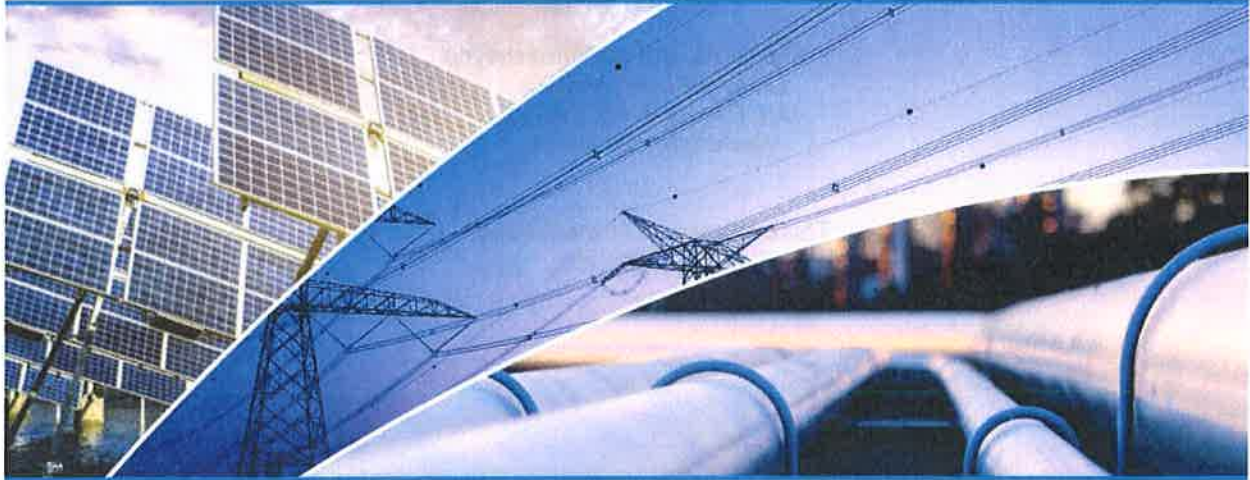


# *Annual Energy Outlook 2018*

with projections to 2050



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February 2018

U.S. Energy Information Administration  
Office of Energy Analysis  
U.S. Department of Energy  
Washington, DC 20585

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## Overview/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, technological progress, and energy policies. Strong domestic production coupled with relatively flat energy demand allows the United States to become a net energy exporter over the projection period in most cases. In the Reference case, natural gas consumption grows the most on an absolute basis, and nonhydroelectric renewables grow the most on a percentage basis.



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

- Projections in the *Annual Energy Outlook 2018* (AEO2018) 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, as many of the events that shape energy markets and future developments in technologies, demographics, and resources cannot be foreseen with certainty.
- More information about the assumptions used in developing these projections will be available shortly after the release of the AEO.
- The AEO is published pursuant to the Department of Energy Organization Act of 1977, which requires the U.S. Energy Information Administration (EIA) Administrator to prepare annual reports on trends and projections for energy use and supply.



## What is the Reference case?

- The Reference case projection assumes trend improvement in known technologies along with a view of economic and demographic trends reflecting the current views of leading economic forecasters and demographers.
- The Reference case generally assumes that current laws and regulations affecting the energy sector, including sunset dates for laws that have them, are unchanged throughout the projection period.
- The potential impacts of proposed legislation, regulations, and standards are not included.
- EIA addresses the uncertainty inherent in energy projections by developing side cases with different assumptions of macroeconomic growth, world oil prices, technological progress, and energy policies.
- Projections in the AEO should be interpreted with a clear understanding of the assumptions that inform them and the limitations inherent in any modeling effort.



## What are the side cases?

- Oil prices are driven by global market balances that are primarily influenced by factors external to the NEMS model. In the High Oil Price case, the price of Brent crude, in 2017 dollars, reaches \$229 per barrel (b) by 2050, compared with \$114/b in the Reference case and \$52/b in the Low Oil Price case.
- In the High Oil and Gas Resource and Technology case, lower costs and higher resource availability than in the Reference case allow for higher production at lower prices. In the Low Oil and Gas Resource and Technology case, assumptions of lower resources and higher costs are applied.
- The effects of the economic assumptions on energy consumption are addressed in the High and Low Economic Growth cases, which assume compound annual growth rates for U.S. gross domestic product of 2.6% and 1.5%, respectively, from 2017–50, compared with 2.0%/year growth in the Reference case.
- Cases assuming the Clean Power Plan is implemented show how the presence of that policy could affect energy markets and emissions compared with the Reference, resource, economic, and oil price cases.
- AEO2018 will also include additional side cases—which are not discussed here—and will support a series of *Issues in Focus* articles that will be released in 2018.



