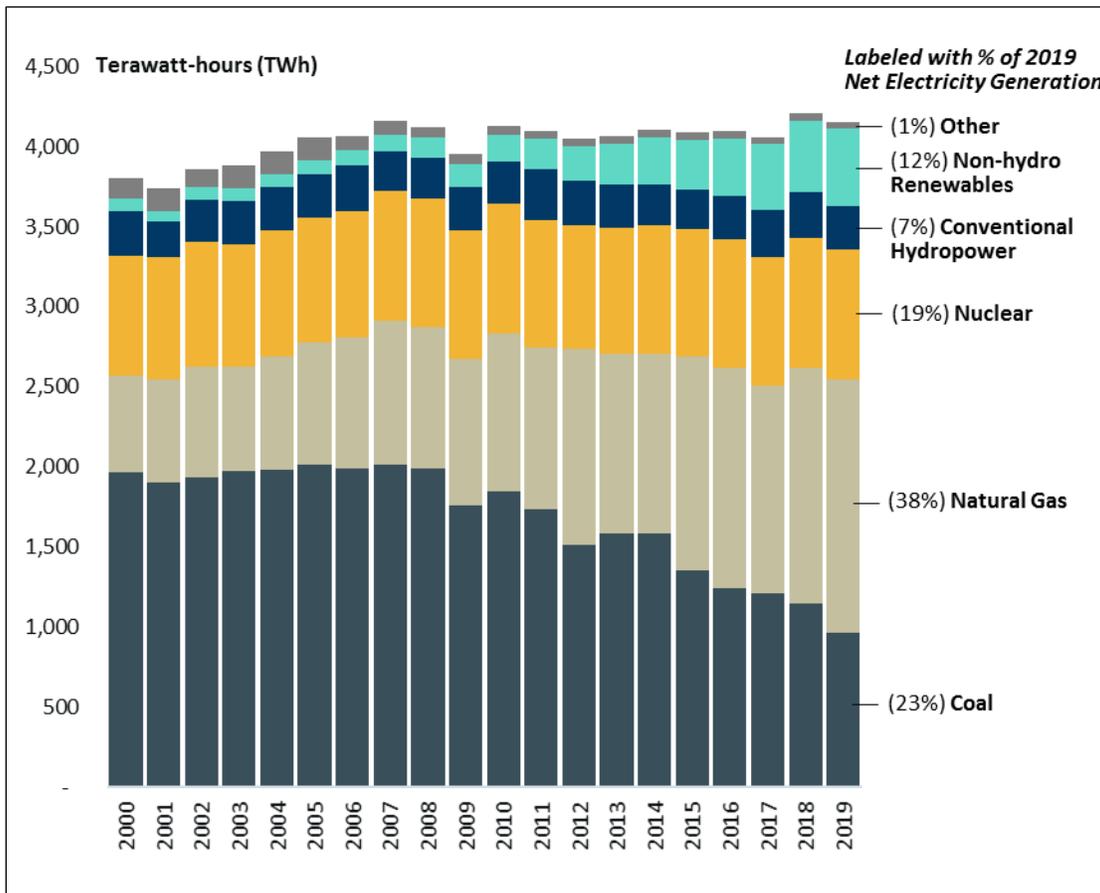
<sup>71</sup> “Cost-of-service” is a ratemaking concept used for the design and development of rate schedules to ensure that the filed rate schedules recover only the cost of providing the electric service at issue. This concept attempts to correlate the utility’s costs and revenue with the service provided to each of the various customer classes.

turbines. Generally, electricity must be used as soon as it is produced because the technologies and regulatory regimes to facilitate large-scale, economic energy storage are not yet widely available.

The choice of power generation technology in the United States is heavily influenced by the cost of fuel. Historically, the use of fossil fuels has provided some of the lowest prices for generating electricity. As a result, fossil fuels (coal and natural gas) have accounted for about two-thirds of electricity generation since 2000. However, while some renewable sources of electricity (notably wind and solar PV power) do not require a fuel, the electricity they produce varies with the wind and available sunlight. Prices for renewables have fallen in the last decade resulting in increased deployment of wind and solar PV.

**Figure 9** illustrates the changing mix of fuels used for U.S. electric power generation from 2000 to 2019. Beginning in 2016, natural gas surpassed coal as a percentage of net electricity generation, and total renewable generation (including hydropower) is equal with nuclear power in 2019.

**Figure 9. U.S. Net Electricity Generation by Fuel, 2000-2019**



**Source:** Data for 2000-2010 from U.S. Energy Information Administration (EIA), *Electric Power Annual 2010*, Table 2.1.A, November 2011, and data for 2011-2019 from EIA Electric Power Monthly Table I.1, July 2020.

**Notes:** “Other” includes petroleum liquids, petroleum coke, pumped storage (which tends to be a negative value), blast furnace gas and other manufactured and waste gases derived from fossil fuels, non-biogenic municipal solid waste, batteries, hydrogen, purchased steam, sulfur, tire-derived fuel, and other miscellaneous energy sources. “Non-hydro Renewables” includes wood, black liquor, other wood waste, biogenic municipal solid waste, landfill gas, sludge waste, agricultural byproducts, other biomass, geothermal, solar thermal, solar

photovoltaic, and wind. Beginning in 2014, EIA reported net generation from small-scale solar photovoltaic facilities which are also included in Non-hydro Renewables.

The overtaking of coal by natural gas in 2016 reflects a range of factors, and the changing economics of power generation. Electricity production has largely been influenced by regional resources and policies advocating renewable electricity at the state level. Historically, since coal was readily available across a large part of the United States, coal power plants were able to dominate electricity production for many decades. However, improvements in natural gas combined-cycle generation technology since 2000,<sup>72</sup> and the costs of compliance with environmental regulations, have led to older, less-efficient coal plants being used less or retired from service. Also as discussed earlier, the use of hydraulic fracturing and directional drilling technology since 2008 has led to an increased supply and availability of natural gas. The resulting lower prices for natural gas have added market pressure to shift away from coal to natural gas for power generation.

## U.S. Consumption

For many years, the growth in sales of electricity could be directly related to growth in the economy. However, with energy efficiency in homes and appliances increasing, a decoupling of growth in electricity demand from growth in gross domestic product (GDP) has occurred.<sup>73</sup> According to EIA, the linkage has been declining over the last 60 years, as U.S. economic growth is outpacing electricity use.<sup>74</sup>

EIA's projections point to a continued decline in electricity use relative to economic growth. While there may be years of relative growth in the future, EIA does not expect a sustained return to the situation between 1975 and 1995, when the two growth measures were nearly equal in value, or the earlier period in which the growth rate in electricity use far exceeded the rate of economic growth.

Although near-term U.S. electricity demand may fluctuate as a result of year-to-year changes in weather, trends in long-term demand tend to be driven by economic growth offset by increases in energy efficiency. In the AEO2020 Reference case, the annual growth in total U.S. electricity demand is projected to average about 1% from 2019 through 2050.<sup>75</sup>

## Nuclear Power: An Industry Facing Stress<sup>76</sup>

Nuclear power has supplied about one-fifth of annual U.S. electricity generation during the past three decades. In 2019, nuclear reactors generated 19% of U.S. electricity supply, behind only natural gas and coal.<sup>77</sup> Ninety-four reactors are currently operating at 56 plant sites in 29 states.

<sup>72</sup> There has been a 22% efficiency improvement in natural gas power generation since 2000. EIA, "Table 8.1 Average Operating Heat Rate for Selected Energy Sources," December 7, 2017, [https://www.eia.gov/electricity/annual/html/epa\\_08\\_01.html/](https://www.eia.gov/electricity/annual/html/epa_08_01.html/), and EIA, "Table A6. Approximate Heat Rates for Electricity, and Heat Content of Electricity 1949-2011."

<sup>73</sup> "The value of the goods and services produced in the United States is the gross domestic product." See <https://www.bea.gov/resources/learning-center/what-to-know-gdp>.

<sup>74</sup> "Total annual U.S. electricity consumption increased in all but 10 years between 1950 and 2019, and 7 of the years with year-over-year decreases occurred between 2007 and 2019." EIA, *Electricity Explained: Use of Electricity*, August 28, 2020, <https://www.eia.gov/energyexplained/electricity/use-of-electricity.php>.

<sup>75</sup> Ibid.

<sup>76</sup> Mark Holt, CRS Specialist in Energy Policy, is the lead author of this section.

<sup>77</sup> EIA, "Net Generation for All Sectors, Annual," Electricity Data Browser, online database, accessed August 13, 2020,

They generated electricity at 93.5% of their total capacity in 2019, the highest rate of any generation source.<sup>78</sup> Total net generation of nuclear power in 2019 was 809 billion kilowatt-hours.<sup>79</sup>

One new power reactor began commercial operation in 2016: Watts Bar 2 in Tennessee, the first new U.S. reactor since its twin unit began operating in 1996. Two more power reactors are currently under construction in Georgia at the Vogtle plant site. Ten additional new reactors have received licenses from the Nuclear Regulatory Commission (NRC), but construction of those projects is uncertain. An application for a microreactor (with a small fraction of the generating capacity of a conventional nuclear plant) is currently under review.<sup>80</sup>

Despite the strong operational performance of existing nuclear plants, the U.S. nuclear industry has faced significant stress recently. Eleven reactors have permanently closed since the beginning of 2013, and the owners of four more have announced their retirement by the mid-2020s.<sup>81</sup> Construction of two new reactors at the Summer plant site in South Carolina was cancelled following a bankruptcy filing in 2017 by the project's lead contractor, Westinghouse Electric Company.<sup>82</sup> Most of the closed and threatened nuclear power plants sell their electricity at competitive market prices, in contrast to plants that recover their costs (including a reasonable rate of return) through regulated rates. Nuclear plants that rely on power markets have seen falling wholesale power prices and stagnant demand (see “U.S. Consumption” above), combined with relatively high operating and capital costs in some cases, particularly at plants with a single reactor.<sup>83</sup>

Some contend that electricity markets are undervaluing the reliability of nuclear generation, its role in diversifying the nation's power supply, and its importance in reducing greenhouse gas emissions.<sup>84</sup> Nuclear power accounted for 52% of U.S. sources considered to be zero-carbon electricity generation in 2019.<sup>85</sup> A major government effort to preserve nuclear power as a non-direct carbon emitting electricity source is being implemented by the state of New York, which is providing payments in the form of zero-emission credits (ZECs) to four upstate reactors that had been at risk of retirement. The state of Illinois enacted legislation in 2016 to provide ZECs to prevent the planned closure of three at-risk reactors. State assistance has also been enacted in New Jersey, Connecticut, and Ohio (although the Ohio program is currently on hold). Carbon emissions prices set by the Regional Greenhouse Gas Initiative may also improve the economic

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<http://www.eia.gov/electricity/data/browser/>.

<sup>78</sup> EIA, *Electric Power Monthly with Data for May 2020*, Tables 6.7.A and 6.7.B, <https://www.eia.gov/electricity/monthly>. Other 2019 capacity factors for major generation sources were coal, 47.5%; natural gas combined-cycle, 57.3%; geothermal, 69.6%; hydropower, 41.2%; solar photovoltaic, 24.3%; and wind power, 34.3%.

<sup>79</sup> *Ibid.*, Table 1.1. Net generation excludes electricity used to operate the power plant.

<sup>80</sup> Nuclear Regulatory Commission (NRC), “Combined License Applications for New Reactors,” updated May 6, 2020, <https://www.nrc.gov/reactors/new-reactors/col.html>.

<sup>81</sup> See Table 1 of CRS Report R42853, *Nuclear Energy: Overview of Congressional Issues*, by Mark Holt. The Duane Arnold plant permanently closed in August 2020.

<sup>82</sup> Brad Plumer, “U.S. Nuclear Comeback Stalls as Two Reactors Are Abandoned,” *New York Times*, January 20, 2018, sec. Climate, <https://www.nytimes.com/2017/07/31/climate/nuclear-power-project-canceled-in-south-carolina.html>.

