

# *Annual Energy Outlook 2014:* transportation modeling updates and preliminary results



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*For*

*Working Group 2*

*September 25, 2013 | Washington, DC*

*By*

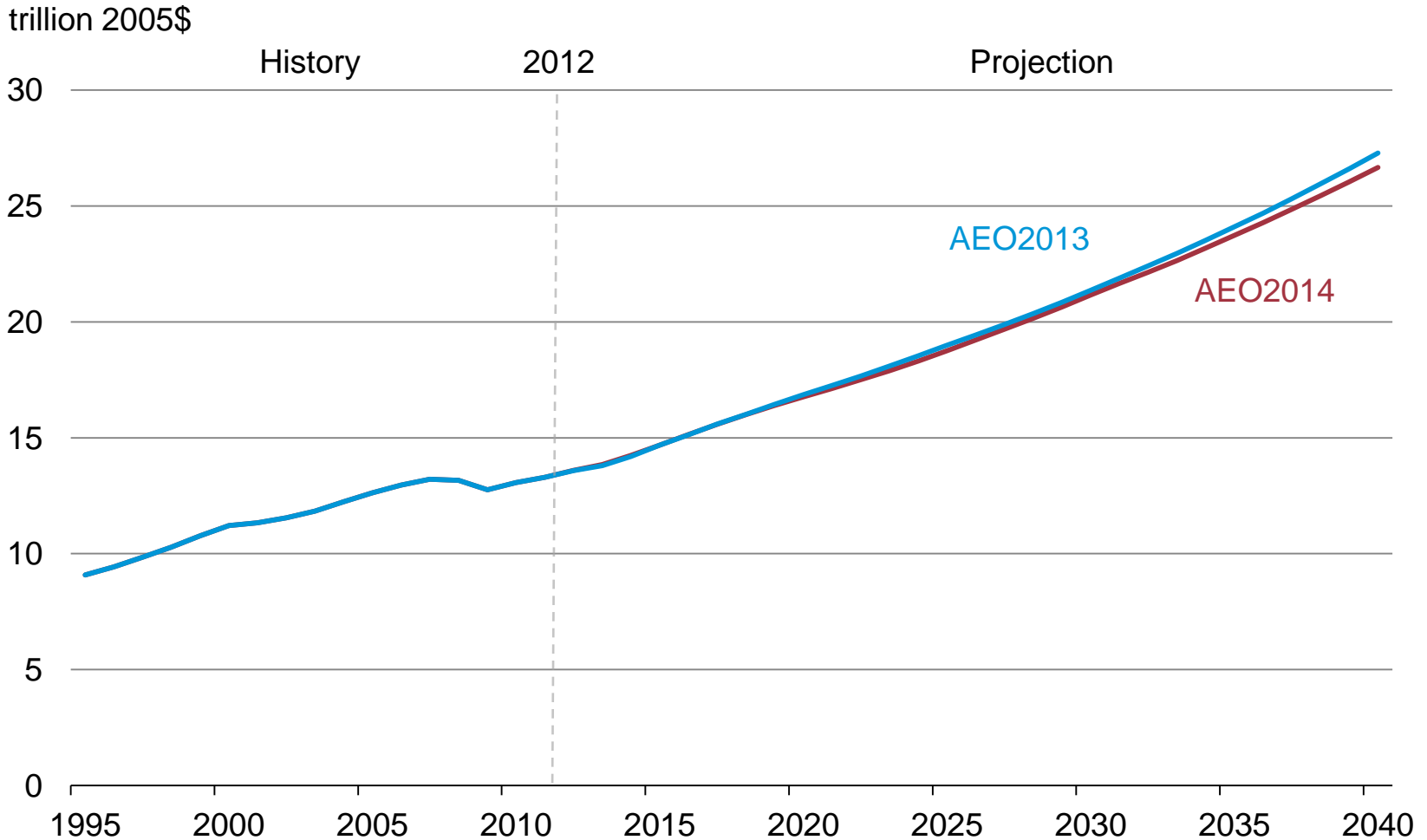
*Trisha Hutchins and Nicholas Chase*

*Office of Transportation Energy Consumption and Efficiency Analysis*

# Overview

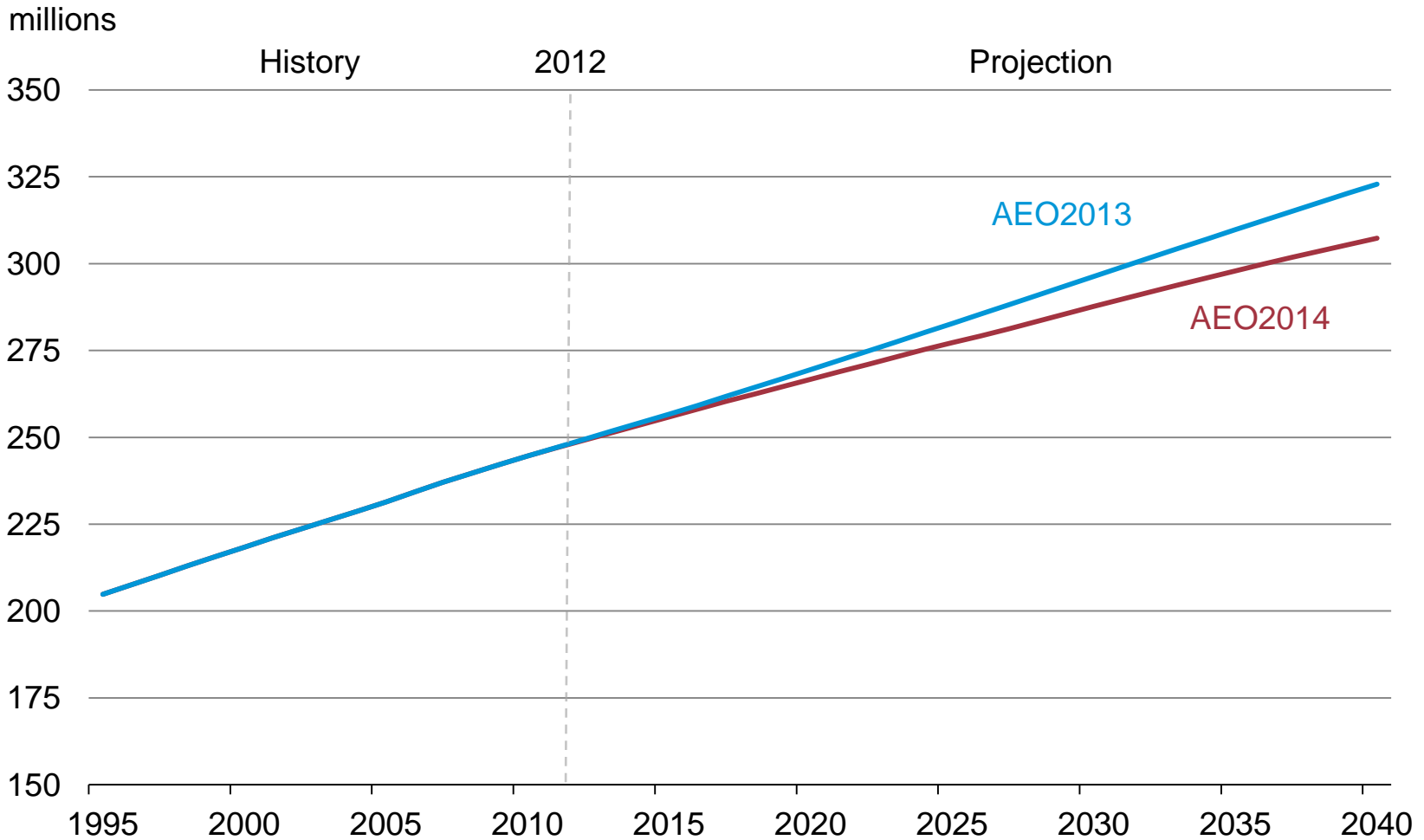
- **Macroeconomic drivers**
  - GDP, population, world oil price
- **Light-duty vehicle**
  - New travel demand module including population demographics
  - New region specific consumer behavior and E85 demand
  - Updated battery electric vehicle cost, efficiency, and availability
- **Heavy-duty vehicle, 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



