Annual Energy Outlook 2019

with projections to 2050

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U.S. Energy Information Administration

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The Annual Energy Outlook provides long-term energy projections for the United States

- Projections in the *Annual Energy Outlook 2019* (AEO2019) are not predictions of what will happen, but rather modeled projections of what may happen given certain assumptions and methodologies.
- The AEO is developed using the National Energy Modeling System (NEMS), an integrated model that captures interactions of economic changes and energy supply, demand, and prices.
- Energy market projections are subject to much uncertainty because many of the events that shape energy markets as well as future developments in technologies, demographics, and resources cannot be foreseen with certainty. To illustrate the importance of key assumptions, AEO2019 includes a Reference case and six side cases that systematically vary important underlying assumptions.
- More information about the assumptions used in developing these projections will be available shortly after the release of the AEO2019.
- The AEO is published to satisfy the Department of Energy Organization Act of 1977, which requires the Administrator of the U.S. Energy Information Administration to prepare annual reports on trends and projections for energy use and supply.

What is the Reference case?

- The AEO2019 Reference case represents EIA's best assessment of how U.S. and world energy markets will operate through 2050, based on many key assumptions. For instance, the Reference case projection assumes improvement in known energy production, delivery, and consumption technology trends.
- The economic and demographic trends reflected in the Reference case reflect current views of leading economic forecasters and demographers.
- The Reference case generally assumes that current laws and regulations that affect the energy sector, including laws that have end dates, are unchanged throughout the projection period. This assumption is important because it permits EIA to use the Reference case as a benchmark to compare policy-based modeling.
- The potential impacts of proposed legislation, regulations, or standards are not included in the AEO2019 cases.
- The Reference case should be interpreted as a reasonable baseline case that can be compared with the cases that include alternative assumptions.

What are the side cases?

- The side cases in AEO2019 show the effect that changing important model assumptions have on the projections when compared with the Reference case.
- Two AEO2019 side cases are the High and Low Oil Price cases, which represent international conditions outside the United States that could collectively drive prices to extreme, sustained deviations from the Reference case price path.
- Additional AEO2019 side cases are the High and Low Oil and Gas Resource and Technology cases, where production costs and resource availability within the United States are varied, allowing for more or less production at given world oil and natural gas prices.
- The two AEO2019 side cases that vary the effects of economic assumptions on energy consumption are the High and Low Economic Growth cases, which modify population growth and productivity assumptions throughout the projection period to yield higher or lower compound annual growth rates for U.S. gross domestic product than in the Reference case.

Key takeaways

EIA's *Annual Energy Outlook* provides modeled projections of domestic energy markets through 2050, and it includes cases with different assumptions regarding macroeconomic growth, world oil prices, and technological progress.

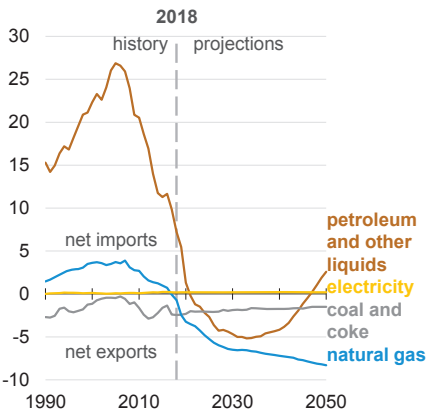
Key takeaways from the Reference case

- The United States becomes a net energy exporter in 2020 and remains so throughout the projection period as a result of large increases in crude oil, natural gas, and natural gas plant liquids (NGPL) production coupled with slow growth in U.S. energy consumption.
- Of the fossil fuels, natural gas and NGPLs have the highest production growth, and NGPLs account for almost one-third of cumulative U.S. liquids production during the projection period.
- Natural gas prices remain comparatively low during the projection period compared with historical prices, leading to increased use of this fuel across end-use sectors and increased liquefied natural gas exports.
- The power sector experiences a notable shift in fuels used to generate electricity, driven in part by historically low natural gas prices. Increased natural gas-fired electricity generation; larger shares of intermittent renewables; and additional retirements of less economic existing coal and nuclear plants occur during the projection period.
- Increasing energy efficiency across end-use sectors keeps U.S. energy consumption relatively flat, even as the U.S. economy continues to expand.

