Annual Energy Outlook 2014: transportation modeling updates and preliminary results

For
Working Group 2
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By
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Office of Transportation Energy Consumption and Efficiency Analysis
Overview

• Macroeconomic drivers
  – GDP, population, world oil price

• Light-duty vehicle
  – New travel demand module including population demographics
  – New region specific consumer behavior and E85 demand
  – Updated battery electric vehicle cost, efficiency, and availability

• Heavy-duty vehicle, freight rail, and domestic marine
  – New region, mode, and commodity specific freight travel demand
  – Updated freight rail and domestic marine efficiency
  – Added LNG as a fuel choice for freight locomotives
Real GDP is lower in the AEO2014

Source: AEO2014 preliminary
Population 16+ is lower in the AEO2014

Source: AEO2014 preliminary
World oil price is lower in the AEO2014

Source: AEO2014 preliminary
Light-duty vehicle
Light-duty vehicle travel

• Recent studies indicate possible structural shift in travel behavior
  – Decoupled link between travel behavior and economic growth
  – Population shifts to urban areas
  – Telecommuting, e-commerce, etc.
  – Travel by age cohort and the aging population

• New regional travel model
  – VMT estimated by Census Division and aggregated to national level
  – Based on travel behavior and regional licensing rates for males/females
  – 13 licensing rate age groups and 5 VMT age groups
Growth in driver licensing by age cohort

Source: AEO2014 preliminary
Driving population distribution by age group

Source: AEO2014 preliminary
Change in travel—16-19 year old age cohort

VMT per licensed driver (thousands/year)

Source: AEO2014 preliminary
Change in travel—20-34 year old age cohort

VMT per licensed driver (thousands/year)

Source: AEO2014 preliminary
Change in travel—35-54 year old age cohort

VMT per licensed driver (thousands/year)

Source: AEO2014 preliminary
Change in travel—55-64 year old age cohort

VMT per licensed driver (thousands/year)

Source: AEO2014 preliminary
Change in travel—65+ year old age cohort

VMT per licensed driver (thousands/year)

Source: AEO2014 preliminary
Licensed drivers increase over the projection period

licensed drivers (millions)

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<td>2025</td>
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Source: AEO2014 preliminary
VMT per licensed driver decreases until 2024

Source: AEO2014 preliminary
LDV travel lower in AEO2014

Source: AEO2014 preliminary
Total LDV energy use is lower in AEO2014 due to less travel demand.

Source: AEO2014 preliminary
Consumer preference for E85

• E85 demand determined using a probability model developed by Greene at ORNL
  – Market share determined by fuel prices and E85 availability

• AEO2013 model assumed single consumer behavior across census divisions with differences in fuel availability and fuel prices determining demand

• New model will reflect differences in consumer behavior across census divisions
  – Model developed by Greene at ORNL
  – Market share determined by fuel prices and E85 availability
  – Potential issues related to inherent preference and habit formation
Consumer choice for E85

E85 market share

Assumes E85 is $0.10 cheaper per gallon of gasoline equivalent

E85 fuel availability

AEO2013

AEO2014
E85 consumption greater in AEO2014

billion gallons

Source: AEO2014 preliminary
Battery electric vehicle modeling updates

• Battery size (kWh)
  – Updated using OEM manufacturer websites for model year 2012 and 2013
  – Modified depth-of-discharge improvement

• Non-battery systems cost
  – EPA OMEGA model provides total cost for 2012 through 2025 (by vehicle type and by size class)
  – EPA/NHTSA 2017-2025 Final Rule JTSD provide near and long-term learning rates
  – These data used to develop non-battery systems cost by vehicle type and size class
Battery cost ($/kWh)
  - Battery costs vary by vehicle type (HEV, PHEV10, PHEV40, EV100, EV200)
  - Cost developed using current OEM price data, Argonne’s BatPaC model, and EPA/NHTSA’s 2017-2025 Final Rule JTSD

Battery vehicle model year availability
  - Availability by size class reflect recent manufacturer offerings and product announcements

Fuel economy equivalent
  - All-electric fuel efficiency calculated using battery size and vehicle all-electric range
Price of midsize plug-in hybrid electric vehicle with 40 mile range higher in AEO2014

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<th>Time Period</th>
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<th>AEO2013</th>
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<td>Medium-term (2025)</td>
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<tr>
<td>Long-term (2040)</td>
<td>30</td>
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thousand 2012$
Gasoline LDVs (including with micro hybridization) account for 82% of sales in 2040

U.S. light car and truck new sales millions

Projections

- Gasoline without hybridization
- Gasoline with micro hybridization
- E85 flex fuel
- Diesel
- Hybrid electric
- Plug-in hybrid electric
- Electric
- Gaseous and fuel cell

