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United States Senate
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Chairman Murkowski, Ranking Member Manchin, and Members of the Committee, I appreciate the opportunity to appear before you today to provide testimony on U.S. energy.

This is a transformational time for the United States energy industry. After decades of the United States importing more energy than it exports, EIA now forecasts that our country will become a net energy exporter in 2020. The crossover to being a net exporter occurs as crude oil production continues to increase. The United States produced almost 11 million barrels per day (b/d) of crude oil in 2018, exceeding our previous 1970 record of 9.6 million barrels. EIA expects that U.S. crude oil production will continue to set annual records until 2030 and will remain greater than 14.0 million b/d through 2040.

The U.S. oil and natural gas industry, consisting of natural gas, crude oil, and other liquids production, has seen impressive growth as hydraulic fracturing and horizontal drilling have led to economically competitive development of shale resources that were previously uneconomical to develop. Favorable geology and recent technological and operational improvements have allowed petroleum liquids production from tight rock formations within the Permian region in Texas and New Mexico to grow to an average of 3.5 million b/d in 2018, compared with 2.5 million b/d in 2017. Nearly all of the growth in U.S. crude oil production in 2018 came from tight oil formations, and tight oil production accounted for 58% of total crude oil production in 2018 compared with 53% in 2017.

The United States is now the world's largest producer of crude oil, surpassing Saudi Arabia and Russia in 2018. Our natural gas plant liquids (NGPL) production, a component of the total liquid fuels production, set an all-time high of 4.4 million b/d in 2018. The combined increases in crude oil and NGPL output, coupled with our sophisticated and plentiful refining capacity, have led the United States to become a major exporter of petroleum products. By the fourth quarter of 2020, EIA expects exports of petroleum products from the United States to exceed imports by an average of 0.9 million b/d.

The steady increase in U.S. crude oil production contributes to a relatively steady Brent oil price of $73 to $74 per barrel (2018 dollars) until 2022, after which crude oil prices are projected to steadily rise to $108 per barrel in 2050.

U.S. net imports of liquid fuels, which include crude oil and petroleum products, have declined steadily since 2007, and we estimate that they averaged 1.2 million b/d in the fourth quarter of 2018. This amount is less than half of the volume the United States imported just one year ago, when our net imports averaged 2.7 million b/d during the fourth quarter of 2017. However, although imports have declined, the United States will continue to import crude oil. This robust trade in crude oil and refined products indicates the United States is becoming a globally significant "merchant refiner."

Similar developments in domestic shale natural gas resources have enabled the United States to become a net exporter of natural gas. In 2017, total natural gas exports from the United States exceeded imports for the first time since the 1950s. In 2018, U.S. dry natural gas production reached an all-time high of 30 trillion cubic feet (Tcf). In the long term, EIA projects that natural gas production will initially grow by 7% per year and then slow to less than 1% per year after 2020. As a result, net U.S. natural gas exports will continue to grow as liquefied natural gas (LNG) and pipeline exports increase.

Abundant, domestic natural gas supplies and the resulting relatively low natural gas prices have led to other changes in the U.S. energy landscape. Despite total U.S. electricity demand remaining relatively flat during the past decade, natural gas displaced less economically competitive sources of electric power generation to become the largest share of electric power generation in 2016.

Wind and solar capacity and generation also reached all-time highs in 2018. According to our just-released *Annual Energy Outlook 2019* (AEO2019), under current policies and regulations, EIA's Reference case projects that renewable sources will surpass nuclear in 2020 and coal after 2025. As a result, EIA projects that carbon dioxide (CO2) emissions will remain at least 2% lower than the 2020 level through 2050.

The AEO2019 Reference case assumes a 1.9% compound annual growth rate for real U.S. gross domestic product through 2050 and 0.2% per year growth in total energy consumption through 2050. Industrial consumption of energy grows the fastest, taking advantage of relatively low natural gas prices, while electric power consumption increases at a slower rate as a result of efficiency improvements. EIA projects that residential and commercial buildings will maintain relatively steady energy consumption, as demand growth and demographic shifts offset efficiency gains.

EIA projects that energy consumption in the U.S. transportation sector will decrease through the mid-2030s as fuel economy increases offset growth in vehicle miles traveled. However, as current regulations requiring additional efficiency increases expire after 2027, we project that motor gasoline consumption will start to rise again, leading to total transportation sector consumption increases after 2040.