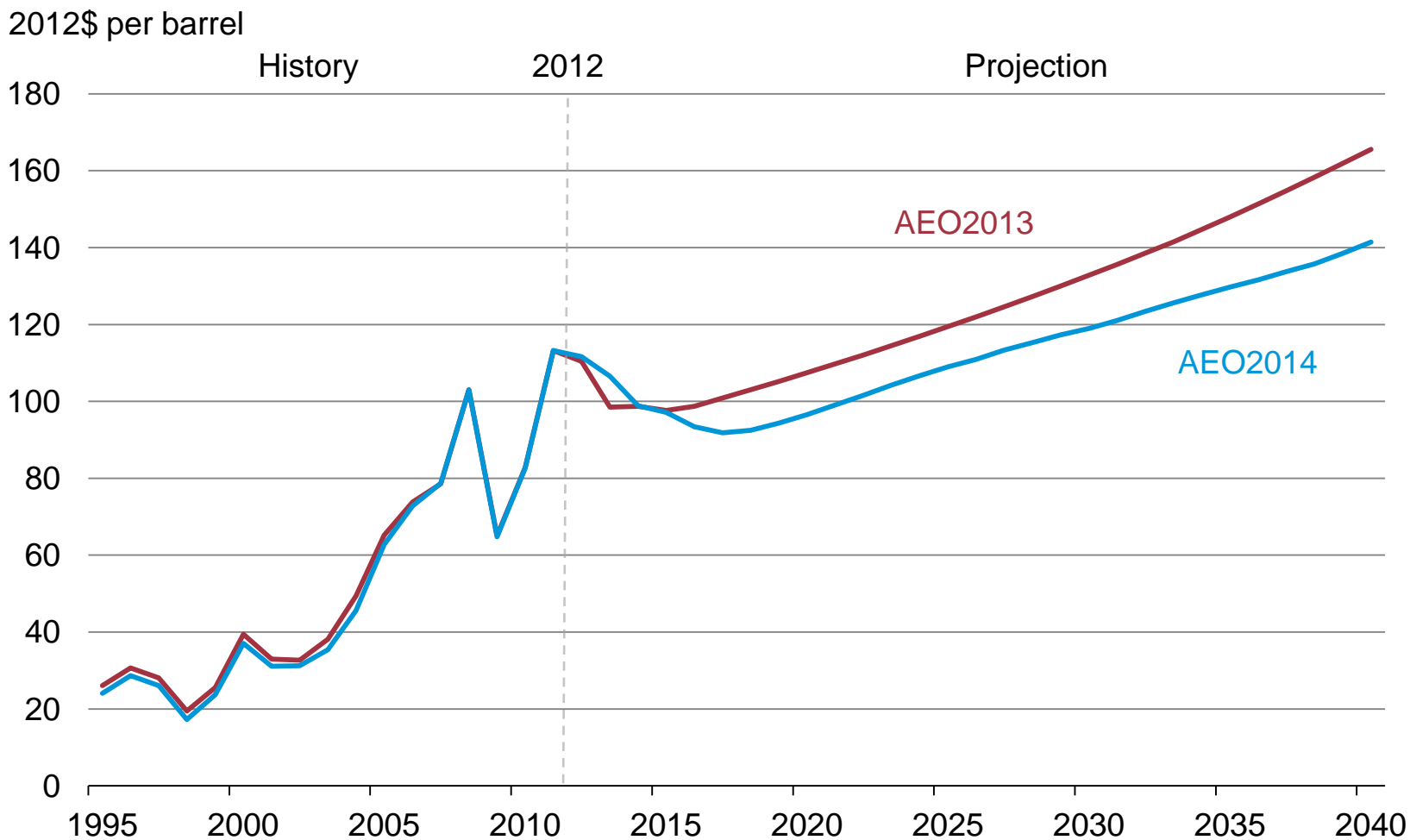
Source: AEO2014 preliminary

# Population 16+ is lower in the AEO2014



Source: AEO2014 preliminary

# World oil price is lower in the AEO2014

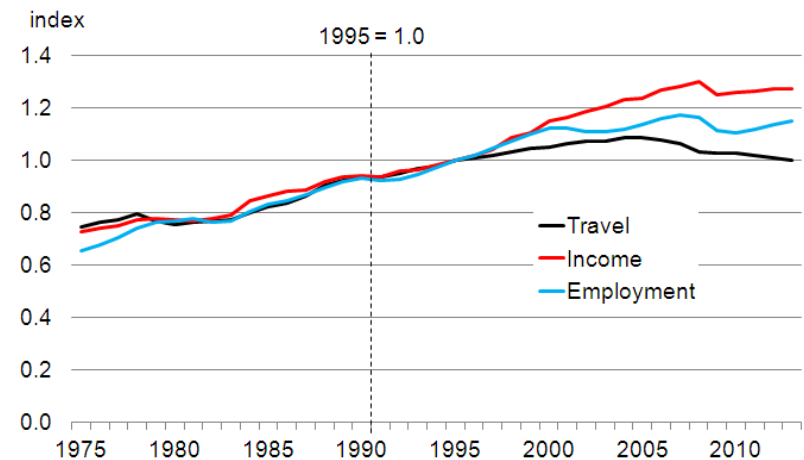


Source: AEO2014 preliminary

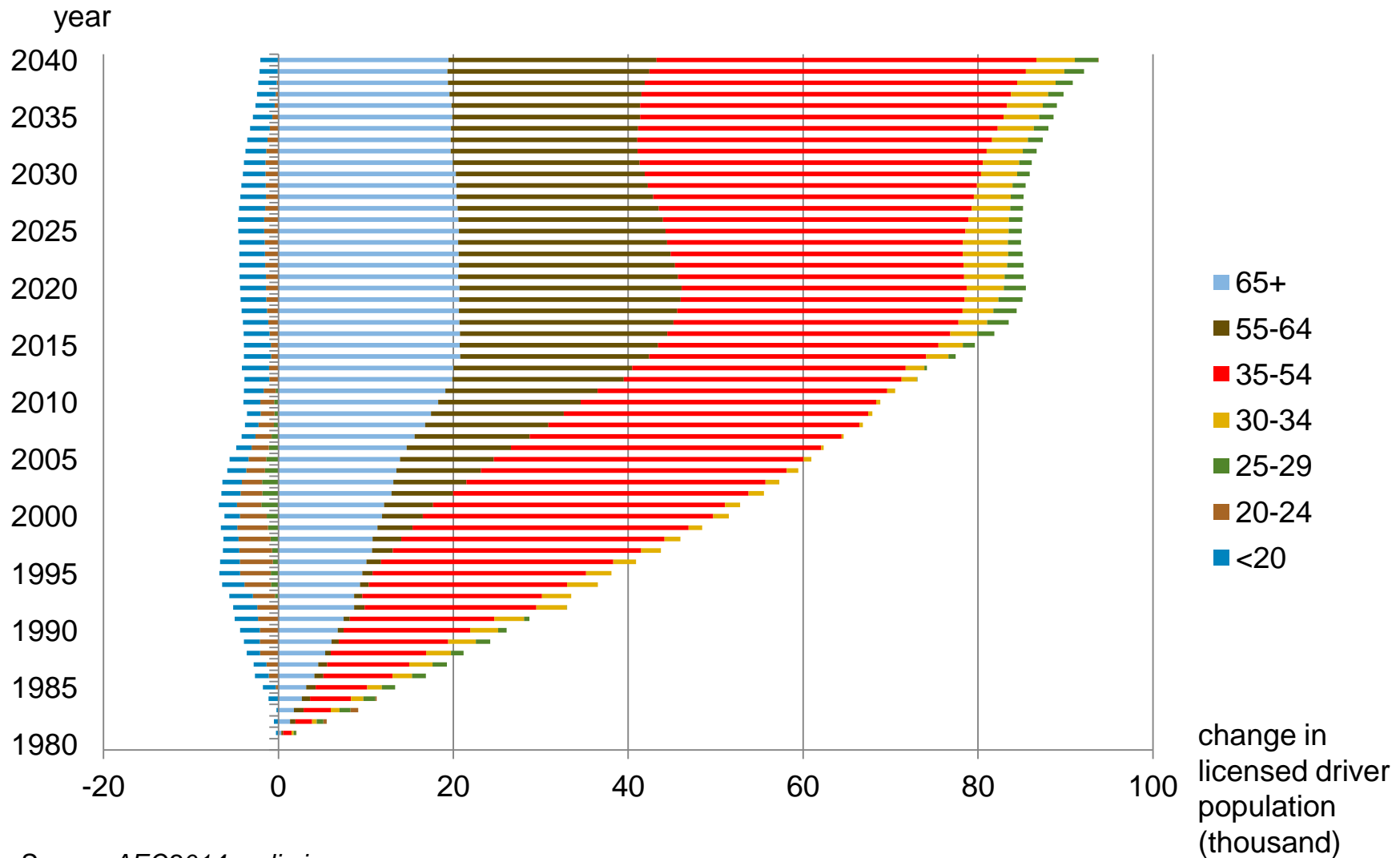
# Light-duty vehicle

# 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

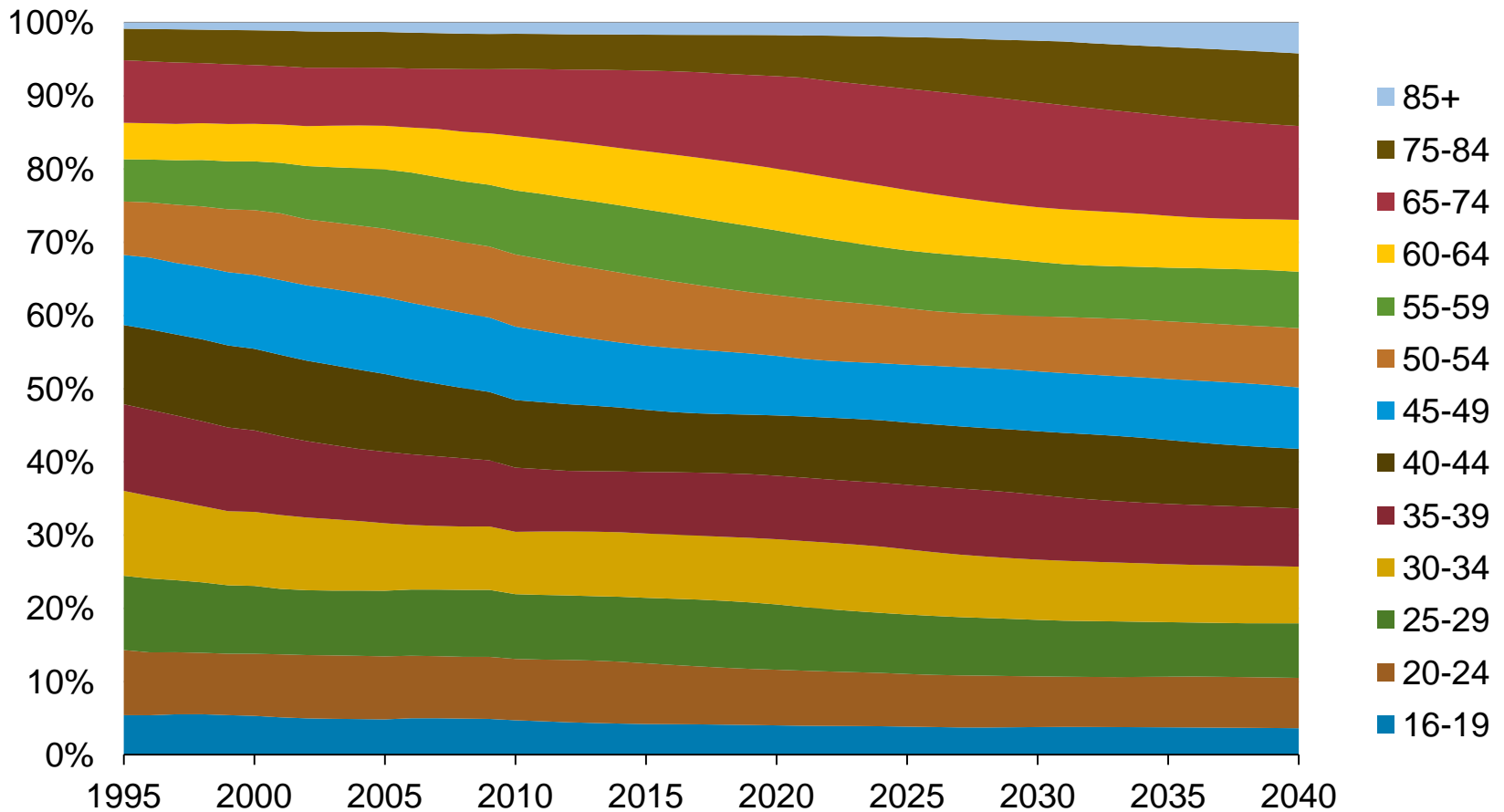


Source: AEO2014 preliminary



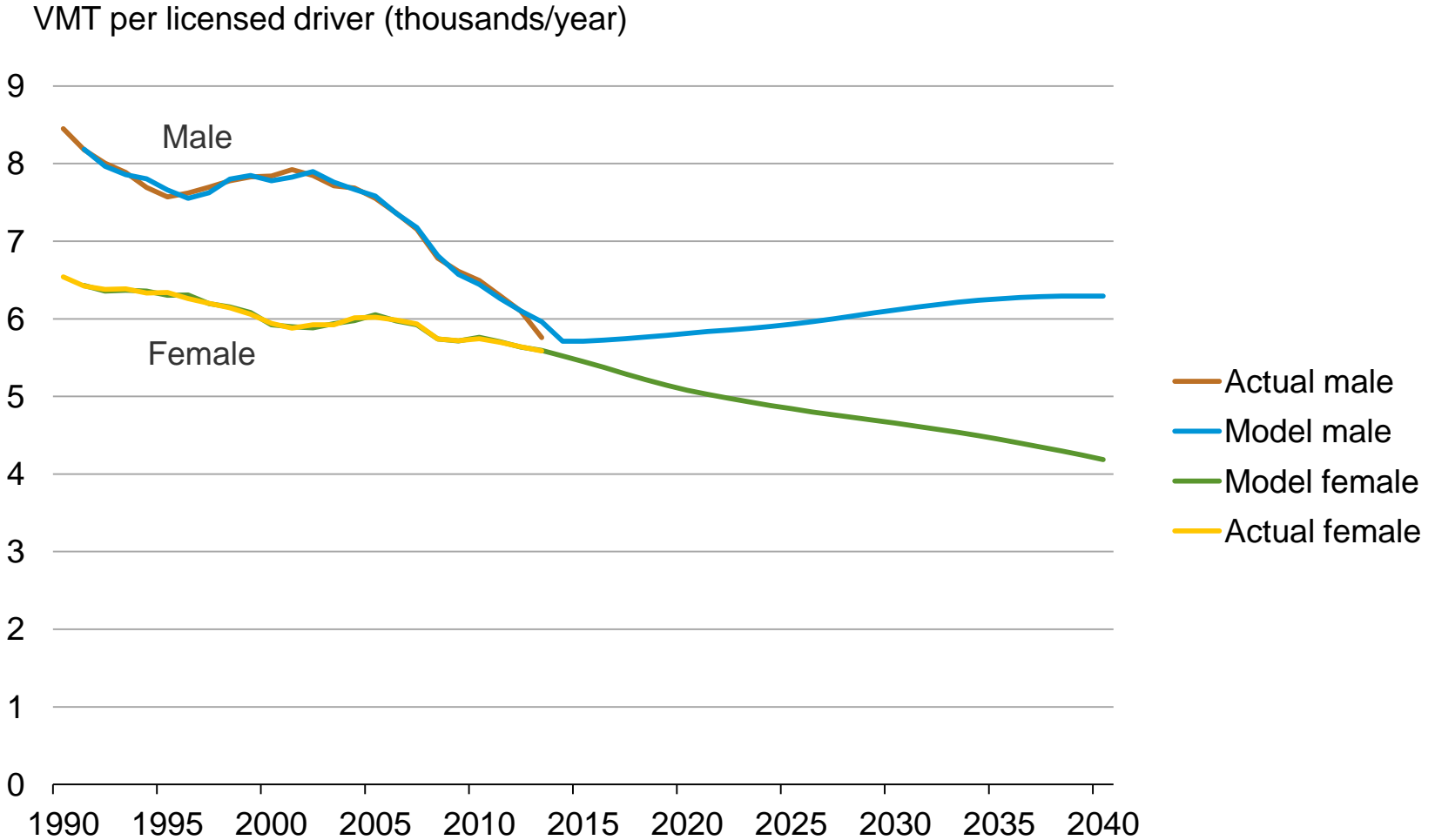
# Driving population distribution by age group