Source: AEO2014 preliminary
LDV energy consumption by fuel remains predominantly motor gasoline with only small shares of other fuels, mostly diesel.
Heavy-duty vehicle, freight rail, and domestic marine
Regionalize freight movement by mode and commodity

- Total freight ton-mile data available from
  - Railroad (Class I): U.S. Department of Transportation, Surface Transportation Board, Annual Reports (R-1) (1995-2011)

  - Commodity Flow Survey contains ton-mile data by origin and destination state by mode and by commodity

- Historic heavy-duty truck ton-mile and vehicle miles traveled data show direct relationship
Projecting regional freight movement by mode and commodity

• Ton-mile per dollar of industrial output
  – by census division and commodity derived from historical data (CFS2007) and NEMS Macro model value of industrial output

• Heavy-duty truck
  – ton-miles (vehicle miles traveled) projected using ton-mile per dollar value of output, by census division and commodity

• Freight rail
  – ton-miles split into non-coal and coal; non-coal projected using ton-mile per dollar value of output, by census division and commodity; while coal ton-miles use growth rate of coal ton-miles from NEMS coal module

• Domestic marine
  – ton-miles projected using ton-mile per dollar value of output by census division and commodity, with relationship showing phased-out historical rate of decline
Heavy-duty freight vehicle miles traveled lower in AEO2014 due to lower macroeconomic growth and new methodology.

Source: AEO2014 preliminary
Rail ton-miles higher and domestic marine ton-miles lower in AEO2014 due to methodology change

![Graph showing ton-miles traveled (billion) for history, 2012, and projection from 1995 to 2040 for Freight rail and Domestic marine.](source: AEO2014 preliminary)
Freight rail and domestic marine efficiency

• Freight rail efficiency (Btu/ton-mile)
  – Railroad (Class I): U.S. Department of Transportation, Surface Transportation Board, Annual Reports (R-1) have ton-mile and fuel consumption data (1995-2011)
  – Projected efficiency improves by 0.7% annually (1/2 historic rate)

• Domestic waterborne freight efficiency (Btu/ton-mile)
  – Transportation Energy Data Book (31st edition), Waterborne Commerce on Taxed Waterways
  – Projected efficiency improves by 0.8% annually (1/2 historic rate)
Freight rail and domestic marine efficiencies improve at ½ the historic rate

Btu / 1,000 ton-miles

Source: EIA, Annual Energy Outlook 2013; USDOT Surface Transportation Board; Transportation Energy Data Book Ed. 31
LNG Class I freight locomotives

• Price differential between LNG and diesel fuel has raised interest (fuel cost is 23% of total operating expense)

• BNSF will acquire 6 line-haul locomotives (3 from GE, 3 from EMD) in pilot program
  – Testing will begin in late 2013 and continue for at least 1 year
  – BNSF would “move quickly” if pilot program proves a success

• Canadian National Railways line-haul locomotive pilot program testing 2 ECI conversion kits (3,000 HP) and will acquire 2 line-haul locomotives from EMD (4,300 HP) with Caterpillar/EMD HPDI technology and Westport tender car
  – Conversion kit testing in Canada began in late 2012
  – Experiencing some mechanical and logistical challenges but too early to tell success/failure
Modeling LNG as a fuel choice for freight locomotives

- LNG fuel choice based on endogenous fuel economics calculation
  - Incremental cost of LNG engine + fuel tender = $1,000,000
  - Annual ton-miles travelled per locomotive = 70,868,670
  - Efficiency (Btu/ton-mile) is fuel neutral
  - Discount rate = 11.5% (Class I Railroad average return on equity)
  - Payback period = 15 years
  - LNG locomotives available as fuel starting in 2015
  - Class I Railroads pay about 80% of retail price of transportation diesel fuel
  - Phase-in of new/rebuild LNG locomotives over 5 years each for BNSF/GT; CSX, NS, UPRR; KCS/Soo
Total transportation energy consumption

Source: AEO2014 preliminary
Transportation energy consumption declines across projection, LDV energy share falls while HDV energy share rises

Source: AEO2014 preliminary
Motor gasoline declines as share of transportation fuel consumed while diesel fuel rises

Source: AEO2014 preliminary
Discussion/questions

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Annual Energy Outlook | www.eia.gov/forecasts/aeo
Annual vehicle miles traveled by licensed drivers

Source: NHTS and FHWA Highway Statistics
Decline in licensing rates for age cohorts under 54 years old while increase for age cohorts above

Source: NHTS
Driver licenses by age cohort

Source: FHWA Highway
Example: heavy-duty truck ton-mile distribution by census division and commodity, CFS2007

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<th>census division</th>
<th>chemicals</th>
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Example: heavy-duty truck ton-mile per dollar of industrial output

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