Short-term energy trend highlights

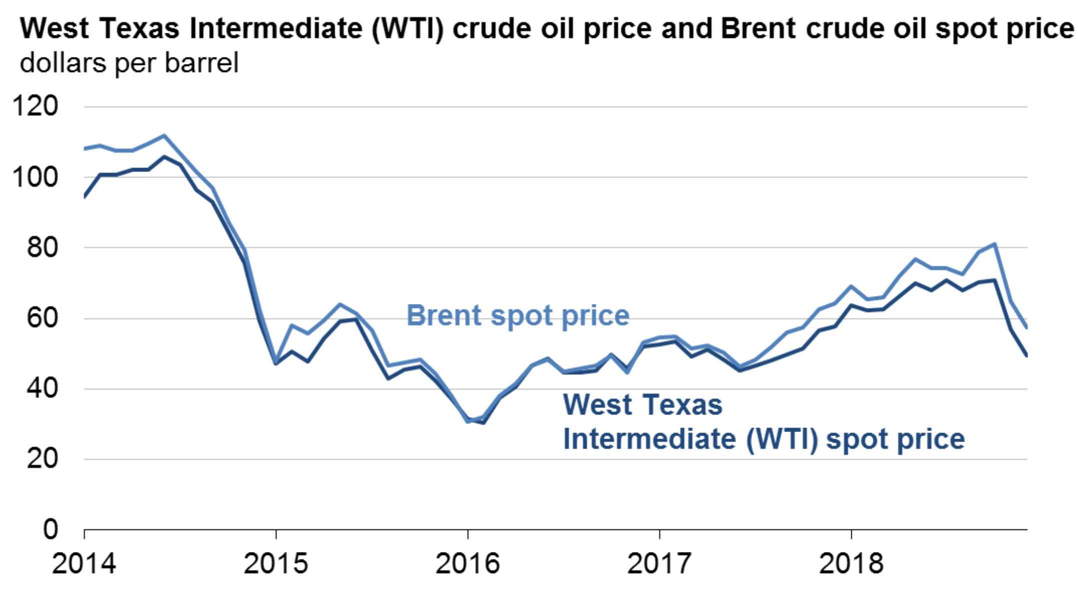
Energy commodity prices saw annual increases in 2018 compared with 2017, however commodity prices ended 2018 lower than they began the year

Crude oil prices had been increasing for most of 2018 in response to the increased potential for supply constraints and declining global petroleum inventories throughout much of 2017. The potential supply constraints include the declining Iranian exports as a result U.S. sanctions targeting its oil sector, declining production in Venezuela, and periodic disruptions from other producers including Libya and Nigeria.

Brent crude oil reached a four-year high of $86 per barrel (b) on October 3, 2018. However, several factors contributed to the subsequent sharp fall in crude oil prices. Crude oil production in the United States, Russia, and Saudi Arabia increased to or near record highs. Concerns about slowing global economic growth and its impact on oil demand also contributed to recent declines in crude oil prices. Waivers granted to certain countries that import Iranian crude oil also helped to ease concerns about crude oil availability in the near term. Crude oil prices ended 2018 lower than where they started at the beginning of the year for the first time since 2015.

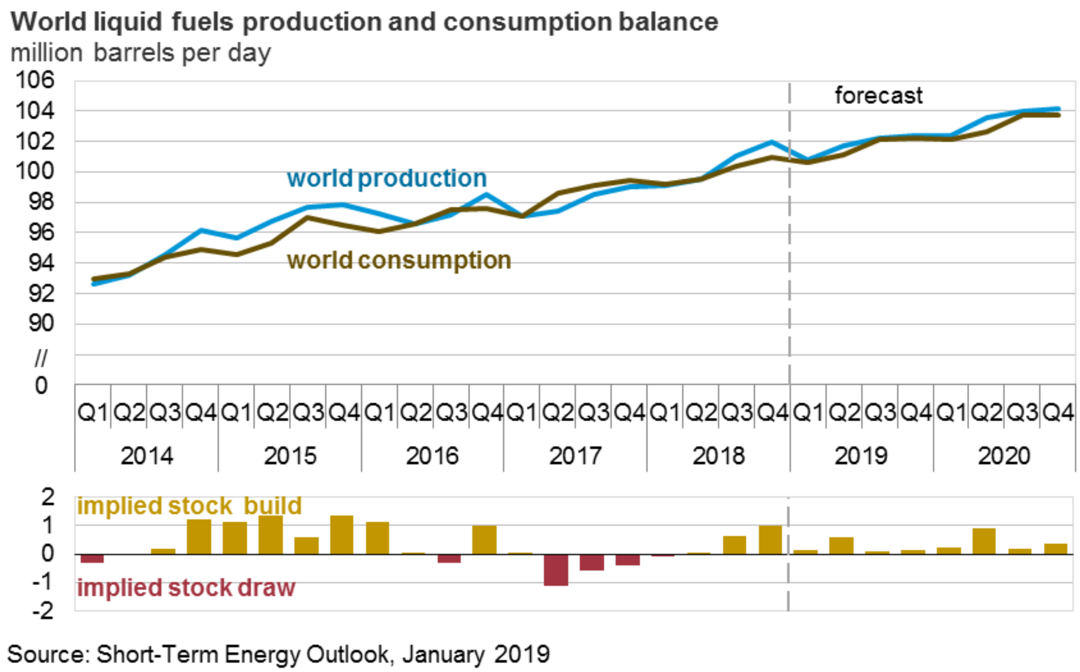
The West Texas Intermediate (WTI) crude oil prices ended 2018 lower than $50/b despite having increased to almost $71/b in July 2018, the highest average monthly price for WTI since late 2014. Prices have remained at about the same level thus far in 2019 (Figure 1).

