The Outlook for Transportation Fuel Prices and Transportation Energy Use: Insights from AEO2017



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Outline

- Short-term outlook for crude oil and petroleum products
- Overview of the Annual Energy Outlook 2017
- Fuel prices
- Transportation energy consumption
- Projecting light-duty electric vehicle sales in the National Energy Modeling System (NEMS)



The global liquid fuels market is expected to be balanced or slightly over-supplied through the end of 2018

World liquid fuels production and consumption balance million barrels per day (MMb/d)

MMb/d



Source: EIA, Short-Term Energy Outlook May 2017

As a result, commercial crude oil inventories in OECD countries are expected to remain at or above the five-year range

OECD commercial stocks of crude oil and other liquids

days of supply



North America is projected to be the largest source of liquid fuels production growth over the next two years

World crude oil and liquid fuels production growth million barrels per day



OPEC countries North America Russia and Caspian Sea Latin America North Sea Other Non-OPEC



U.S. producers will be the largest source of non-OPEC production growth in 2017 and 2018

Non-OPEC crude oil and liquid fuels production growth

million barrels per day





Growth in global consumption of liquid fuels will be led by non-OECD economies in 2017 and 2018

World liquid fuels consumption growth

million barrels per day



Source: EIA, Short-Term Energy Outlook May 2017



While U.S. consumption of liquid fuels will increase slightly in 2017 and 2018, led primarily by HGLs

U.S. liquid fuels product supplied million barrels per day (MMb/d)

annual change (MMb/d)



Source: EIA, Short-Term Energy Outlook May 2017

The price outlook for crude oil remains highly uncertain, with potential future supply and demand shocks able to significantly change prices West Texas Intermediate (WTI) crude oil price dollars per barrel



Note: Confidence interval derived from options market information for the 5 trading days ending May 4, 2017. Intervals not calculated for months with sparse trading in near-the-money options contracts.

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



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



Energy consumption varies minimally across all AEO cases, bounded by the High and Low Economic Growth cases

Total energy consumption quadrillion British thermal units



Source: EIA, Annual Energy Outlook 2017

Domestic energy consumption remains relatively flat in the Reference case, but the fuel mix changes significantly

Energy consumption (Reference case) quadrillion British thermal units



Source: EIA, Annual Energy Outlook 2017

Energy production ranges from nearly flat in the Low Oil and Gas Resource and Technology case, to continued growth in the High Resource and Technology case Total energy production quadrillion British thermal units



Source: EIA, Annual Energy Outlook 2017



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United States energy production continues to increase in the Reference case, led by growth in natural gas and renewables

Energy production (Reference case) quadrillion British thermal units



Source: EIA, Annual Energy Outlook 2017



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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



The U.S. remains a net importer of petroleum in the reference case, but could move to a net exporter if domestic production is higher Petroleum net imports as a percentage of products supplied percent



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





Prices



In the long-term, there is a wide set of potential outcomes for both crude oil prices and U.S. crude oil production

North Sea Brent oil price 2016 dollars per barrel



Crude oil production million barrels per day



Source: EIA, Annual Energy Outlook 2017



Real fuel prices in the transportation sector are lowest for natural gas, highest for electricity



Note: Motor gasoline is sales weighted-average price for all grades. Includes Federal, State, and local taxes. Source: EIA, Annual Energy Outlook 2017.



Natural gas prices also depend on developments in the oil market, with coproduction and substitution linking these markets

Henry Hub natural gas price 2016 dollars per million Btu



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



Transportation Energy Demand



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



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

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

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Light-duty vehicle sales remain primarily gasoline-only with modest increase of other vehicle fuel types

U.S. light-duty passenger car and truck sale millions

Source: EIA, Annual Energy Outlook 2017 Reference case

Share of vehicles with micro hybrid subsystem increase across the projection

Gasoline micro hybrid share of new gasoline vehicle

sales

Source: EIA, Annual Energy Outlook 2017 Reference case

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

energy consumption

quadrillion British thermal units

Medium- and heavy-duty vehicle metrics

travel indicator

billion vehicle-miles traveled

stock fuel economy miles per gallon

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

Projecting Light-Duty Electric Vehicle Sales in the National Energy Modeling System (NEMS)

Modeling vehicle choice in the NEMS transportation module involves both manufacturers (building) and consumers (buying)