<sup>83</sup> For more information, see CRS Report R44715, *Financial Challenges of Operating Nuclear Power Plants in the United States*, by Phillip Brown and Mark Holt.

<sup>84</sup> For example, see “Electricity Markets: Markets Must Value Clean, Reliable, Sustainable Energy,” Nuclear Energy Institute, <https://www.nei.org/advocacy/preserve-nuclear-plants/electricity-markets>.

<sup>85</sup> EIA, “U.S. Energy-Related Carbon Dioxide Emissions, 2019,” Figure 11, September 30, 2020, <https://www.eia.gov/environment/emissions/carbon/>.

competitiveness of nuclear plants.<sup>86</sup> Nuclear power incentives at the federal level have also been proposed, such as an investment tax credit or economic assistance to reactors at risk of closing. A federal nuclear energy production tax credit was extended by the Bipartisan Budget Act of 2018 (P.L. 115-123, Sec. 40501).

Economic and other challenges facing existing commercial nuclear power plants have contributed to increased government and industry interest in unconventional, or “advanced,” nuclear power technologies. Proponents of advanced reactors contend that they would be safer, more efficient, and less expensive to build and operate than today’s conventional light water reactors (LWRs). Some of the designs are also intended to produce less long-lived radioactive waste than existing reactors. Nearly all advanced designs currently under development would be far smaller than conventional reactors, which typically have around 1,000 megawatts (MW) of electric generating capacity. Most proposed advanced reactors would have less than 300 MW of electrical capacity, which DOE classifies as small modular reactors (SMRs). Some have less than 20 MW of electrical capacity, which DOE classifies as microreactors.<sup>87</sup> DOE officially launched an Advanced Reactor Demonstration Program on May 14, 2020, with FY2020 funding of \$230 million for “cost-shared partnerships with industry.”<sup>88</sup>

However, some others express doubts that new nuclear plants, even with advanced technology, can overcome such drawbacks as accident risk, high costs, and disposal of radioactive waste. Focusing on renewable energy and energy efficiency would be far more effective in reducing carbon emissions, they argue.<sup>89</sup> It is not clear, however, that these alternatives can provide sufficient baseload power supplies to replace nuclear, at least in the near term.

All but 3 of today’s 94 nuclear power reactors (**Figure 10**) began operating before 1990, and most started commercial operation before 1980. They were initially licensed by NRC to operate for 40 years, a period that for more than half of U.S. reactors expired before 2020. However, most reactors have been issued 20-year license renewals, pushing back the license expiration of almost all nuclear plants at least to the 2030s. Subsequent 20-year renewals, for a total operating life of 80 years, are also allowed. NRC has issued four such subsequent license renewals for up to 80 years of operation. Another four subsequent license renewal applications are currently under review, and at least seven more have been announced.<sup>90</sup>

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<sup>86</sup> Proctor, Darrell, “Pennsylvania Move to Join RGGI May Save Nuclear Plant,” *Power*, March 15, 2020, <https://www.powermag.com/pennsylvania-move-to-join-rggi-may-save-nuclear-plant>. For additional information on state incentives, see section on “Nuclear Plant Economic Viability” in CRS Report R42853, *Nuclear Energy: Overview of Congressional Issues*, by Mark Holt.

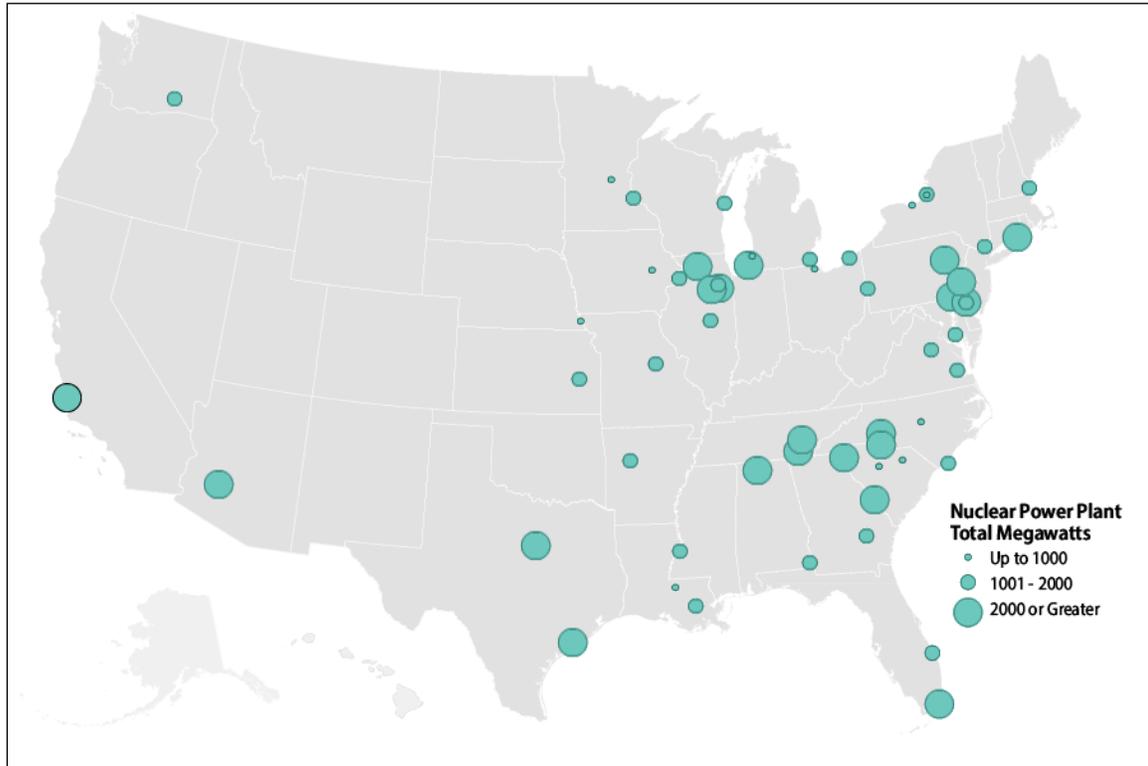
<sup>87</sup> Department of Energy (DOE), Office of Nuclear Energy, “What Is a Nuclear Microreactor?,” October 23, 2018, <https://www.energy.gov/ne/articles/what-nuclear-microreactor>.

<sup>88</sup> DOE, Office of Nuclear Energy, “U.S. Department of Energy Launches \$230 Million Advanced Reactor Demonstration Program,” May 14, 2020, <https://www.energy.gov/ne/articles/us-department-energy-launches-230-million-advanced-reactor-demonstration-program>. For more information, see CRS Report R45706, *Advanced Nuclear Reactors: Technology Overview and Current Issues*, by Danielle A. Arostegui and Mark Holt.

<sup>89</sup> Nuclear Information and Resource Service, “Nukes and Climate Change,” web page, accessed August 13, 2020, <https://www.nirs.org/climate/>.

<sup>90</sup> NRC, “Status of Subsequent License Renewal Applications,” updated September 21, 2020, <https://www.nrc.gov/reactors/operating/licensing/renewal/subsequent-license-renewal.html>.

**Figure 10. U.S. Operating Commercial Nuclear Power Reactors**  
As of July 2020



**Source:** CRS analysis of U.S. Energy Information Administration, U.S. Total Nuclear and Uranium Data and Map, updated July 2020, <https://www.eia.gov/beta/states/data/dashboard/nuclear-uranium>.

## Renewable Energy: Continued Growth<sup>91</sup>

Federal policies that support the use of renewable energy date mainly back to the mid-1970s—the years following the 1973 oil embargo and the ensuing gasoline price volatility. At that time, support for renewable energy was generally oriented towards achieving energy security goals (e.g., steady, independent access to domestic energy sources). While energy security remains a policy objective, much of the current debate regarding renewable energy relates to the environment (e.g., GHG emission reduction) and the economy (e.g., affordability).

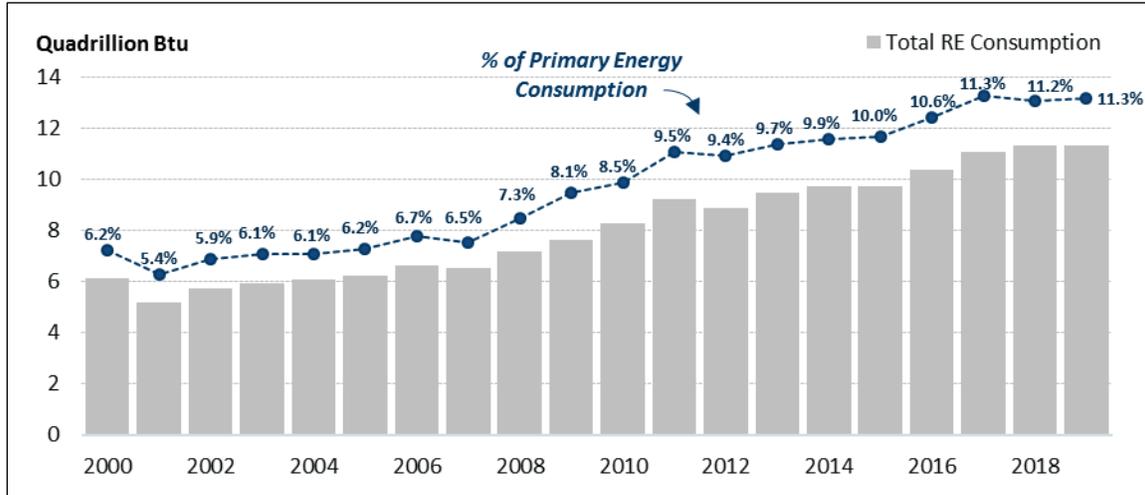
Renewable energy is a relatively small portion of the total U.S. energy portfolio, constituting slightly more than 11% of total U.S. energy consumption in 2019.<sup>92</sup> However, renewable energy consumption has increased since 2000, nearly doubling between 2000 and 2019, as illustrated in **Figure 11**.<sup>93</sup> Most of this growth was due to increased use of wind and solar for electric power generation and biofuels for transportation.

<sup>91</sup> Kelsi Bracmort, Specialist in Natural Resources and Energy Policy, and Ashley Lawson, Analyst in Energy Policy, are the lead authors of this section.

<sup>92</sup> EIA, *Monthly Energy Review*, Table 1.1, “Primary Energy Overview,” November 2020. Renewable energy sources include hydropower, geothermal, solar, wind, and biomass (including biofuels).

<sup>93</sup> *Ibid.*

**Figure 11. Renewable Energy Consumption in the United States, 2000-2019**



**Source:** CRS analysis of U.S. Energy Information Administration, *Monthly Energy Review*, November 2020, <https://www.eia.gov/totalenergy/data/monthly/>.

Renewable energy is available in a variety of distinct forms that use different conversion technologies to produce usable energy products (e.g., heat, electricity, and liquid fuels). Each energy product derived from a renewable source has unique market and policy considerations.<sup>94</sup>

Renewable energy is consumed within the electric power, industrial, transportation, residential, and commercial sectors. As indicated in **Table 4**, the contribution of the different renewable energy sources to each sector varies. For example, nearly all hydropower is consumed in the electric power sector and most of the industrial sector renewable energy use is in the form of biomass energy generation.<sup>95</sup>

**Table 4. U.S. Renewable Energy Consumption by Sector and Source, 2019**

	Trillion Btu					
	Residential	Commercial	Industrial	Transportation	Electric Power	Total
Hydropower	0	2	9	0	2,552	<b>2,563</b>
Geothermal	40	24	4	0	134	<b>201</b>
Solar	252	103	28	0	635	<b>1,018</b>
Wind	0	2	1	0	2,623	<b>2,626</b>
Biomass	529	149	2,387	1,411	448	<b>4,924</b>
<b>Total</b>	<b>821</b>	<b>279</b>	<b>2,429</b>	<b>1,411</b>	<b>6,392</b>	<b>11,332</b>

<sup>94</sup> For example, renewable electricity generation is supported by state-level renewable portfolio standards—where enacted—in addition to federal-level tax incentives for certain renewable energy sources. Biofuels, on the other hand, are supported by the federal-level Renewable Fuel Standard (RFS) that requires a specified volume of renewable fuels to be included in the national fuel supply each year.