Figure 1. Brent and West Texas Intermediate (WTI) spot prices



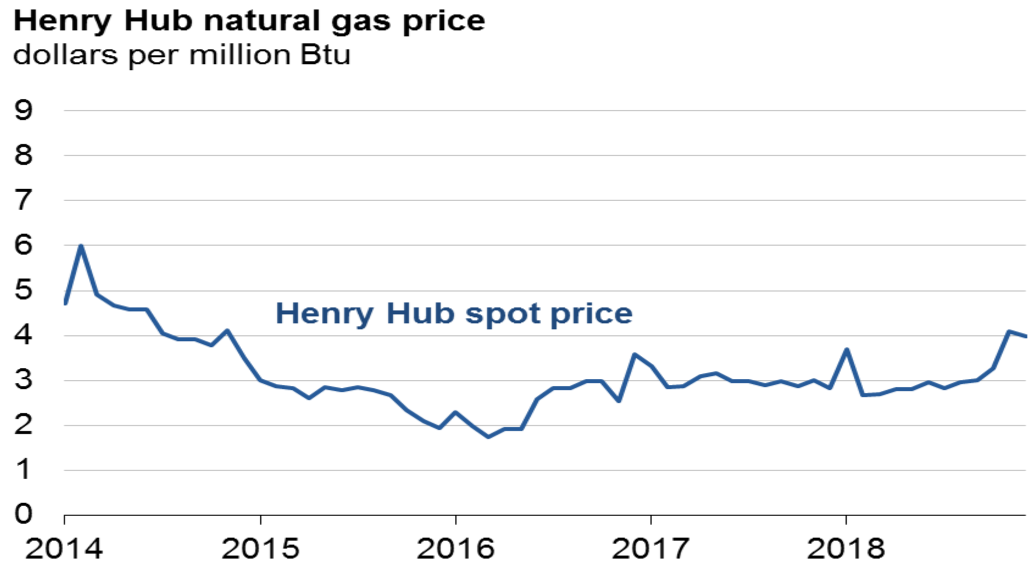
EIA expects that, in the short term, similar market trends will continue to prevail as global oil production is expected to exceed global consumption in 2019 and 2020; however, the global market is expected to become more balanced in 2019 and 2020 (Figure 2).

Figure 2. Oil supply growth continues to slightly outpace consumption growth in 2019 and 2020



Henry Hub natural gas prices remained lower than an average of $3 per million British thermal units (MMBtu) in seven months in 2018 and averaged $3.14 per MMBtu for the year. Spot natural gas prices remained lower than$3 per MMBtu for much of the year as domestic production reached new record highs, which more than offset the effects of record levels of consumption and exports (Figure 3).

Figure 3. Despite an uptick in prices at the end of 2018, Henry Hub spot price averaged about $3 per MMBtu



EIA estimates that coal production fell by about 20 million short tons (MMst) in 2018, despite a 19 MMst increase in coal exports. Average coal prices were $2.07 per MMBtu in 2018 and are expected to remain at about that level in 2019 and 2020. Low natural gas prices have primarily contributed to reduced demand for coal in the United States, with coal accounting for 28% of total U.S. electricity generation in 2018, compared with 45% in 2010. Natural gas accounted for 35% of total U.S. electricity generation, compared with 24% in 2010.

Residential sector retail electricity prices averaged 12.9 cents/kilowatthour in 2018, and prices are expected to rise to 13.3 cents/kilowatthour in 2019. Similarly, industrial and commercial electricity prices are expected to rise in 2019.

Among renewable sources, hydroelectricity continued to provide the most electricity generation in 2018, with wind generation trailing only slightly behind that of hydroelectricity. EIA expects that wind generation will exceed that of hydroelectricity in 2019. Overall, renewable generation provided 17% of total U.S. electricity generation in 2018.

Long-term energy trend highlights

EIA's *Annual Energy Outlook 2019* (AEO2019), released on January 24, 2019, projects that the United States will become a net energy exporter in 2020 and is projected to remain so through 2050 as a result of large production increases in crude oil, natural gas, and natural gas plant liquids (NGPL) coupled with slower growth in U.S. energy consumption.

