

# The Outlook for Electricity Markets, Transportation Energy Use, and Hydrocarbon Production in the United States: Insights from AEO2017



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*Energy Week*

*Scott Institute for Energy Innovation*

*Carnegie Mellon University*

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*By*

*Howard Gruenspecht, Acting Administrator*

## Key takeaways from AEO2017

- With strong domestic production and relatively flat demand, the United States becomes a net energy exporter over the projection period in most cases
- U.S. crude oil production rebounds from recent lows, driven by continued development of tight oil resources; with consumption flat to down compared to recent history, net crude oil and petroleum product imports as a percentage of U.S. product supplied decline across most cases
- Across most cases, natural gas production increases despite relatively low and stable prices, supporting higher levels of domestic consumption and natural gas exports
- With modest electricity demand growth, the primary driver for new electricity generation capacity in the Reference case is the retirement of fossil fuel units, largely spurred by the Clean Power Plan (CPP), the near-term availability of renewable tax credits, state-level policies to promote renewables, and nuclear retirements; even if the CPP is not implemented natural gas and renewables are the primary sources of new generation capacity; the future generation mix is sensitive to the price of natural gas and the growth in electricity demand

## Key takeaways from AEO2017 (continued)

- Transportation energy consumption peaks in 2018 in the Reference case because rising fuel efficiency outweighs increases in total travel and freight movements throughout the projection period
- Despite growth in the number of households and the amount of commercial floorspace, improved equipment and efficiency standards contribute to residential and commercial energy consumption remaining relatively flat or declining slightly from 2016 to 2040 in the Reference case
- With economic growth and relatively low energy prices, industrial energy consumption increases during the projection period across all cases; energy intensity declines in the Reference case and most side cases as a result of technological improvements

# Overview

## Why long-term projections ~~might/could~~ will be wrong

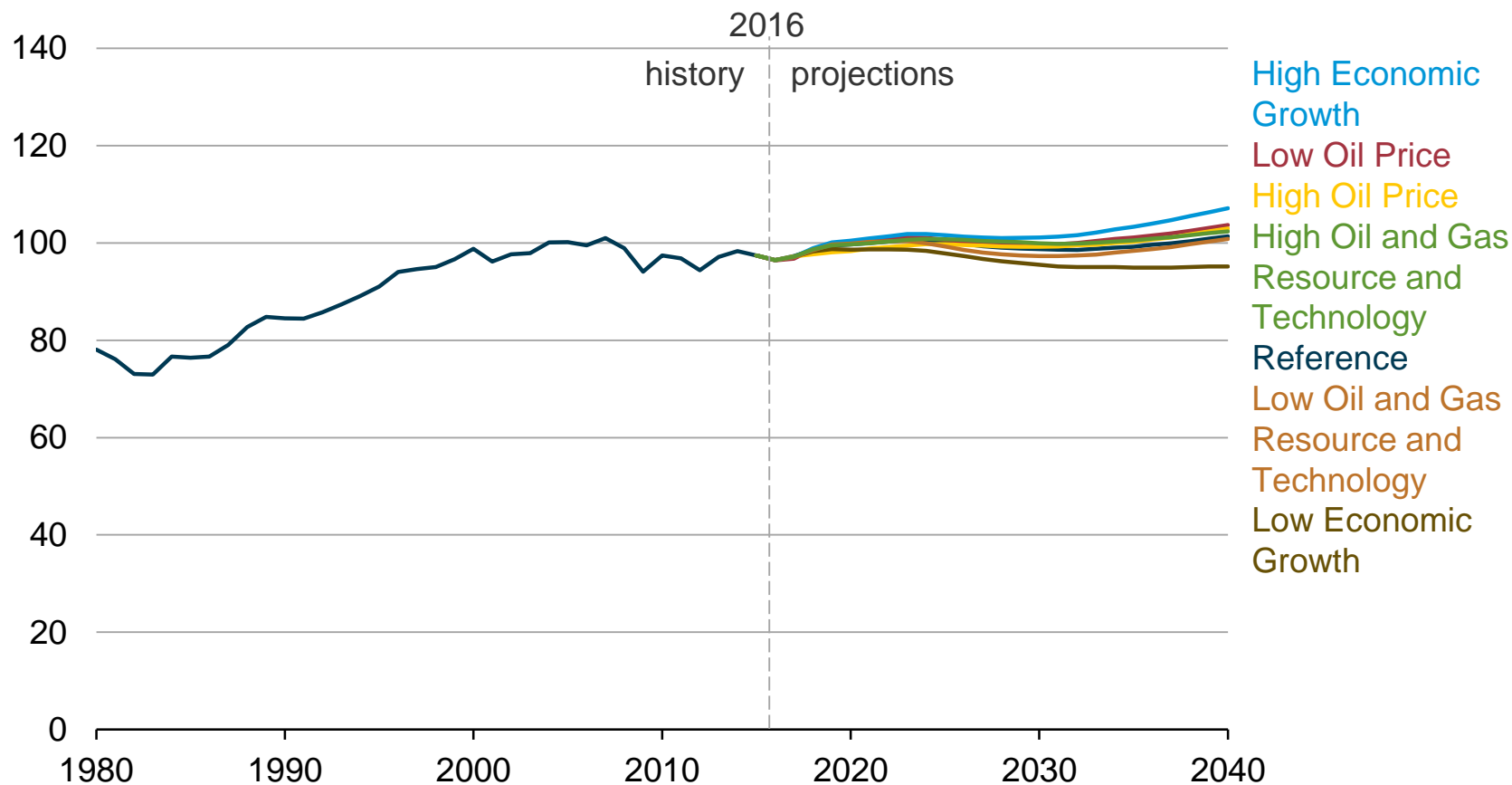
- Different relative fuel prices
- Faster / slower economic and energy demand growth
- Changing policies and regulations
- Changing consumer preferences
- Faster / slower technology progress
- Technology breakthroughs

## AEO2017 includes side cases with different assumptions of macroeconomic growth, world oil prices, technological progress, and energy policies

- Oil prices are primarily driven by global market balances that are mainly influenced by factors external to the NEMS model; in the Reference case, oil prices reach \$109/b in 2016 dollars, compared to \$43/b in the Low Oil Price case and \$228/b in the High 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, more pessimistic assumptions about resources and costs are applied
- The effects of 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 1.6%, respectively, from 2016–40, compared with 2.2% annual growth in the Reference case
- A case assuming that the Clean Power Plan (CPP) is not implemented can be compared to the Reference case to show how that policy could affect energy markets and emissions

# Energy consumption varies modestly across the AEO cases, bounded by the High and Low Economic Growth cases

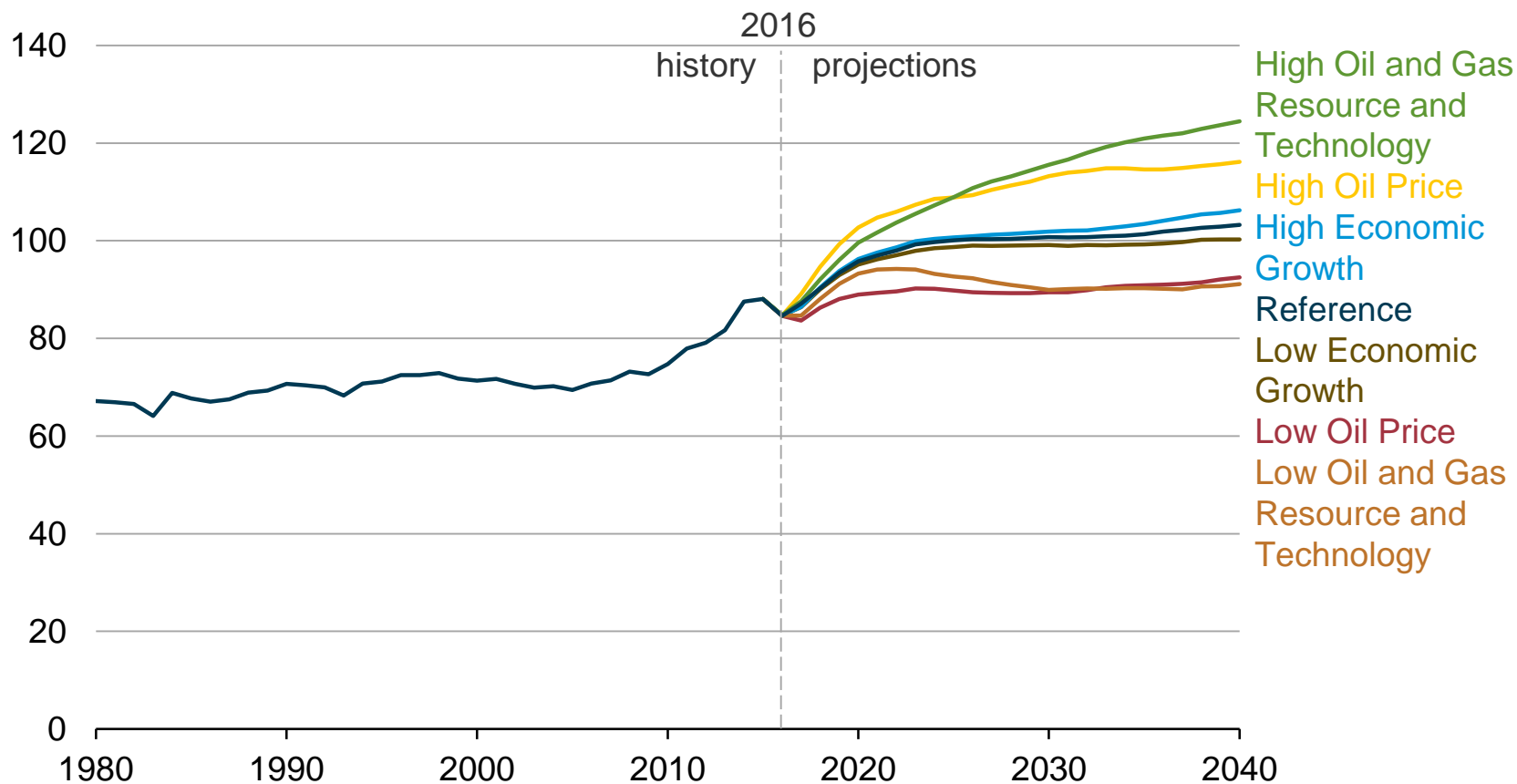
Total energy consumption  
quadrillion British thermal units



Source: EIA, Annual Energy Outlook 2017

# Energy production varies more substantially across AEO cases, bounded by the Oil and Gas Resource and Technology cases

Total energy production  
quadrillion British thermal units

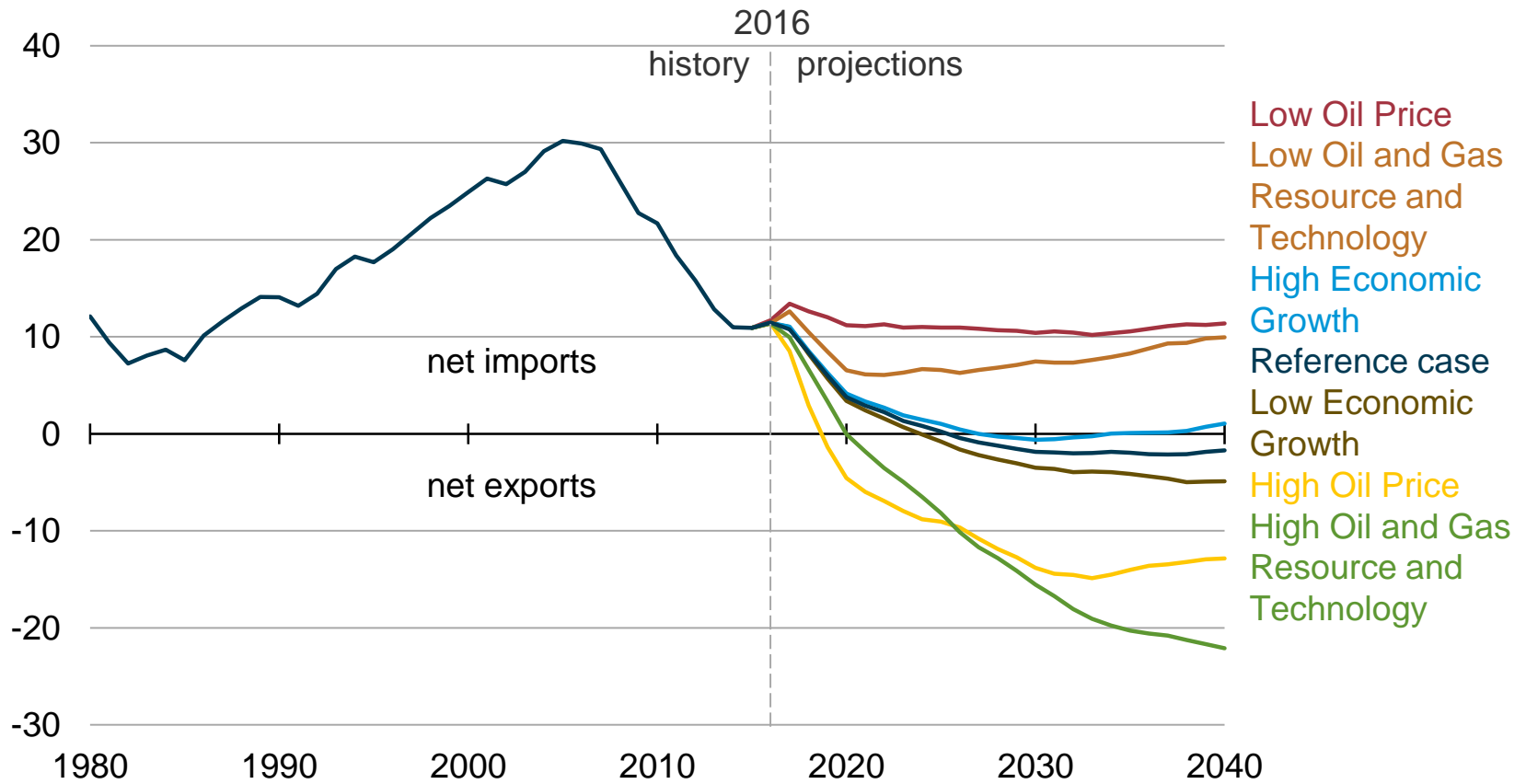


Source: EIA, Annual Energy Outlook 2017



# The United States becomes a net energy exporter in most cases as petroleum liquid imports fall and natural gas exports rise