percent of population



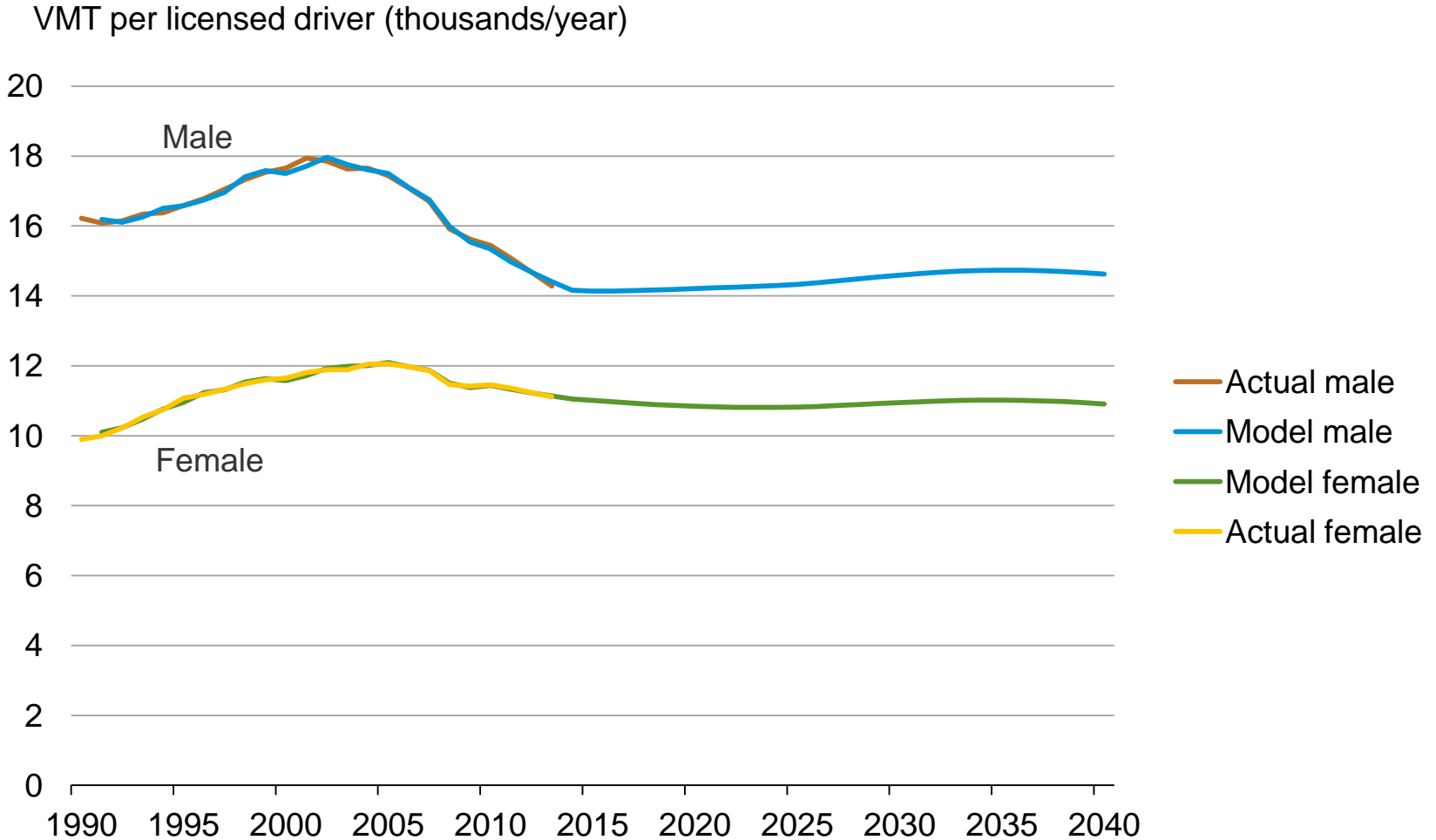
Source: AEO2014 preliminary

# Change in travel—16-19 year old age cohort



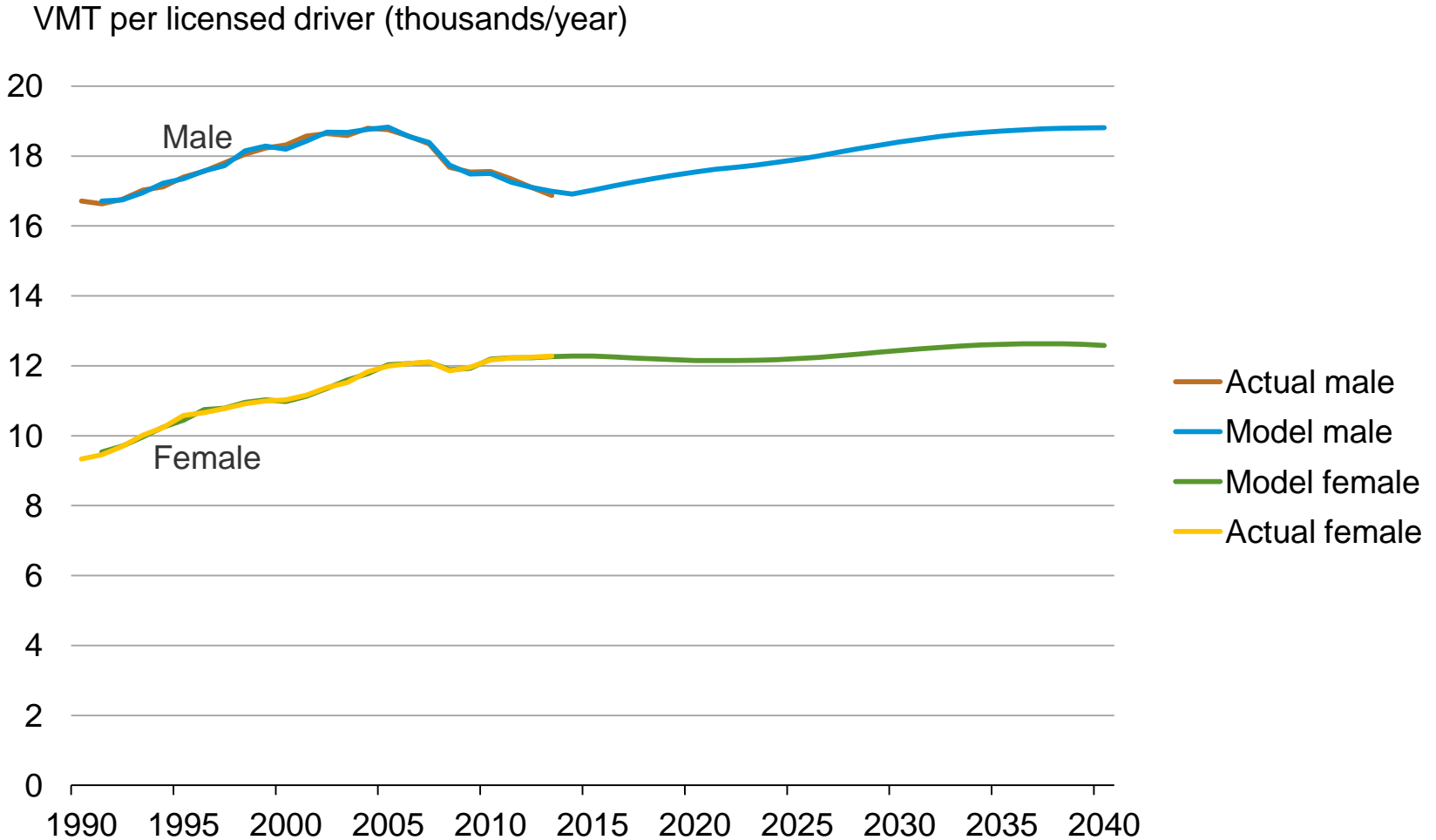
Source: AEO2014 preliminary

# Change in travel—20-34 year old age cohort



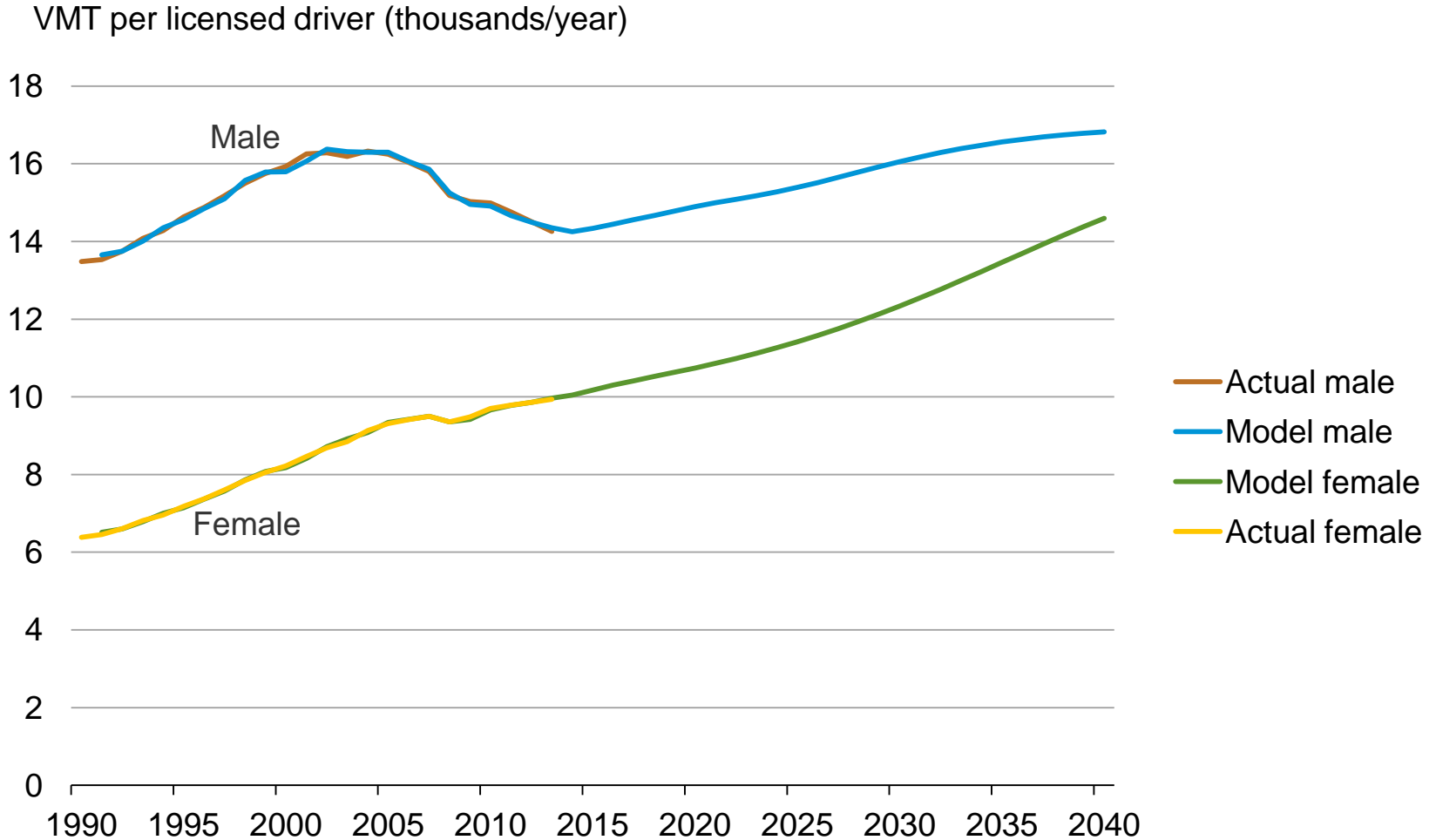
Source: AEO2014 preliminary

# Change in travel—35-54 year old age cohort



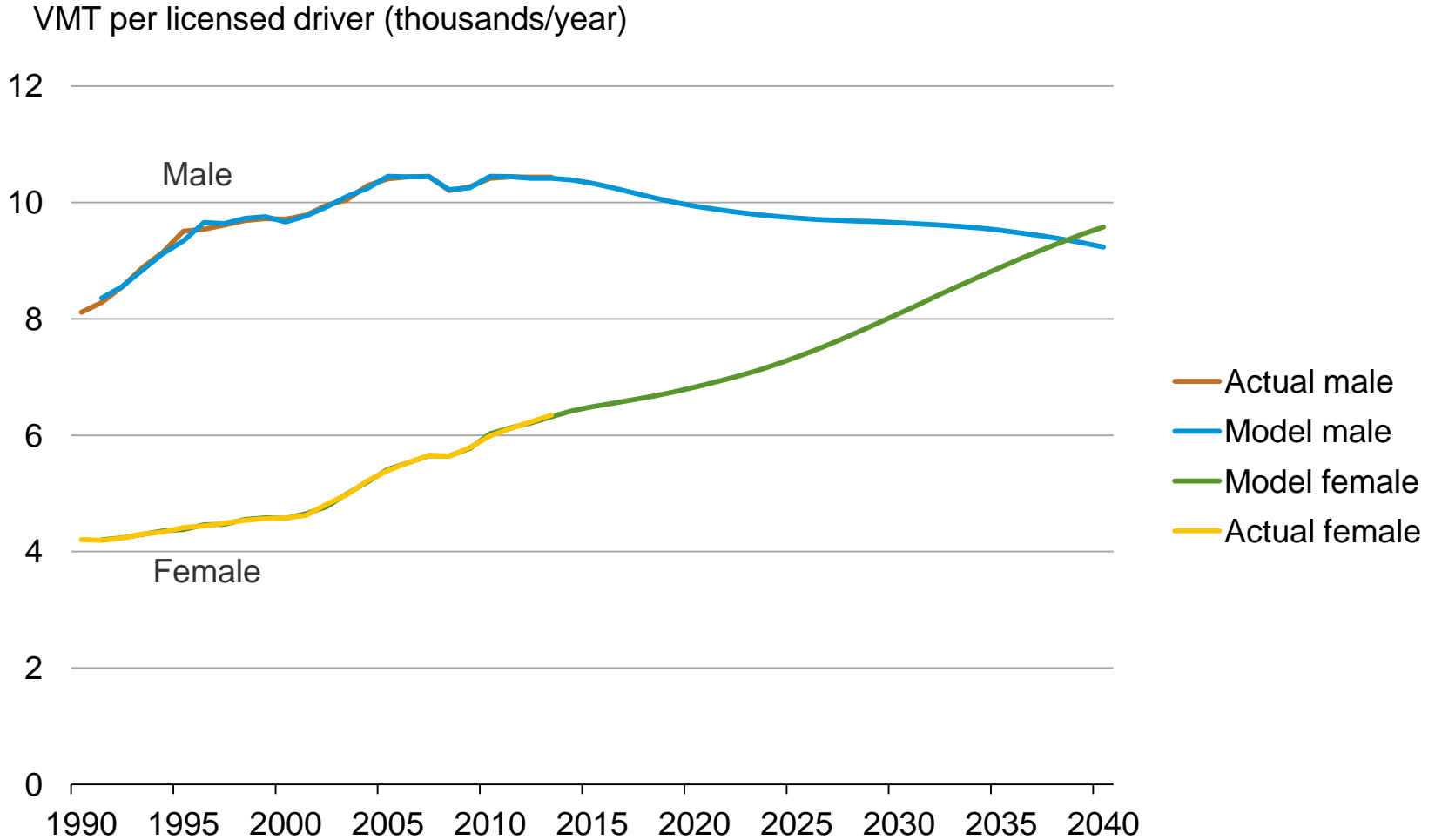