The United States produced 10.9 million barrels per day (b/d) of crude oil in 2018, passing the 10 million b/d mark for the first time and surpassing the previous record of 9.6 million b/d set in

1970, according to Short-Term Energy Outlook January 2019. The growth in liquid fuels production is projected to continue through 2050. In the short term, EIA also forecasts the United States to be a net exporter of petroleum in the fourth quarter of 2020, with liquid fuel net exports exceeding crude oil net exports by nearly 0.9 million b/d.

Similarly, natural gas production reached an all-time high in 2018. Production of natural gas and NGPL is expected to have the highest growth of all fossil fuels and account for nearly one-third of U.S. liquids production through 2050. Natural gas prices are projected to remain comparatively low through 2050, leading to increased use of natural gas across end-use sectors as well as increasing LNG exports.

The electric power sector is projected to see a notable shift in fuel mix. Growth in solar, wind, and natural gas-fired electricity generation is projected to be accompanied by additional retirements of coal and nuclear power plants. As a result of this changing fuel mix, the electric power sector is projected to see a steady decrease in carbon dioxide (CO2) intensity after 2030. Carbon dioxide intensity refers to CO2 emissions per unit energy output in British thermal units.

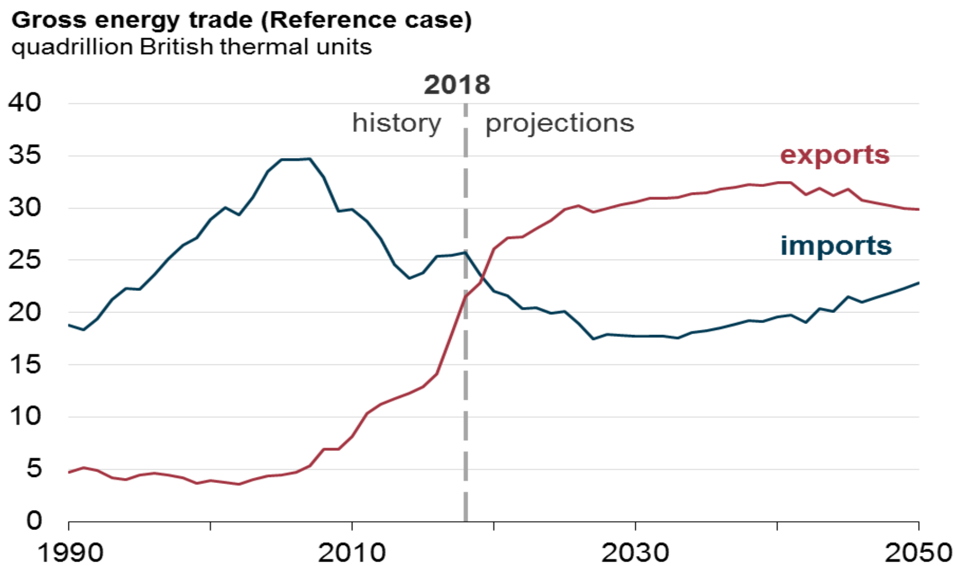
Total energy

The United States becomes a net energy exporter in 2020

The United States is projected to become a net energy exporter in 2020 in the AEO2019 Reference case for the first time since the 1950s. The projected changes in net energy trade are driven mostly by evolving trade flows of liquid fuels and natural gas, and the United States will remain a net energy exporter through 2050, as increases in crude oil, natural gas, and natural gas plant liquids production continue to outpace growth in domestic consumption of petroleum products.

EIA projects that the gap between energy imports and exports widens until the 2040s when falling domestic crude oil production leads to a decrease in exports, and a growing U.S. economy and higher domestic gasoline consumption leads to increase imports. (Figure 4).

Figure 4. United States energy imports and exports, 1990-2050



Although the United States is expected to become a net energy exporter, heavy and medium crude oil will continue to be imported through the projection period to meet the needs of many U.S. refiners. An increasing share of United States crude oil production is expected to be light and sweet oil, but much of the Gulf Coast refining capacity is optimized to process heavy, sour crude grades.

In addition to configurational mismatches between production and refining, transportation constraints also will continue to lead refiners to rely on crude oil imports to meet refining capacity. For example, insufficient infrastructure exists to move the necessary crude oil production supply from the Gulf region to meet domestic refinery demand on the East and West Coasts.

The United States will continue to be a net exporter of coal and coke, but exports are not expected to increase because of competition from other global suppliers closer to major consuming markets.

Petroleum liquids production

U.S. crude oil and natural gas plant liquids production exceeds its peak 1970 level; consumption of petroleum liquids remains lower than its 2004 peak level

The United States is now the largest producer of crude oil in the world. According to AEO2019 projections, U.S. crude oil production will continue to grow as upstream producers increase output because of rising prices and cost reductions.