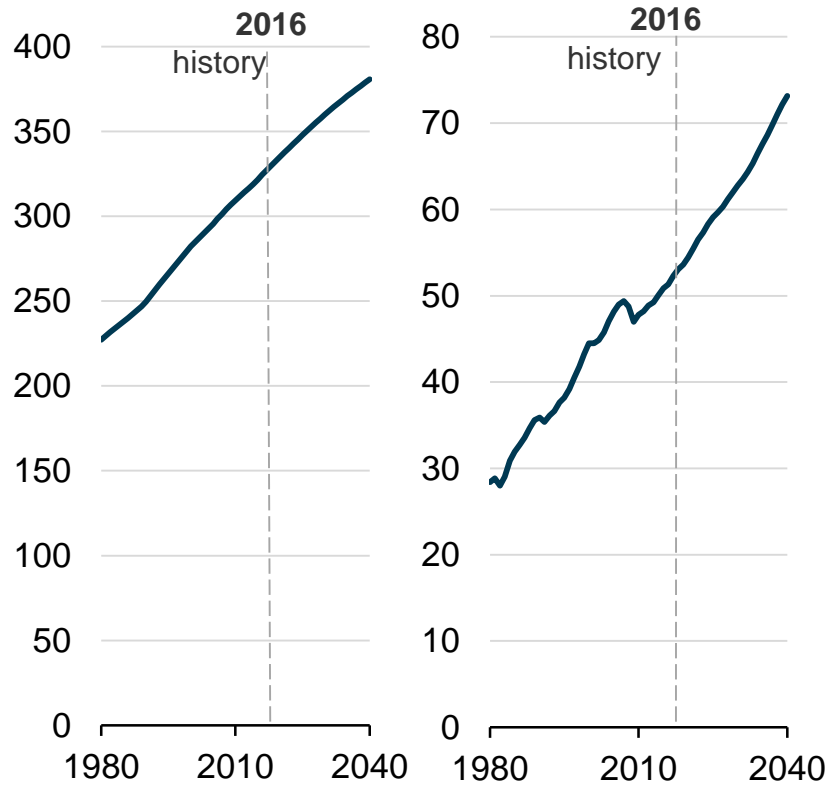
Net energy trade  
quadrillion British thermal units



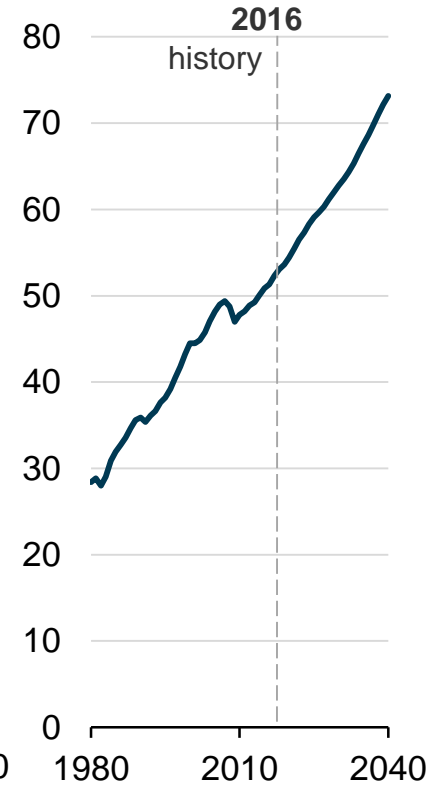
Source: EIA, Annual Energy Outlook 2017

# Although population and economic output per capita are assumed to continue rising, energy intensity and carbon intensity are projected to continue falling in the Reference case

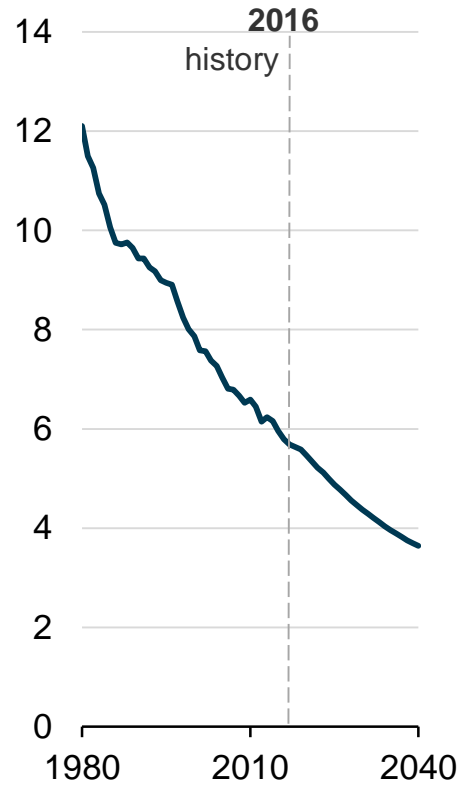
**U.S. population**  
million people



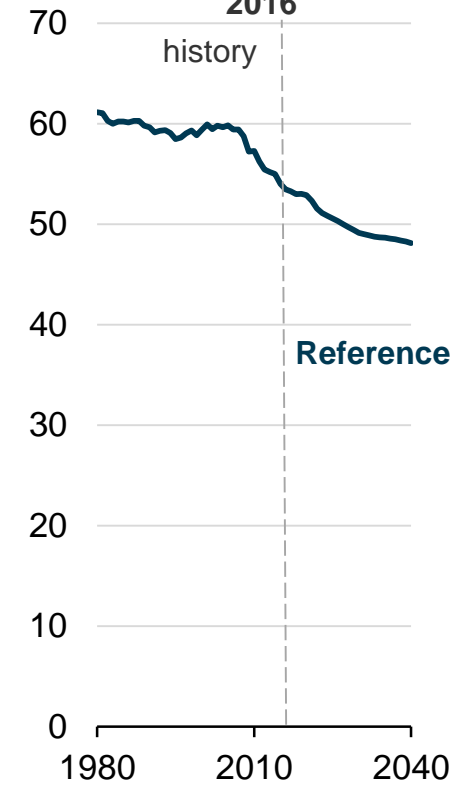
**Gross domestic product per capita**  
thousand dollars per person



**Energy intensity**  
thousand British thermal units per dollar



**Carbon intensity**  
metric tons CO2 per billion British thermal units

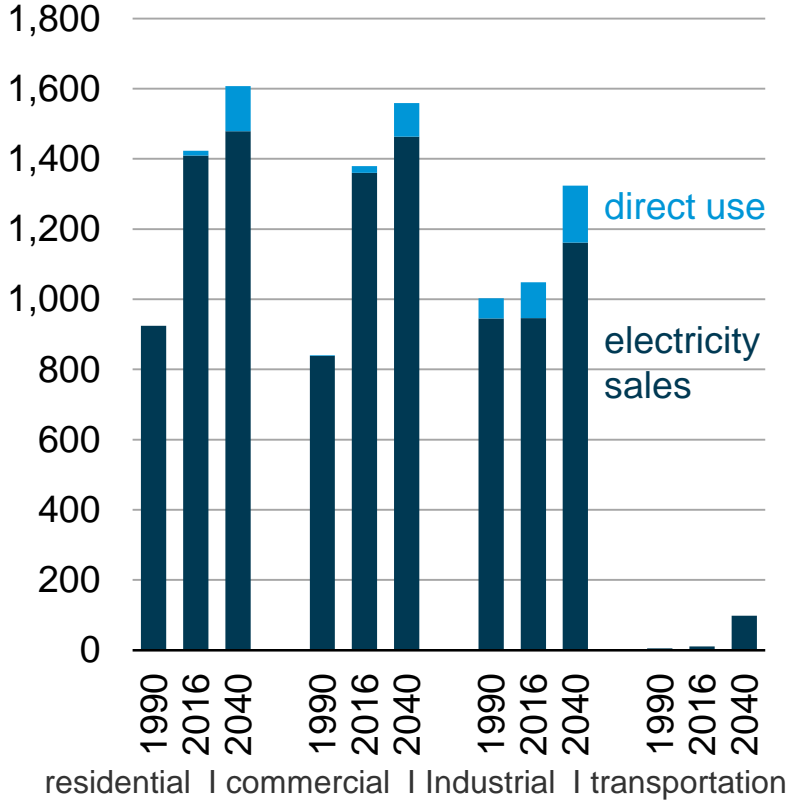


Source: EIA, Annual Energy Outlook 2017

# Electricity

# Electricity use continues to increase, but the rate of growth remains lower than historic averages in the Reference case

Electricity use by sector  
billion kilowatthours



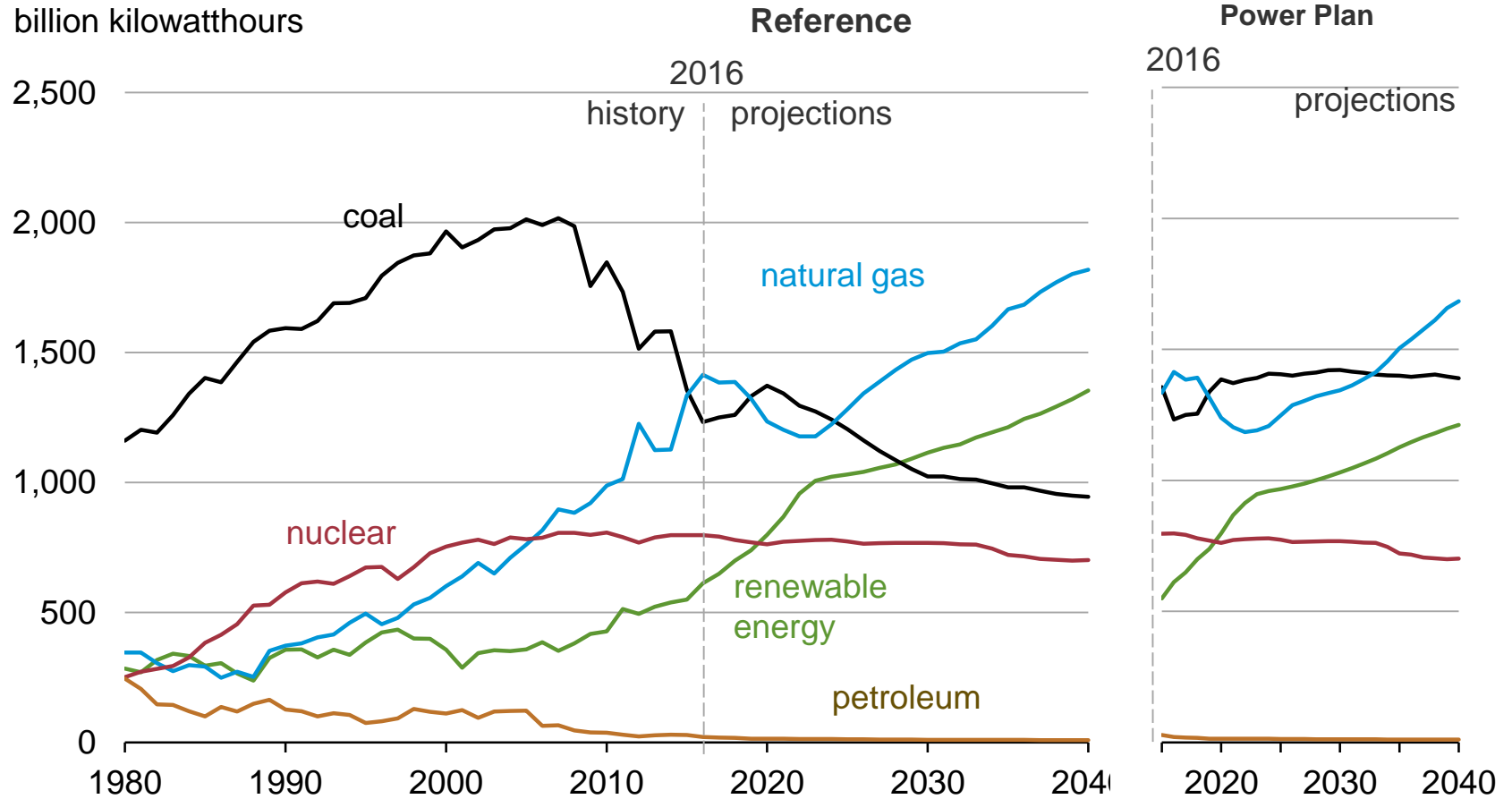
Electricity use growth rate  
percent growth (three-year rolling average)