Source: AEO2014 preliminary

# Change in travel—55-64 year old age cohort



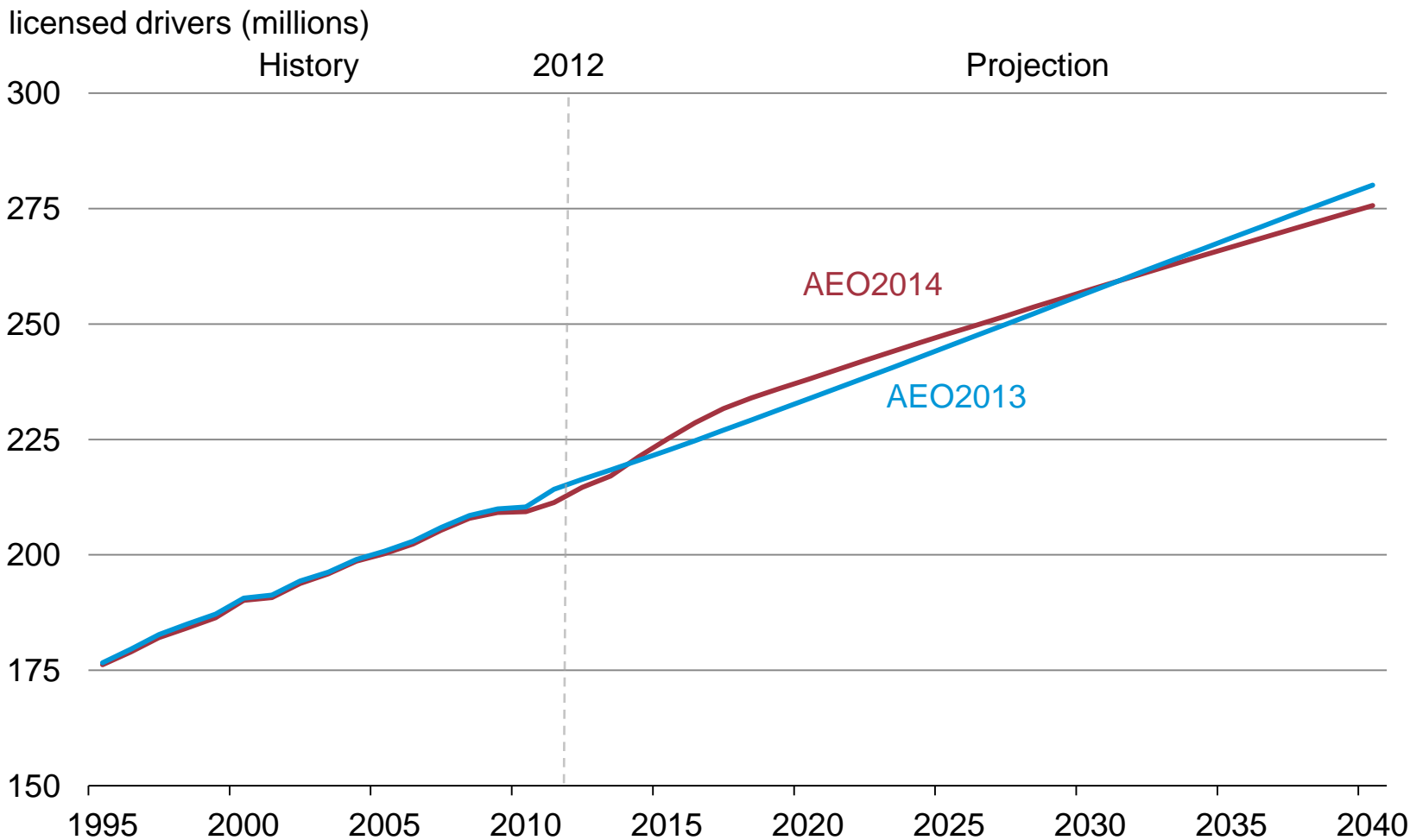
Source: AEO2014 preliminary

# Change in travel—65+ year old age cohort



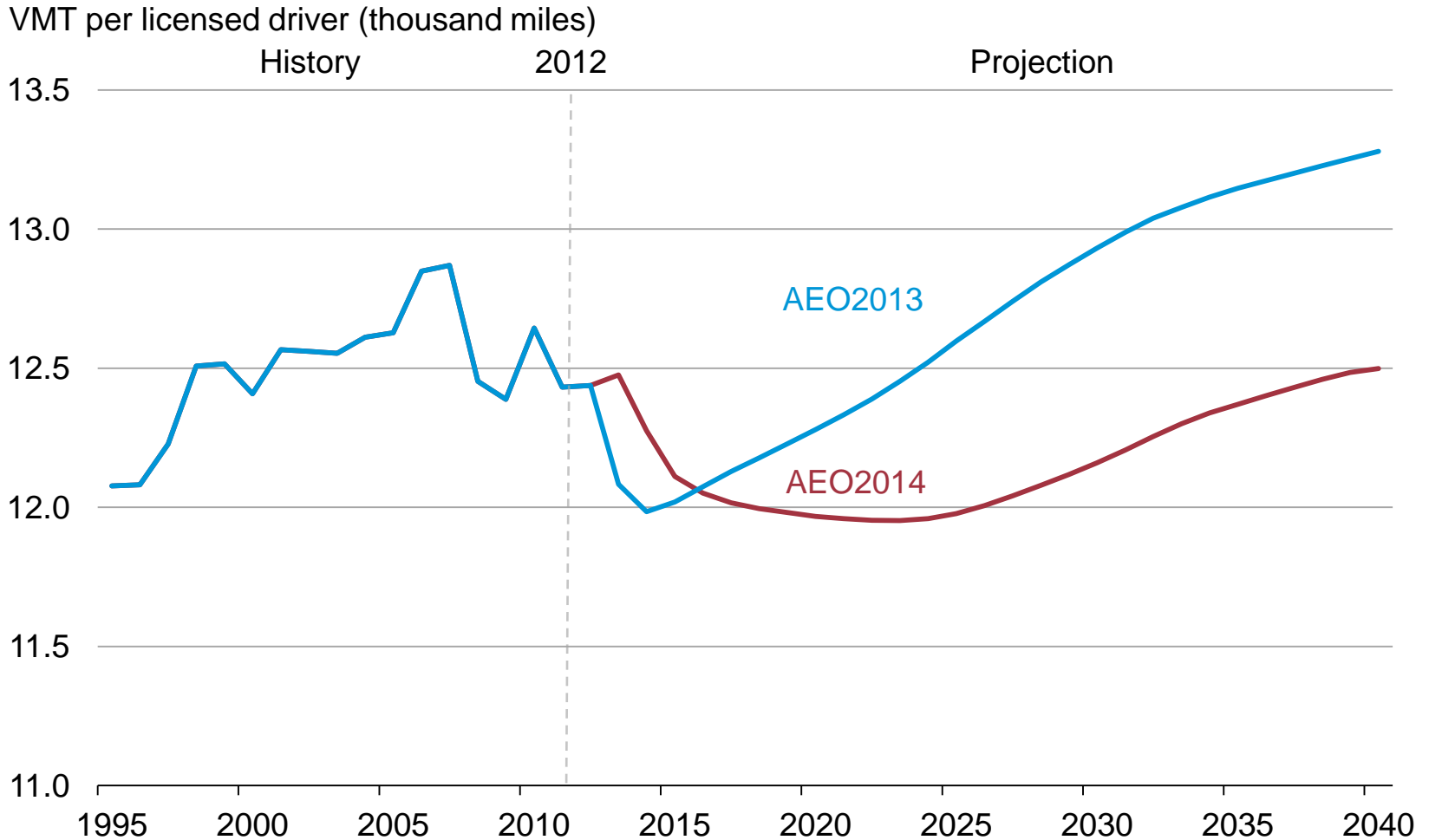
Source: AEO2014 preliminary

# Licensed drivers increase over the projection period



Source: AEO2014 preliminary

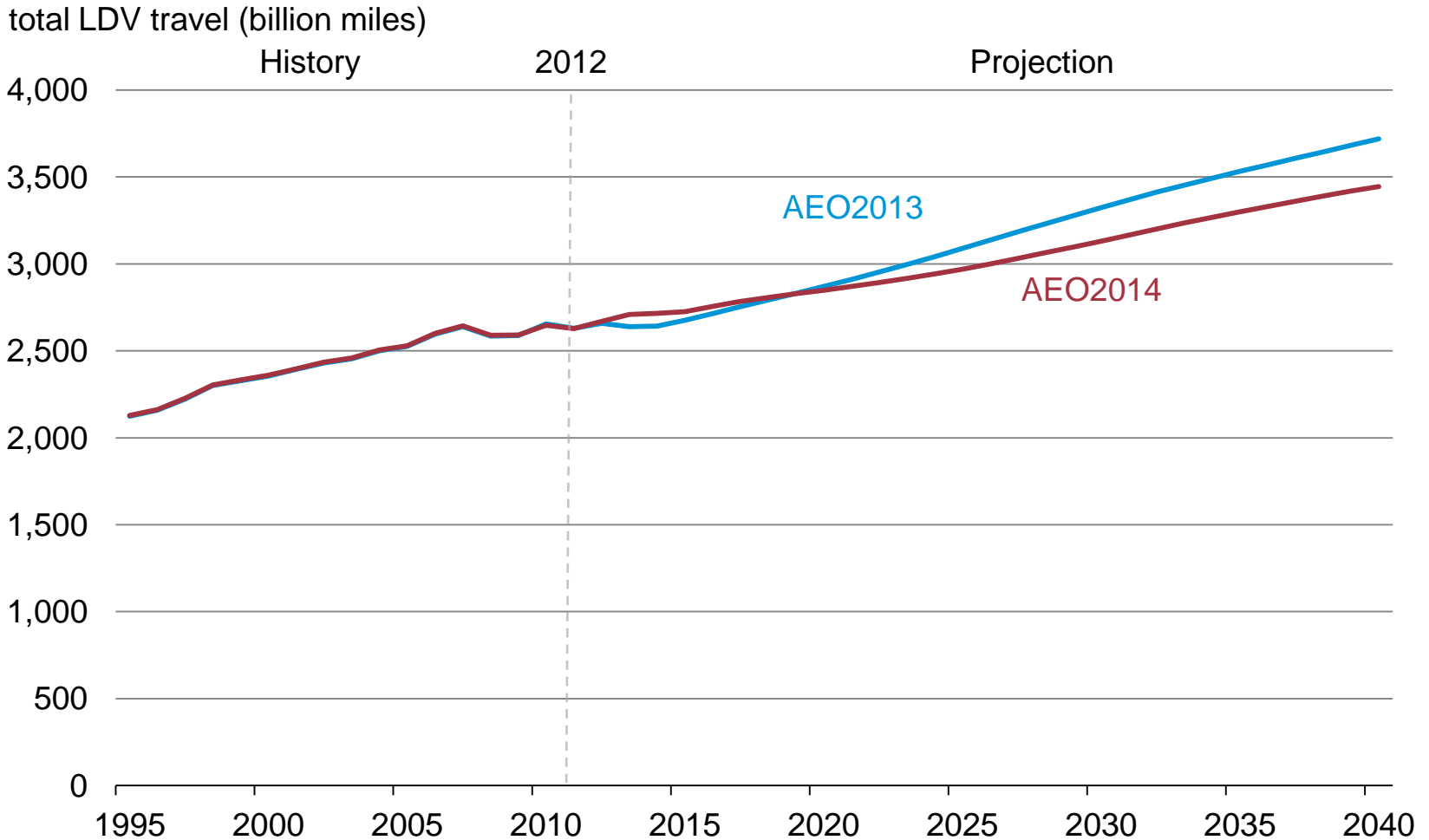
# VMT per licensed driver decreases until 2024