U.S. crude oil production continues to set annual records exceeding 14.0 million b/d in the mid-2020s and remaining above that level through 2040. The continued development of tight oil and shale gas resources, particularly those in the East and Southwest regions, supports growth in NGPL production. NGPL production, already at a record high, is projected to grow in the long term, exceeding 6 million b/d before 2030.

Petroleum product consumption is projected to remain mostly steady through the projection period, although projected consumption is sensitive to changes in assumptions regarding oil prices and economic growth.

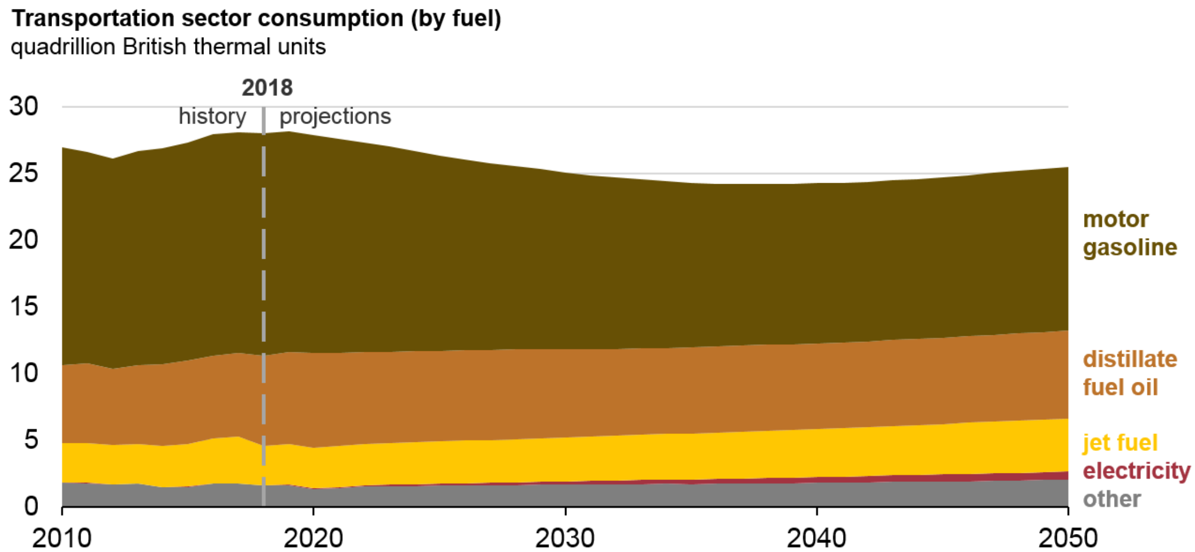
As a result of increasing crude oil and other petroleum liquids production and relatively unchanged petroleum product consumption, the United States is projected to be a net exporter of petroleum on a volume basis from 2020 to 2049.

Petroleum liquids consumption

Transportation energy consumption generally declines between 2019 and 2037 as fuel economy increases offset growth in vehicle miles traveled
Figure 5 shows jet fuel energy consumption will grow more than any other transportation fuel during the projection period as increases in GDP lead to growth in air transportation that outpaces increases in aircraft fuel efficiency. Electricity use in the transportation sector starts from a relatively low base and continues to grow through 2050.

Motor gasoline and distillate fuel oil's combined share of total transportation energy consumption decreases through 2050 as a result of gains in energy efficiency supported by current laws and regulation. However, assuming no further policy actions, while increases in fuel economy standards reduce the total consumption of motor gasoline through the mid-2020s, the plateauing of mandated energy efficiency gains after 2027 is projected to result in increasing consumption of motor gasoline in the second part of the projection period (Figure 5).