Source: EIA, Annual Energy Outlook 2017

# Fuel prices and current laws and regulations drive growing shares of renewables and natural gas in the electricity generation mix as coal's share declines over time in the Reference case

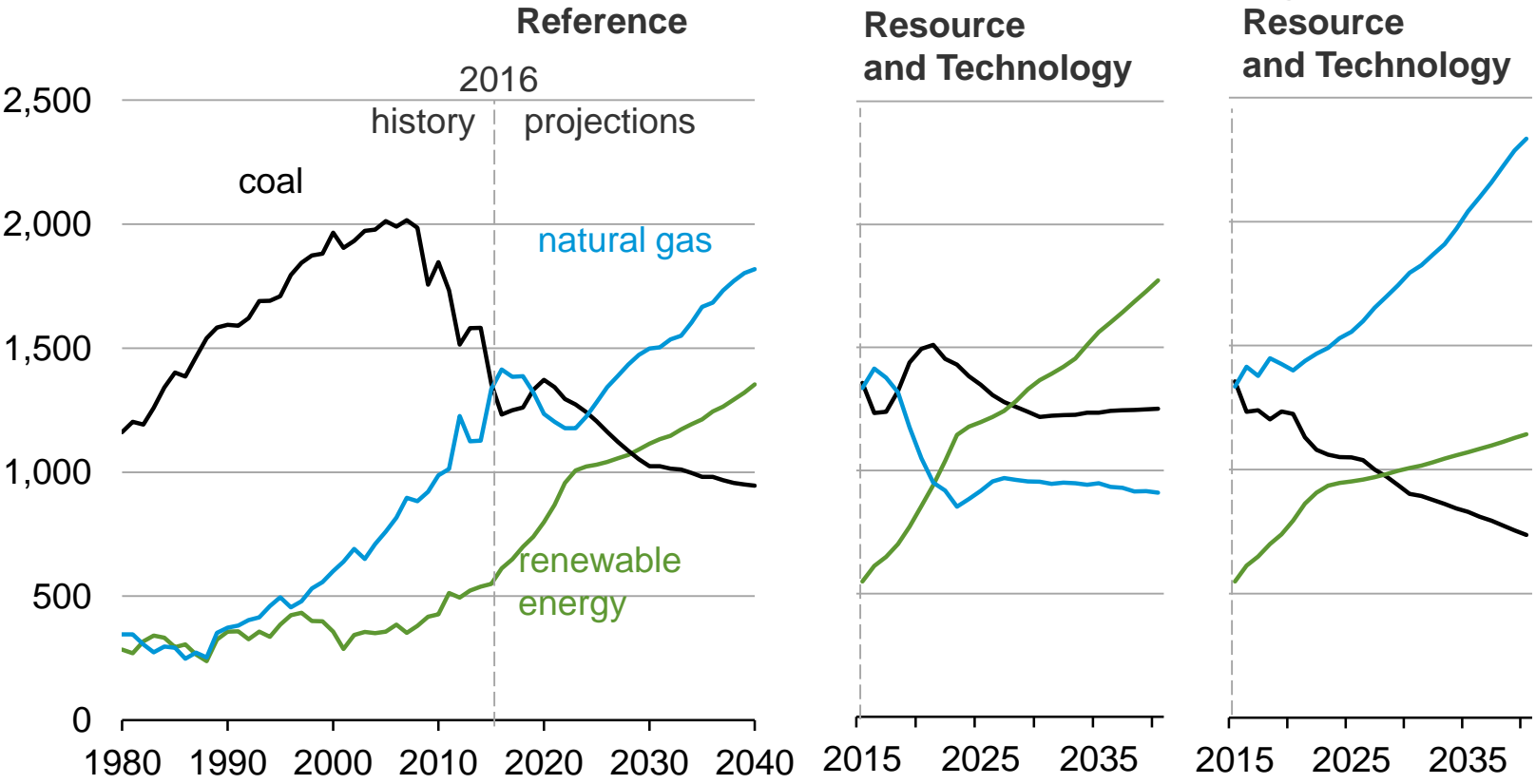
U.S. net electricity generation from select fuels  
billion kilowatthours



Source: EIA, Annual Energy Outlook 2017

# Natural gas resource availability affects prices and plays a critical role in determining the mix of coal, natural gas, and renewable generation

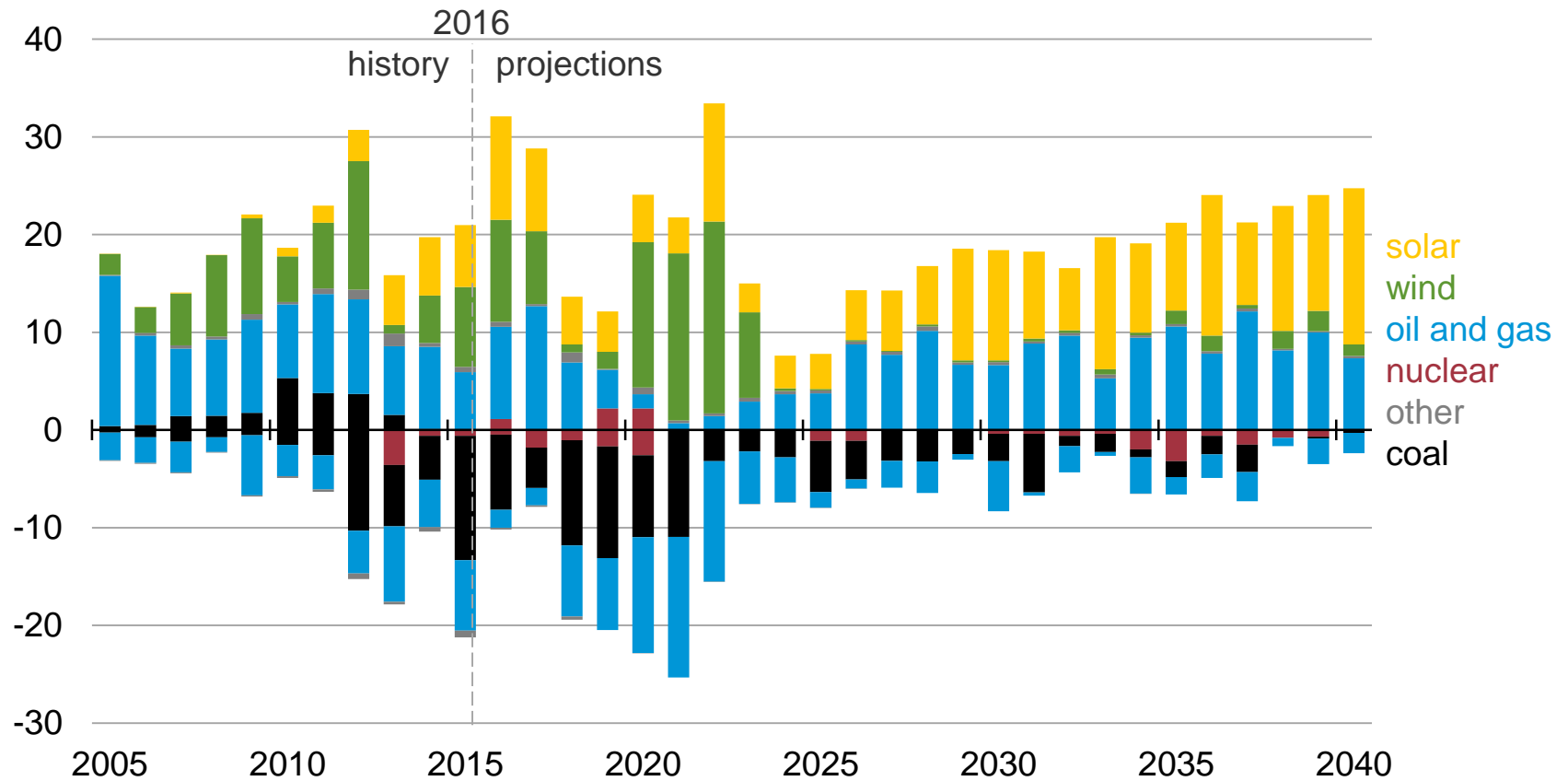
U.S. net electricity generation from select fuels  
billion kilowatthours



Source: EIA, Annual Energy Outlook 2017

# Lower capital costs and the availability of tax credits boost near-term wind additions and sustain solar additions; whereas coal-fired unit retirements in the Reference case are driven by low natural gas prices and the Clean Power Plan

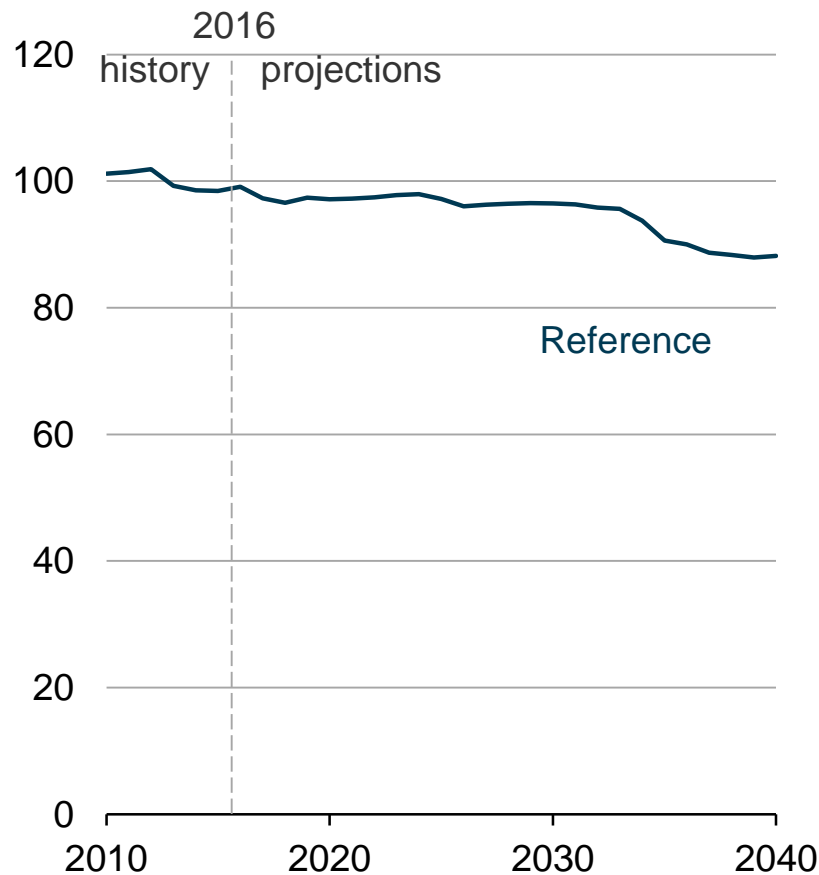
Annual electricity generating capacity additions (+) and retirements (-) (Reference case)  
gigawatts



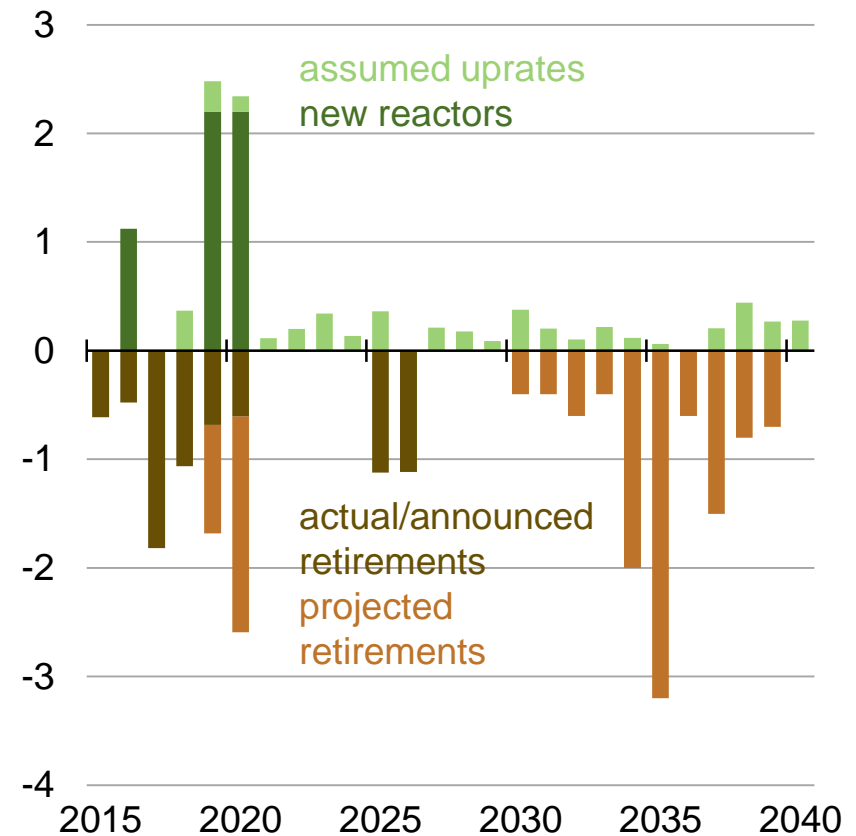
Source: EIA, Annual Energy Outlook 2017

# The assumption that 25% of nuclear plants that reach age 60 are retired leads to net nuclear capacity decreases in AEO2017