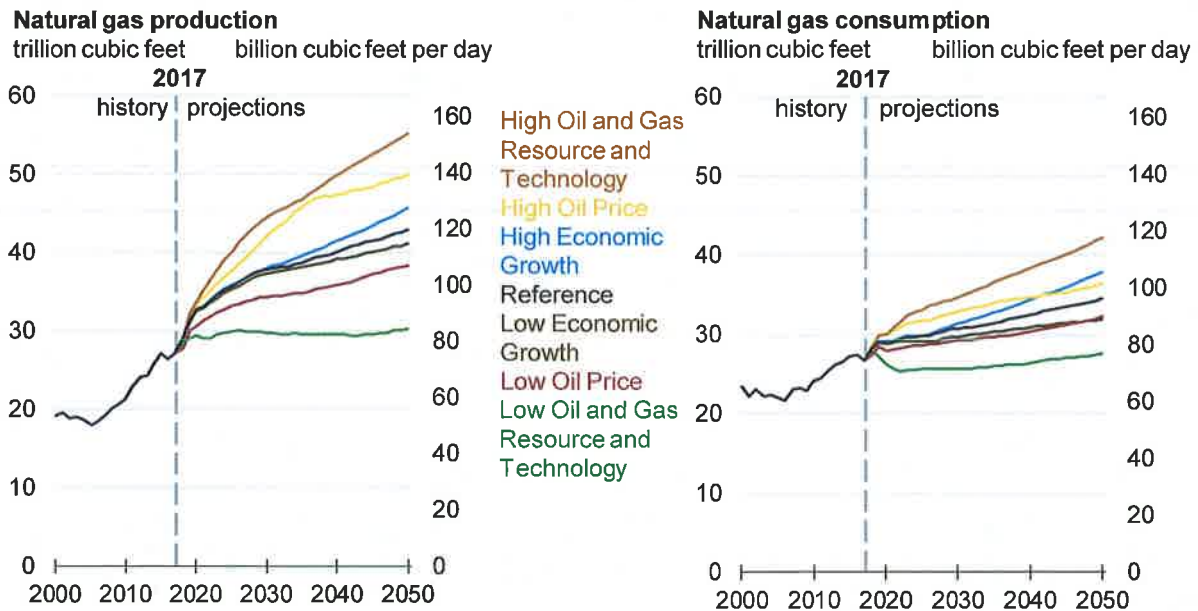




## Natural gas

Natural gas production increases in every case, supporting higher levels of domestic consumption and natural gas exports. However, these projections are sensitive to resource and technology assumptions.

## U.S. natural gas consumption and production increase in all cases—



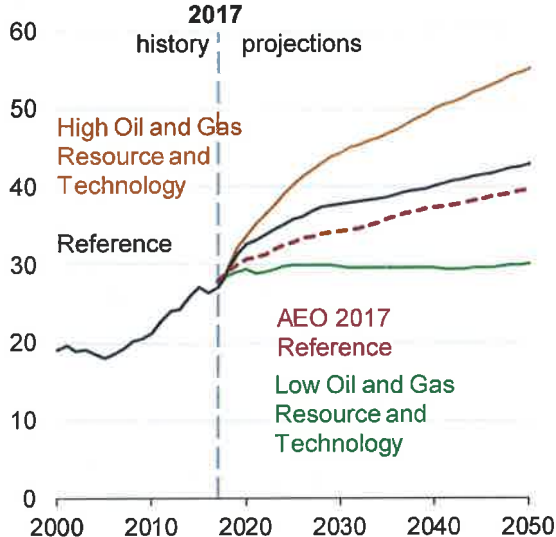
## —with production growth outpacing natural gas consumption in all cases

- Natural gas production in the Reference case grows 6%/year from 2017 to 2020, which is greater than the 4%/year average growth rate from 2005 to 2015. However, after 2020, it slows to less than 1%/year for the remainder of the projection.
- Near-term production growth across all cases is supported by growing demand from large natural gas-intensive, capital-intensive chemical projects and from the development of liquefaction export terminals in an environment of low natural gas prices.
- After 2020, production grows at a higher rate than consumption in all cases except in the Low Oil and Gas Resource and Technology case, where production and consumption remain relatively flat as a result of higher production costs.
- In all cases other than the Low Oil and Gas Resource and Technology case, U.S. natural gas consumption increases over the entire projection period.