Figure 5. Transportation sector consumption declines through 2037



Natural gas

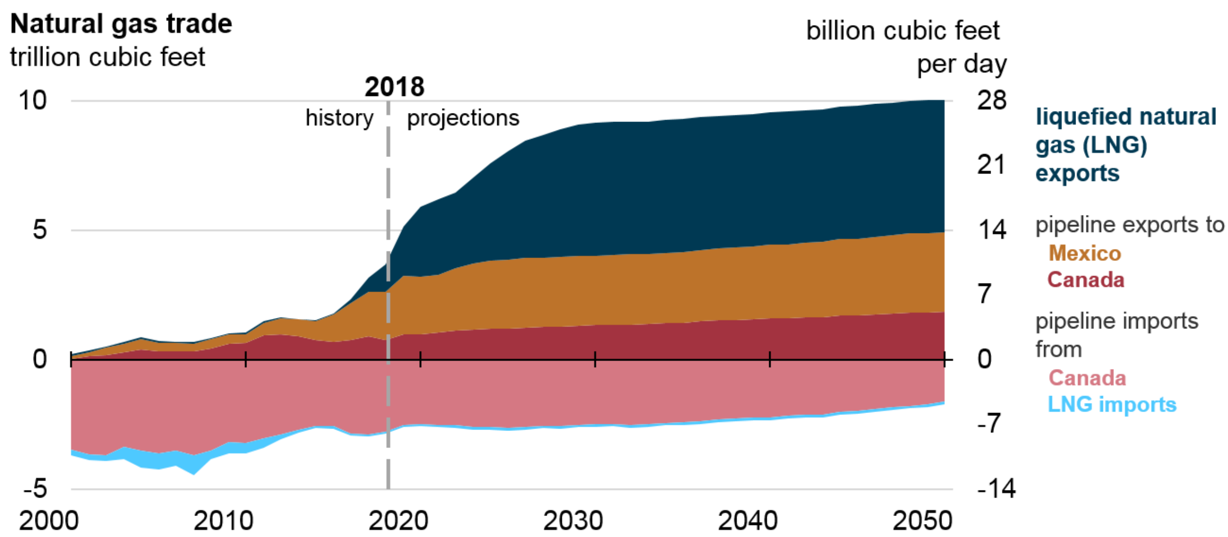
Natural gas production growth outpaces natural gas consumption growth
Domestic natural gas production increases through the projection period, driven by tight and shale natural gas production. The size of the associated resources and the improvements in technology allow for the development of tight and shale resources at lower costs. In particular, the eastern United States is projected to drive the growth in natural gas output, followed by production growth along the Gulf Coast. Dry natural gas production reaches 43.4 Tcf by 2050.

Growth in drilling in the Southwest region drives increases in natural gas production from tight oil formations. Because drilling activity in oil formations primarily depends on crude oil prices rather than on natural gas prices, the increase in natural gas production from oil-directed drilling puts downward pressure on natural gas prices.

Offshore natural gas production in the United States remains mostly unchanged during the projection period as production from new discoveries generally offset declines in legacy fields.

The projected growth in U.S. natural gas consumption, although significant, is not expected to keep pace with production growth, allowing net natural gas exports to continue to grow through 2050 (Figure 6). As additional LNG export terminals are constructed, growth in exports is projected to be led by waterborne trade, but LNG exports will remain highly sensitive to crude oil and natural gas prices.

Figure 6. Net exports of natural gas will continue to grow through 2050



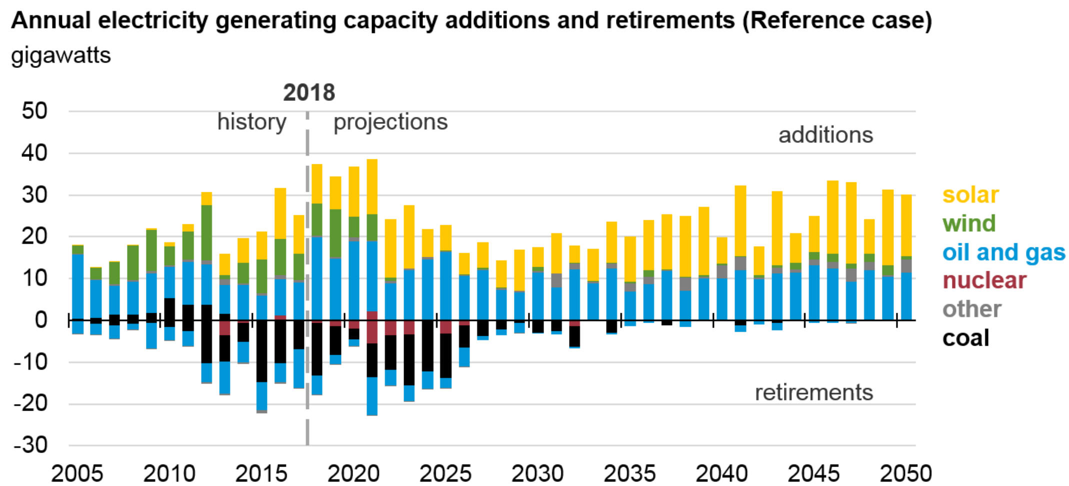
Electric power

Electric power and industrial demand drive natural gas consumption
Continued, relatively low natural gas prices will lead to increasing use of natural gas across most end-use sectors. The industrial sector is projected to be the largest consumer of natural gas, as the chemical industry and industrial heat and power grow through the projection period.

Relatively low natural gas prices also lead to higher use of natural gas for electric power generation. Natural gas-powered generation is projected to grow through the projection period and remain the largest fuel by share in this sector through 2050 in the Reference case, under current laws and regulations.