<sup>95</sup> EIA, *Monthly Energy Review*, Table 10.2c Renewable Energy Consumption: Electric Power Sector and Table 10.2b Renewable Energy Consumption: Industrial and Transportation Sectors, November 2020.

**Source:** U.S. Energy Information Administration, *Monthly Energy Review*, Table 10.2a, “Consumption: Residential and Commercial Sectors,” Table 10.2b, “Consumption: Industrial and Transportation Sectors,” and Table 10.2c, “Consumption: Electric Power Sector,” November 2020.

**Notes:** Values may not sum due to independent rounding. Biomass includes wood, waste, fuel ethanol, and biodiesel.

Renewable energy consumption has grown over the last couple of decades. The electric power sector was the largest renewable energy consumer in 2019, accounting for 56% of total renewable energy consumption (see **Table 4**). Following the trend for renewable energy overall, electric power renewable energy consumption nearly doubled between 2000 and 2019.<sup>96</sup> The industrial sector was the second-largest renewable energy consumer in 2019, with consumption levels increasing approximately 26% between 2000 and 2019.

The following sections discuss renewable transportation fuels and renewable electricity generation trends from 2000 to the present, and provide some context about the policy and market dynamics that have contributed to the growth of these separate and distinct markets. It is beyond the scope of this report to include either detailed descriptions or analysis of each renewable energy source or a comprehensive assessment of each consumption sector.

## Renewable Transportation Fuels

Renewable energy production and consumption in the transportation sector comes in the form of two primary types of renewable fuels: ethanol and biodiesel. The primary use of ethanol is as a blending component of motor gasoline. Although it can vary by vehicle type and access to high level ethanol-gasoline blends, ethanol content generally represents approximately 10% of gasoline by volume (i.e., E10). Biodiesel is a direct substitute for diesel fuel, and can be blended at various volume amounts including 5% (i.e., B5) and 20% (i.e., B20).

U.S. ethanol and biodiesel production and consumption in the United States have experienced growth over the last 15 years. Significant growth occurred following the establishment and expansion of the Renewable Fuel Standard—a mandate that U.S. transportation fuel contain a minimum volume of biofuel.<sup>97</sup> U.S. ethanol production has steadily increased from approximately 1.6 billion gallons in 2000 to just under 16 billion gallons in 2019.<sup>98</sup> Ethanol consumption increased from 1.7 billion gallons in 2000 to more than 14 billion gallons in 2019.<sup>99</sup> During the same period biodiesel production increased from 9 million gallons in 2001 to approximately 1.7 billion gallons in 2019.<sup>100</sup> Including imported fuel, biodiesel consumption increased from 10 million gallons in 2001 to approximately 1.8 billion gallons in 2019.<sup>101</sup>

<sup>96</sup> Ibid. Table 10.2c Renewable Energy Consumption: Electric Power Sector.

<sup>97</sup> For more information, see CRS Report R43325, *The Renewable Fuel Standard (RFS): An Overview*, by Kelsi Bracmort.

<sup>98</sup> EIA, *Monthly Energy Review*, Table 10.3, November 2020.

<sup>99</sup> Ibid.

<sup>100</sup> EIA, *Monthly Energy Review*, Table 10.4, November 2020. The *Monthly Energy Review* reports biodiesel data starting in 2001.

<sup>101</sup> Ibid.

## Renewable Electricity

U.S. electricity generation from renewable sources more than doubled between 2000 and 2019.<sup>102</sup> The contribution of renewable energy to the U.S. power sector increased from 9% in 2000 to 18% in 2019.<sup>103</sup> While hydropower generation has represented 6% to 8% of total U.S. electric power generation since 2000, essentially all of the growth in renewable electricity generation during this period was from non-hydro renewables, particularly wind and solar.<sup>104</sup>

### Non-Hydro Renewables

Non-hydro renewable energy sources (i.e., wind, solar, geothermal, and biomass) for electricity generation have been supported by policies at both the state and federal level. Renewable portfolio standard (RPS) policies instituted in many states have been a demand catalyst for these renewables, especially wind and solar.<sup>105</sup> Federal tax incentives—in the form of investment and production tax credits,<sup>106</sup> as well as accelerated depreciation—have provided a federal-level financial incentive that has resulted in renewable electricity being financially attractive to both project investors and power purchasers. These policies have contributed to growth in the use of non-hydro renewable energy sources to generate electric power in the United States.<sup>107</sup> In 2019 non-hydro renewable energy sources provided 12% of total U.S. electric power generation, up from 2% in 2000 (see **Figure 12**).

Wind and solar have dominated growth in non-hydro renewables for electricity generation, while generation from biomass and geothermal has remained essentially flat. Electricity generation from wind energy increased by a factor of 67 between 2000 and 2019, growing from less than 5 Terawatt-hours (TWh) to more than 300 TWh. Electricity generation from solar energy increased by more than a factor of 200 between 2000 and 2019, growing from 0.5 TWh to 107 TWh (see **Figure 12**).

U.S. electricity demand has been relatively flat from 2000 to 2019, as discussed in the section “The Electric Power Sector: In Transition.” As a result, electricity from non-hydro renewables has grown in both absolute terms and as a share of the total.

<sup>102</sup> Data for 2000-2010 from EIA, *Electric Power Annual 2010*, Table 2.1.A, November 2011. Data for 2012-2019 from EIA, *Electric Power Monthly with Data for May 2020*, Table 1.1, July 2020.

<sup>103</sup> Ibid.

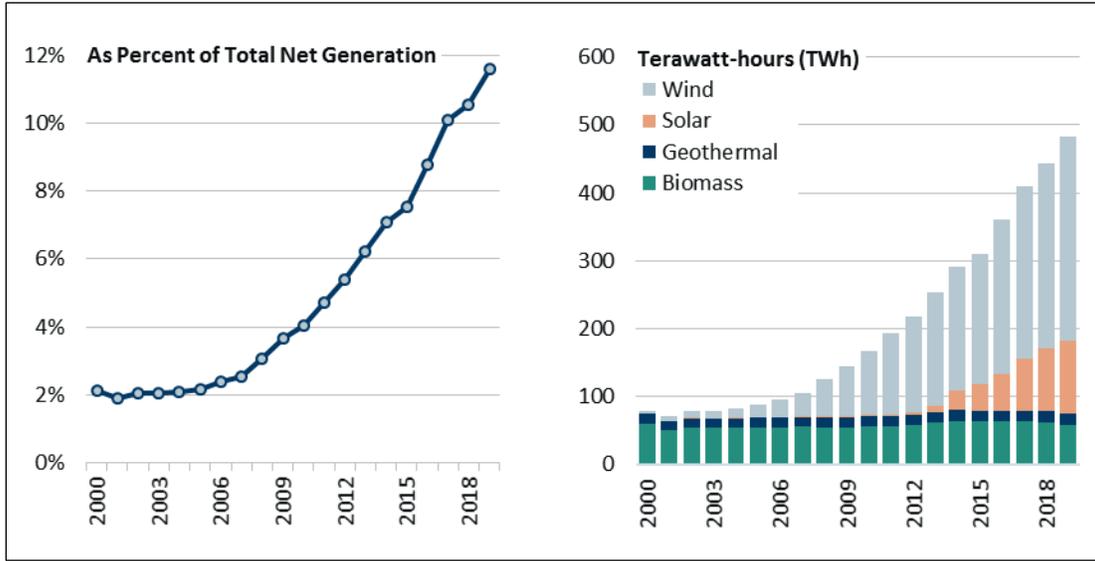
<sup>104</sup> Due to the established nature of hydropower, and a lack of significant change in the amount of hydroelectric generation over the last 20 years, this section limits discussion of renewable electricity to non-hydro renewables.

<sup>105</sup> For additional information about Renewable Portfolio Standard policies, see CRS Report R45913, *Electricity Portfolio Standards: Background, Design Elements, and Policy Considerations*, by Ashley J. Lawson, and the Database of State Incentives for Renewables and Efficiency (DSIRE) summary map of state renewable policies available at <https://s3.amazonaws.com/ncsolarcen-prod/wp-content/uploads/2019/07/RPS-CES-June2019.pdf>.

<sup>106</sup> For additional information about investment tax credits for renewable electricity generation technologies, see CRS In Focus IF10479, *The Energy Credit: An Investment Tax Credit for Renewable Energy*, by Molly F. Sherlock. For additional information about production tax credits for renewable electricity production, see CRS Report R43453, *The Renewable Electricity Production Tax Credit: In Brief*, by Molly F. Sherlock.

<sup>107</sup> Galen Barbose, *U.S. Renewables Portfolio Standard 2019 Annual Status Update*, Lawrence Berkeley National Laboratory, July 2019, p. 14.

**Figure 12. Non-Hydro Renewable Electricity Generation, 2000-2019**

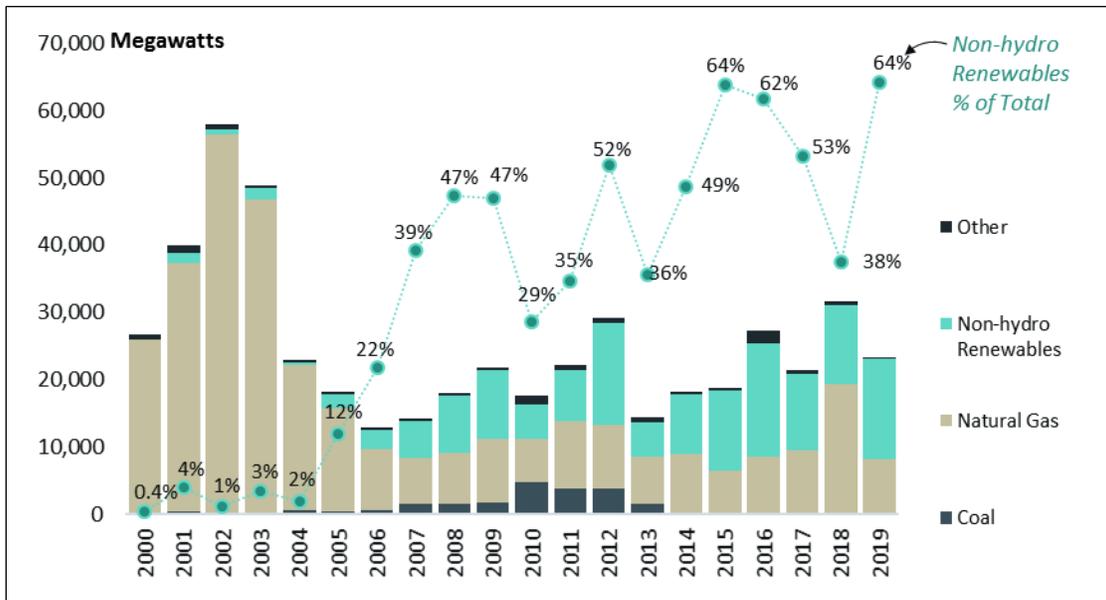


**Source:** U.S. Energy Information Administration (EIA), *Electric Power Annual 2010*, Table 2.1.A, November 2011, and EIA, *Electric Power Monthly with Data for May 2020*, Table 1.1, July 2020.

**Notes:** EIA defines utility-scale solar as facilities with at least 1 megawatt (MW) capacity. Utility-scale solar includes solar thermal and solar photovoltaic. Percent of total includes utility-scale and small-scale solar. EIA began reporting small-scale solar generation estimates in 2014. In that year, small-scale solar comprised 39% of all generation from solar energy.