Source: AEO2014 preliminary

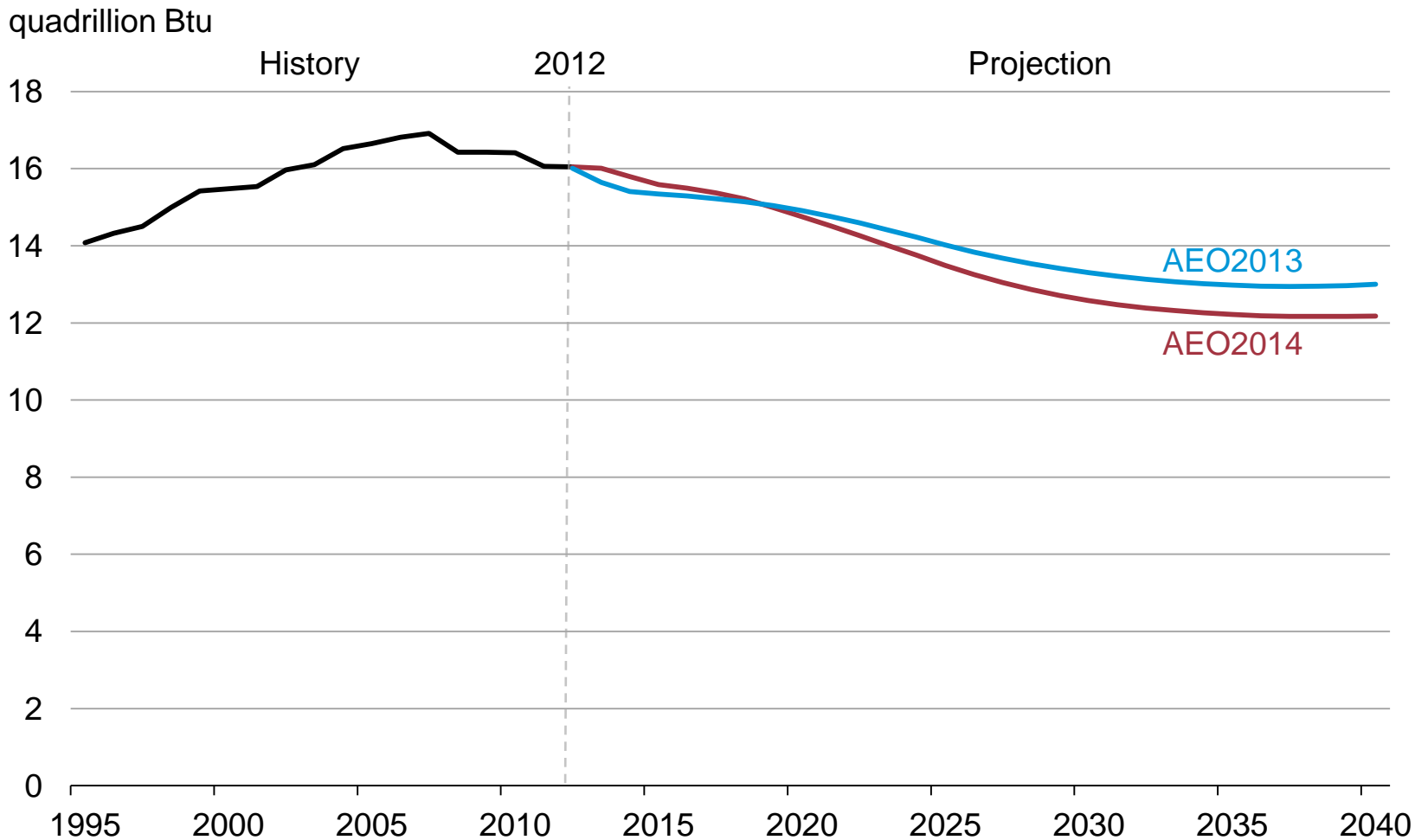


# LDV travel lower in AEO2014



Source: AEO2014 preliminary

# Total LDV energy use is lower in AEO2014 due less travel demand



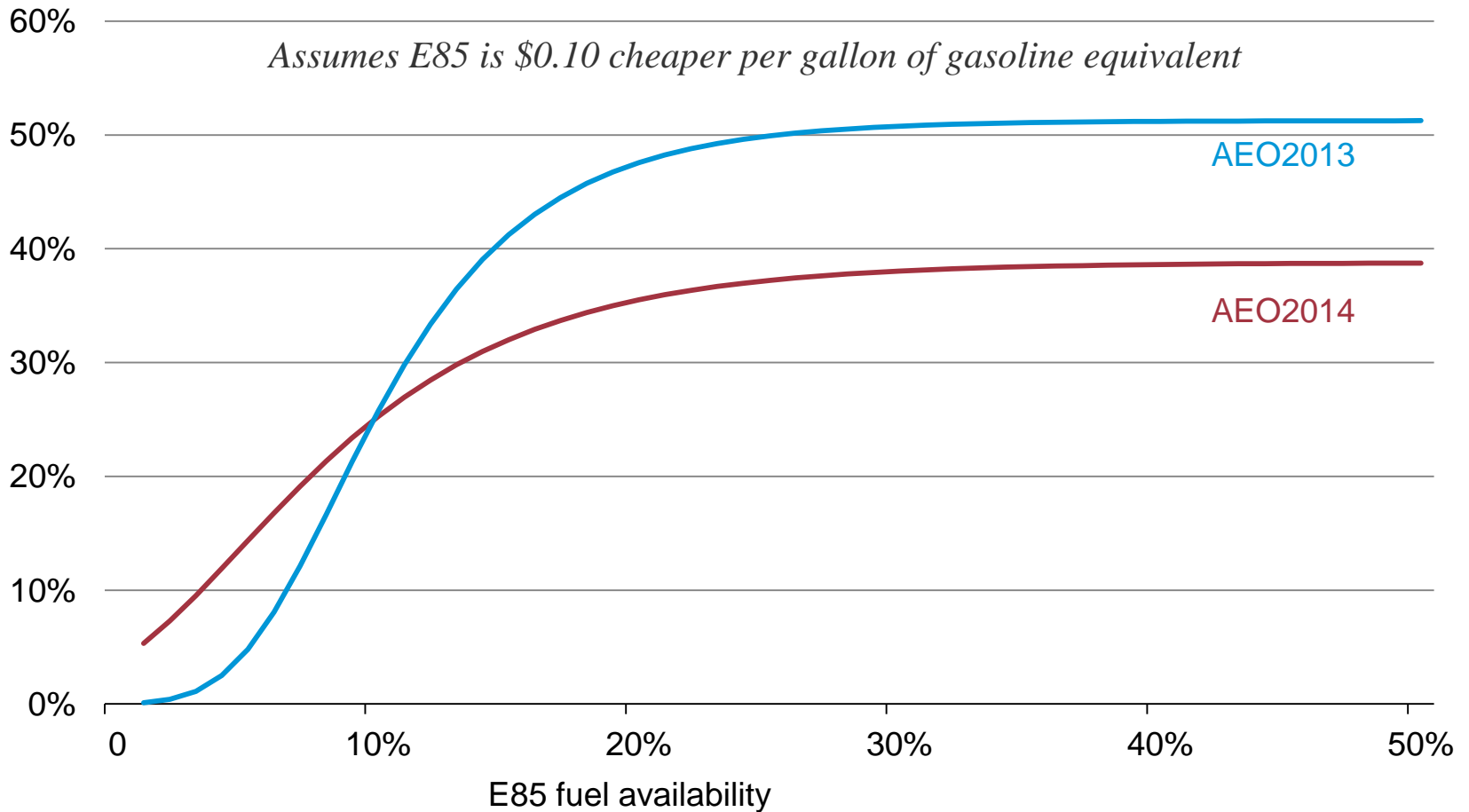
Source: AEO2014 preliminary

# 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

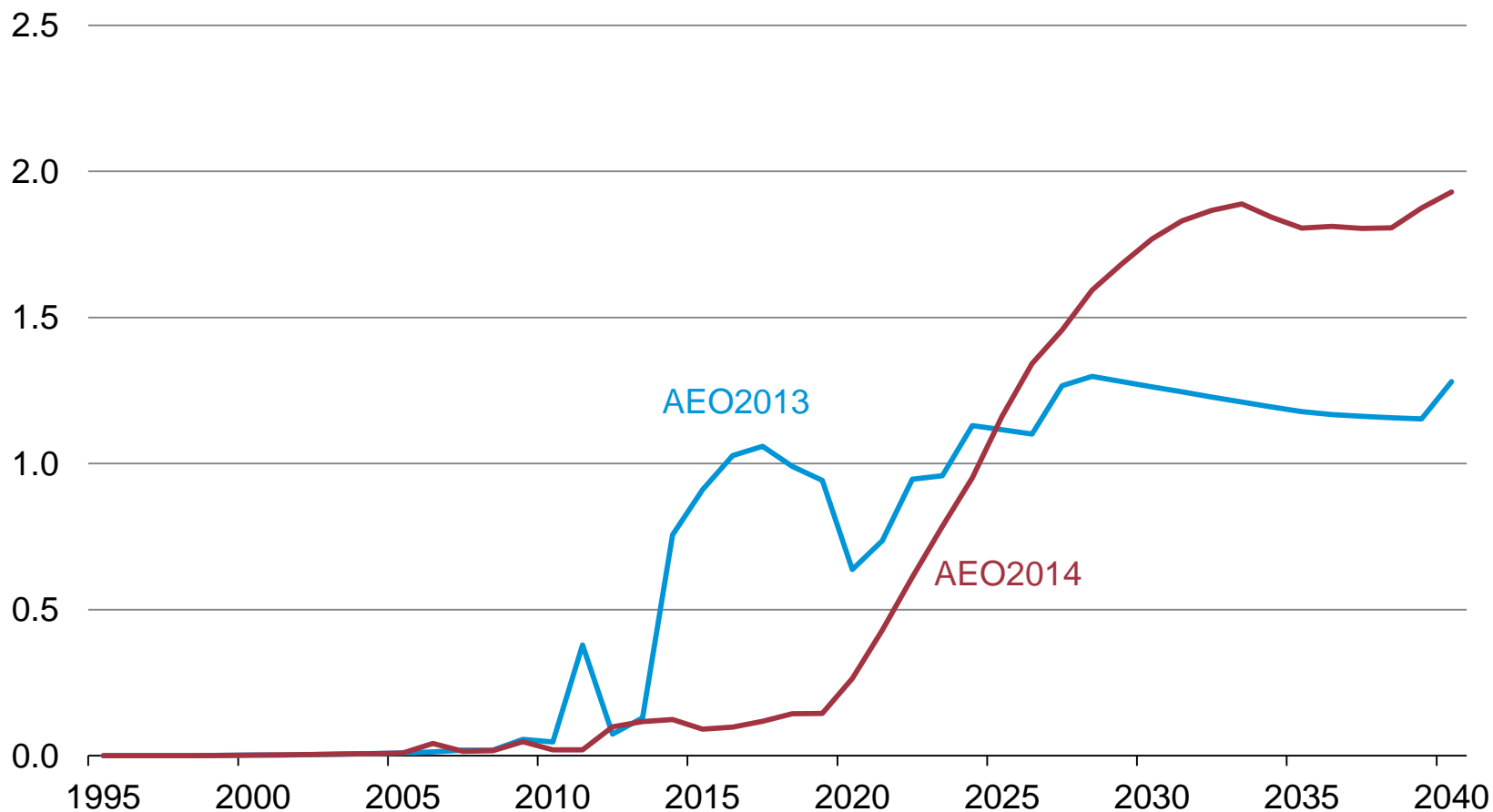
# Consumer choice for E85

E85 market share



# E85 consumption greater in AEO2014

billion gallons



Source: AEO2014 preliminary

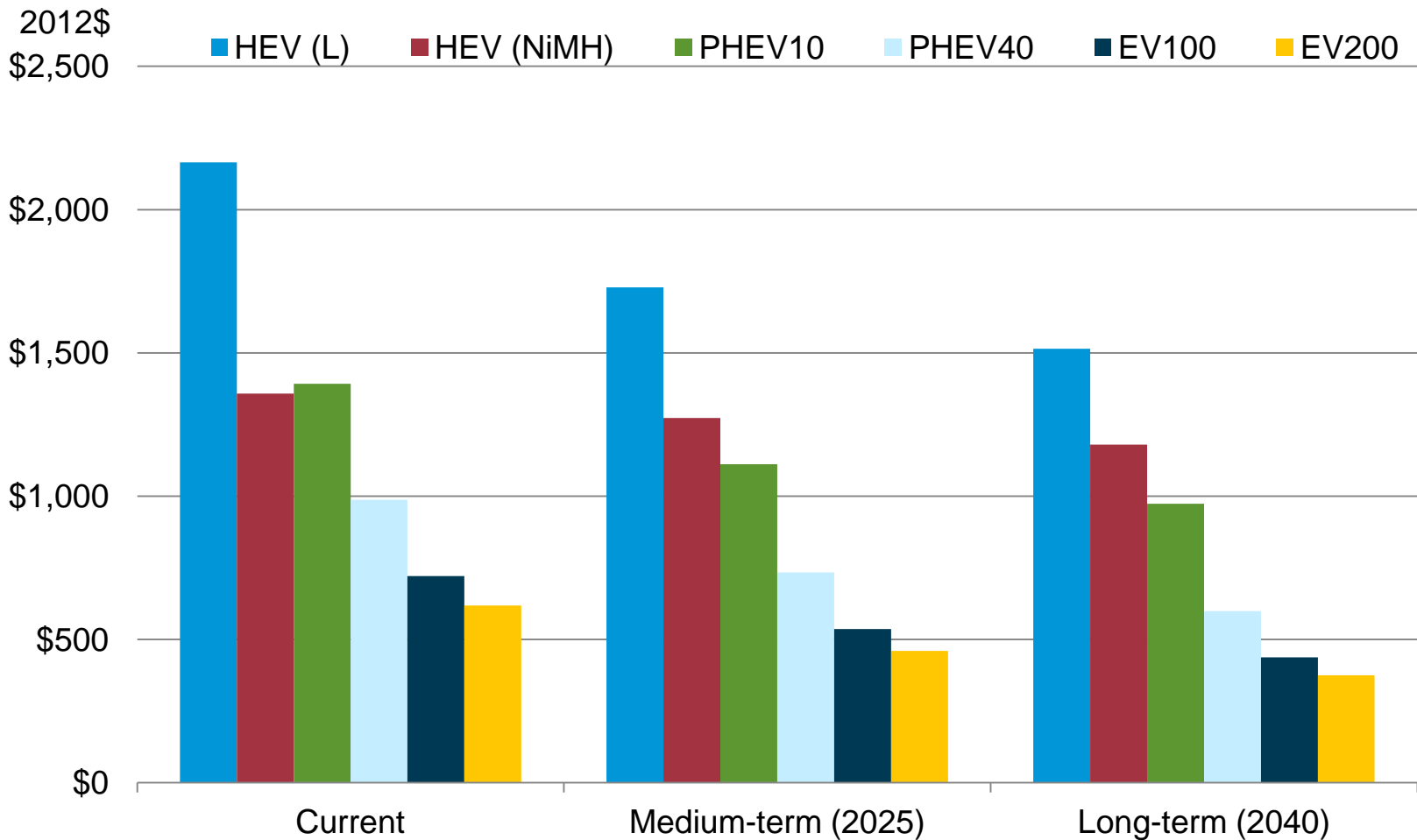
# Battery electric vehicle modeling updates

- 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 electric vehicle modeling updates (continued)

- 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

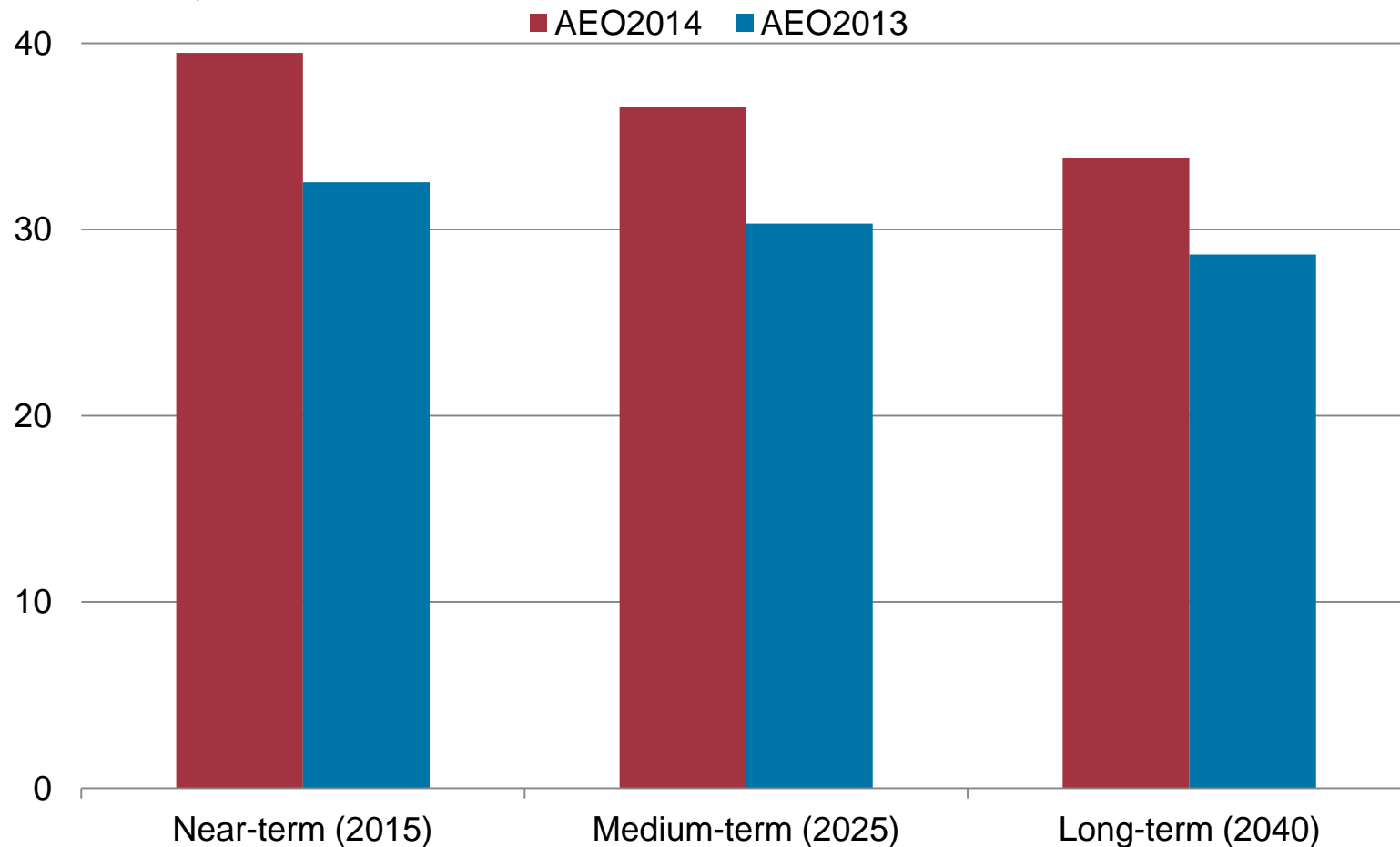
# Battery cost to consumer (\$/kWh)