The United States becomes a net energy exporter after 2020 in the Reference case—

Gross energy trade (Reference case)
quadrillion British thermal units

Net energy imports (Reference case)
quadrillion British thermal units



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—but the United States continues to import and export throughout the projection period

- The United States has been a net energy importer since 1953, but continued growth in petroleum and natural gas exports results in the United States becoming a net energy exporter by 2020 in all cases.
- In the Reference case, the United States becomes a net exporter of petroleum liquids after 2020 as U.S. crude oil production increases and domestic consumption of petroleum products decreases. Near the end of the projection period, the United States returns to being a net importer of petroleum and other liquids on an energy basis as a result of increasing domestic gasoline consumption and falling domestic crude oil production in those years.
- The United States became a net natural gas exporter on an annual basis in 2017 and continued to export more natural gas than it imported in 2018. In the Reference case, U.S. natural gas trade, which includes shipments by pipeline from and to Canada and to Mexico as well as exports of liquefied natural gas (LNG), will be increasingly dominated by LNG exports to more distant destinations.
- The United States continues to be a net exporter of coal (including coal coke) through 2050 in the Reference case, but coal exports are not expected to increase because of competition from other global suppliers closer to major world markets.

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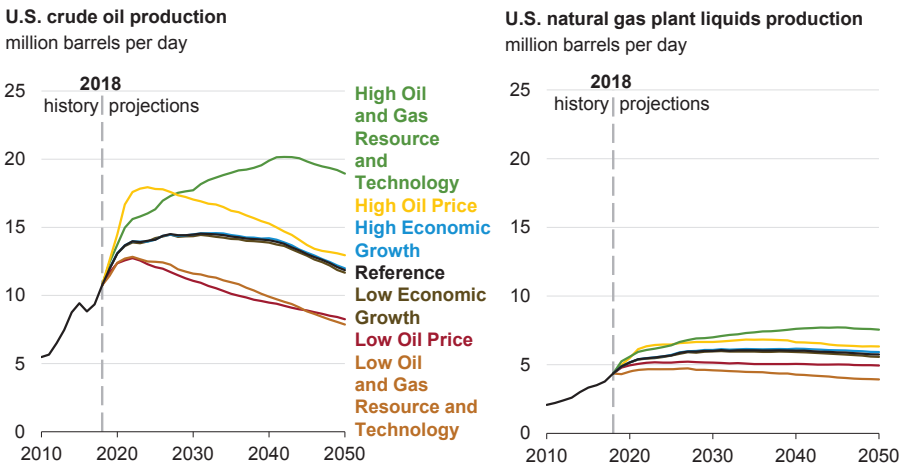
Production of U.S. crude oil and natural gas plant liquids continues to grow through 2025 in the Reference case—

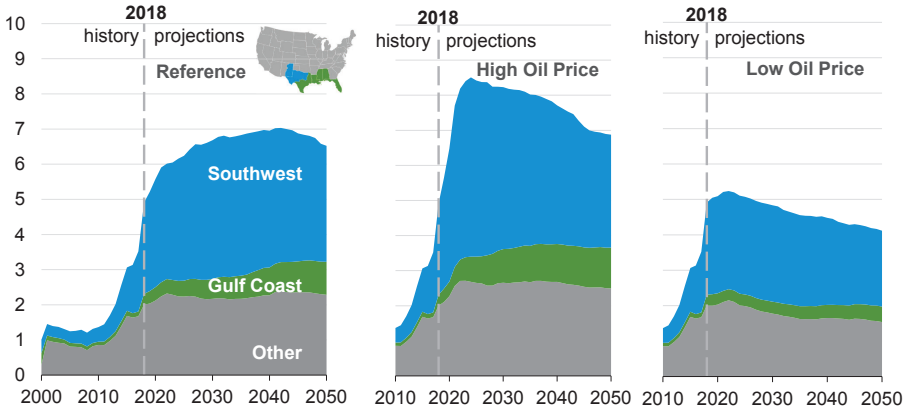


—and natural gas plant liquids comprise nearly one-third of cumulative 2019–2050 U.S. liquids production

- In the Reference case, U.S. crude oil production continues to set annual records through 2027 and remains greater than 14.0 million barrels per day (b/d) through 2040. Lower 48 onshore tight oil development continues to be the main source of growth in total U.S. crude oil production.
- The continued development of tight oil and shale gas resources supports growth in natural gas plant liquids (NGPL) production, which reaches 6.0 million b/d by 2029 in the Reference case.
- The High Oil and Gas Resource and Technology case represents a potential upper bound for crude oil and NGPL production, as additional resources and higher levels of technological advancement result in continued growth in crude oil and NGPL production. In the High Oil Price case, high crude oil prices lead to more drilling in the near term, but cost increases and fewer easily accessible resources decrease production of crude oil and NGPL.
- Conversely, under conditions with fewer resources, lower levels of technological advancement, and lower crude oil prices, the Low Oil and Gas Resource and Technology case and the Low Oil Price case represent potential lower bounds for domestic crude oil and NGPL production. Changes in economic growth have little impact on domestic crude oil and NGPL production.