In terms of new electric power capacity additions, non-hydro renewables exceeded that of coal and natural gas in four of the last five years (except 2018; see **Figure 13**). The large majority of non-hydro renewable capacity additions came from wind and solar.

**Figure 13. Electric Power Capacity Additions, 2000-2019**



**Source:** CRS analysis of U.S. Energy Information Administration, *Form EIA-860*.

**Notes:** Figure shows summer capacity for all capacity additions. Non-hydro Renewables includes wind (onshore and offshore), solar photovoltaic (utility-scale and small-scale), and solar thermal. Data for small-scale capacity additions are not available prior to 2015.

## Small-Scale Solar

Generation from small-scale solar has grown in recent years, albeit at a slightly slower pace than larger projects.<sup>108</sup> Some of the factors discussed above have also contributed to growth in small-scale solar. Other state policies, such as net metering, affect small-scale solar uniquely.<sup>109</sup>

Costs and benefits for small-scale solar differ from larger solar projects. Electricity generated from small solar projects is several times more expensive on a per megawatt (MW) basis than electricity generated from large ones.<sup>110</sup> The cost difference arises in part from the fact that large solar projects benefit from economies of scale and cost less than half as much to build as small projects per MW.<sup>111</sup> Another factor is that small projects may not be ideally situated for electricity generation. For example, PV panels on rooftops may be partially shaded or north-facing, thus receiving less sunlight throughout the year than more ideally-situated panels (e.g., a “solar farm” which may be installed on an unshaded area).

Proponents of small-scale solar may value some characteristics that large projects do not have: they can be installed on developed land in urban areas; they rarely require new electricity transmission infrastructure; and, under certain circumstances, they can financially benefit individuals and communities.<sup>112</sup>

Small-scale solar—typically rooftop installations at a residential, commercial, or industrial location—has made up 38% of all solar capacity additions, on average, from 2015 to 2019.<sup>113</sup> Generation from small-scale solar (new and existing installations) made up 33%-39% of generation from all solar PV over those same years.<sup>114</sup>

<sup>108</sup> Solar photovoltaic (PV) panels—the most commonly used solar electricity technology today—can be assembled in configurations of different sizes, ranging from large “solar farms” to small-scale installations such as those on rooftops. Different organizations use different definitions for “small-scale” solar. For more information, see CRS Report R46196, *Solar Energy: Frequently Asked Questions*, coordinated by Ashley J. Lawson.

<sup>109</sup> CRS Report R46010, *Net Metering: In Brief*, by Ashley J. Lawson.

<sup>110</sup> Levelized cost of energy (LCOE) is one measure of the cost of electricity. LCOE estimates reflect the net present cost to generate electricity over the lifetime of a facility, normalized by the amount of electricity (usually in megawatt-hours, MWh) the facility is expected to produce. LCOE estimates account for costs for building, operating, and maintaining a facility (including fuel costs, if any), but do not typically account for system costs such as electricity transmission infrastructure that might be required to deliver electricity. In 2019, the firm Lazard estimated LCOE of \$29-\$38 per MWh for large-scale solar; \$74-\$179 per MWh for rooftop solar on commercial and institutional buildings; and \$150-\$227 per MWh for rooftop solar on residential buildings. Lazard, *Levelized Cost of Energy Analysis, Version 13.0*, October 2020.

<sup>111</sup> Ran Fu, David Feldman, and Robert Margolis, *U.S. Solar Photovoltaic System Cost Benchmark: Q1 2018*, National Renewable Energy Laboratory (NREL), November 2018. Megawatt (MW) is a measure of the capacity of an installation to generate electricity.

<sup>112</sup> One financial benefit comes through the policy of net metering, which is implemented in many states. For more information, see CRS Report R46010, *Net Metering: In Brief*, by Ashley J. Lawson.

<sup>113</sup> EIA, *Electric Power Monthly*, Table 6.1.A, “Net Summer Capacity for Utility Scale Solar Photovoltaic and Small Scale Solar Photovoltaic Capacity (Megawatts).” Data on capacity additions before 2015 is not available. Small-scale solar made up 40%-43% in all years except 2016, when small-scale made up 26% of additions.

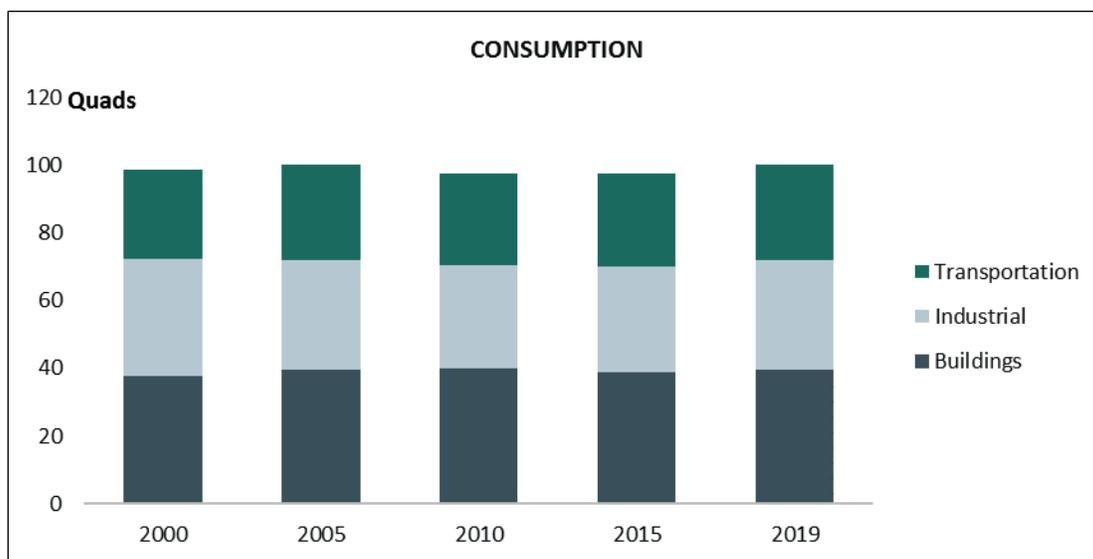
<sup>114</sup> EIA, *Electric Power Monthly*, Table 1.1, “Net Generation by Energy Source.”

## Energy Efficiency: An Untapped Resource<sup>115</sup>

Federal policies supporting energy conservation and energy efficiency date mainly back to the mid-1970s, the years following the 1973 oil embargo and energy price volatility that resulted. At that time, support for energy conservation and energy efficiency was generally oriented towards achieving energy security goals, providing relief from high energy prices to low-income households, and encouraging energy conservation. Energy conservation and energy efficiency are not synonymous. *Energy conservation* is any action or behavior that results in consuming less energy (e.g., turning off a lamp when leaving a room). *Energy efficiency* is providing the same or an improved level of service with less energy (e.g., replacing an incandescent light bulb with a light-emitting diode (LED) light bulb).

Although energy security remains a policy objective, much of the current debate about supporting energy efficiency is related to the benefits of reduced energy consumption (e.g., consumers saving money, energy sector avoiding GHG emissions) and the costs to builders and manufacturers (e.g., investments in equipment or processes to meet mandatory or voluntary performance metrics). Proponents of increased energy efficiency see an untapped “resource” that can mitigate the demand for additional energy supplies. Perceived benefits of energy efficiency include lowered energy bills, reduced demand for energy, improved energy security and independence, and reduced air pollution and GHG emissions. Challenges to energy efficiency include market barriers that do not incentivize builders or developers to invest in energy efficiency, customers’ lack of information or awareness of energy saving opportunities and investment returns, and policy barriers that focus on energy supply rather than investment in energy use and efficiency.

**Figure 14. U.S. Total Energy Consumption by Sector 2000-2019**  
Quadrillion Btu (Quads)



**Source:** Data compiled by CRS from U.S. Energy Information Administration, *Monthly Energy Review*, Table 2.1, July 2020, [https://www.eia.gov/totalenergy/data/monthly/pdf/sec2\\_3.pdf](https://www.eia.gov/totalenergy/data/monthly/pdf/sec2_3.pdf).

**Notes:** Total energy consumption by end-use sectors in this chart includes electrical system energy losses, which are allocated proportionally to the amount of electricity retail sales to each end-use sector.

<sup>115</sup> Corrie Clark, CRS Analyst in Energy Policy, is the lead author of this section.

According to the EIA, U.S. total energy consumption is about 100 quadrillion Btu (Quads).<sup>116</sup> Of that total, the buildings and industrial sectors collectively consume approximately 72% of U.S. total energy, and the transportation sector consumes approximately 28% (see **Figure 14**).<sup>117</sup> Increased adoption of energy-efficiency technologies by these sectors could potentially realize significant energy savings and reduce emissions to the environment.

Improvements in energy efficiency may not translate into overall energy consumption reductions. If demand for energy services remained constant, then improving energy efficiency would reduce energy consumption. However, demand for energy services can change. For example, consumers could offset gains in appliance efficiency standards by buying larger appliances or multiple appliances.<sup>118</sup> This type of outcome is commonly referred to as the “rebound effect.”<sup>119</sup>

## Efficiency in Buildings

The residential and commercial buildings sector accounts for 39% of U.S. total energy consumption.<sup>120</sup> DOE estimates that building energy use could be reduced by more than 20% through implementation of technologies that are known to be cost-effective.<sup>121</sup> Policy options to increase energy efficiency in the building sector include building energy codes, mandatory appliance and equipment energy conservation standards, and voluntary programs such as the ENERGY STAR program.<sup>122</sup>

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<sup>116</sup> For 2019, EIA estimated energy consumption to be 100 Quads. In light of the COVID-19 pandemic, EIA has estimated that energy consumption declined to approximately 93 Quads. EIA, *Annual Energy Outlook*, Table A2, “Energy Consumption by Sector and Source,” 2020, <https://www.eia.gov/outlooks/aeo/data/browser/#/?id=2-AEO2020&cases=ref2020&sourcekey=0>; EIA, *Annual Energy Outlook*, Table A2, “Energy Consumption by Sector and Source,” 2021, [https://www.eia.gov/outlooks/aeo/excel/aeotab\\_2.xlsx](https://www.eia.gov/outlooks/aeo/excel/aeotab_2.xlsx).

<sup>117</sup> The building sector is an end-use energy consumption segment of the nation’s energy system that is comprised of residential and commercial buildings. The industrial sector is an end-use energy consumption segment of the nation’s energy system that is comprised of energy-intensive manufacturing, non-energy-intensive manufacturing, and nonmanufacturing activities.

<sup>118</sup> According to EIA, from 1978 to 1997, the percentage of households that reported a second refrigerator remained consistently between 12% and 15% for every residential energy consumption survey cycle; however, between 1997 and 2015, the percentage of households increased to 30% of all housing units. EIA also found that households with multiple refrigerators tended to have more rooms than those households with only one refrigerator. EIA, “What’s New in How We Use Energy at Home,” May 2018, <https://www.eia.gov/consumption/residential/reports/2015/overview/index.php>.