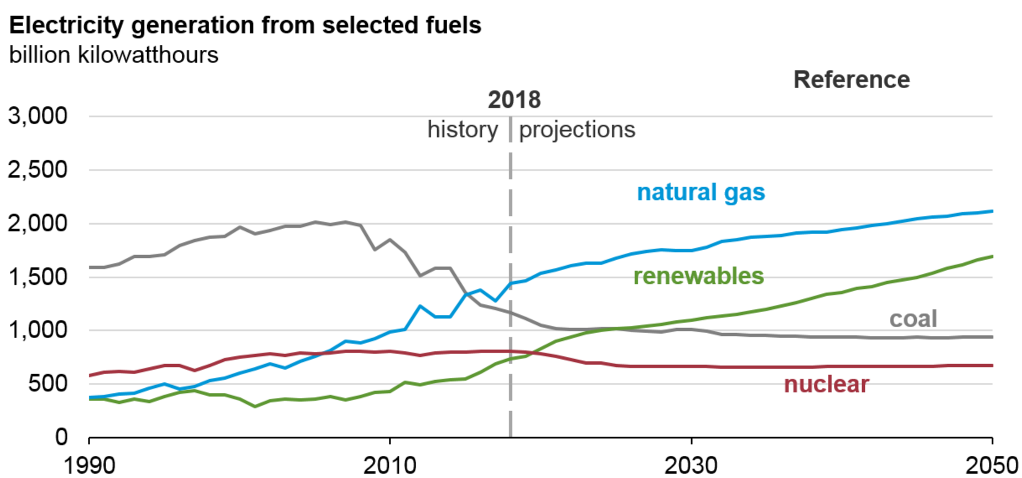
Additions to electric power generation will be met by natural gas and renewables
Generation from renewable electricity sources, including hydroelectricity, grows the most during the projection period. This growth is initially supported by various tax incentives that are expected to phase out through the 2020s. Without the tax incentives, renewable generation continues to grow at a slower rate as capital costs to construct new generating capacity continue to decline.

Figure 7. Natural gas and renewables additions dominate



Although coal and nuclear continue to decrease in nearly all cases, these fuels will continue to play a role in the U.S. electricity generation mix through the projection period. Renewable electricity generation surpasses nuclear generation about 2020 and surpasses coal about 2025 (Figure 8).

Figure 8. Electric power generation mix sees a transformation in the medium term



Long-term trends in capacity additions for electricity generation are dominated by the addition of solar and natural gas capacity. Wind capacity additions are more modest, and less economically competitive coal, nuclear, and natural gas plants are expected to see capacity retirements. About 42% of coal-fired capacity and about 22% of current nuclear capacity is projected to retire by 2050.

Natural gas prices and policy incentives drive the growth in electricity generation fuel mix. In the AEO2019 Reference case, relatively low natural gas prices lead to natural gas-powered generation growing steadily and remaining the dominant fuel through 2050. However, these results are highly sensitive to natural gas prices. AEO2019 side cases show that low natural gas prices favor the growth of natural gas-power generation, while high natural gas prices favor renewable generation. In the high natural gas price case, renewables are projected to become the leading source of electricity generation by 2030. (Figure 7).

Carbon dioxide

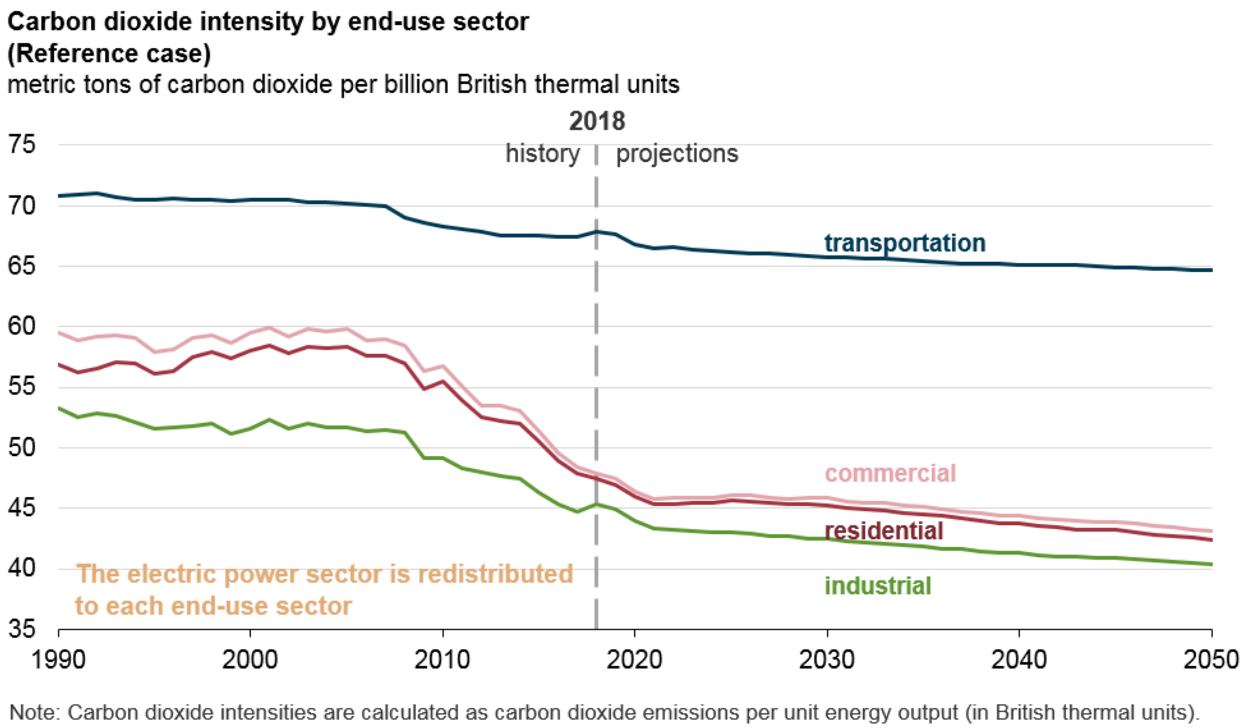
Despite overall increases in energy consumption, carbon dioxide intensity declines across end-use sectors