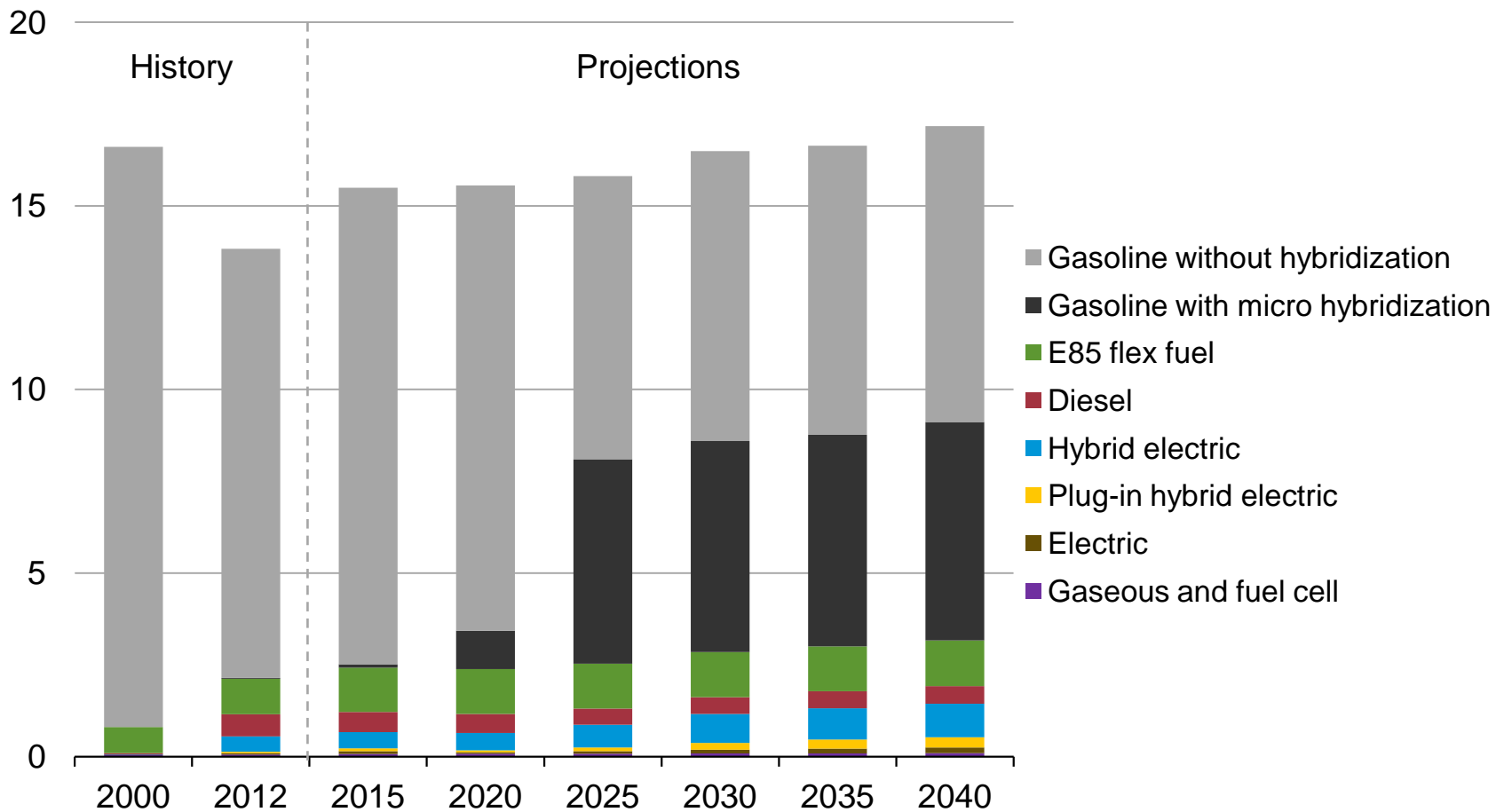
# Price of midsize plug-in hybrid electric vehicle with 40 mile range higher in AEO2014

thousand 2012\$



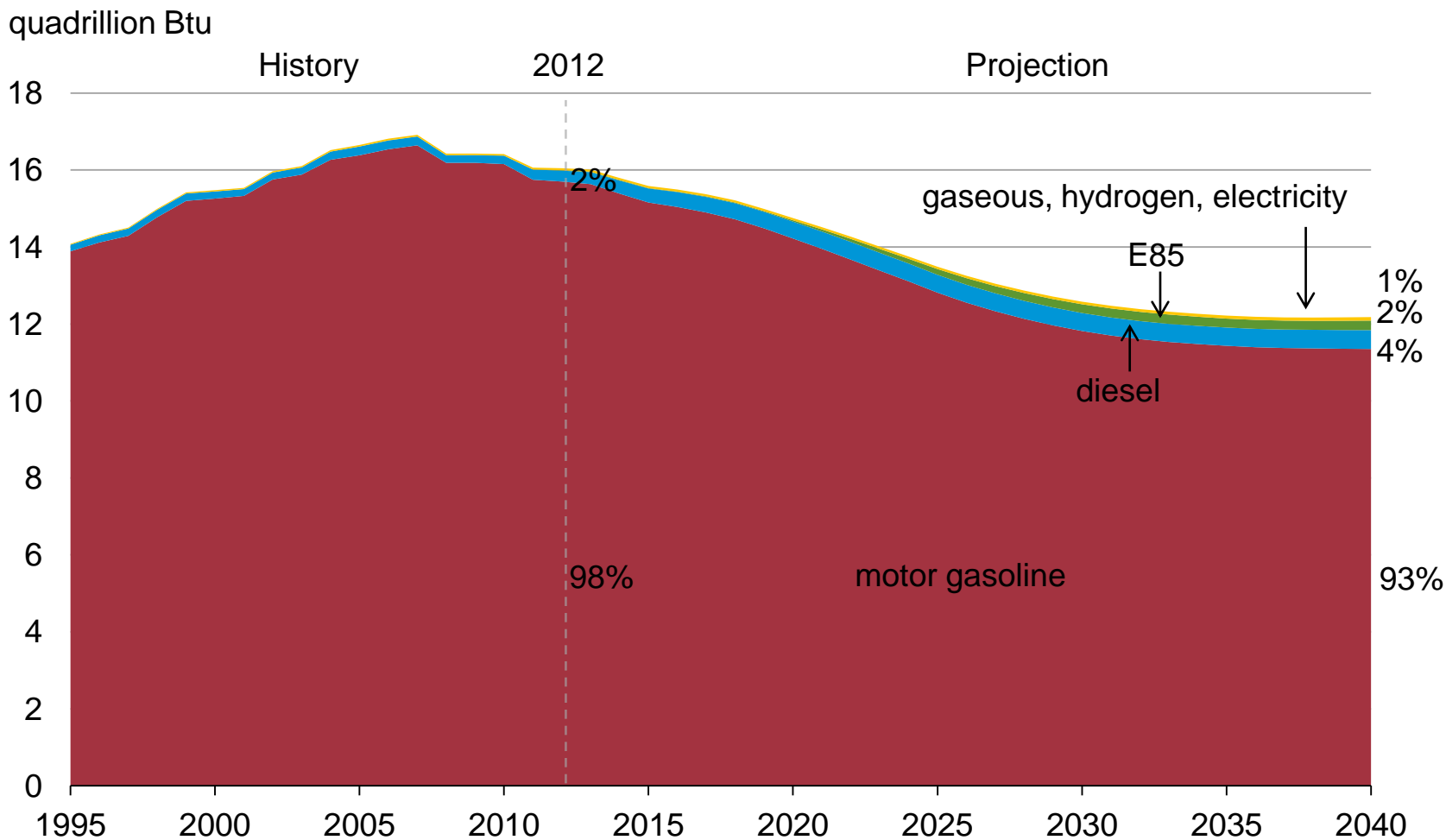
# Gasoline LDVs (including with micro hybridization) account for 82% of sales in 2040

U.S. light car and truck new sales  
millions



Source: AEO2014 preliminary

# LDV energy consumption by fuel remains predominantly motor gasoline with only small shares of other fuels, mostly diesel



Source: AEO2014 preliminary

# Heavy-duty vehicle, freight rail, and domestic marine

# Regionalize freight movement by mode and commodity

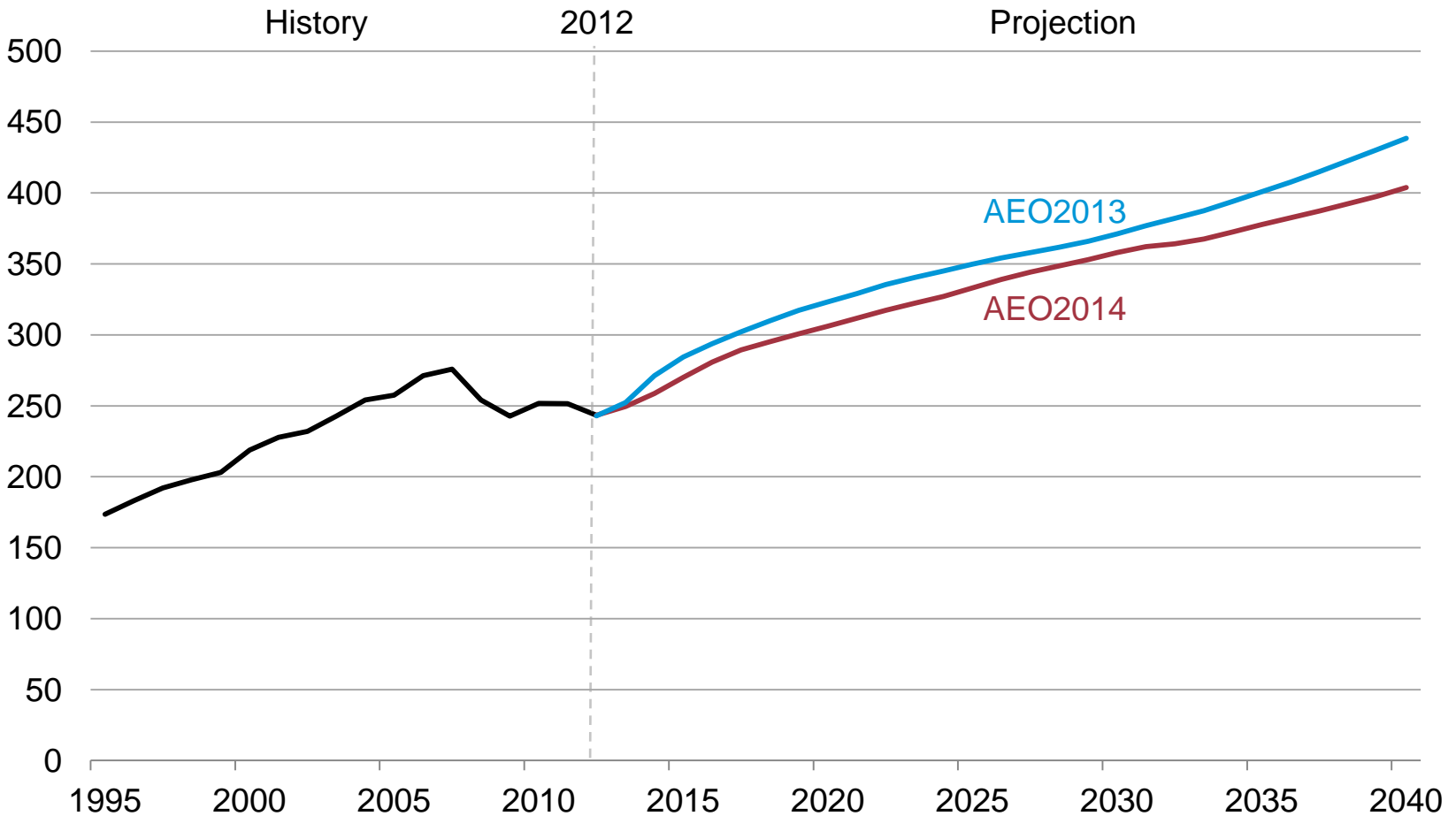
- Total freight ton-mile data available from
  - Railroad (Class I): U.S. Department of Transportation, Surface Transportation Board, Annual Reports (R-1) (1995-2011)
  - Domestic waterborne commerce: U.S. Army Corps of Engineers, Waterborne Commerce of the United States, Annual Editions (1995-2010)
  - Truck: U.S. Department of Transportation, National Transportation Statistics (1995-2009); VMT, Federal Highway Administration (1995-2011)
- Regional ton-mile data by commodity available in Commodity Flow Survey (2007, 2002, 1997), U.S. Department of Transportation and U.S. Census Bureau
  - 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