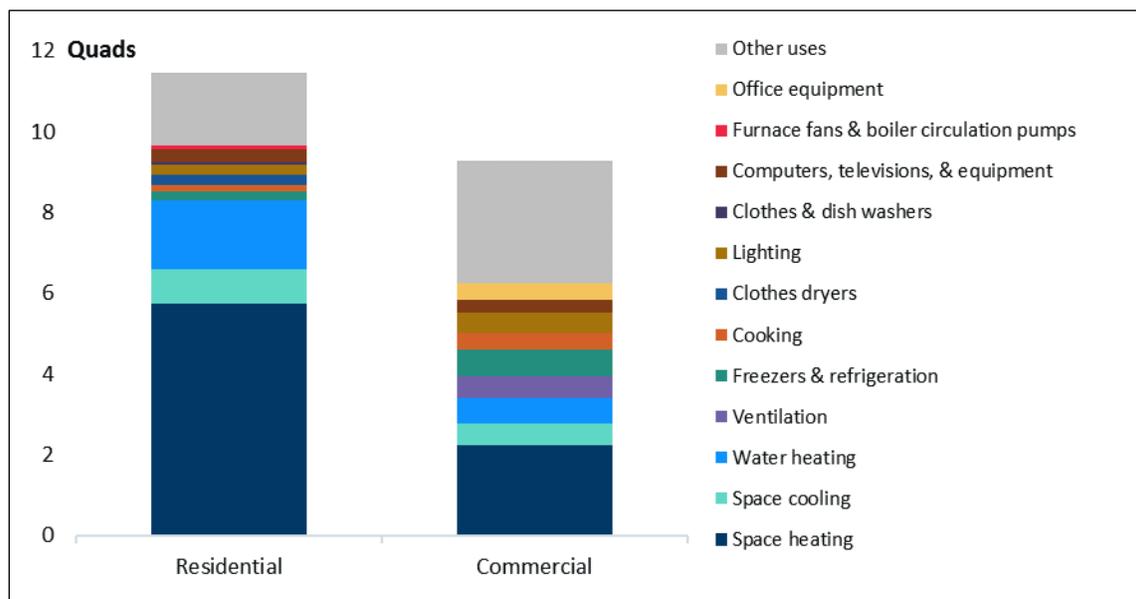
<sup>119</sup> S. Sorrell, J. Dimitropoulos, and M. Sommerville, “Empirical Estimates of the Direct Rebound Effect: A Review,” *Energy Policy*, 2009, vol. 37, no. 4, pp. 1356-1371.

<sup>120</sup> See EIA, *Annual Energy Outlook*, Table A2, “Energy Consumption by Sector and Source,” 2020, [https://www.eia.gov/outlooks/aeo/excel/aeotab\\_2.xlsx](https://www.eia.gov/outlooks/aeo/excel/aeotab_2.xlsx).

<sup>121</sup> DOE, “Chapter 5: Increasing Efficiency of Building Systems and Technologies,” *Quadrennial Technology Review*, September 2015, p. 2, at <https://energy.gov/sites/prod/files/2017/03/f34/qtr-2015-chapter5.pdf>.

<sup>122</sup> For more information on building practices and building energy codes, see CRS Report R46719, *Green Building Overview and Issues*, by Corrie E. Clark. For more information on appliance and equipment standards, see CRS In Focus IF11354, *Department of Energy Appliance and Equipment Standards Program*, by Corrie E. Clark. For more information on ENERGY STAR®, an internationally recognized voluntary labeling program for energy-efficient products, homes, buildings, and manufacturing plants that is jointly administered by EPA and DOE, see CRS In Focus IF10753, *ENERGY STAR Program*, by Corrie E. Clark.

**Figure 15. Estimated U.S. Delivered Energy Consumption by End Use, 2019**  
Quadrillion Btu (Quads)



**Source:** CRS using EIA, *Annual Energy Outlook*, Tables A4-A5, January 2020.

**Notes:** “Other uses” for residential buildings include (but are not limited to) wood used for primary and secondary heating in wood stoves or fireplaces. “Other uses” for commercial buildings include (but are not limited to) miscellaneous uses such as transformers, medical imaging and other medical equipment, elevators, escalators, off-road electric vehicles, laboratory fume hoods, laundry equipment, coffee brewers, water services, emergency generators, combined heat and power in commercial buildings, and manufacturing performed in commercial buildings.

## Efficiency in Transportation

In 2019, the transportation sector consumed approximately 28.11 Quads of total U.S. energy, accounting for 72% of all U.S. petroleum use.<sup>123</sup> Of the total energy consumed, approximately 57% is attributable to light duty vehicles and commercial light trucks, 21% is attributable to freight trucks, and 9% is attributable to aircraft (see **Figure 16**). DOE estimates that efficiency improvements to the internal combustion engine alone could increase fuel economy for passenger vehicles by 35-50%, and commercial vehicles by 30-40%, both compared to a 2009 baseline.<sup>124</sup> Two agencies establish fuel standards for passenger vehicles: the Corporate Average Fuel Economy (CAFE) standards are promulgated by the National Highway Traffic Safety Administration (NHTSA), and the Light-Duty Vehicle GHG Emission Standards are promulgated by the U.S. Environmental Protection Agency (EPA; see shaded box below on “Fuel Efficiency Standards for Vehicles”).<sup>125</sup> In addition to policy options such as mandatory standards, other energy efficiency considerations for the transportation sector include procurement goals for

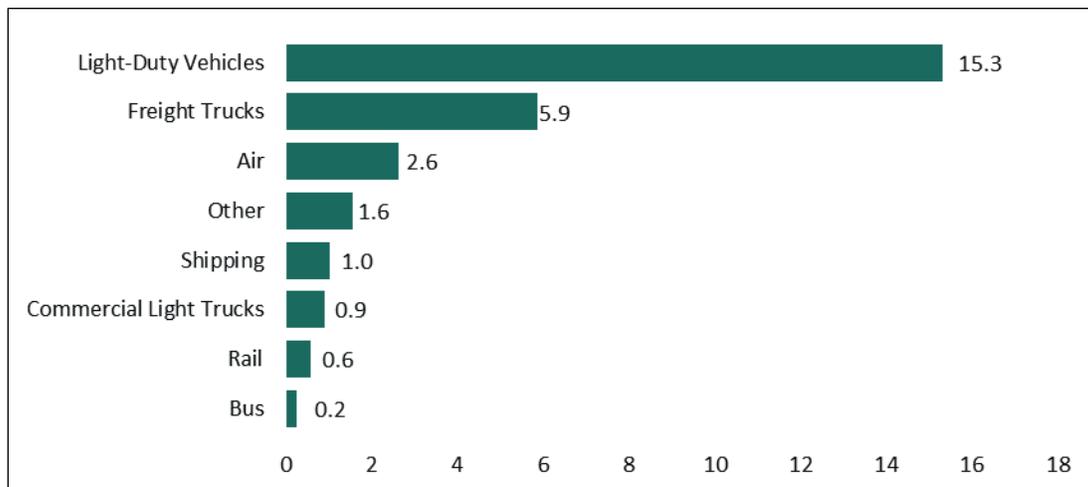
<sup>123</sup> EIA, *Annual Energy Outlook*, Table A2, “Energy Consumption by Sector and Source,” 2020, [https://www.eia.gov/outlooks/aeo/excel/aeotab\\_2.xlsx](https://www.eia.gov/outlooks/aeo/excel/aeotab_2.xlsx).

<sup>124</sup> DOE, “Chapter 8: Advancing Clean Transportation and Vehicle Systems and Technologies,” *Quadrennial Technology Review*, September 2015, pp. 282-283, at <https://energy.gov/sites/prod/files/2017/03/f34/qtr-2015-chapter8.pdf>.

<sup>125</sup> For more information on fuel economy standards and greenhouse gas standards, see CRS In Focus IF10871, *Vehicle Fuel Economy and Greenhouse Gas Standards*, by Richard K. Lattanzio, Linda Tsang, and Bill Canis.

federal fleets and potential expansion of alternative fuel and electric vehicle recharging infrastructure.<sup>126</sup>

**Figure 16. U.S. Transportation Sector Energy Use by Mode in 2019**  
Quadrillion Btu



**Source:** CRS using EIA, *Annual Energy Outlook*, Table A7, January 2020.

**Notes:** Shipping includes domestic and international shipping. Rail includes passenger and freight. Other includes recreational boats, military, lubricants, and pipeline fuel.

## Efficiency in Industry and Manufacturing

According to the EIA, and the industrial sector consumes about 33% of U.S. total energy.<sup>127</sup> Nearly two-thirds of the energy consumption from this sector is associated with manufacturing (see **Figure 17**). The bulk chemicals subsector consumes the most energy of 16 manufacturing subsectors, with an estimated 7.5 Quads in 2019.<sup>128</sup> In 2010, the National Academies estimated that implementing existing, cost-effective efficiency technologies in the industrial sector could reduce energy consumption by 14-22%.<sup>129</sup> A more recent study by EIA estimated that industrial sector energy intensity could be reduced by 44% globally between 2018 and 2040.<sup>130</sup> Policy options to increase energy efficiency in the industrial sector include mandatory equipment energy

<sup>126</sup> For more information on electrification issues, see CRS Report R46231, *Electric Vehicles: A Primer on Technology and Selected Policy Issues*, by Melissa N. Diaz; CRS Report R46420, *Environmental Effects of Battery Electric and Internal Combustion Engine Vehicles*, by Richard K. Lattanzio and Corrie E. Clark; and CRS Report R45747, *Vehicle Electrification: Federal and State Issues Affecting Deployment*, by Bill Canis, Corrie E. Clark, and Molly F. Sherlock.

<sup>127</sup> See EIA, *Annual Energy Outlook*, Table A2, “Energy Consumption by Sector and Source,” 2020, [https://www.eia.gov/outlooks/aeo/excel/aeotab\\_2.xlsx](https://www.eia.gov/outlooks/aeo/excel/aeotab_2.xlsx).

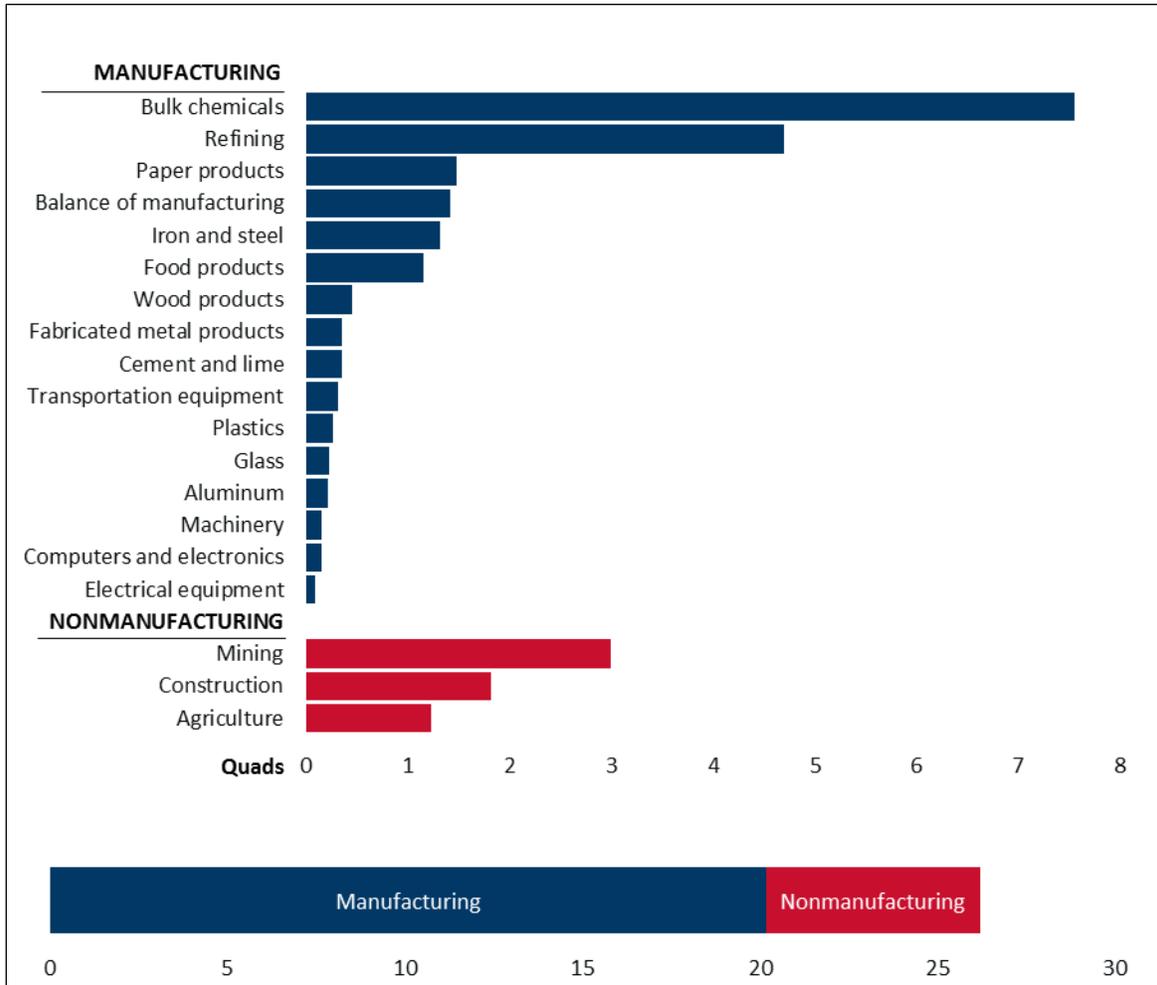
<sup>128</sup> EIA, *Annual Energy Outlook*, Reference Case Projection Table 27. “Bulk Chemical Industry Energy Consumption,” 2020, [https://www.eia.gov/outlooks/aeo/tables\\_ref.php](https://www.eia.gov/outlooks/aeo/tables_ref.php).