Nuclear electricity generating capacity gigawatts



Year-over-year nuclear capacity changes gigawatts

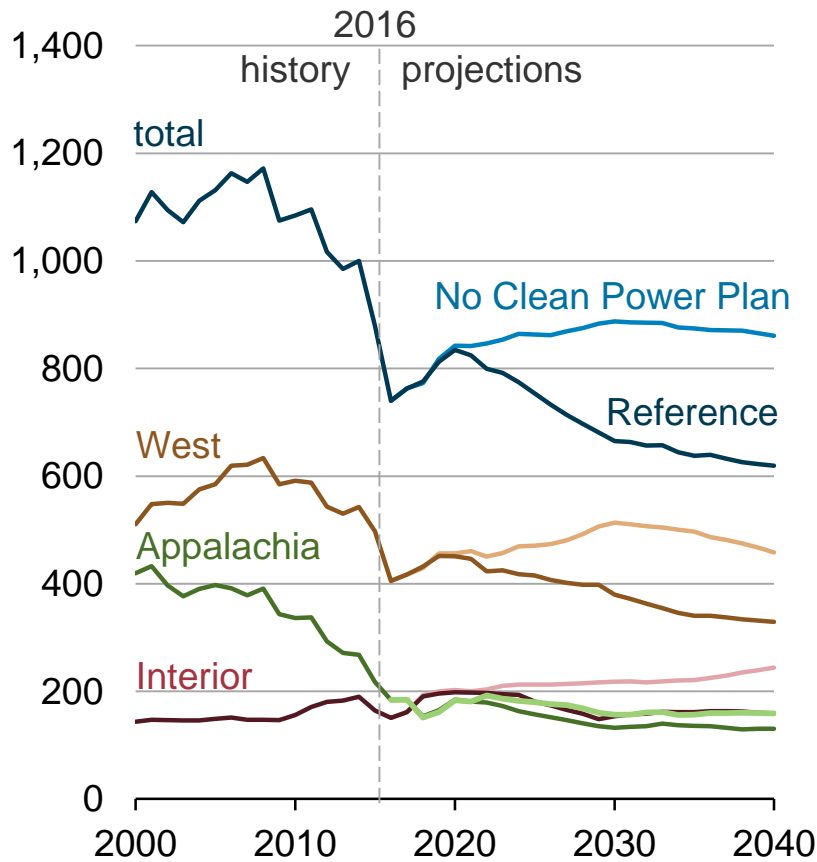


Source: EIA, Annual Energy Outlook 2017

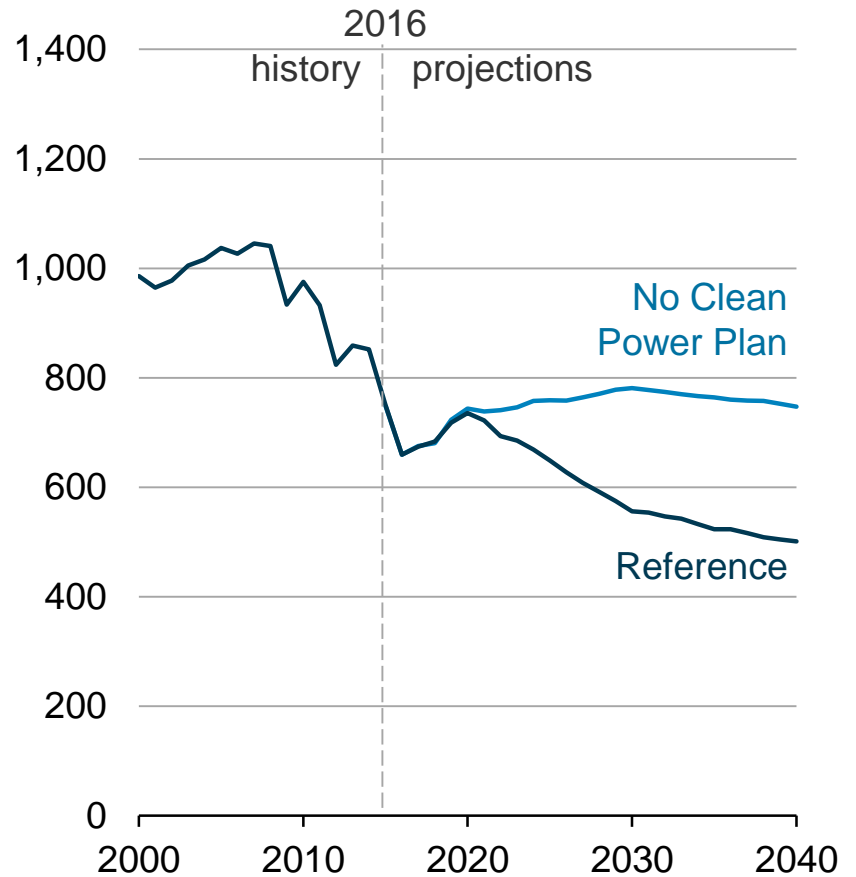


# Coal production decreases, primarily in the Western region

Coal production  
million short tons



Coal consumption in electric power sector  
million short tons



Source: EIA, Annual Energy Outlook 2017

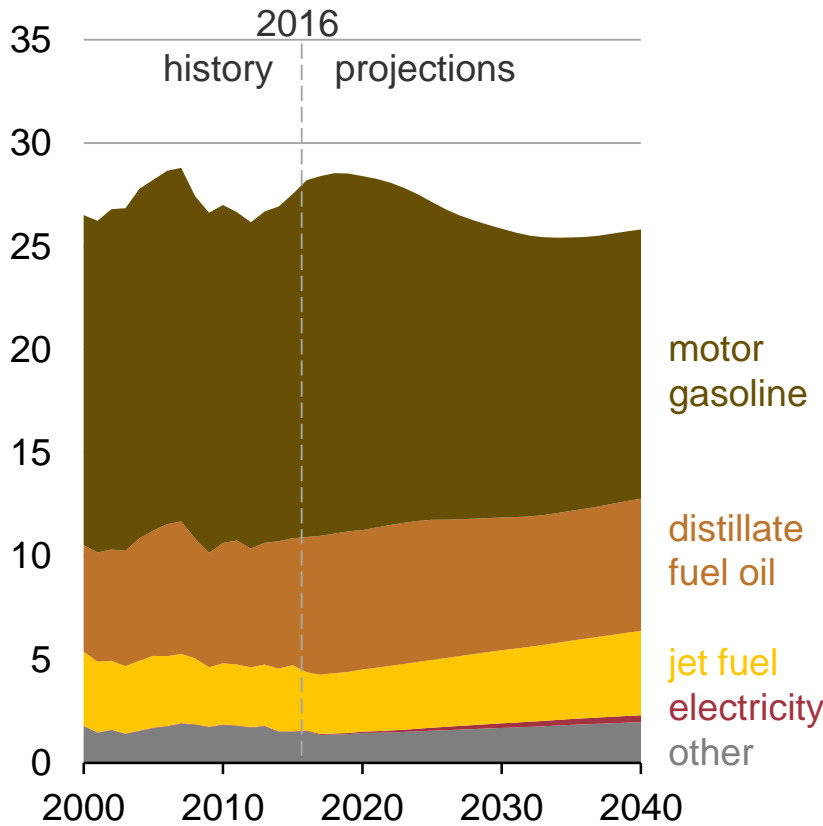
## Food for thought – electricity

- Possible effect of “deep decarbonization” strategies for buildings and transportation in increasing electricity use
- Actual retirement pattern of existing nuclear capacity
- “Going big” (larger, more interconnected grids to smooth effects of intermittent renewables) vs. “going small” (microgrids, on-site storage)
  - To what extent is experience with cellular communications technology an appropriate indicator for developments surrounding distributed renewable power?
- Relative roles of storage and load that is more responsive to variable generation in accommodating more non-dispatchible generation on the grid

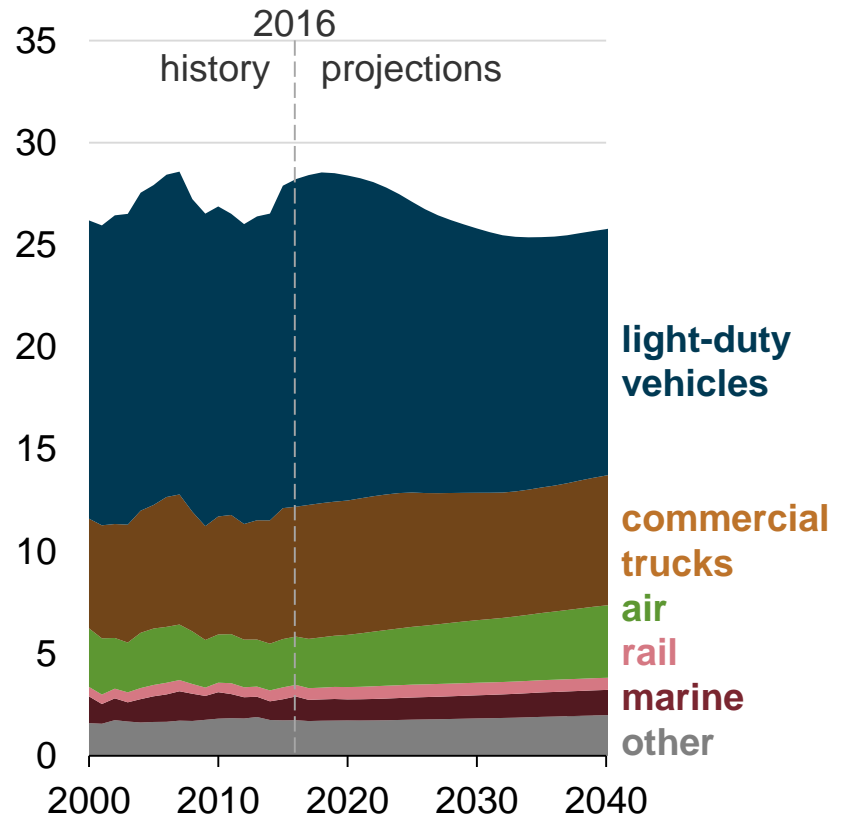
# Transportation

# Transportation energy use declines between 2018 and 2034 in the Reference case, driven by improvements in fuel economy

Transportation sector consumption  
quadrillion British thermal units



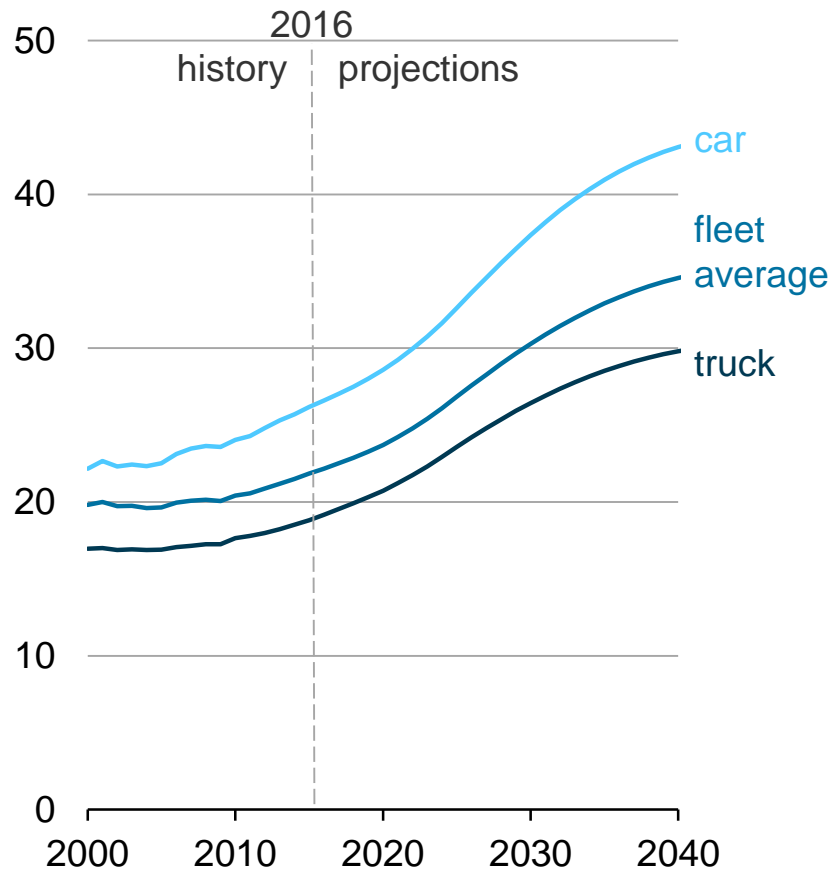
Transportation sector consumption  
quadrillion British thermal units