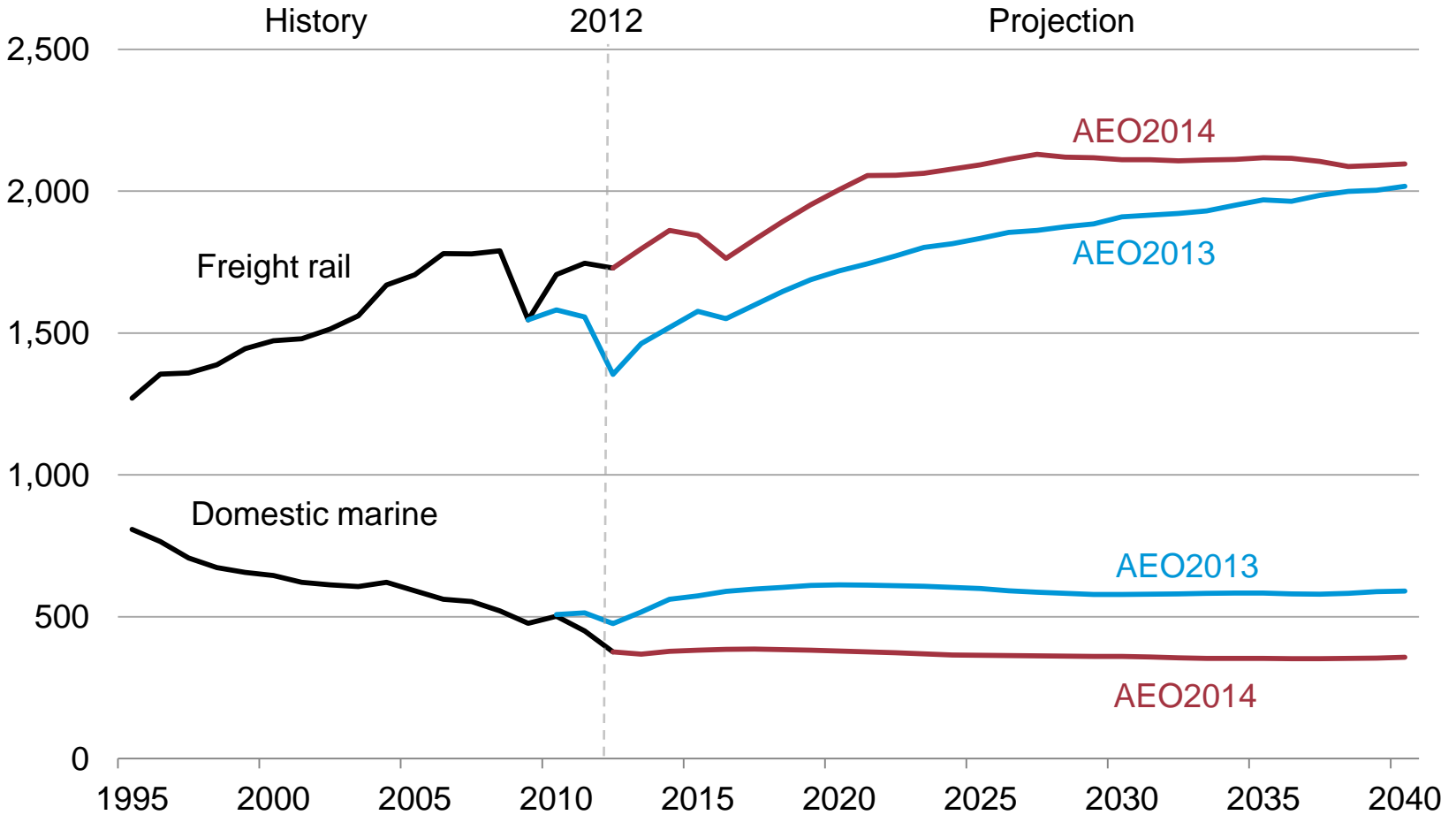
vehicle miles traveled  
(billion)



Source: AEO2014 preliminary

# Rail ton-miles higher and domestic marine ton-miles lower in AEO2014 due to methodology change

ton-miles traveled  
(billion)



Source: AEO2014 preliminary

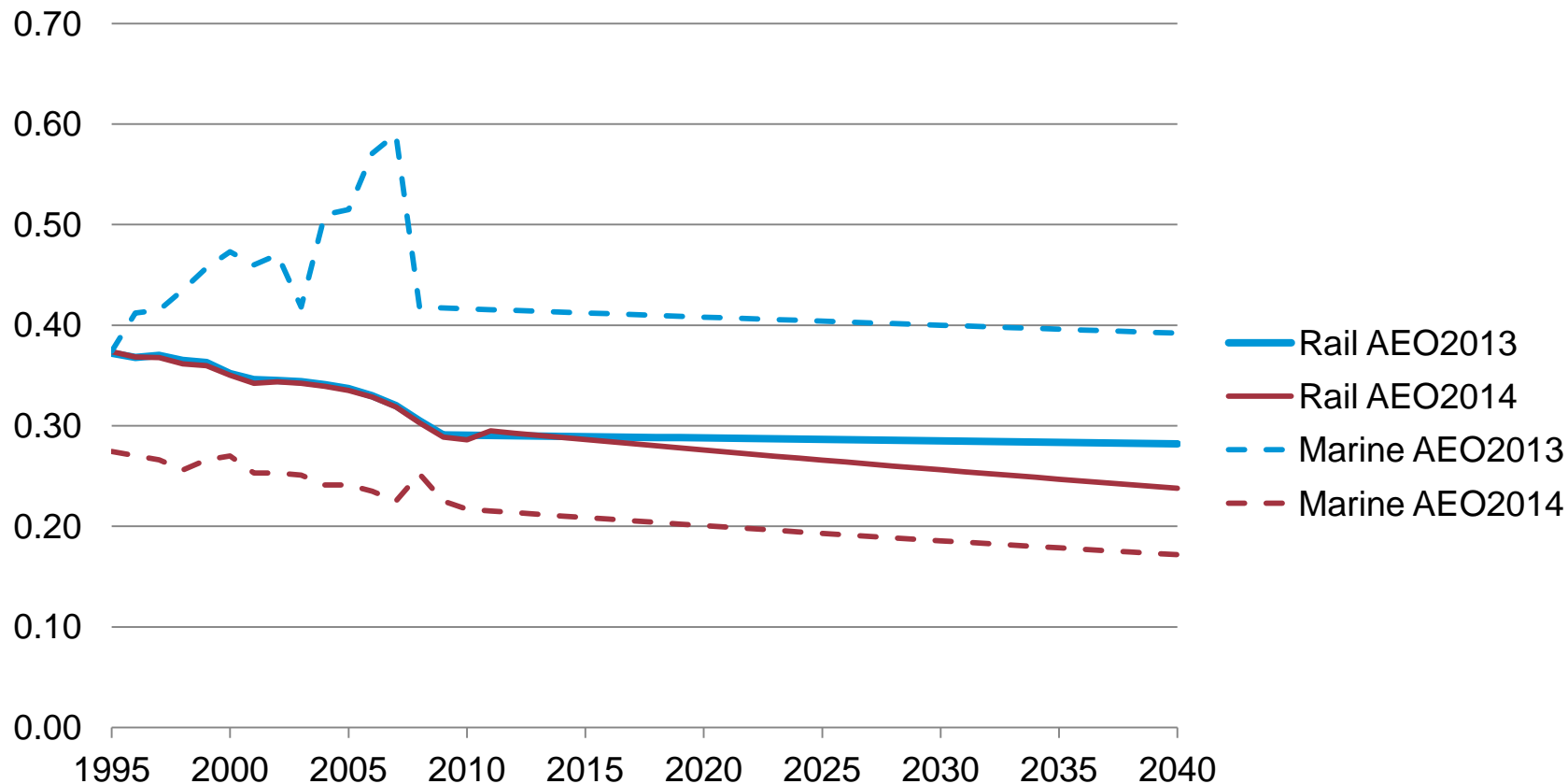


# Freight rail and domestic marine efficiency

- 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 (31<sup>st</sup> edition), Waterborne Commerce on Taxed Waterways
  - Projected efficiency improves by 0.8% annually (1/2 historic rate)

# Freight rail and domestic marine efficiencies improves at 1/2 the historic rate

Btu / 1,000 ton-miles



Source: EIA, Annual Energy Outlook 2013; USDOT Surface Transportation Board; Transportation Energy Data Book Ed. 31

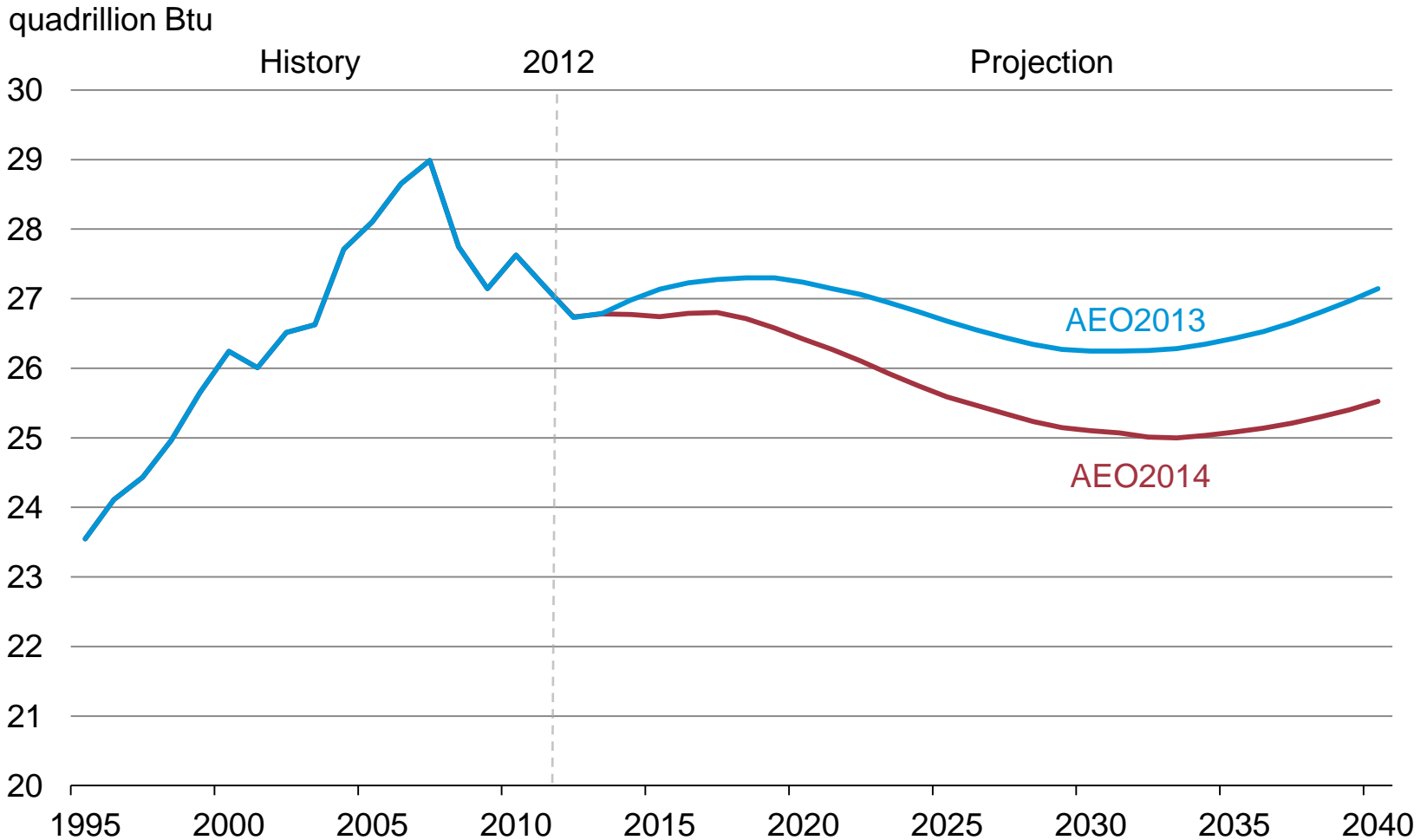
# LNG Class I freight locomotives

- 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

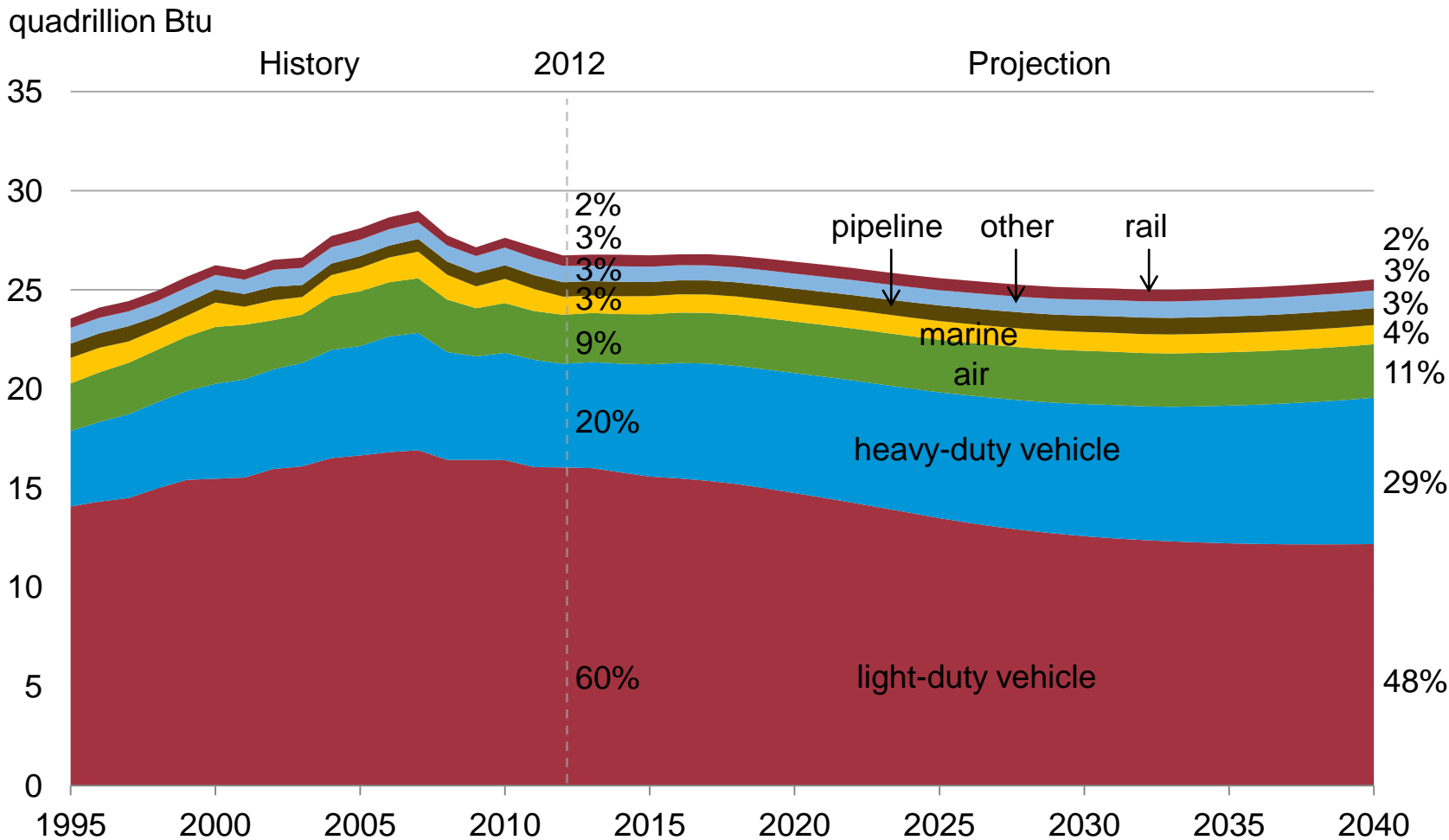
- LNG fuel choice based on endogenous fuel economics calculation
  - Incremental cost of LNG engine + fuel tender = \$1,000,000
  - Annual ton-miles travelled per locomotive = 70,868,670
  - Efficiency (Btu/ton-mile) is fuel neutral
  - Discount rate = 11.5% (Class I Railroad average return on equity)
  - 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