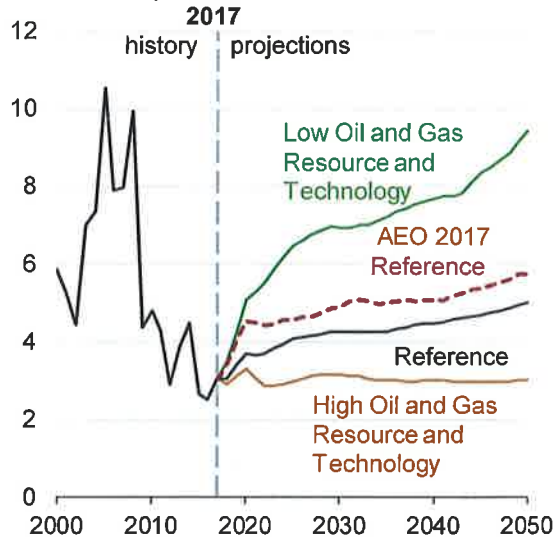


## Natural gas prices across cases are dependent on resource and technology assumptions—

**Dry natural gas production**  
trillion cubic feet



**Natural gas spot price at Henry Hub**  
2017 dollars per million British thermal units

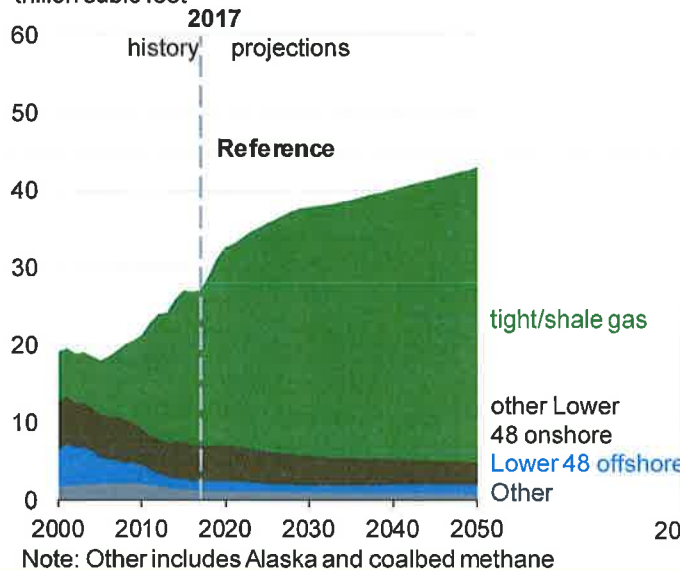


## —and Henry Hub prices in the AEO2018 Reference case are 14% lower on average through 2050 than in AEO2017

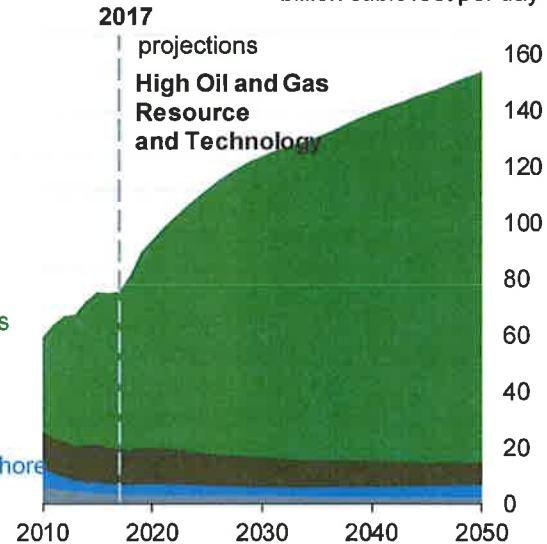
- Growing demand in domestic and export markets leads to increasing natural gas spot prices over the projection period at the U.S. benchmark Henry Hub in the Reference case despite continued technological advances that support increased production.
- To satisfy the growing demand for natural gas, production must expand into less prolific and more expensive-to-produce areas, which will put upward pressure on production costs.
- The High Oil and Gas Resource and Technology case, which reflects lower costs and higher resource availability, shows an increase in production and lower prices relative to the Reference case. In the Low Oil and Gas Resource and Technology case, high prices, which result from higher costs and fewer available resources, result in lower domestic consumption and lower exports over the projection period.
- Natural gas prices in the AEO2018 Reference case are lower than in the AEO2017 Reference case because of an estimated increase in lower-cost resources, primarily in the Permian and Appalachian basins, which support higher production levels at lower prices over the projection period.