The United States continues to produce large volumes of natural gas from oil formations, even with relatively low oil prices—

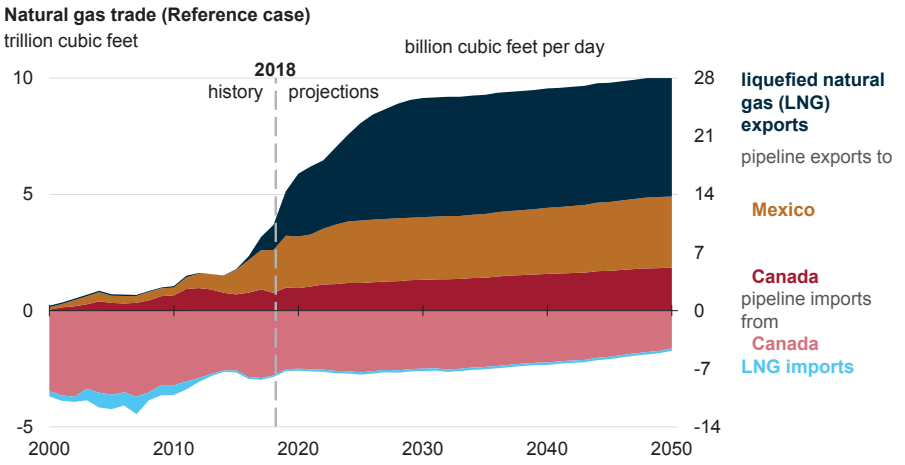
Dry natural gas production from oil formations
trillion cubic feet



—putting downward pressure on natural gas prices

- The percentage of dry natural gas production from oil formations increased from 8% in 2013 to 17% in 2018 and remains near this percentage through 2050 in the Reference case.
- Growth in drilling in the Southwest region, particularly in the Wolfcamp formation in the Permian basin, is the main driver for natural gas production growth from tight oil formations.
- The Low Oil Price case, with the U.S. crude oil benchmark West Texas Intermediate (WTI, Cushing, Oklahoma) price at $58 per barrel or lower, is the only case in which natural gas production from oil formations is lower in 2050 than at current levels.
- The level of drilling in oil formations primarily depends on crude oil prices rather than natural gas prices. Increased natural gas production from oil-directed drilling puts downward pressure on natural gas prices throughout the projection period.

U.S. net exports of natural gas continue to grow in the Reference case—

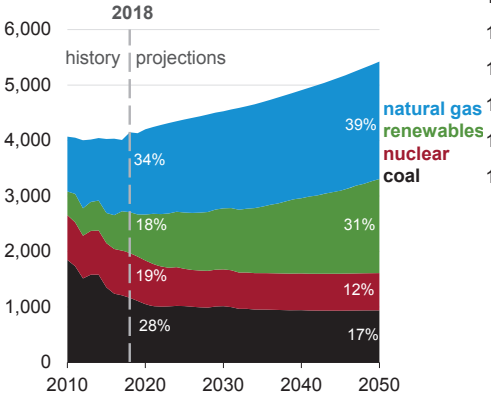


—as liquefied natural gas becomes an increasingly significant export

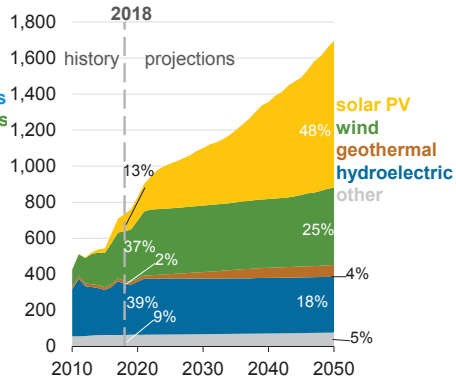
- In the Reference case, U.S. liquefied natural gas (LNG) exports and pipeline exports to Canada and to Mexico increase until 2030 and then flatten through 2050 as relatively low, stable natural gas prices make U.S. natural gas competitive in North American and global markets.
- After LNG export facilities currently under construction are completed by 2022, U.S. LNG export capacity increases further. Asian demand growth allows U.S. natural gas to remain competitive there. After 2030, U.S. LNG is no longer as competitive because additional suppliers enter the global LNG market, reducing LNG prices and making additional U.S. LNG export capacity uneconomic.
- Increasing natural gas exports to Mexico are a result of more pipeline infrastructure to and within Mexico, resulting in increased natural gas-fired power generation. By 2030, Mexican domestic natural gas production begins to displace U.S. exports.
- As Canadian natural gas faces competition from relatively low-cost U.S. natural gas, U.S. imports of natural gas from Western Canada continue to decline from historical levels. U.S. exports of natural gas to Eastern Canada continue to increase because of its proximity to U.S. natural gas resources in the Marcellus and Utica plays and because of recent additions to pipeline infrastructure.

