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

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By
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Office for Petroleum, Natural Gas, and Biofuels Analysis
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.
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

Note: Colored band around days of supply of crude oil and other liquids stocks represents the range between the minimum and maximum from Jan. 2012 - Dec. 2016.

Source: EIA, Short-Term Energy Outlook May 2017
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)

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

Source: EIA, Short-Term Energy Outlook May 2017
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

Source: EIA, Short-Term Energy Outlook May 2017
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)

Source: EIA, Short-Term Energy Outlook May 2017

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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.

Source: EIA, Short-Term Energy Outlook May 2017
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.

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
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
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

Reference

2000 2010 2020 2030 2040

2016

history projections

U.S. total

2016

projections

tight oil

2020 2030 2040

2016

projections

non-tight oil

Source: EIA, Annual Energy Outlook 2017

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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 in percent.

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)

Source: EIA, Annual Energy Outlook 2017
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

2016
history projections

2016
history projections

Source: EIA, Annual Energy Outlook 2017
Real fuel prices in the transportation sector are lowest for natural gas, highest for electricity.

Real petroleum prices
2016 dollars per barrel

North Sea Brent oil price (left)

Diesel fuel (right)

Motor gasoline (right)

2015 2020 2025 2030 2035 2040

2016 $/gallon

Real fuel prices in the transportation sector
2016 $/MMBtu

Electricity

Diesel fuel

Motor gasoline

Natural gas

2015 2020 2025 2030 2035 2040

Note: Motor gasoline is sales weighted-average price for all grades. Includes Federal, State, and local taxes.

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.

Source: EIA, Annual Energy Outlook 2017
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

Source: EIA, Annual Energy Outlook 2017
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

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.

Medium- and heavy-duty vehicle metrics

<table>
<thead>
<tr>
<th>Travel Indicator</th>
<th>Stock Fuel Economy</th>
<th>Energy Consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Billion vehicle-miles traveled</td>
<td>Miles per gallon</td>
<td>Quadrillion British thermal units</td>
</tr>
</tbody>
</table>

*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)

<table>
<thead>
<tr>
<th>Passenger Car Size Class (interior volume—cubic feet)</th>
<th>Light-Duty Truck Size Class (test weight—lbs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mini (&lt;85)</td>
<td>Small Pickup (&lt;4500)</td>
</tr>
<tr>
<td>Subcompact (85-99)</td>
<td>Standard Pickup (&gt;4500)</td>
</tr>
<tr>
<td>Compact (99-109)</td>
<td>Small SUV</td>
</tr>
<tr>
<td>Midsize (110-120)</td>
<td>Standard SUV</td>
</tr>
<tr>
<td>Large (&gt;120)</td>
<td>Small Van</td>
</tr>
<tr>
<td>2 seater</td>
<td>Standard Van</td>
</tr>
</tbody>
</table>
Manufacturer Technology Choice Component (MTCC)—manufacturer groups

<table>
<thead>
<tr>
<th>Passenger Car Manufacturer</th>
<th>Light-Duty Truck Manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic</td>
<td>Domestic 1</td>
</tr>
<tr>
<td>Asian</td>
<td>Domestic 2</td>
</tr>
<tr>
<td>European</td>
<td>Domestic 3</td>
</tr>
<tr>
<td>Sports/Luxury</td>
<td>Import 1</td>
</tr>
<tr>
<td></td>
<td>Import 2</td>
</tr>
</tbody>
</table>
## Manufacturer Technology Choice Component (MTCC)—vehicle fuel types

<table>
<thead>
<tr>
<th>Vehicle fuel type</th>
<th>Manufacturer Technology Choice Component (MTCC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gasoline</td>
<td>Gasoline Hybrid</td>
</tr>
<tr>
<td>Diesel</td>
<td>Dedicated CNG</td>
</tr>
<tr>
<td>Flex Fuel (ethanol)</td>
<td>Dedicated LPG</td>
</tr>
<tr>
<td>Electric—100 mile range</td>
<td>Bi-fuel CNG</td>
</tr>
<tr>
<td>Electric—200 mile range</td>
<td>Bi-fuel LPG</td>
</tr>
<tr>
<td>Plug-in Hybrid Electric—10 mile</td>
<td>Methanol Fuel Cell</td>
</tr>
<tr>
<td>Plug-in Hybrid Electric—40 mile range</td>
<td>Gasoline Fuel Cell</td>
</tr>
<tr>
<td>Diesel Hybrid</td>
<td>Hydrogen Fuel Cell</td>
</tr>
</tbody>
</table>

- Micro and mild hybridization are considered vehicle subsystems
Manufacturer Technology Choice Component (MTCC)—adopting vehicle subsystem technology

- 86 subsystem technologies available
  - **Vehicle**: Mass Reduction I to V; Aerodynamics I and II; Tires I and II; Low Drag Brakes; Secondary Axle Disconnect
  - **Transmission**: 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
  - **Accessories/Electrification**: 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

Vehicle Class
- Conventional Fuel ICE
  - Gasoline, Diesel, FFV, Bi-Fuel
    - FFV
  - Alternative Fuel ICE
    - CNG, LPG
    - Bi-Fuel CNG, LPG
- Hybrid
  - HEV (gasoline), HEV (diesel), PHEV10 (gasoline), PHEV40 (gasoline)
- Electric
  - EV100, EV200
- Fuel Cell
  - Hydrogen, Methanol, Gasoline
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

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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


Short-Term Energy Outlook | www.eia.gov/steo

Annual Energy Outlook | www.eia.gov/aeo

International Energy Outlook | www.eia.gov/ieo

Monthly Energy Review | www.eia.gov/mer

Today in Energy | www.eia.gov/todayinenergy
Backup
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/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*
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)

Reference

Low Oil and Gas Resource and Technology

High Oil and Gas Resource and Technology

Source: EIA, Annual Energy Outlook 2017
Natural gas

U.S. natural gas production and imports
billion cubic feet per day (Bcf/d)

Federal Gulf of Mexico production (right axis)
U.S. net imports (right axis)
Marketed production forecast (left axis)
Total marketed production (left axis)

2015 2016 2017 2018

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.

Source: EIA, Annual Energy Outlook 2017
Higher natural gas prices in 2017 will reduce its use for electricity generation compared to 2016

U.S. natural gas consumption
billion cubic feet per day (Bcf/d)

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

<table>
<thead>
<tr>
<th>Year</th>
<th>2010</th>
<th>2016</th>
<th>2020</th>
<th>2030</th>
<th>2040</th>
</tr>
</thead>
<tbody>
<tr>
<td>trillion cubic feet</td>
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</table>

- **2016:**
  - Electric power
  - Industrial
  - Transportation
  - Commercial
  - Residential

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<tr>
<td>billion cubic feet per day</td>
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</table>

Source: EIA, Annual Energy Outlook 2017
Increased natural gas trade is dominated by liquefied natural gas exports in the Reference case.

- liquefied natural gas (LNG) exports
- pipeline exports to Canada and Mexico
- pipeline imports from Canada and LNG imports

Natural gas trade history and projections from 1980 to 2040.
Natural gas inventories are expected to return to average levels in first quarter 2018

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

Forecast

deviation from average

Note: Colored band around storage levels represents the range between the minimum and maximum from Jan. 2012 - Dec. 2016.

Source: EIA, Short-Term Energy Outlook May 2017

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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

- Historical spot price
- STEO forecast price
- NYMEX futures price
- 95% NYMEX futures upper confidence interval
- 95% NYMEX futures lower confidence interval

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.

Source: EIA, Short-Term Energy Outlook May 2017
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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