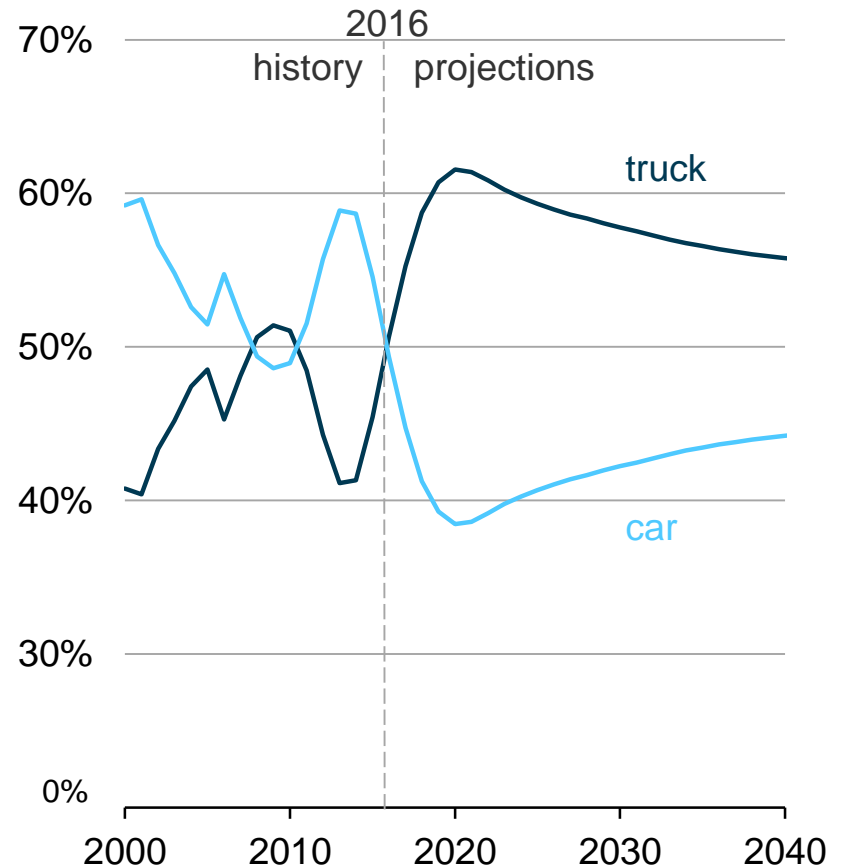
Source: EIA, Annual Energy Outlook 2017

# Average light-duty fuel economy improves in the Reference case, even as the share of light-duty trucks increases

Light-duty stock fleet fuel economy miles per gallon



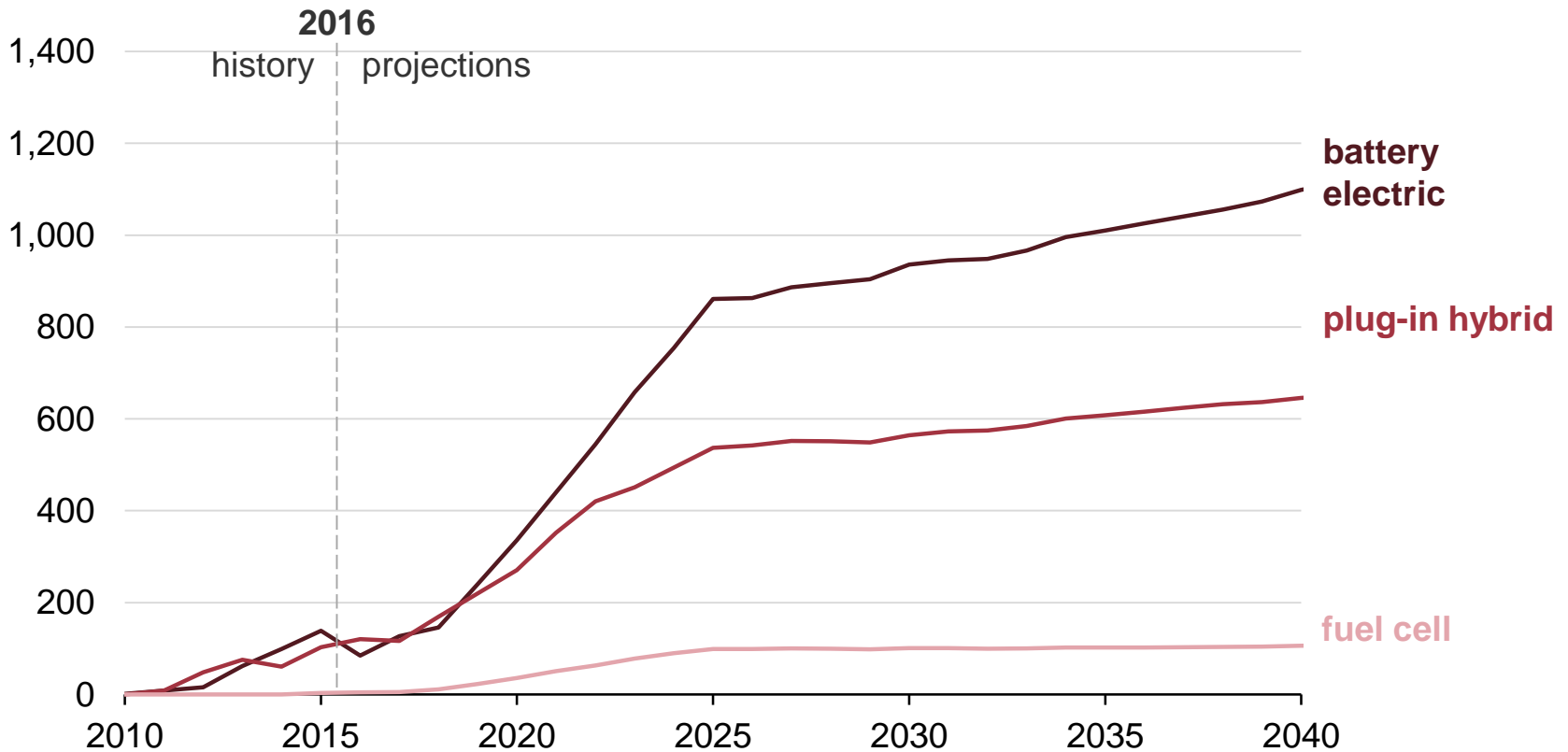
Light-duty vehicle sales shares percent



Source: EIA, Annual Energy Outlook 2017

# Sales of battery electric, plug-in electric hybrid, and fuel cell vehicles increase in the Reference case because of lower projected battery costs and existing state policies

New light-duty vehicle sales  
thousands of vehicles

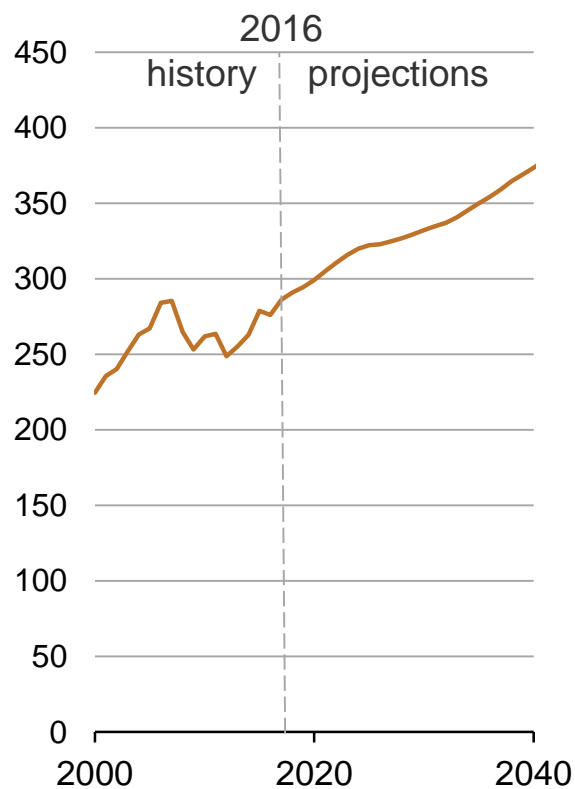


Source: EIA, Annual Energy Outlook 2017

# With the second phase of fuel efficiency regulations, medium- and heavy-duty vehicle energy consumption declines over 2027-33 despite continued growth in miles traveled