Changes in the fuel mix primarily drive the lower carbon dioxide (CO_2) intensity, which can vary greatly depending on the mix of fuels consumed in each sector. For example, the generation fuel mix in the electric power sector now relies on less carbon-intensive sources, such as natural gas and renewables. This fuel mix is in contrast to the fuel mix a decade ago when the electric power sector relied on coal as a feedstock. Given the projected trends in the electric power sector fuel mix, CO_2 will continue to decrease through 2050.

In 2018, CO_2 emissions increased by 3% as a result of increased energy consumption. Consumption rose due to robust economic growth and unfavorable weather conditions. EIA projects that emissions will remain about 2% lower than the 2020 level across the projection period. However, EIA projects that energy-related CO_2 emissions will initially decline through 2040 and then increase in the last decade of the projection period. This pattern primarily follows petroleum emissions. Petroleum emissions are projected to decline until 2040, but they will then rise as vehicle-miles traveled increase and motor gasoline consumption begins to increase again toward the end of the projection period. The increase in gasoline consumption is a result of current regulations not requiring additional fuel efficiency increases after 2027. This projection is highly uncertain because many fuel efficiency standards are currently under discussion.

Natural gas CO_2 emissions are projected to increase through 2050, and coal-related CO_2 emissions are projected to decline as coal-fired electric power plants retire. The generation fuel mix in the electric power sector has changed significantly since the mid-2000s, with lower generation from high-carbon intensive coal and higher generation from natural gas and carbon-free renewables, such as wind and solar. This change resulted in the overall CO_2 intensity of the electric power sector declining by 25% from the mid-2000s to 2018 and continuing to decline through 2050. Electric power, however, can be considered in the context of each end-use sector, and Figure 9 shows CO_2 intensities with the electric power sector redistributed to each end-use sector. Carbon intensities are calculated as carbon dioxide emissions per unit energy output in British thermal units.

Figure 9. Carbon dioxide intensity by end-use sector



About EIA

The U.S. Energy Information Administration (EIA) was established by the Department of Energy Organization Act of 1977 as the primary federal government authority on energy statistics and analysis. It is one of the 13 principal federal statistical agencies and is responsible for collecting, analyzing, and disseminating relevant, accurate, and timely energy information to inform public and private decision-making.

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EIA Annual Energy Outlook (AEO) and Short-Term Energy Outlook (STEO)

EIA prepares short- and long-term outlooks. The *Short-Term Energy Outlook* (STEO) examines trends over the next one to two years. The *Annual Energy Outlook* (AEO) models projections over the next 20 to 25 years.

EIA's AEO2019 was released on January 24, 2019. It is the annual report on the long-term outlook for the energy system of the United States and provides data projections through 2050. Like all modeled projections and forecasts, the AEO2019 projections depend on input assumptions that are highly uncertain. However, the Reference case assumes current laws and regulations remain unchanged during the projection period, which makes it a useful as a baseline that can inform potential future policy discussions.

EIA's STEO is a monthly forecast covering the current and upcoming calendar year, and it provides monthly forecast data for supply, consumption, and prices across energy commodities. The STEO published January 15, 2019, is the first to include forecasts for 2020.

Conclusion

This is an exciting and transformational time for the United States energy industry as world energy markets adjust to the United States becoming a major global supplier and exporter for years to come.

Madam Chairman and Members of the Committee, thank you for the opportunity to present this information. This concludes my testimony.