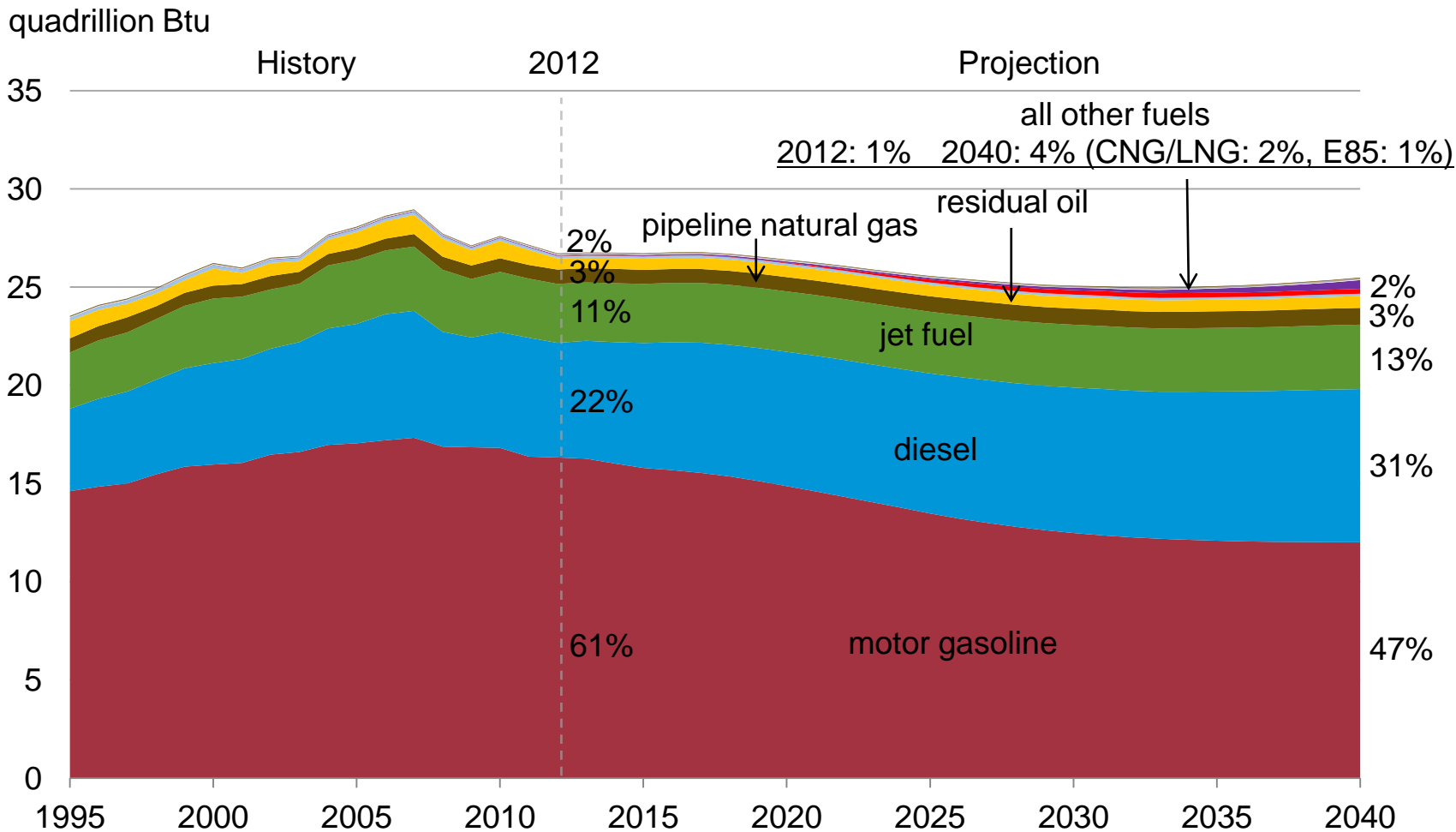
Source: AEO2014 preliminary

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

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

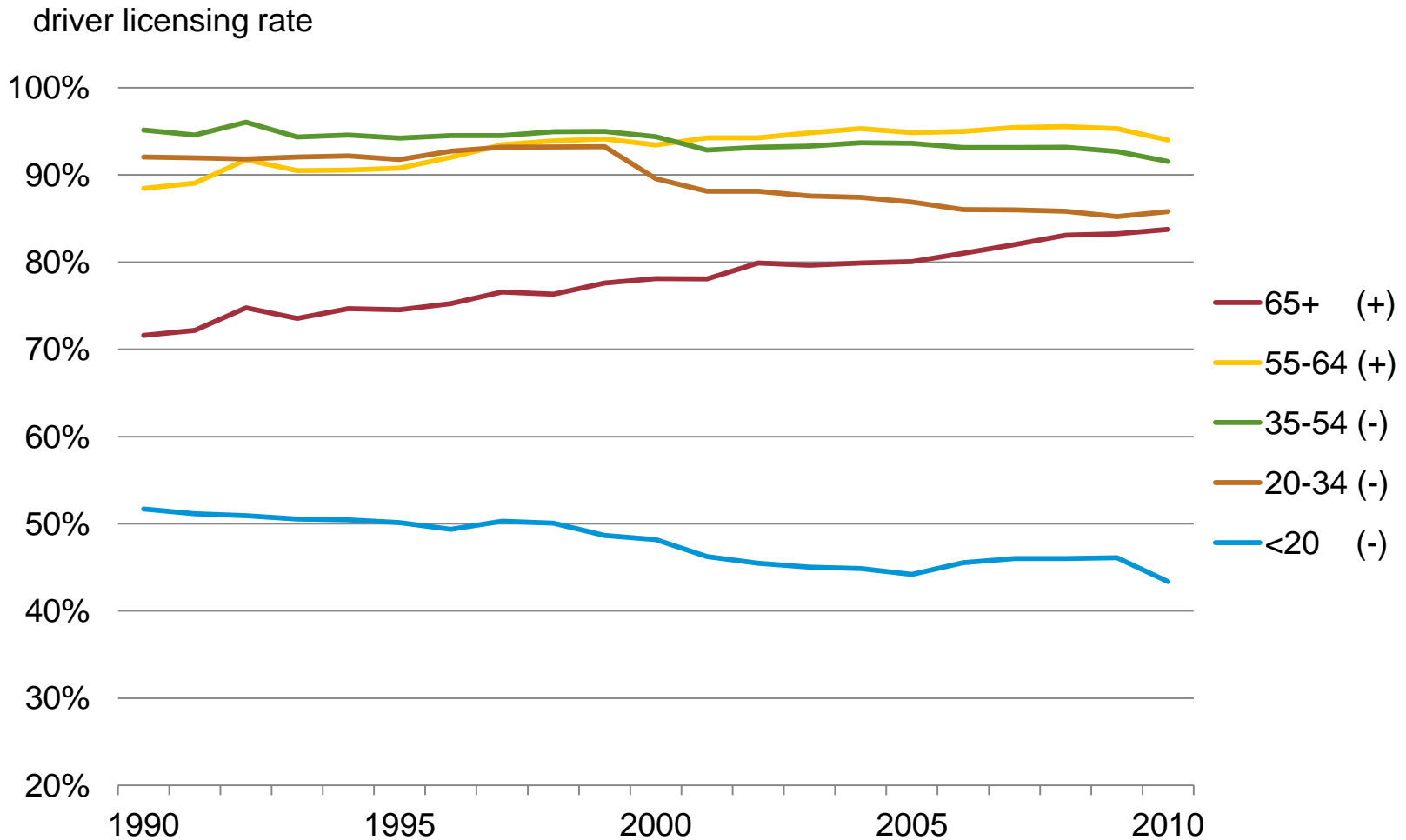


# Annual vehicle miles traveled by licensed drivers



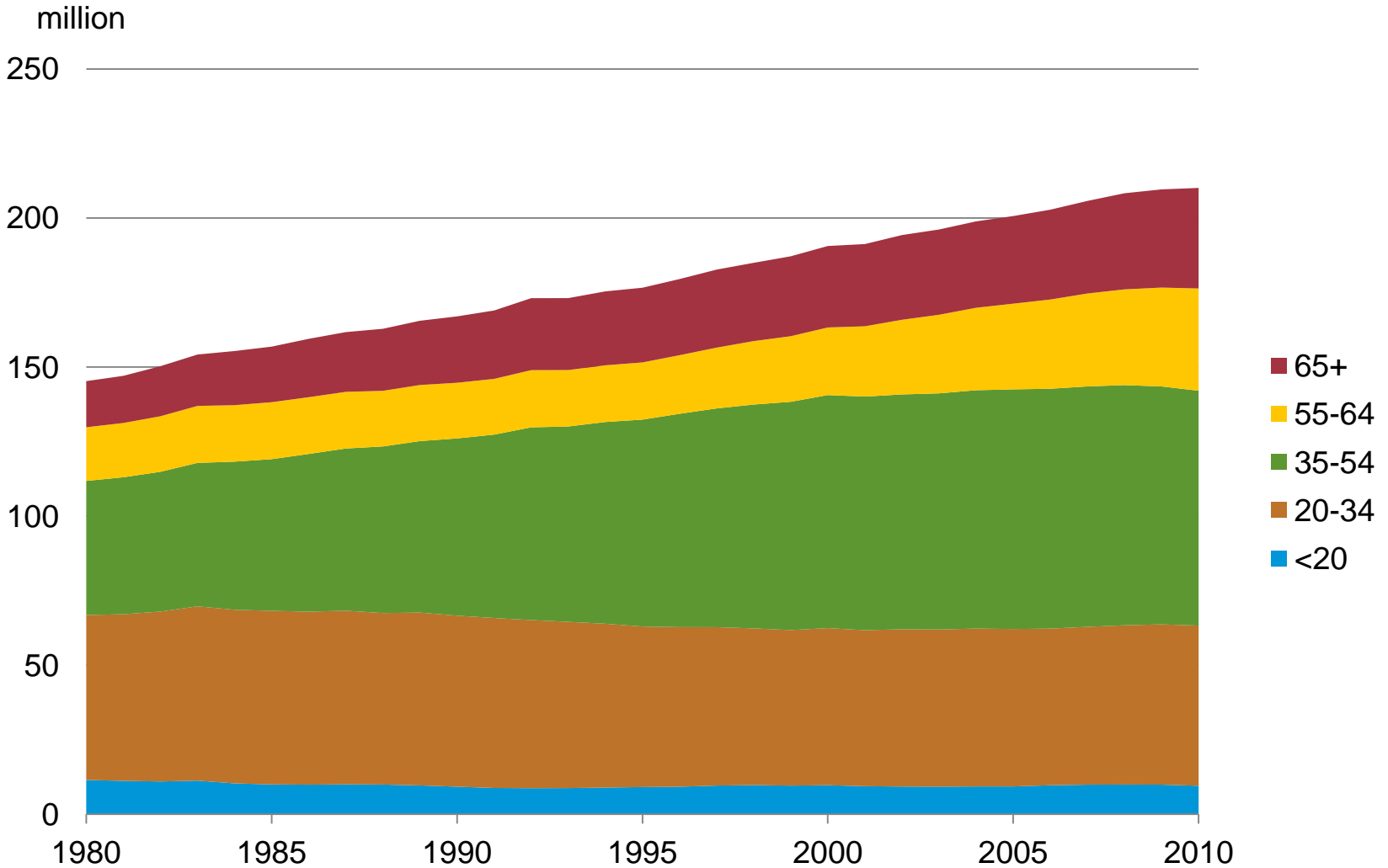
Source: NHTS and FHWA Highway Statistics

# 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

census division	chemicals rubber plastic	primary metals	proc food	paper products	petroleum products	stone, clay, glass, concrete	metal durables	other mfg	agri	mining
1	0.2%	0.2%	0.5%	0.2%	0.2%	0.1%	0.1%	0.4%	0.1%	0.2%
2	1.2%	1.1%	2.0%	0.5%	0.5%	0.4%	0.5%	1.5%	0.5%	1.1%
3	2.5%	3.1%	3.0%	1.1%	0.6%	1.1%	1.9%	2.4%	0.8%	1.6%
4	0.8%	0.6%	1.9%	0.3%	0.4%	0.6%	0.6%	1.0%	1.8%	1.3%
5	2.3%	1.3%	2.4%	1.1%	0.8%	1.5%	0.9%	3.4%	0.8%	1.9%
6	0.8%	1.0%	0.9%	0.6%	0.3%	0.7%	0.7%	1.5%	0.2%	1.3%
7	2.5%	1.9%	2.1%	0.7%	1.5%	1.3%	1.1%	2.2%	0.7%	1.5%
8	0.6%	0.4%	0.8%	0.2%	0.4%	0.7%	0.2%	1.2%	0.4%	0.8%
9	1.5%	0.9%	3.6%	0.9%	0.9%	1.1%	1.0%	3.3%	1.3%	1.0%

# Example: heavy-duty truck ton-mile per dollar of industrial output

census division	chemicals rubber plastic	primary metals	proc food	paper products	petroleum products	stone, clay, glass, concrete	metal durables	other mfg	agri	mining
1	0.07	0.33	0.25	0.27	1.63	0.31	0.01	0.10	0.02	3.68
2	0.09	0.28	0.32	0.25	0.93	0.26	0.03	0.18	0.19	1.00
3	0.14	0.43	0.26	0.31	1.23	0.54	0.04	0.23	0.25	1.22
4	0.13	1.31	0.22	0.14	2.04	0.70	0.04	0.21	0.58	1.44
5	0.14	0.53	0.24	0.39	4.66	0.56	0.04	0.21	0.16	0.83
6	0.15	0.35	0.24	0.37	2.85	0.75	0.04	0.34	0.07	0.65
7	0.14	0.57	0.28	0.38	2.26	0.85	0.03	0.39	0.17	0.06
8	0.23	0.75	0.22	0.33	21.62	0.61	0.01	0.29	0.18	0.11
9	0.13	0.76	0.44	0.29	1.87	0.67	0.02	0.32	0.17	0.15