## Increased U.S. natural gas production is the result of continued development of shale gas and tight oil plays—

**Natural gas production by type**  
trillion cubic feet



billion cubic feet per day

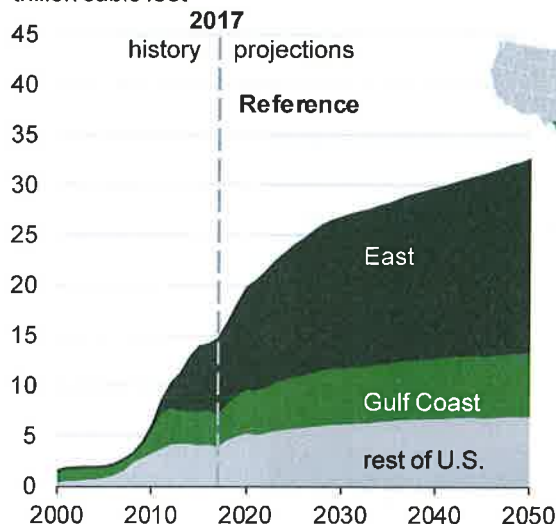


## —which account for more than three-quarters of natural gas production by 2050

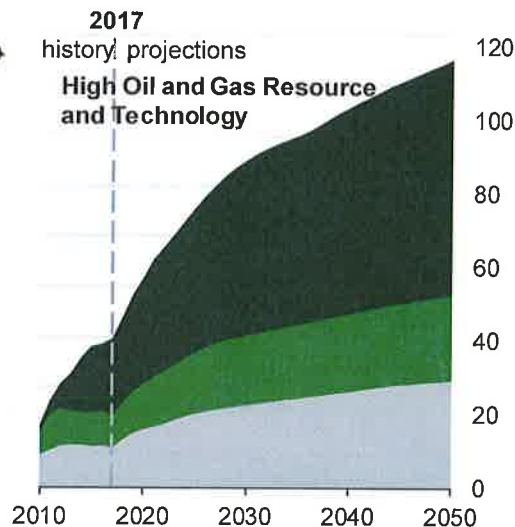
- Natural gas production from shale gas and tight oil plays as a share of total U.S. natural gas production is projected to continue to grow in both share and absolute volume because of the large size of the associated resources, which extend over more than 500,000 square miles.
- Offshore natural gas production in the United States stays nearly flat over the projection period as production from new discoveries generally offsets declines in legacy fields.
- Production of coalbed methane gas generally continues to decline through 2050 because of unfavorable economic conditions for producing that resource.