<sup>129</sup> National Academy of Sciences, National Academy of Engineering, and National Research Council, *Real Prospects for Energy Efficiency in the United States*, 2010, p.15, at <https://doi.org/10.17226/12621>.

<sup>130</sup> Energy intensity refers to energy use per unit of gross value added. The projection is for International Energy Agency (IEA) countries and other major economies as determined by IEA. IEA, *Energy Efficiency 2018: Analysis and Outlooks to 2040*, 2018, p. 101, at <https://www.iea.org/reports/energy-efficiency-2018>.

conservation standards and voluntary programs such as the Better Plants program or ENERGY STAR program.<sup>131</sup>

**Figure 17. U.S. Industrial Sector Energy Consumption in 2019**  
 Quadrillion Btu (Quads)



**Source:** CRS using EIA, *Annual Energy Outlook*, Reference Tables 24-34, January 2020.

**Notes:** Nonmanufacturing (in red) includes mining, agriculture, and construction sectors. Manufacturing includes other sectors (in blue). Energy consumption includes energy for combined heat and power plants that have a non-regulatory status and small on-site generating systems.

**Fuel Efficiency Standards for Vehicles<sup>132</sup>**

<sup>131</sup> Better Plants is a voluntary program administered by DOE for industrial scale energy users (e.g., manufacturers) who voluntarily set a goal such as reducing energy intensity by 25% over a 10-year period. For more information on Better Plants, see <https://betterbuildingssolutioncenter.energy.gov/better-plants>.

<sup>132</sup> For more information, see CRS Report R40506, *Cars, Trucks, Aircraft, and EPA Climate Regulations*, by James E. McCarthy and Richard K. Lattanzio, and CRS In Focus IF10871, *Vehicle Fuel Economy and Greenhouse Gas Standards*, by Richard K. Lattanzio, Linda Tsang, and Bill Canis.

Light-duty vehicles and commercial light trucks use approximately 58% of delivered energy used by the transportation sector.<sup>133</sup> Two key federal statutes regulate the fuel efficiency of these vehicles. First, the Energy Policy and Conservation Act (EPCA, P.L. 94-163) established Corporate Average Fuel Economy (CAFE) standards for passenger cars starting in model year (MY) 1978 and light trucks in MY1979. Over time, the statute has been amended to require tighter standards, to significantly modify the structure of the program, and to include heavy-duty trucks. Second, GHG emissions—which are closely linked with fuel consumption—are regulated under the Clean Air Act (CAA, 42 U.S.C. §7521 et seq.). In addition, the State of California, which has authority to set its own vehicle emissions standards, has established GHG standards, which other states have adopted. (States are preempted from setting their own fuel economy standards, and are generally preempted from setting their own emissions standards except that they may adopt the California standards.) In September 2019, the U.S. Environmental Protection Agency (EPA) formally revoked California’s authority to set its own vehicle emissions standards as part of the Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule, which overhauls the CAFE and GHG standards for model years 2021 and beyond. As of January 2021, the Biden Administration is reviewing this rule.

Because of concerns over three competing sets of regulations on the same topic, in 2009 the EPA and the National Highway Traffic Safety Administration (NHTSA) (which administer emissions and fuel economy standards, respectively) developed a set of memoranda of understanding among the agencies, the automakers, and California. EPA and NHTSA first issued joint CAFE/emissions standards for MY2012-MY2016, on cars and light trucks, calling for significantly higher fuel economy than previously required. Some of this was in response to a requirement in the Energy Independence and Security Act of 2007 (EISA, P.L. 110-140), although the final standards achieved the EISA target earlier than required. In 2012, the agencies issued a second phase of light duty vehicle standards for MY2017-MY2025 for emissions and MY2017-MY2022 for fuel economy (EPCA prohibits NHTSA from setting standards for longer than five model years). If achieved, these standards would ultimately push car and light truck average fuel economy above 50 miles per gallon. Because of the long time frame of the emissions standards, and the need for a new rulemaking on fuel economy, the agencies committed to a Midterm Evaluation (MTE) of the MY2022-MY2025 portion of the GHG standards. On January 12, 2017, EPA decided to maintain the GHG standards as promulgated. However, for the CAFE standards, a new rulemaking remained necessary. On March 15, 2017, President Trump announced that EPA and NHTSA would reinstate the MTE process.<sup>134</sup> EPA released a revised final determination on April 2, 2018. It stated the MY2022-MY2025 standards were “not appropriate and, therefore, should be revised.”<sup>135</sup> With this revision, EPA and NHTSA announced that they would initiate a new rulemaking.<sup>136</sup> On August 2, 2018, EPA and NHTSA opened the public comment period on the proposed revision of the standards.

## Energy on Federal Lands: A Declining Share<sup>137</sup>

The surface area of the 50 United States is approximately 2.4 billion acres, of which approximately 650 million acres are owned by the federal government. *Onshore federal lands* include all federal surface lands and the 710 million acres of the federal subsurface mineral estate.<sup>138</sup> The federal government also owns and manages the approximately 1.7 billion offshore

<sup>133</sup> Data for 2016 in terms of million barrels per day oil equivalent from EIA, *Annual Energy Outlook 2018*, Table A7, [https://www.eia.gov/outlooks/aeo/section\\_appendices.php](https://www.eia.gov/outlooks/aeo/section_appendices.php).

<sup>134</sup> The White House, Office of the Press Secretary, *President Donald J. Trump: Buy American and Hire American for the United States Automobile Industry*, Washington, DC, March 15, 2017, <https://www.whitehouse.gov/the-press-office/2017/03/15/president-donald-j-trump-buy-american-and-hire-american-united-states>.

<sup>135</sup> U.S. Environmental Protection Agency (EPA), “Mid-Term Evaluation of Greenhouse Gas Emissions Standards for Model Year 2022-2025 Light-Duty Vehicles: Notice; Withdrawal,” 83 *Federal Register* 16077, Friday, April 13, 2018.

<sup>136</sup> For more information, see CRS Report R45204, *Vehicle Fuel Economy and Greenhouse Gas Standards: Frequently Asked Questions*, by Richard K. Lattanzio, Linda Tsang, and Bill Canis.

<sup>137</sup> Brandon Tracy, CRS Analyst in Energy Policy, is the lead author of this section; Laura B. Comay, Specialist in Natural Resources Policy, covers issues related to offshore federal lands. Energy and mineral resources on Indian lands are governed by different statutes and authorities, and are not included in this section.

<sup>138</sup> The federal government retains the mineral rights on some land whose surface is privately owned; this joint ownership is known as *split estate*.

acres in federal waters on the U.S. outer continental shelf (OCS);<sup>139</sup> these federal lands are known as *offshore federal lands*.

Weighing the use of onshore federal lands for energy production against other uses has long been a fundamental question for Congress. The Federal Land Policy Management Act (FLPMA)<sup>140</sup> establishes statutory authority for the U.S. Department of the Interior (DOI) and the Bureau of Land Management (BLM) to manage onshore federal lands. Part of this authority includes the management of the federal onshore mineral estate, which includes oil, natural gas, coal, and other mineral resources. Oil, natural gas, and coal resources are commonly included in discussions of energy resources.

FLPMA directs the BLM to manage onshore federal lands according to the principles of *multiple use* and *sustained yield*.<sup>141</sup> FLPMA codifies the policy that public lands remain in federal ownership, unless DOI determines disposal of public lands is in the national interest, and that *fair market value* is to be obtained for use of federal lands. Under FLPMA, BLM prepares *resource management plans* (or *land use plans*) through a defined process that incorporates public input, including environmental, historical, and societal values, from a variety of stakeholders.<sup>142</sup> Where BLM is not the surface management agency of lands on which an energy or mineral development is proposed, FLPMA directs BLM to coordinate with the surface management agency. FLPMA provides authority to DOI to withdraw lands from mineral entry (i.e., prohibit new energy and mining developments). When approving energy and mineral developments on onshore federal lands, BLM must comply with the National Environmental Policy Act (NEPA), the Endangered Species Act (ESA), and the National Historic Preservation Act (NHPA), among other laws.<sup>143</sup>

When in the onshore federal mineral estate, some energy resources (e.g., oil, natural gas, coal) are defined as leasable minerals, which are governed by the Mineral Leasing Act (MLA) of 1920.<sup>144</sup> Provisions in the MLA specify that covered minerals should be leased competitively (noncompetitively if certain conditions apply) and how revenues, including bonuses, rents, royalties, and other fees, from mineral leases on federal lands should be disbursed among the Treasury, federal programs, and states.<sup>145</sup> All disbursements to states resulting from mineral leases are to be reduced by the applicable sequestration rate for the given fiscal year,<sup>146</sup> and by a 2% administrative fee.<sup>147</sup> The Mineral Leasing Act for Acquired Lands (MLAAL) specifies that

<sup>139</sup> The OCS generally applies to lands beginning three miles from a coastal state's recognized shoreline.

<sup>140</sup> P.L. 94-579. FLPMA is codified at 43 U.S.C. §§1701 et seq. For a background on FLPMA, see BLM, *The Federal Land Policy and Management Act of 1976, as amended*, September 2016, available at [https://www.blm.gov/sites/blm.gov/files/AboutUs\\_LawsandRegs\\_FLPMA.pdf](https://www.blm.gov/sites/blm.gov/files/AboutUs_LawsandRegs_FLPMA.pdf).

<sup>141</sup> *Ibid.* pp. 2-3.

<sup>142</sup> *Ibid.*, p. 5. For more information on the BLM's planning process, see <https://www.blm.gov/programs/planning-and-nepa/what-informs-our-plans>.

<sup>143</sup> BLM, "Operations and Production," <https://www.blm.gov/programs/energy-and-minerals/oil-and-gas/operations-and-production>.

<sup>144</sup> The Mineral Leasing Act (MLA) of 1920 is generally codified at 30 U.S.C. §§181-287. The MLA applies only to *public domain lands*; the Mineral Leasing Act for Acquired Lands (MLAAL) generally extends the MLA to *acquired lands*. The MLAAL (P.L. 80-382) is generally codified at 30 U.S.C. §§351 et seq. About 90% of all federal lands are public domain lands, while the other 10% are acquired lands. For more information on federal lands, see CRS Report R42346, *Federal Land Ownership: Overview and Data*, by Carol Hardy Vincent and Laura A. Hanson.

<sup>145</sup> 30 U.S.C. §191.

<sup>146</sup> For discussion of sequestration of mandatory spending, including mineral leasing revenues, see CRS Report R45941, *The Annual Sequester of Mandatory Spending through FY2029*, by Charles S. Konigsberg.