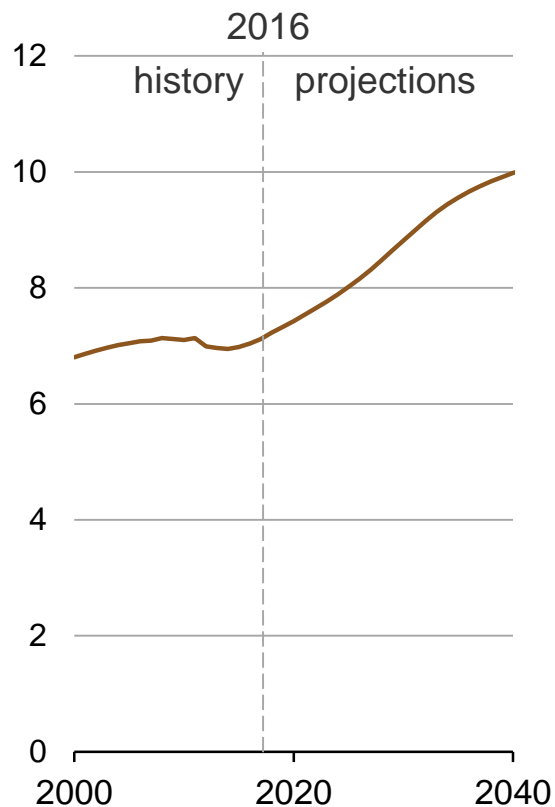
## travel indicator

billion vehicle-miles traveled



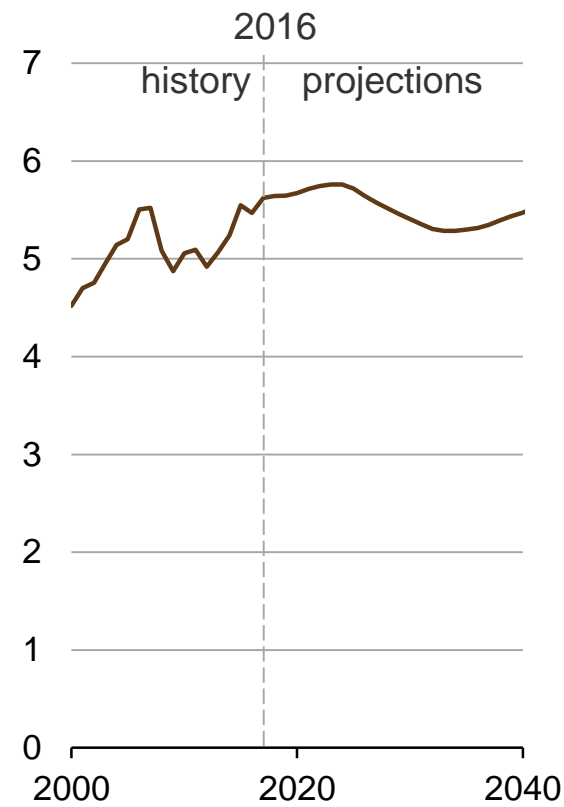
## stock fuel economy

miles per gallon



## energy consumption

quadrillion British thermal units



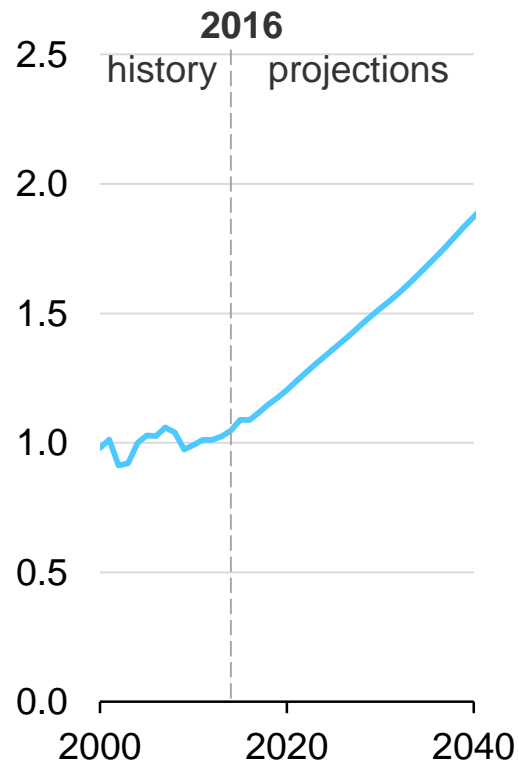
Source: EIA, Annual Energy Outlook 2017

# Even with improving commercial aircraft efficiency, jet fuel use rises in the Reference case with increased travel

## Air transportation metrics

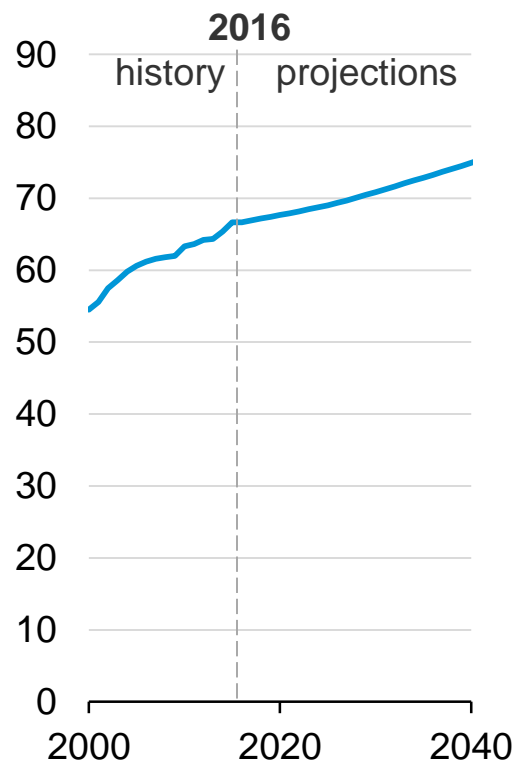
### travel indicator

trillion seat-miles available



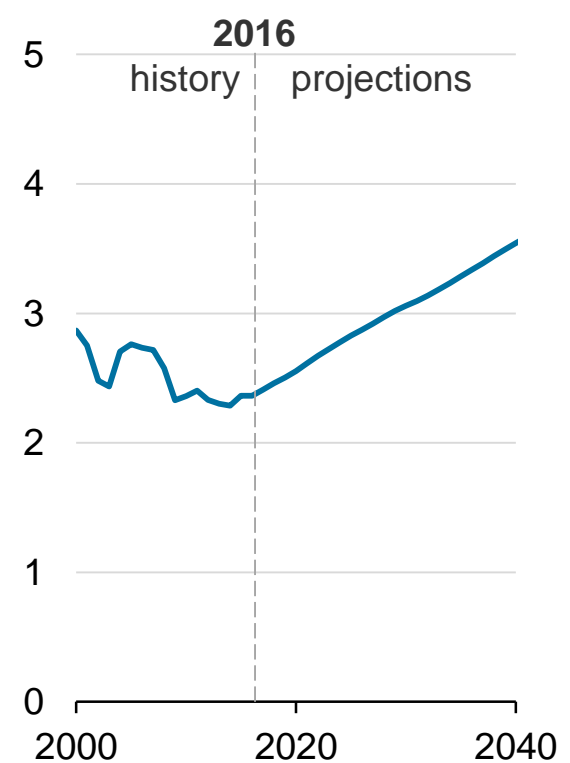
### stock fuel economy

seat-miles per gallon



### jet fuel consumption

quadrillion British thermal units



Source: EIA, Annual Energy Outlook 2017



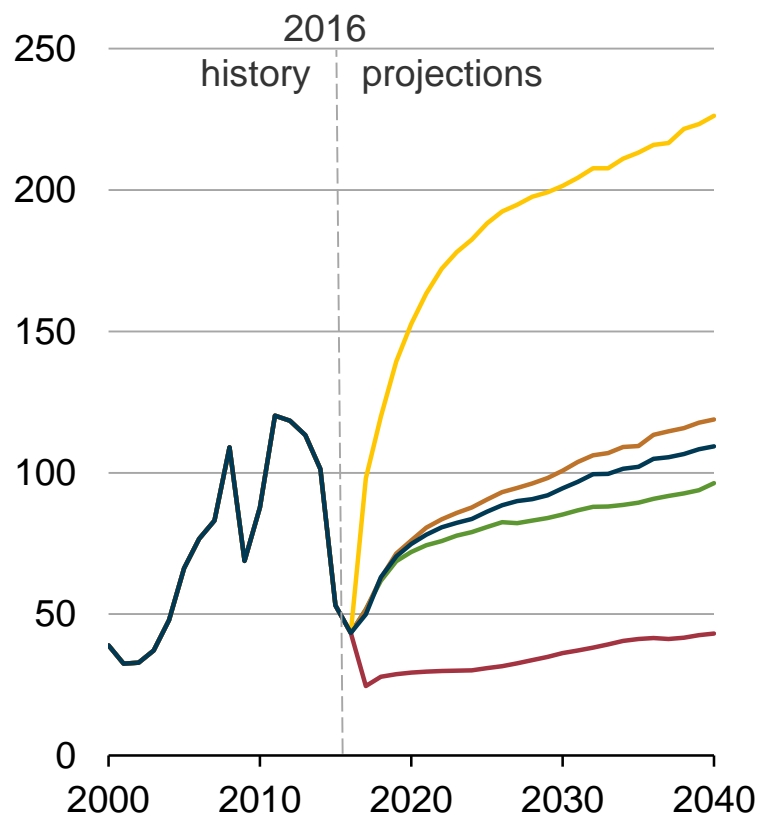
## Food for thought – transportation

- Ride sharing
- Autonomous vehicle technology in both passenger and freight applications
- Actual uptake of vehicles fueled by electricity and/or hydrogen
- Teleworking and telepresence
- Possible pursuit of deep decarbonization
- Future vehicle efficiency and taxation policies

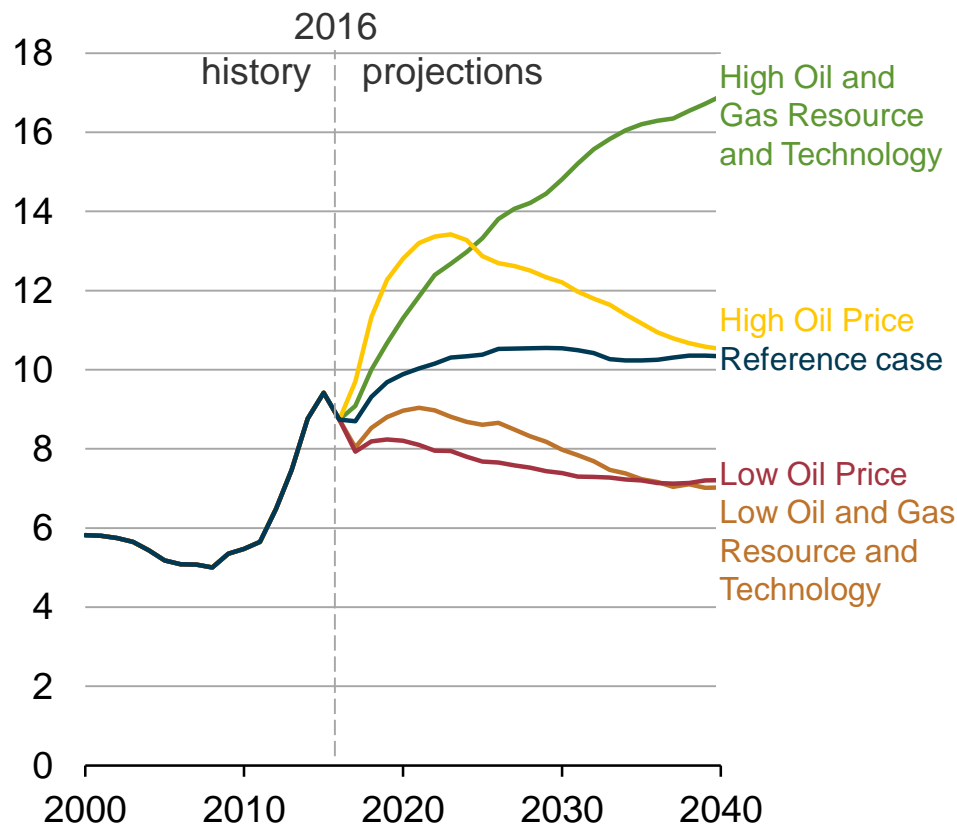
# Hydrocarbon production and trade

# Reference case oil prices and production rise from current levels, price paths and production levels in the side cases are very different from those in the Reference case

North Sea Brent oil price  
2016 dollars per barrel



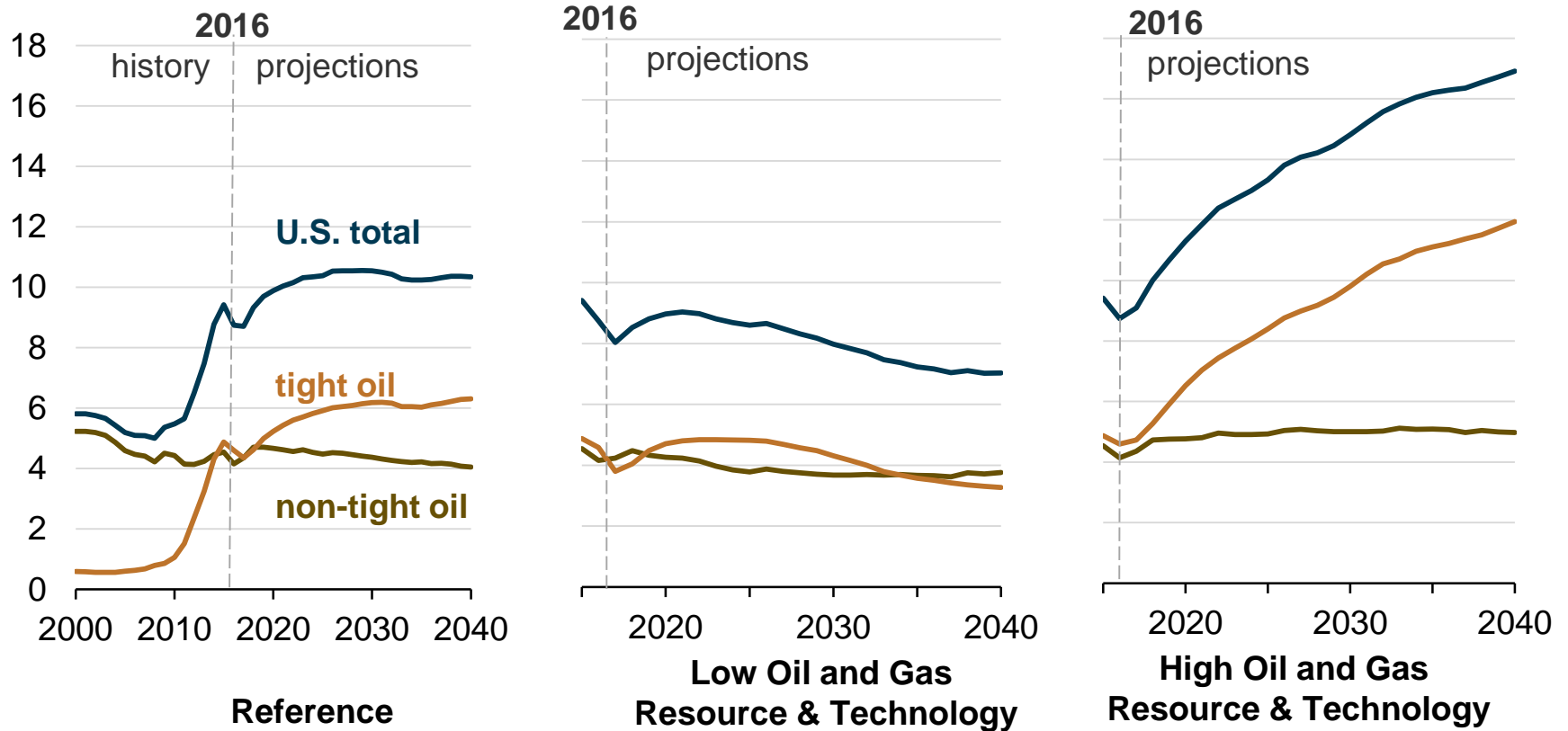
Crude oil production  
million barrels per day



Source: EIA, Annual Energy Outlook 2017

# Tight oil dominates U.S. production in the Reference case, but other types of oil production continue to yield significant volumes