## Plays in the East lead production of U.S. natural gas from shale resources in the Reference case—

**Shale gas production by region**  
trillion cubic feet



billion cubic feet per day

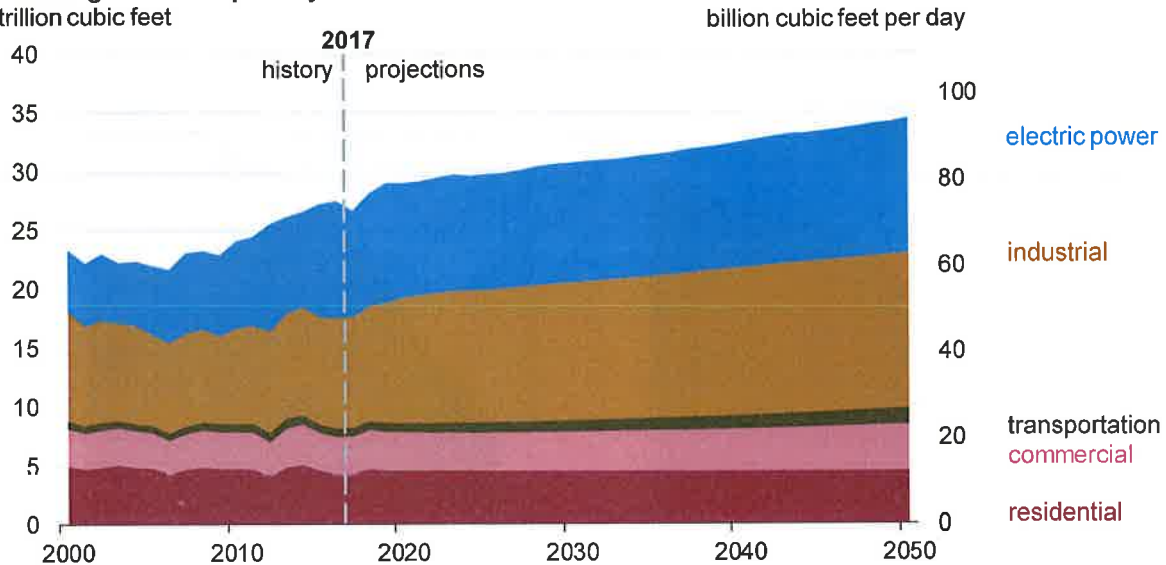


## —followed by growth in Gulf Coast onshore production

- Continued development of the Marcellus and Utica plays in the East is the main driver of growth in total U.S. shale gas production across most cases and the main source of total U.S. dry natural gas production.
- Production from the Eagle Ford and Haynesville plays in the Gulf Coast region is a secondary source to domestic dry natural gas, with production largely leveling off after 2028.
- Associated natural gas production from tight oil production in the Permian basin grows strongly through the projection period.
- Continued technological advancements and improvements in industry practices are expected to lower costs and to increase the volume of oil and natural gas recovery per well. These advancements have a significant cumulative effect in plays that extend over wide areas and that have large undeveloped resources (Marcellus, Utica, and Haynesville).

## Industrial and electric power demand drives natural gas consumption growth—

**Natural gas consumption by sector**  
trillion cubic feet



—as consumption in the residential and commercial sectors remains relatively flat over the projection period in the Reference case

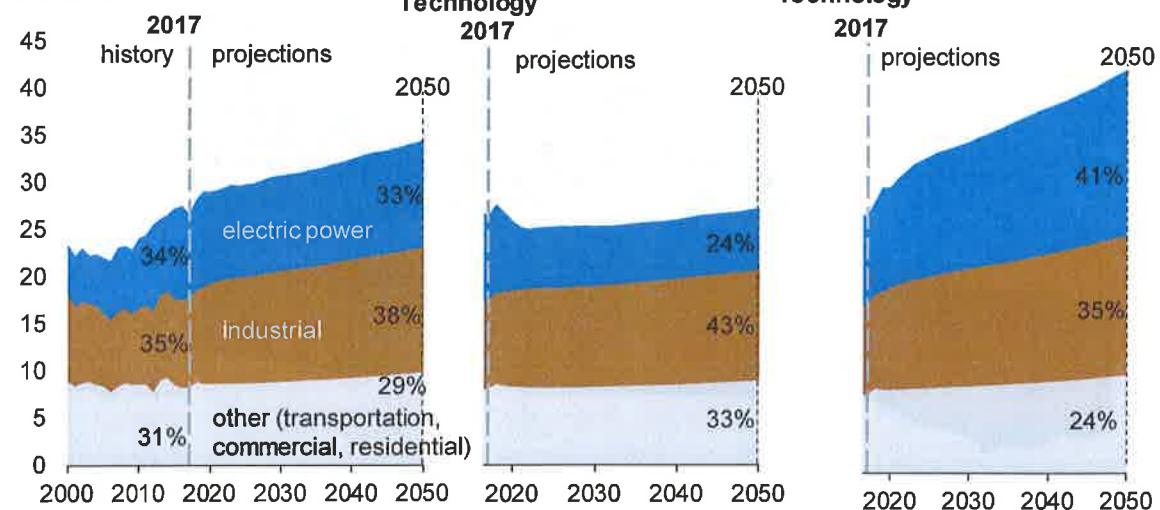
- The industrial sector is the largest consumer of natural gas in the Reference case. Major natural gas consumers in this sector include the chemical industry (where natural gas is used as a feedstock in the production of methanol and ammonia), industrial heat and power, and liquefied natural gas export facilities.
- Natural gas used for electric power generation generally increases over the projection period but at a slower rate than in the industrial sector. This growth is supported by the scheduled expiration of renewable tax credits in the mid-2020s.
- Natural gas consumption in the residential and commercial sectors remains largely flat because of efficiency gains and population shifts that counterbalance demand growth.
- Although natural gas use rises in the transportation sector, particularly for freight and marine shipping, it remains a small share of total natural gas consumption, and natural gas remains a small share of transportation fuel demand.