<sup>147</sup> 30 U.S.C. §191(b).

revenues from leases on acquired lands should be disbursed in the same manner as other leases on those lands.<sup>148</sup>

Offshore resources are governed by the Outer Continental Shelf Lands Act of 1953 (OCSLA), as amended.<sup>149</sup> In accordance with the federal Submerged Lands Act of 1953 (SLA), federal offshore lands begin three geographical miles from a coastal state's officially recognized coast.<sup>150</sup> The Gulf of Mexico Energy Security Act (GOMESA) contains additional provisions related to oil and natural gas leasing and revenue disbursement on offshore federal lands in the Gulf of Mexico region.<sup>151</sup> The Bureau of Ocean Energy Management (BOEM), within DOI, administers offshore energy leasing and issuance of rights-of-way (ROW). Leasing of offshore federal lands follows a competitive process similar to that of onshore leasing, including the payments of bonuses, rents, royalties, and other fees. Revenues from offshore leases are disbursed among the Treasury, federal programs, and states, according to applicable laws.

## Oil and Natural Gas

Oil and natural gas resources are commonly coproduced on federal lands (i.e., both commodities from a given well). Leases are required to produce oil and natural gas on federal lands.<sup>152</sup>

In 2019, production of oil on onshore federal lands totaled 281 million barrels (6.3% of total domestic production), an increase of 20% from 2018. In 2019, the production of natural gas on onshore federal lands totaled 3,326 billion cubic feet (8.2% of total domestic production), an increase of 0.3% from 2018.<sup>153</sup> Onshore oil and natural gas production from federal lands are low compared to production from nonfederal lands, due in part to differences in geology. Of the 242 million acres associated with domestic shale plays, approximately 24 million acres, or 9.9% of the total, are in the federal mineral estate.<sup>154</sup> In FY2019, BLM administered 24,127 oil and natural gas leases in producing status, covering 12.4 million acres.<sup>155</sup>

In FY2019, onshore oil and natural gas leases resulted in federal revenues of \$4.202 billion. Total oil and natural gas lease revenues represent the sum of royalties, \$2.931 billion; bonuses, \$1.181 billion;<sup>156</sup> other revenue, \$67 million; and rents, \$22 million.<sup>157</sup> Approximately 86% of federal onshore energy and mineral revenues come from oil and gas leasing.

In 2019, offshore oil production resulted in 696 million barrels (15.6% of total domestic oil production), an increase of 7.6% from 2018. Offshore natural gas leases produced 1,059 billion

<sup>148</sup> 30 U.S.C. §355(a). This section also notes that these disbursements are subject to the 2% administrative fee specified in 30 U.S.C. §191(b).

<sup>149</sup> 43 U.S.C. §§1331 et seq.

<sup>150</sup> 43 U.S.C. §§1301-1315.

<sup>151</sup> 43 U.S.C. §1331 note.

<sup>152</sup> For more information on oil and natural gas production on federal lands, see CRS Report R46537, *Revenues and Disbursements from Oil and Natural Gas Production on Federal Lands*, by Brandon S. Tracy.

<sup>153</sup> CRS calculations using data from Office of Natural Resources Revenue (ONRR), <https://revenue.data.doi.gov/>.

<sup>154</sup> CRS calculations using data from USA Contiguous Albers Equal Area Conic USGS version.

<sup>155</sup> BLM, *Public Land Statistics 2019, 2020*, Table 3-17, p. 108.

<sup>156</sup> The bonuses value for FY2019 reflects an unusually large collection of \$976 million for October 2018 from a lease sale in New Mexico. This value falls in calendar year 2018 and fiscal year 2019 (ONRR, "Revenue by Month," <https://revenue.data.doi.gov/downloads/revenue-by-month/>).

<sup>157</sup> Values include the ONRR categories of "Oil," "Gas," "Oil & Gas," and "Natural Gas Liquids," and \$32 million in APD fees collected by BLM (CRS calculations using BLM data).

cubic feet (2.6% of total domestic gas production), an increase of 3.7% from 2018.<sup>158</sup> In FY2019, offshore oil and gas leases resulted in federal revenues of \$5.57 billion. These revenues include \$5.04 billion from royalties, \$407 million from bonus bids, \$103 million from rents, and \$19 million came from other sources.<sup>159</sup> Approximately 92% of federal offshore energy and mineral revenues come from oil and gas leasing.

## Coal

Coal is a leasable mineral and may be subject to provisions in the MLA, MLAAL, and other statutes.<sup>160</sup> Leases are required to produce coal on onshore federal lands. All domestic coal mining is subject to the Surface Mining Control and Reclamation Act of 1977.<sup>161</sup>

Generally, coal leases are to be issued through the competitive process *lease by application*.<sup>162</sup> This process begins when an interested party files an application of interest with the BLM for a tract of land previously identified as suitable for coal mining by the BLM; leases are awarded to the qualified bidder offering the highest acceptable bid. Before a coal lease is issued, the successful bidder must post a lease bond to the BLM.<sup>163</sup> Holders of coal leases on federal lands must pay annual rents before production begins and royalties on production.

In 2019, coal produced on onshore federal leases totaled 291 million tons, a decrease of 6.4% from 2018.<sup>164</sup> Coal produced on onshore federal leases contributed 41% to total domestic coal production in 2019.<sup>165</sup> At the end of FY2019, BLM continued to manage 287 coal leases covering 437,039 acres. During FY2019, two new coal leases were issued and 14 coal leases were terminated, cancelled, expired, or fully relinquished.<sup>166</sup>

In FY2019, coal leases on federal lands resulted in federal revenues of \$514 million. Total coal lease revenues include \$505 million from royalties, \$13 million from bonuses, -\$4 million from other revenue, and \$1 million from rents.<sup>167</sup> Approximately 11% of federal onshore energy and mineral revenues came from coal leasing in FY2019.

## Renewable Sources

### *Hydroelectric Power*<sup>168</sup>

Of the approximately 80,000 MW of total U.S. installed conventional hydroelectric capacity, approximately 38,000 MW is federally owned and operated, primarily by the U.S. Army Corps of

<sup>158</sup> ONRR, “Query Data,” at <https://revenue.data.doi.gov/query-data>.

<sup>159</sup> Ibid.

<sup>160</sup> Coal leasing on federal land is governed by Sections 2-8A of the Mineral Leasing Act of 1920 (30 U.S.C. §§201 et seq.) and by the Mineral Leasing Act for Acquired Lands of 1947 (30 U.S.C. §§351 et seq.).

<sup>161</sup> 30 U.S.C. §§1201 et seq.

<sup>162</sup> 43 C.F.R. §3425.

<sup>163</sup> 43 C.F.R. §3422.4.

<sup>164</sup> ONRR, “Production,” <https://revenue.data.doi.gov/>.

<sup>165</sup> CRS calculations using ONRR and EIA data.

<sup>166</sup> BLM, *Public Land Statistics 2019, 2020*, Table 3-18, pp. 111-113.

<sup>167</sup> CRS calculations using ONRR data. Companies have seven years to adjust their production data and amounts owed, which can result in negative values in some cases.

<sup>168</sup> For more information on federal and nonfederal hydropower, see CRS Report R42579, *Hydropower: Federal and Nonfederal Investment*, by Kelsi Bracmort, Adam Vann, and Charles V. Stern.

Engineers and the U.S. Bureau of Reclamation (Reclamation).<sup>169</sup> Federal waters and existing facilities may be available for nonfederal uses, including pumped storage. Reclamation indicates that over 7,300 MW of pumped storage are in the planning stages by nonfederal entities at Reclamation projects.<sup>170</sup> Ongoing research in unconventional hydropower (e.g., run-of-river, micro-hydro, marine hydrokinetics) may allow greater development of such technologies on federal lands and waters.<sup>171</sup>

### *Geothermal Energy*

Development of geothermal resources on onshore federal lands requires a lease issued by BLM, pursuant to the Geothermal Steam Act of 1970.<sup>172</sup> Leases for geothermal resources are to be issued through competitive lease sales; unleased parcels shall be made available for noncompetitive leasing for two years. Geothermal leases require the payments of rents and royalties; royalties may be assessed on direct resource use, electricity sold, and by-products covered by the MLA.

In FY2019, BLM managed 317 geothermal leases on onshore federal lands, of which 214 were issued through competitive lease sales. The geothermal leases cover 484,204 acres. Included in these values were, during FY2019, two new leases issued through a competitive lease sale and seven leases issued noncompetitively.<sup>173</sup> Revenues from geothermal leases on federal lands totaled \$17 million in FY2019; \$16 million of this value was from royalties.<sup>174</sup> For states other than Alaska, 50% of geothermal lease revenues are disbursed to the state in which the geothermal resource is located, and 25% of the revenues are disbursed to the county in which the resource is located.<sup>175</sup>

### *Solar and Wind*

Solar and wind projects on onshore federal lands require issuance of rights-of-ways pursuant to FLPMA.<sup>176</sup> Holders of ROWs for solar and wind energy facilities and associated power lines pay rent on the acres of land encumbered and capacity fees.<sup>177</sup> In FY2019, BLM administered 88 ROWs for solar and wind activities.<sup>178</sup> In addition to BLM, other federal surface management agencies issue ROWs for wind and solar projects. Offshore leases are managed by BOEM. As of December 2020, BOEM was managing 16 active commercial offshore wind leases, but none has

<sup>169</sup> U.S. Department of Energy, *Hydropower Vision*, July 2016, p.11, <https://www.energy.gov/sites/prod/files/2018/02/f49/Hydropower-Vision-021518.pdf>.

<sup>170</sup> Bureau of Reclamation, *Bureau of Reclamation—Hydropower Generation Summary*, November 2020, p. 5.

<sup>171</sup> For more information on DOE's role in researching hydropower, see DOE, "Water Power Technologies Office," <https://www.energy.gov/eere/water/water-power-technologies-office>.

<sup>172</sup> P.L. 91-581, codified at 30 U.S.C. §§1001 et seq.

<sup>173</sup> BLM, *Public Land Statistics 2019, 2020*, Tables 3-31 and 3-14, pp. 92-100.

<sup>174</sup> CRS calculations using ONRR data.

<sup>175</sup> 30 U.S.C. §1019. Geothermal disbursements to counties are not subject to the 2% administrative fee under the MLA.

<sup>176</sup> 43 U.S.C. §§1761 et seq.

<sup>177</sup> 43 C.F.R. §2800.

<sup>178</sup> BLM, *Public Land Statistics 2019, 2020*, Table 3-4, p. 61.

begun producing electricity.<sup>179</sup> Offshore wind leases resulted in \$411 million of federal revenues from bonuses, rents, royalties, and other fees in FY2019.<sup>180</sup>

### ***Biomass***

Removing biomass from federal lands for energy production has received attention from stakeholders in the biomass supply chain for energy and wildfire management because of its potential widespread availability. In FY2019, BLM sold 94,165 tons of biomass; other federal surface management agencies can sell biomass, including the U.S. Forest Service.<sup>181</sup>

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<sup>179</sup> BOEM, “Renewable Energy: Lease and Grant Information,” at <https://www.boem.gov/renewable-energy/lease-and-grant-information>.

<sup>180</sup> ONRR, “Query Data,” at <https://revenue.data.doi.gov/query-data>.

<sup>181</sup> BLM, *Public Land Statistics 2019, 2020*, Table 3-12, p. 84.

## Appendix A. Selected U.S. Government Entities and Their Energy-Related Roles

**Army Corps of Engineers (Corps)**—part of the Department of Defense, the Army Corps of Engineers manages both federal water resource development projects and regulated activities affecting certain waters and wetlands, including activities associated with infrastructure. Corps permits are required where energy infrastructure crosses certain waters, Corps projects, or Corps-controlled lands.

**Bureau of Land Management (BLM)**—part of the Department of the Interior, BLM has oversight of federal lands and manages onshore oil and natural gas operations.

**Bureau of Ocean Energy Management (BOEM)**—part of the Department of the Interior, BOEM oversees the safe and environmentally responsible development of energy and mineral offshore resources.