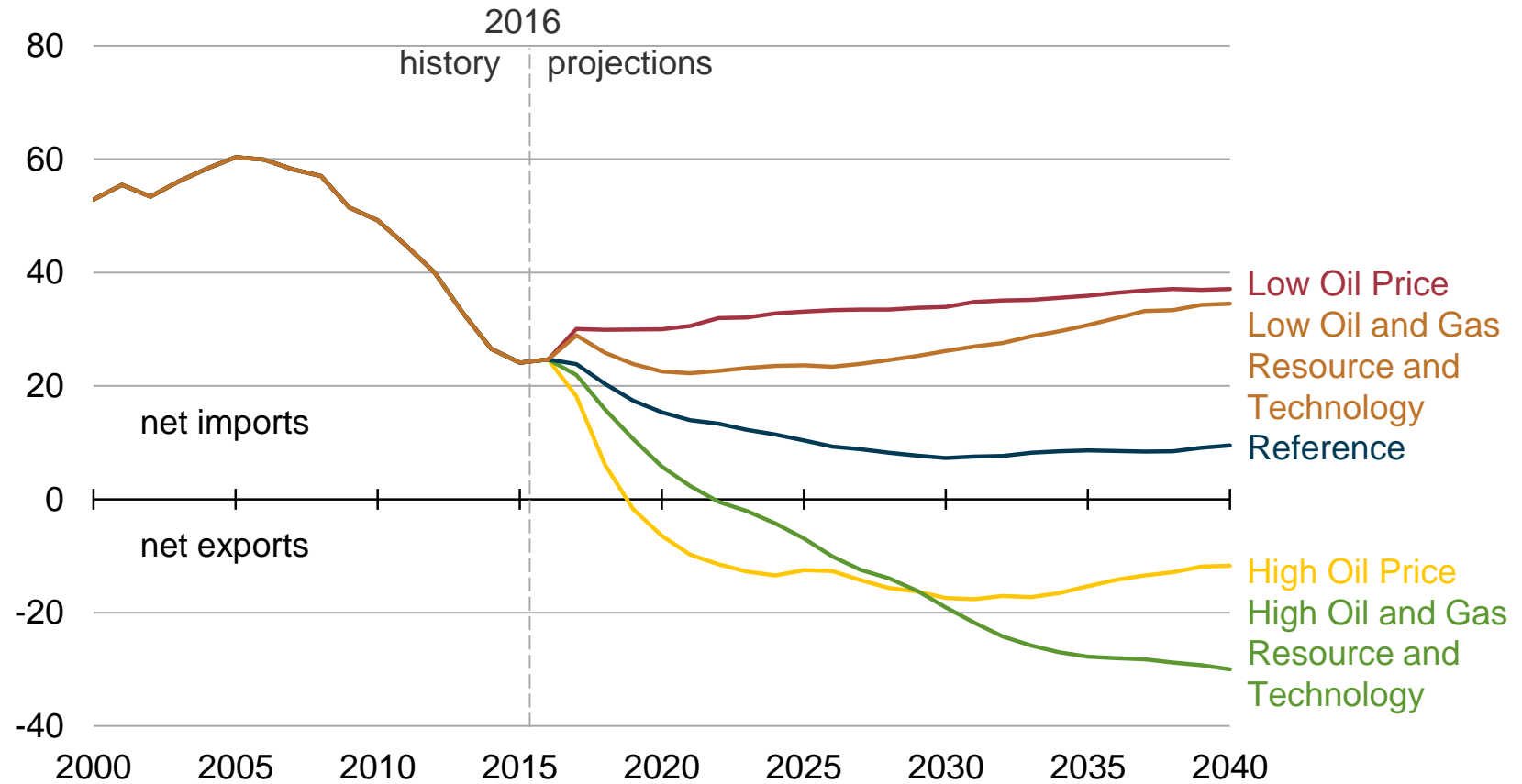
Crude oil production  
million barrels per day



Source: EIA, Annual Energy Outlook 2017

# In the High Oil Price and the High Oil and Gas Resource and Technology cases, the United States becomes a net petroleum exporter

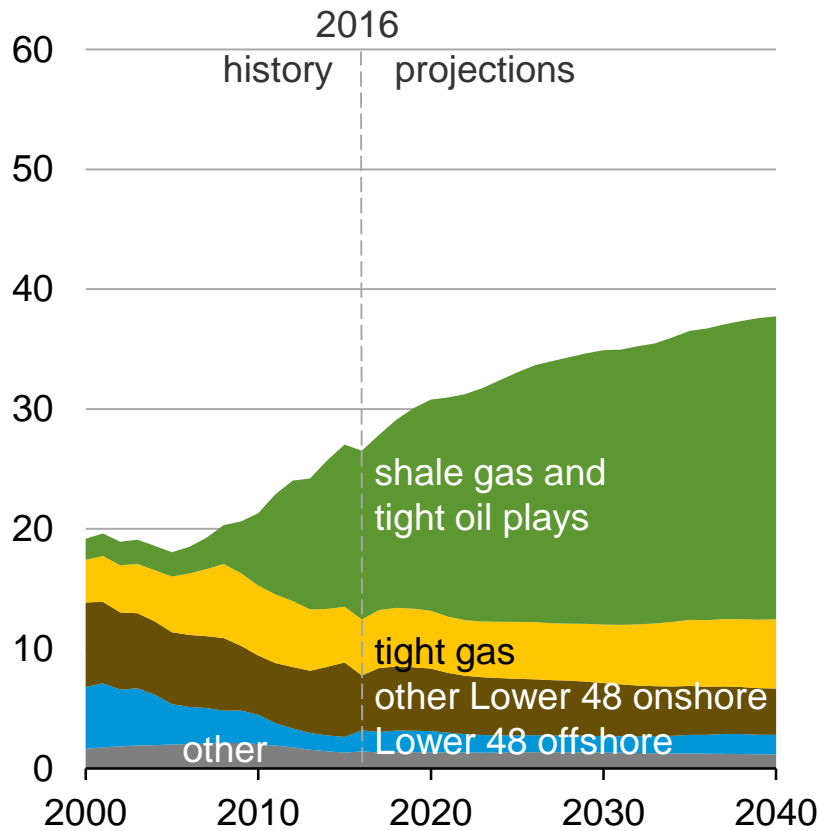
Petroleum net imports as a percentage of products supplied  
percent



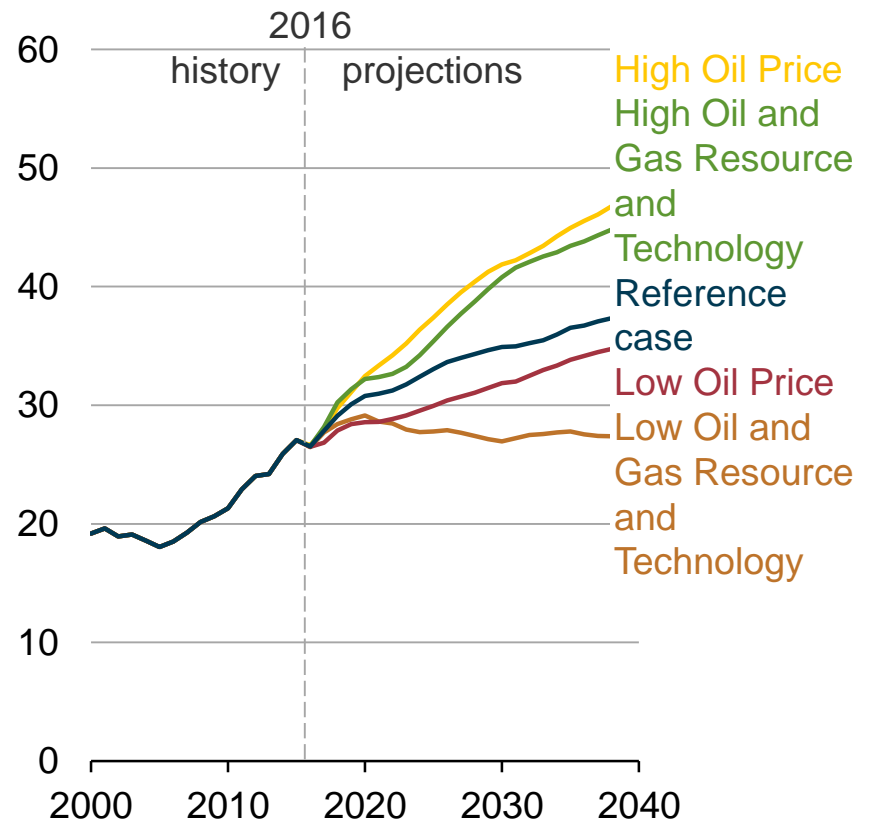
Source: EIA, Annual Energy Outlook 2017

# U.S. dry natural gas production is the result of continued development of shale gas and tight oil plays, alternative assumptions cause significant differences

U.S. natural gas production by type  
trillion cubic feet

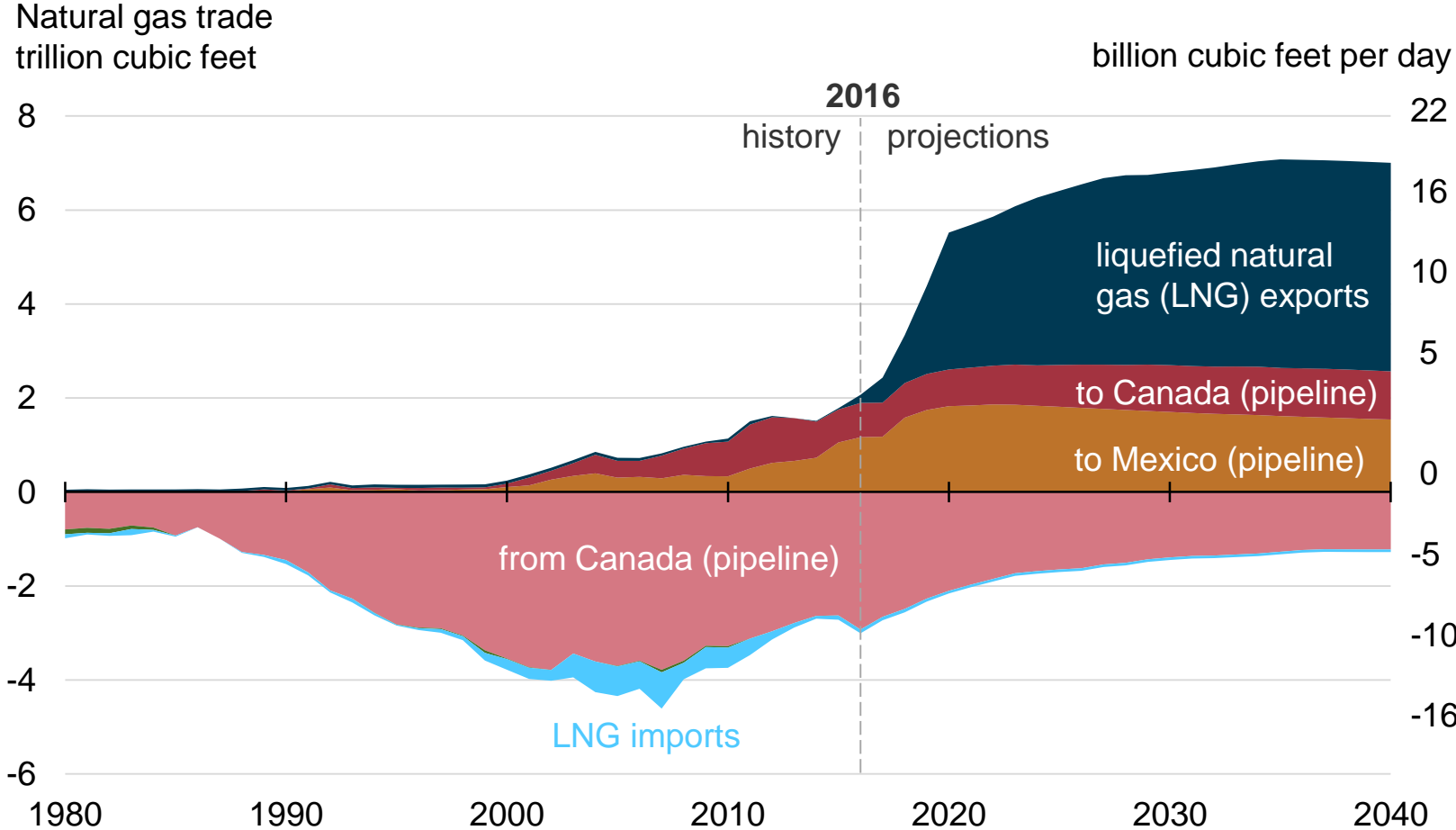


Dry natural gas production  
trillion cubic feet



Source: EIA, Annual Energy Outlook 2017

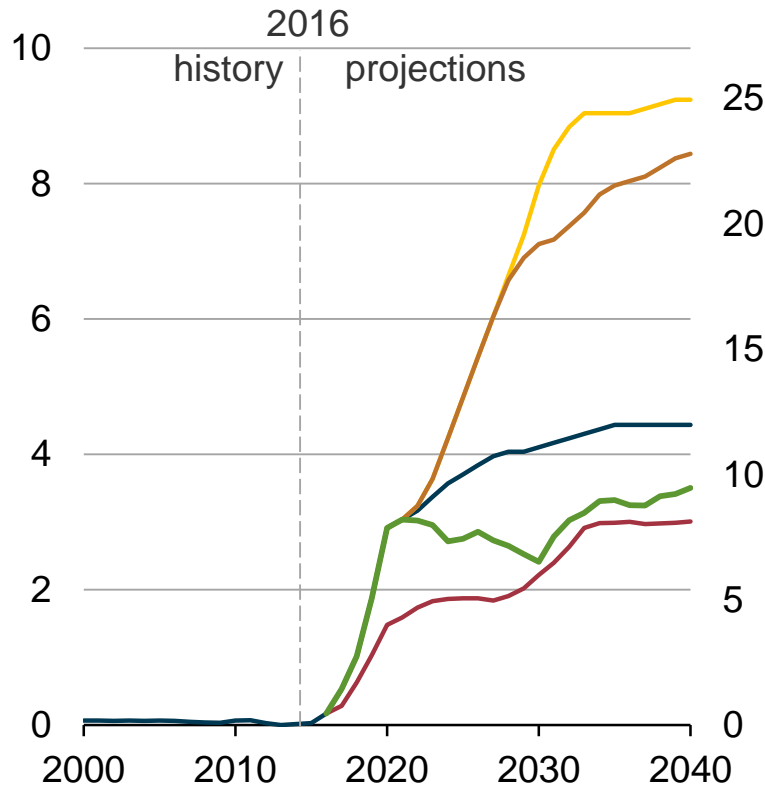
# Increased natural gas trade is dominated by liquefied natural gas exports in the Reference case