## Natural gas supply assumptions that affect prices result in significant changes in natural gas consumption—

### U.S. natural gas consumption by sector

trillion cubic feet

Reference

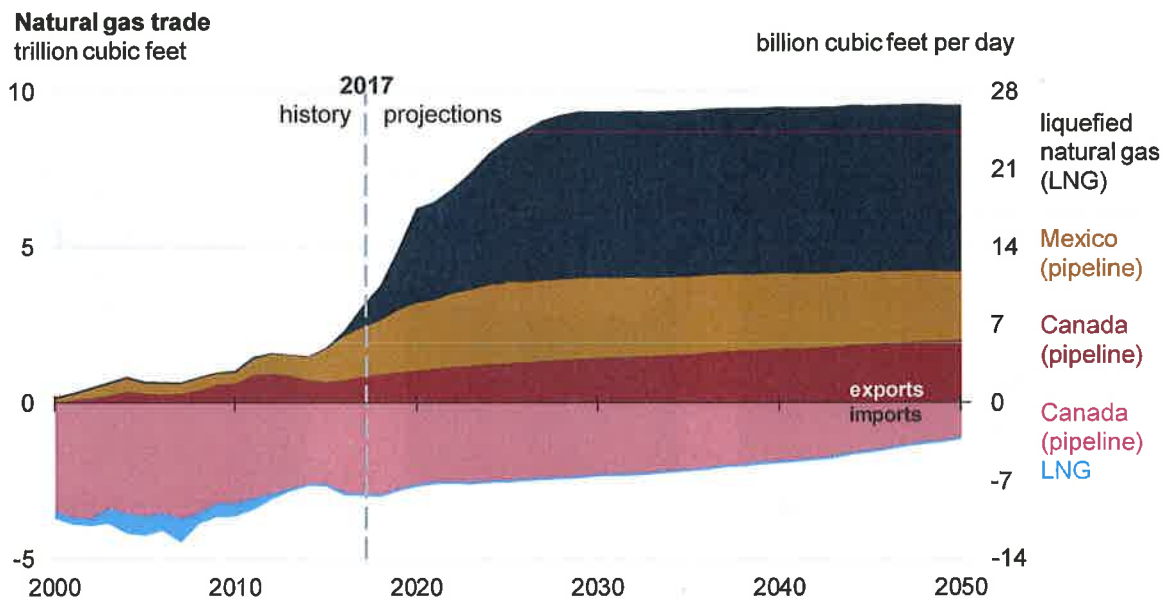


—particularly in the electric power sector as natural gas prices across cases change its competitiveness with other generation fuels

- Between the two largest sectors of natural gas consumption—industrial and electric power—the electric power sector is more responsive to prices. In the short term, electric generators can react quickly to take advantage of changes in relative fuel costs and generally have more fuel options than the industrial sector. In contrast, although energy costs are considered when making long-term decisions about the number, siting, and types of industrial facilities, these costs are only one of many factors.
- The industrial sector is projected to be the largest natural gas-consuming sector in the Reference case, accounting for 38% of the domestic market in 2050. However, in the High Oil and Gas Resource and Technology case, the electric power sector is the largest natural gas consumer. Because Henry Hub spot prices remain lower than \$3.50 per million British thermal units (MMBtu) in that case through the entire projection period, natural gas is more competitive with renewables and coal. By 2050, natural gas use in the electric power sector is 41% of total U.S. domestic natural gas consumption in that case.
- Conversely, in the Low Oil and Gas Resource and Technology case, the electric power sector only accounts for an average 25% of U.S. natural gas use from 2020 to 2050 because of higher natural gas prices—Henry Hub natural gas prices reach \$6.50/MMBtu by 2025 and more than \$9.40/MMBtu by 2050. The industrial sector accounts for 42% of the domestic natural gas market from 2020–2050 in that case.