**Bureau of Safety and Environment Enforcement (BSEE)**—part of the Department of the Interior, BSEE oversees offshore worker safety, environmental stewardship, and resource conservation.

**U.S. Coast Guard**—part of the Department of Homeland Security, the Coast Guard has oversight of marine terminals used for the import and export of oil and natural gas as well as the security of certain hazardous fuel shipments by water.

**U.S. Commodity Futures Trading Commission (CFTC)**—CFTC has oversight of futures markets, including those for energy. CFTC was given additional oversight responsibilities for futures and derivatives under Dodd-Frank legislation.

**U.S. Department of Energy (DOE)**—a Cabinet-level agency responsible for developing and implementing national energy policy, energy research and development, basic science, energy emergency preparedness and security, and defense-related nuclear activities.

**Energy Information Administration (EIA)**—an agency within DOE, it provides independent data and analysis on the U.S. energy sector.

**Environmental Protection Agency (EPA)**—EPA has a broad range of authorities and responsibilities that may impact energy production, transportation, and consumption, particularly as the agency enforces environmental statutes and regulations and sets national standards. EPA has oversight/enforcement of all or part of the Clean Water Act; Clean Air Act; Comprehensive Environmental Response, Compensation, and Liability Act; and the Oil Pollution Act, among other laws.

**Federal Energy Regulatory Commission (FERC)**—an independent federal agency which regulates the interstate transmission of electricity, natural gas, and oil. FERC also issues permits for LNG terminals and interstate natural gas pipelines as well as licensing nonfederal hydropower projects.

**U.S. Fish and Wildlife Service**—Fish and Wildlife has responsibilities for environmental oversight on energy issues such as wind and hydropower production, and pipeline rights-of-way through jurisdictional lands.

**U.S. Forest Service**—part of the Department of Agriculture, the Forest Service is responsible for managing energy and mineral resources, and infrastructure development on federal onshore areas that it owns.

**Maritime Administration (MARAD)**—an agency within the Department of Transportation that regulates offshore LNG and oil terminals.

**National Oceanographic and Atmospheric Administration (NOAA)**—part of the Department of Commerce, NOAA has jurisdiction over pipeline project construction in coastal and/or ocean areas.

**National Highway Traffic Safety Administration (NHTSA)**—part of the Department of Transportation, NHTSA regulates vehicle fuel economy through the CAFE program in coordination with EPA’s vehicle GHG program.

**Nuclear Regulatory Commission (NRC)**—an independent regulatory commission responsible for licensing and regulation of nuclear power plants and other nuclear facilities.

**Office of Fossil Energy**—part of the Department of Energy focusing on production from U.S. oil fields. It also has input into the construction of liquefied natural gas import and export terminals.

**Office of Nuclear Energy**—part of the Department of Energy responsible for nuclear energy research and federal nuclear waste storage and disposal facilities.

**Office of Energy Efficiency and Renewable Energy (EERE)**—part of the Department of Energy that focuses on energy efficiency, such as appliance standards, and renewable energy.

**Pipeline and Hazardous Materials Safety Administration (PHMSA)**—part of the Department of Transportation, PHMSA administers the regulatory program, through the Office of Pipeline Safety (OPS), to assure the safe transportation of natural gas, petroleum, and other hazardous materials by pipeline. OPS develops regulations and other approaches to risk management to assure safety in design, construction, testing, operation, maintenance, and emergency response of pipeline facilities.

## Appendix B. Selected Energy Laws

**Table B-I. Selected Energy Related Laws**

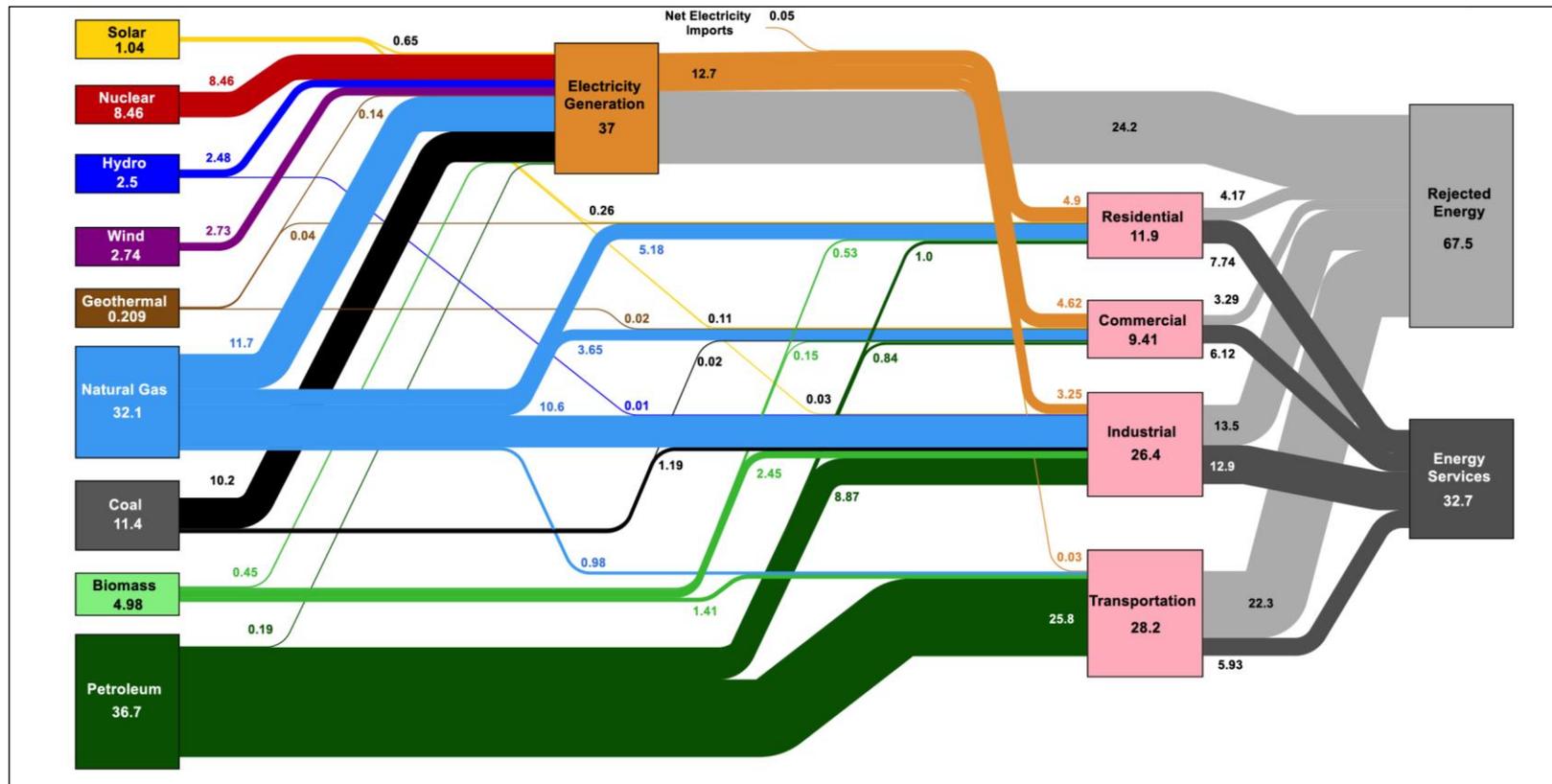
Year	Law	Description
1920	Mineral Leasing Act, P.L. 66-146	Governs leasing of public lands for development of deposits of coal, petroleum, natural gas, and other minerals.
1920	Federal Water Power Act, P.L. 66-280	Originally coordinated development of hydroelectric projects. In 1935, the law was renamed the Federal Power Act. It created the Federal Power Commission (now FERC) and expanded its jurisdiction to include all interstate electricity transmission and wholesale power sales.
1938	Natural Gas Act, P.L. 75-688	Regulates rates for interstate transmission and sales of natural gas. Requires approval by now-DOE and its precursors for natural gas import and export facilities.
1953	Outer Continental Shelf Lands Act, P.L. 83-212	Defines the outer continental shelf under U.S. jurisdiction and empowers the Secretary of the Interior to grant leases for resource development.
1954	Atomic Energy Act, P.L. 83-703	Authorizes nuclear energy research and development, and establishes licensing requirements for the use of nuclear materials, such as in nuclear power plants.
1974	Energy Reorganization Act, P.L. 93-438	Established the Nuclear Regulatory Commission (NRC), splitting the responsibility for nuclear weapons and civilian nuclear power regulation between what is now DOE and NRC, respectively.
1975	Energy Policy and Conservation Act, P.L. 94-163	Established the Strategic Petroleum Reserve, mandated vehicle fuel economy standards, and extended oil price controls.
1977	Department of Energy Organization Act, P.L. 95-91	Established the Department of Energy as a Cabinet-level organization, and established FERC as the successor to the Federal Power Commission and made it an independent agency within DOE.
1978	National Energy Act, P.L. 95-617 - 621	Responded to the 1973 oil crises, and included five statutes: Energy Tax Act, Natural Gas Policy Act, National Energy Conservation Policy Act, Power Plant and Industrial Fuel Use Act, and the Public Utility Regulatory Policies Act.
1980	Energy Security Act, P.L. 96-294	Emphasized alternative energy sources that could be produced domestically to improve U.S. energy security.
1992	Energy Policy Act of 1992, P.L. 102-486	Created framework for competitive wholesale electricity markets.
2005	Energy Policy Act of 2005, P.L. 109-58	Offered tax benefits for energy efficiency and alternative fuel vehicles, increased required amounts of renewable fuel in gasoline, and encouraged more domestic energy production.
2007	Energy Independence and Security Act, P.L. 110-140	Increased vehicle fuel efficiency standards, and revised standards for appliances and lighting.
2015	Consolidated Appropriations Act, 2016, P.L. 114-113	Repealed the crude oil export prohibition contained in the Energy Policy Conservation Act of 1975.
2017	Tax Cuts and Jobs Act, P.L. 115-97	Established an oil and gas program in the Arctic National Wildlife Refuge.

**Source:** Compiled by CRS using information from congressional databases and the John A. Dutton E-Education Institute, College of Earth and Mineral Sciences, Pennsylvania State University, <https://www.e-education.psu.edu/geog432/node/116>.

**Notes:** The list in this table is not comprehensive and the descriptions highlight certain provisions in the legislation and not the entire law. Many of the above laws have been amended, sometimes extensively, since their initial passage. The Department of Energy lists on its website laws which it administers, <https://energy.gov/gc/laws-doe-administers-0>.

# Appendix C. 2019 U.S. Energy Consumption

**Figure C-1. Estimated U.S. Energy Consumption in 2019: 100.2 Quads**  
 Quadrillion British Thermal Units (Quads)



**Source:** The Department of Energy and Lawrence Livermore National Laboratory, <https://flowcharts.llnl.gov/commodities/energy>.

**Notes:** "Rejected Energy" is the portion of energy that goes into a process and comes out, usually as waste heat, to the environment.

## **Appendix D. List of Abbreviations**

Btu—British thermal unit

CAFE—Corporate Average Fuel Economy standards

CCUS—carbon capture, utilization, and storage

DRM—demonstrated reserve base

GDP—gross domestic product

GHG—greenhouse gas

LED—light-emitting diode

LNG—liquefied Natural Gas

LWR—light water reactor

MTE—CAFE midterm evaluation

MW—megawatts

NGL—natural gas liquids

OCS—outer continental shelf

PHMSA—Pipeline and Hazardous Materials Safety Administration

RES—renewable electricity standard

RGGI—Regional Greenhouse Gas Initiative

RPS—renewable portfolio standard

PRB—Powder River Basin

PV—photovoltaic

Quad—quadrillion Btu

ROWs—rights-of-way

SMR—small modular reactor

SPR—Strategic Petroleum Reserve

TWh—Terawatt-hours

ZEC—zero-emission credit

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