- Manufacturers Technology Choice Component (MTCC)
 - adopt vehicle subsystem technologies (86) for different vehicle fuel types (conventional gasoline, hybrid, diesel, etc.) based on value of fuel economy and/or performance improvement
 - alternative fuel vehicles (15)
- Consumer Vehicle Choice Component (CVCC)
 - determines consumer acceptance (market share) by vehicle fuel type (conventional gasoline, hybrid, diesel, etc.)
 - nested multinomial logit model, coefficients vary by size class, for 9 attributes
- Meeting CAFE through the MTCC and CVCC
 - Application of alternative fuel vehicle credits
 - CAFE credits and banking
 - FFV credit limits

Manufacturer Technology Choice Component (MTCC) vehicle attributes and size classes

 Historic and Projected vehicle attributes (fuel economy, horsepower, weight, tank size, interior volume, price, footprint) by size class (6), manufacturer (9), and vehicle fuel type (16)

Passenger Car Size Class (interior volume—cubic feet)	Light-Duty Truck Size Class (test weight—Ibs)
Mini (<85)	Small Pickup (<4500)
Subcompact (85-99)	Standard Pickup (>4500)
Compact (99-109)	Small SUV
Midsize (110-120)	Standard SUV
Large (>120)	Small Van
2 seater	Standard Van

Manufacturer Technology Choice Component (MTCC) manufacturer groups

Passenger Car Manufacturer	Light-Duty Truck Manufacturer
Domestic	Domestic 1
Asian	Domestic 2
European	Domestic 3
Sports/Luxury	Import 1
	Import 2

Manufacturer Technology Choice Component (MTCC) vehicle fuel types

Vehicle fuel type	
Gasoline	Gasoline Hybrid
Diesel	Dedicated CNG
Flex Fuel (ethanol)	Dedicated LPG
Electric—100 mile range	Bi-fuel CNG
Electric—200 mile range	Bi-fuel LPG
Plug-in Hybrid Electric—10 mile	Methanol Fuel Cell
Plug-in Hybrid Electric—40 mile range	Gasoline Fuel Cell
Diesel Hybrid	Hydrogen Fuel Cell

• Micro and mild hybridization are considered vehicle subsystems

Manufacturer Technology Choice Component (MTCC)—adopting vehicle subsystem technology

- 86 subsystem technologies available
 - <u>Vehicle:</u> Mass Reduction I to V; Aerodynamics I and II; Tires I and II; Low Drag Brakes; Secondary Axle Disconnect
 - <u>Transmission</u>: 6 speed Manual; 6, 7, and 8 speed Automatic; Dual Clutch Automated Manual; High Efficiency Gearbox; Aggressive Shift Logic I and II; Early Torque Converter Lockup; Continuously Variable Transmission
 - <u>Accessories/Electrification</u>: Electric Power Steering; Improved Accessories I and II; 12V Micro Hybrid; Integrated Starter Generator Mild Hybrid
 - Engine (most by cylinder and cam profile): Low Friction Lubricants; Engine Friction Reduction I and II; Cylinder Deactivation; Variable Valve Timing (ICP, CCP, DCP); Variable Valve Lift (DVVL, CVVL); Stoichiometric Gasoline Direct Injection; Turbocharging and Downsizing I, II, and III with cooled EGR
- Technology attributes include fuel economy, cost, horsepower and weight adjustment, and base year (2015) penetration (by manufacturer, by size class)
- Technology synergies, supersede notes, and learning rates

Consumer Vehicle Choice Component (CVCC)

- Market penetration by vehicle type determined using a nested multinomial logit model
- Coefficients vary by vehicle size class
- Vehicle attributes
 - vehicle price, fuel price, fuel economy, acceleration, range, luggage space, maintenance cost, fuel availability, model availability, and home refueling
- Mandated vehicle sales requirements
 - Low Emission Vehicle Program (LEVP) and EPAct Fleet
- CAFE optimization (Hybrid, Diesel, PHEV, and EV penetration)