Electricity generation from natural gas and renewables increases, and the shares of nuclear and coal generation decrease—

Electricity generation from selected fuels (Reference case)
billion kilowatthours



Renewable electricity generation, including end-use (Reference case)
billion kilowatthours

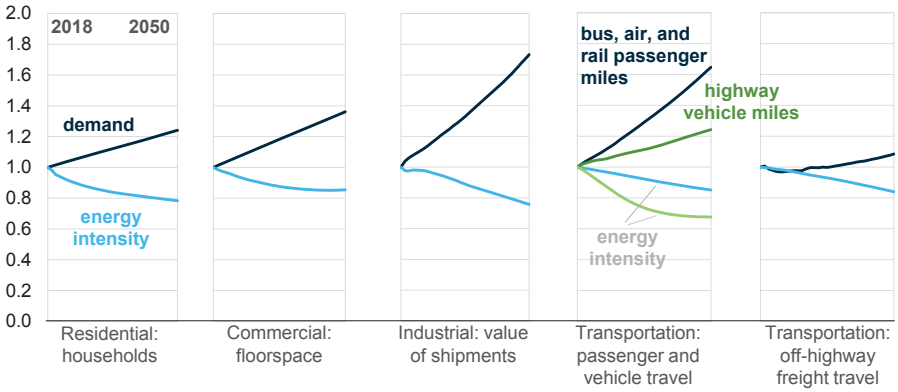


—as lower natural gas prices and declining costs of renewable capacity make these fuels increasingly competitive

- The continuing decline in natural gas prices and increasing penetration of renewable electricity generation have resulted in lower wholesale electricity prices, changes in utilization rates, and operating losses for a large number of baseload coal and nuclear generators.
- Generation from both coal and nuclear is expected to decline in all cases. In the Reference case, from a 28% share in 2018, coal generation drops to 17% of total generation by 2050. Nuclear generation declines from a 19% share of total generation in 2018 to 12% by 2050. The share of natural gas generation rises from 34% in 2018 to 39% in 2050, and the share of renewable generation increases from 18% to 31%.
- Assumptions of declining costs and improving performance make wind and solar increasingly competitive compared with other renewable resources in the Reference case. Most of the wind generation increase occurs in the near term, when new projects enter service ahead of the expiration of key federal production tax credits.
- Solar Investment Tax Credits (ITC) phase down after 2024, but solar generation growth continues because the costs for solar continue to fall faster than for other sources.

End-use activities grow, and energy intensities decrease in all sectors in the Reference case—

Indexed end-use demand drivers and energy intensities by sector (2018–50) (Reference case)
index (2018=1.0)



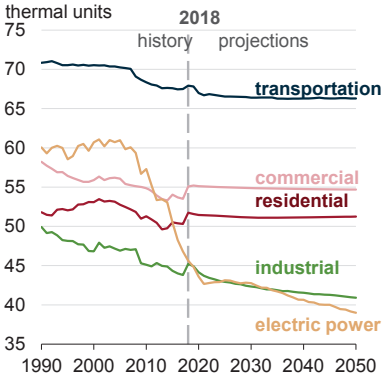
Note: Energy intensities are a lighter shade of the same color as the respective demand, and they are calculated as energy used per unit of respective demand.

—offsetting each other to limit energy consumption growth

- Delivered U.S. energy consumption grows across all major end-use sectors, with electricity and natural gas growing fastest. However, increases in efficiency, represented by declines in energy intensity (the amount of energy consumed per unit of potential demand), partially offset growth in total U.S. energy consumption across all end-use sectors.
- The end-use sectors have different representative metrics for demand used to estimate energy intensity—number of households for the residential sector, floorspace for the commercial sector, industrial value of shipments for the industrial sector, and travel metrics for the transportation sector.
- Transportation travel is measured in three ways, depending on the mode: highway vehicle miles (light- and heavy-duty vehicles), passenger miles (bus, passenger rail, and air), and off-highway freight ton-miles (freight rail, air, and domestic shipping).
- The steepest decline in energy intensity is in the transportation sector, with the level of energy used per highway vehicle-mile traveled declining by 32% from 2018 to 2050 as a result of increasingly stringent fuel economy and energy efficiency standards for light- and heavy-duty vehicles.