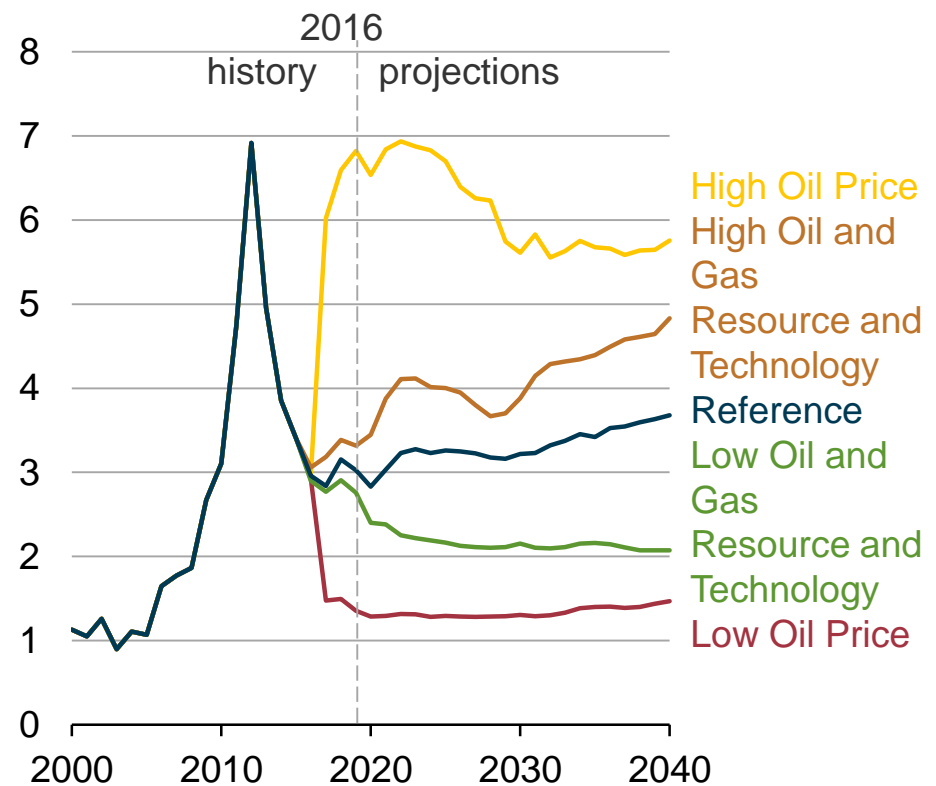
Source: EIA, Annual Energy Outlook 2017

# U.S. LNG export levels vary across cases and reflect both the level of global demand, as well as by the difference between domestic and global natural gas prices

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



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

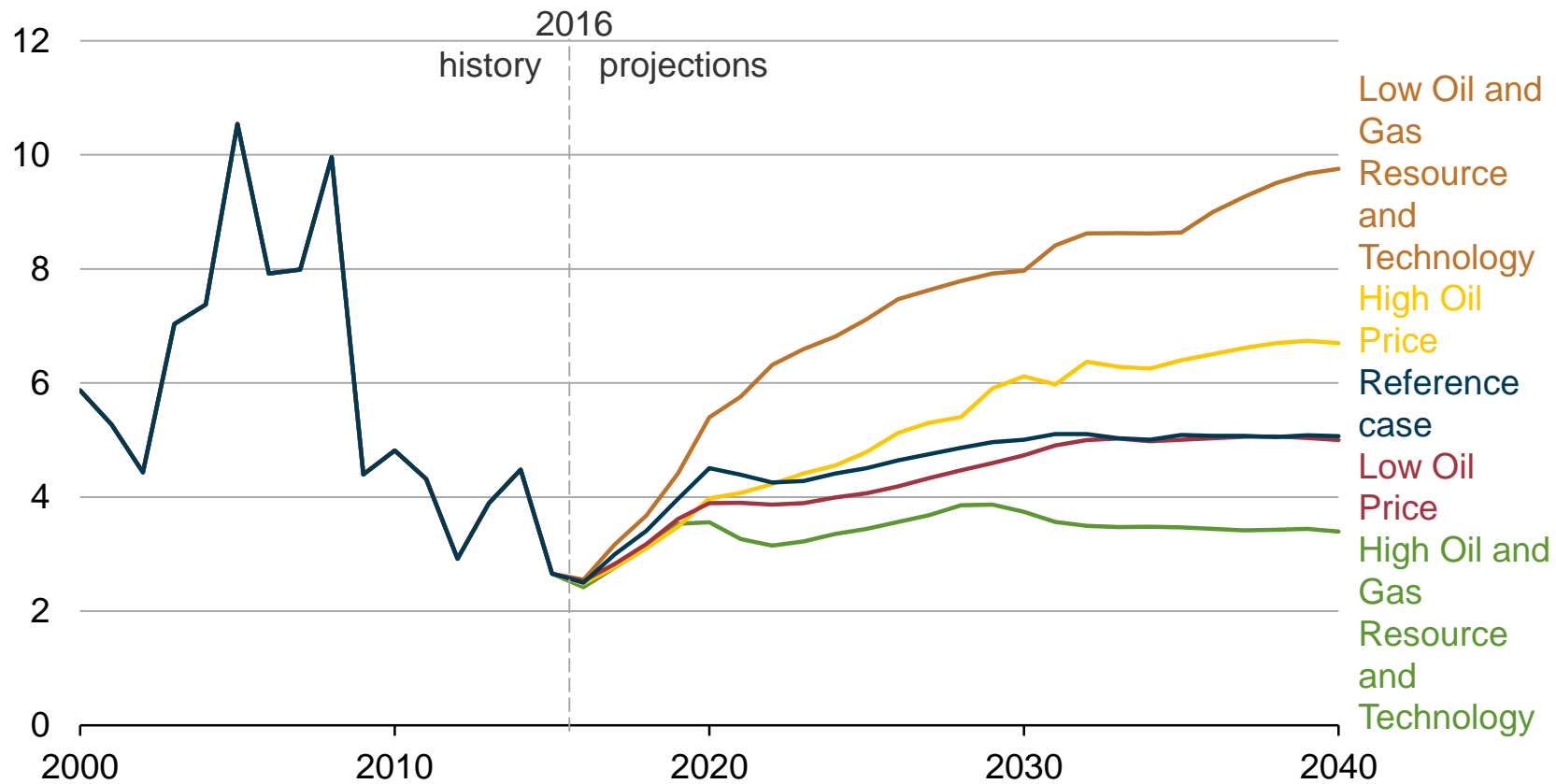


Source: EIA, Annual Energy Outlook 2017



# Future domestic natural gas prices depend on both domestic resource availability and world energy prices

Henry Hub natural gas price  
2016 dollars per million Btu



Source: EIA, Annual Energy Outlook 2017

## Food for thought – hydrocarbon production and trade

- Technology developments – to what extent will they continue to offset depletion of hydrocarbon resources
- Geopolitics in key producing regions – both internationally and within the United States
- Possible pursuit of deep decarbonization, particularly in transportation applications
- Technologies and policies affecting vehicle choice, given dominant role of transportation sector in oil demand

## For more information

U.S. Energy Information Administration home page | [www.eia.gov](http://www.eia.gov)

Annual Energy Outlook | [www.eia.gov/aeo](http://www.eia.gov/aeo)

International Energy Outlook | [www.eia.gov/ieo](http://www.eia.gov/ieo)

Short-Term Energy Outlook | [www.eia.gov/steo](http://www.eia.gov/steo)

Monthly Energy Review | [www.eia.gov/mer](http://www.eia.gov/mer)

Today in Energy | [www.eia.gov/todayinenergy](http://www.eia.gov/todayinenergy)

Drilling Productivity Report | [www.eia.gov/petroleum/drilling/](http://www.eia.gov/petroleum/drilling/)

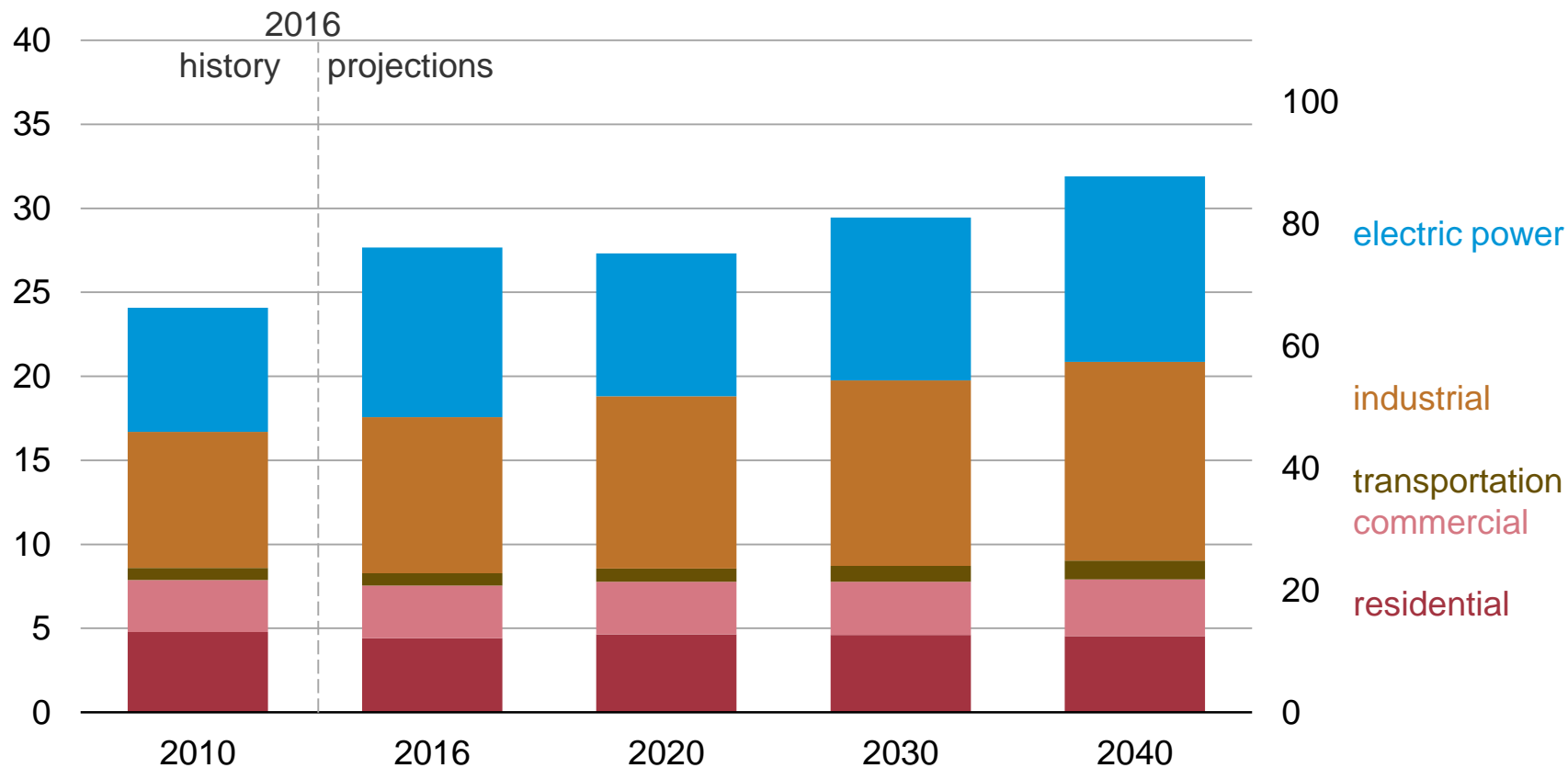
State Energy Portal | [www.eia.gov/state/](http://www.eia.gov/state/)

North American Collaboration on Energy Information | [www.nacei.org/](http://www.nacei.org/)

# Increasing demand from industrial and electric power markets drive rising domestic consumption of natural gas in the Reference case

Natural gas consumption by sector  
trillion cubic feet

billion cubic feet per day



Source: EIA, Annual Energy Outlook 2017