CVCC nesting technology sets

- Conventional ICE fuel capable
 - Gasoline, diesel, compressed natural gas (CNG) and liquefied natural gas (LNG), liquefied petroleum gas (LPG), flex-fuel
- Dedicated alternative fuels
 - CNG, LNG, LPG
- Hybrid and plug-in hybrid
 - Gasoline hybrid, diesel hybrid, 10 mile all-electric range (PHEV10), 40 mile all-electric range (PHEV40)
- Electric battery powered
 - 100 mile all-electric range (EV100), 200 mile all-electric range (EV200)
- Fuel cell
 - Gasoline, methanol, hydrogen

Nesting structure

CAFE test looping process

- Three passes through the MTCC and CVCC
- Each pass determines CAFE compliance
 - Pass 1: Add technologies economically
 - Pass 2: Implement fine for CAFE non-compliance
 - Pass 3: Reduce horsepower to comply with CAFE
- If not in compliance after third pass, force alternative vehicles for CAFE compliance

Battery Electric Vehicle Assumptions

Battery Electric Vehicles in NEMS

- Generalized electric-range groups
 - EV100 (90 actual miles)
 - EV200 (200 actual miles)
 - PHEV10 (10 all-electric miles)
 - PHEV40 (40 all-electric miles)
- Lithium-ion battery costs are modeled for each vehicle type
 - Base year costs based on literature review
 - Cost difference between vehicle types comes from ANL BatPac model
 - Projected costs reduce over time as a function of production and a learning curve to generally match projected costs from literature review

Battery Electric Vehicles in NEMS

- Vehicle miles travelled assumed same for all powertrains
 - VMT per vehicle input by vintage for passenger cars and light trucks
 - Total VMT calculated from vehicle stock projections
- PHEV all-electric vs. conventional usage
 - PHEV10-21% of VMT all-electric
 - PHEV40 58% of VMT all-electric

Battery Costs Projected from 2015

Lithium-ion retail battery costs 2015\$/kW-hr

Battery Electric Vehicle Sales Drivers

- California Zero-Emission Vehicle Mandate
 - Adopted by nine other states
- California AB-32 for GHG Reduction
 - Further increases electric vehicle share
 - Decreases VMT

AEO transportation scenarios

- High technology
 - 10 percent increase in technology fuel economy, 10 percent reduction in technology price
- Low technology
 - 10 percent decrease in technology fuel economy, 10 percent increase in technology price
- High tech battery case (AEO2012)
- Extended policies case
- Import dependency cases (AEO2013)

Potential updates to AEO2018

- Updates to battery electric vehicle models
 - Non-battery systems costs
 - Increase electric-ranges to better represent changing market

For more information

U.S. Energy Information Administration home page | <u>www.eia.gov</u>

Short-Term Energy Outlook / <u>www.eia.gov/steo</u>

Annual Energy Outlook | <u>www.eia.gov/aeo</u>

International Energy Outlook | <u>www.eia.gov/ieo</u>

Monthly Energy Review | <u>www.eia.gov/mer</u>

Today in Energy | <u>www.eia.gov/todayinenergy</u>

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

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

Natural gas

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After dropping in 2016, U.S. natural gas production will increase in 2017 and 2018

--- Marketed production forecast (left axis)

Source: EIA, Short-Term Energy Outlook May 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

Higher natural gas prices in 2017 will reduce its use for electricity generation compared to 2016

Source: EIA, Short-Term Energy Outlook May 2017

But in the long-term, increasing demand from industrial and electric power markets drive rising domestic consumption of natural gas Natural gas consumption by sector

trillion cubic feet

billion cubic feet per day

Source: EIA, Annual Energy Outlook 2017

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

Natural gas inventories are expected to return to average levels in first quarter 2018

U.S. working natural gas in storage billion cubic feet

deviation from average

Future natural gas prices are inherently uncertain, with market participants indicating a range of about \$2 to \$7 per MMBtu Henry Hub natural gas price dollars per million Btu

2017. Intervals not calculated for months with sparse trading in near-the-money options contracts.

Food for thought – natural gas production and trade

- Technology developments to what extent will they continue to offset depletion of hydrocarbon resources
- Possible pursuit of deep decarbonization, particularly in the electricity generation and buildings sectors
- Geopolitics in key oil and natural gas producing regions both internationally and within the United States
- Competitiveness of gas-fired generation with other technologies in developing countries where projected electricity demand growth is concentrated
- Technologies and policies affecting vehicle choice, which given dominant role of transportation sector in oil demand can significantly affect markets for oil and natural gas

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

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