Across end-use sectors, carbon dioxide intensity declines with changes in the fuel mix—

Carbon dioxide intensity by end-use sector (Reference case)
metric tons of carbon dioxide per billion British thermal units



Carbon dioxide intensity by end-use sector (Reference case)
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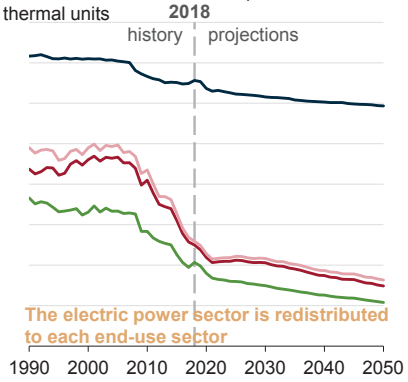


Note: Carbon dioxide intensities are calculated as carbon dioxide emissions per unit energy output (in British thermal units).

—despite overall increases in energy consumption

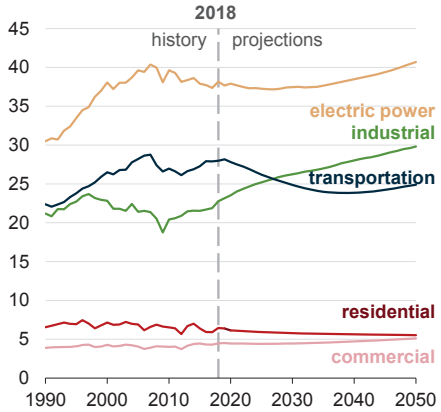
- Carbon dioxide (CO_2) intensity can vary greatly depending on the mix of fuels the end-use sectors consume. Historically, the industrial sector has had the lowest CO_2 intensity, as measured by CO_2 emissions per British thermal unit (Btu). The transportation sector historically has had the highest CO_2 intensity, which continues in the projection because carbon-intensive petroleum remains the dominant fuel used in vehicles throughout the projection period.

- The generation fuel mix in the electric power sector has changed 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.

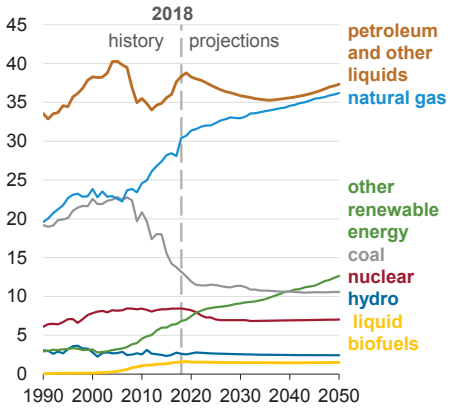
- Accounting for the CO_2 emissions from the electricity sector in the end-use sectors that consume the electricity results in larger declines in CO_2 intensity across those sectors for all AEO2019 cases. In the Reference case, the CO_2 intensities of the residential and commercial sectors decline less than 1% when only their direct CO_2 intensities are counted. When the electric power sector energy is distributed to the end-use sectors, the residential and commercial sectors decline by 11% and 10%, respectively, while the industrial sector declines by 11%. Transportation carbon intensity declines by 5%.

Policy, technology, and economics affect the mix of U.S. fuel consumption—

Energy consumption by sector (Reference case)
quadrillion British thermal units



Energy consumption by fuel (Reference case)
quadrillion British thermal units



—which affects energy consumption patterns throughout the projection period

- In all cases, non-hydroelectric renewables consumption grows the most (on a percentage basis). Implementing policies at the state level (renewable portfolio standards) and at the federal level (production and investment tax credits) has encouraged the use of renewables. Growing renewable use has driven down the costs of renewables technologies (wind and solar photovoltaic), further supporting their expanding adoption by the electric power and buildings sectors.

- Natural gas consumption rises as well, driven by projected low natural gas prices. In the Reference case, the industrial sector becomes the largest consumer of natural gas starting in the early 2020s. This sector will expand the use of natural gas as feedstock in the chemical industries and as lease and plant fuel, for industrial heat and power, and for liquefied natural gas production. Natural gas consumption for electric power also increases significantly in the power sector in response to low natural gas prices and to installing lower cost natural gas-fired combined-cycle generating units.

- The transportation sector is the largest consumer of petroleum and other liquids, particularly motor gasoline and distillate fuel oil. Current fuel economy standards stop requiring additional efficiency increases in 2025 for light-duty vehicles and in 2027 for heavy-duty vehicles, but travel continues to rise, and as a result, consumption of petroleum and other liquids increases later in the projection period.

"Annual Energy Outlook 2019," U.S. Energy Information Administration. To read the full report please see: https://www.eia.gov/outlooks/aeo.