The United States is a net natural gas exporter in the Reference case because of near-term export growth and continued import decline —



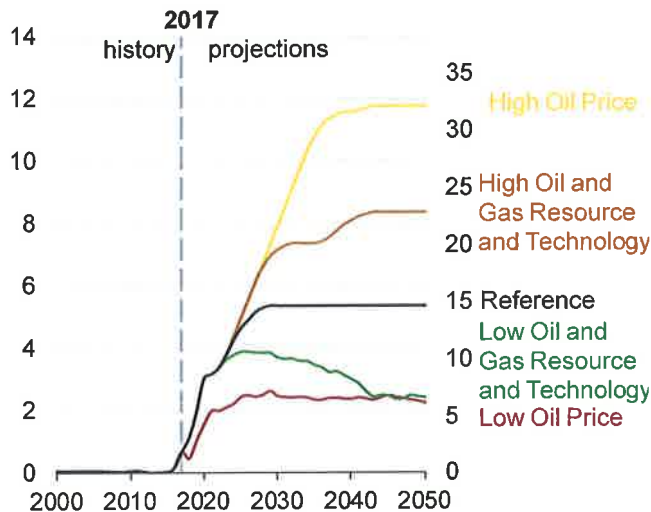
—as liquefied natural gas export facilities allow domestic production to reach global markets

- In the Reference case, pipeline exports to Mexico and liquefied natural gas (LNG) exports increase until 2020. Through 2030, pipeline export growth to Mexico slows, and LNG exports grow rapidly.
- Increasing natural gas exports to Mexico are the result of more pipeline infrastructure to and within that country, allowing for increased natural gas-fired power generation. By the mid-2020s, Mexican domestic natural gas production begins to displace U.S. exports.
- One LNG export facility currently operates in the Lower 48 states with a second facility expected to be operating in March 2018. After the five U.S. LNG export facilities currently under construction are completed by 2021, LNG export capacity is projected to increase as Asian demand grows and U.S. natural gas prices remain competitive. As U.S.-sourced LNG becomes less competitive, export volumes remain constant during the later years of the projection.
- U.S. imports of natural gas from Canada, primarily from its prolific Western region, remain relatively stable for the next few years before declining from historically high levels. U.S. exports of natural gas to Eastern Canada continue to increase because of Eastern Canada's proximity to U.S. natural gas resources in the Marcellus and Utica plays.

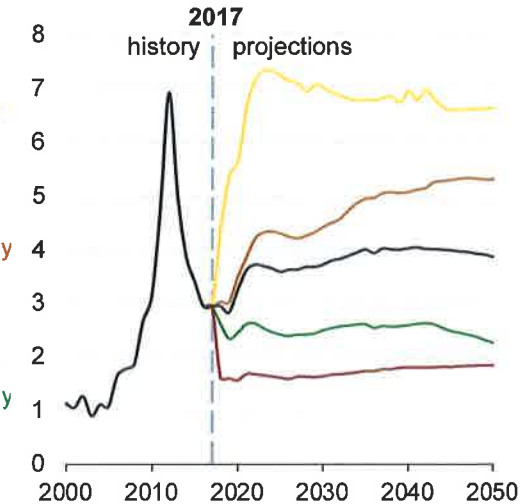


## U.S. liquefied natural gas exports are sensitive to both oil and natural gas prices—

**Liquefied natural gas exports**  
trillion cubic feet billion cubic feet per day



**Oil-to-natural gas price ratio**  
energy-equivalent terms



## —resulting in a wide range of expected U.S. liquefied natural gas export levels across cases

- Historically, most liquefied natural gas (LNG) was traded under long-term, oil price-linked contracts, in part because oil could substitute for natural gas in industry and for power generation. However, as the LNG market expands, contracts are expected to change with weaker ties to oil prices.
- When the oil-to-natural gas price ratio is highest, as in the High Oil Price case, U.S. LNG exports are at their highest levels. Demand for LNG increases as consumers move away from petroleum products. U.S. LNG supplies have the advantage of being priced based on relatively low domestic spot prices instead of on oil-linked contracts.
- In the High Oil and Gas Resource and Technology case, low U.S. natural gas prices make U.S. LNG exports competitive relative to other suppliers. Conversely, higher U.S. natural gas prices in the Low Oil and Gas Resource and Technology case result in lower U.S. LNG exports.
- As more natural gas is traded via short-term contracts or traded on the spot market, the link between LNG and oil prices is projected to weaken over time, making U.S. LNG exports less sensitive to the oil-to-natural gas price ratio and resulting in slower growth in U.S. LNG exports in all cases.