

Annual Energy Outlook 2014: Modeling Updates in the Transportation Sector



John Maples, Patricia Hutchins, Nicholas Chase

Office of Energy Analysis; Energy Consumption and Efficiency Analysis

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Overview

- Light-duty vehicle
 - Vehicle miles traveled by age cohort, update modeling parameters, employment and VMT
 - E85 demand
 - Battery electric vehicle cost, efficiency, and availability
- Heavy-duty vehicle, rail, marine
 - Regionalization of freight movement (vehicle miles traveled and ton-mile) by commodity
 - Rail and marine fuel efficiency update
- Potential future updates
 - Heavy-duty vehicle market by regional, technology, and representation of HD national program
 - Regionalization (U.S.) of international shipping
 - Natural gas as a fuel choice for locomotives and marine vessels

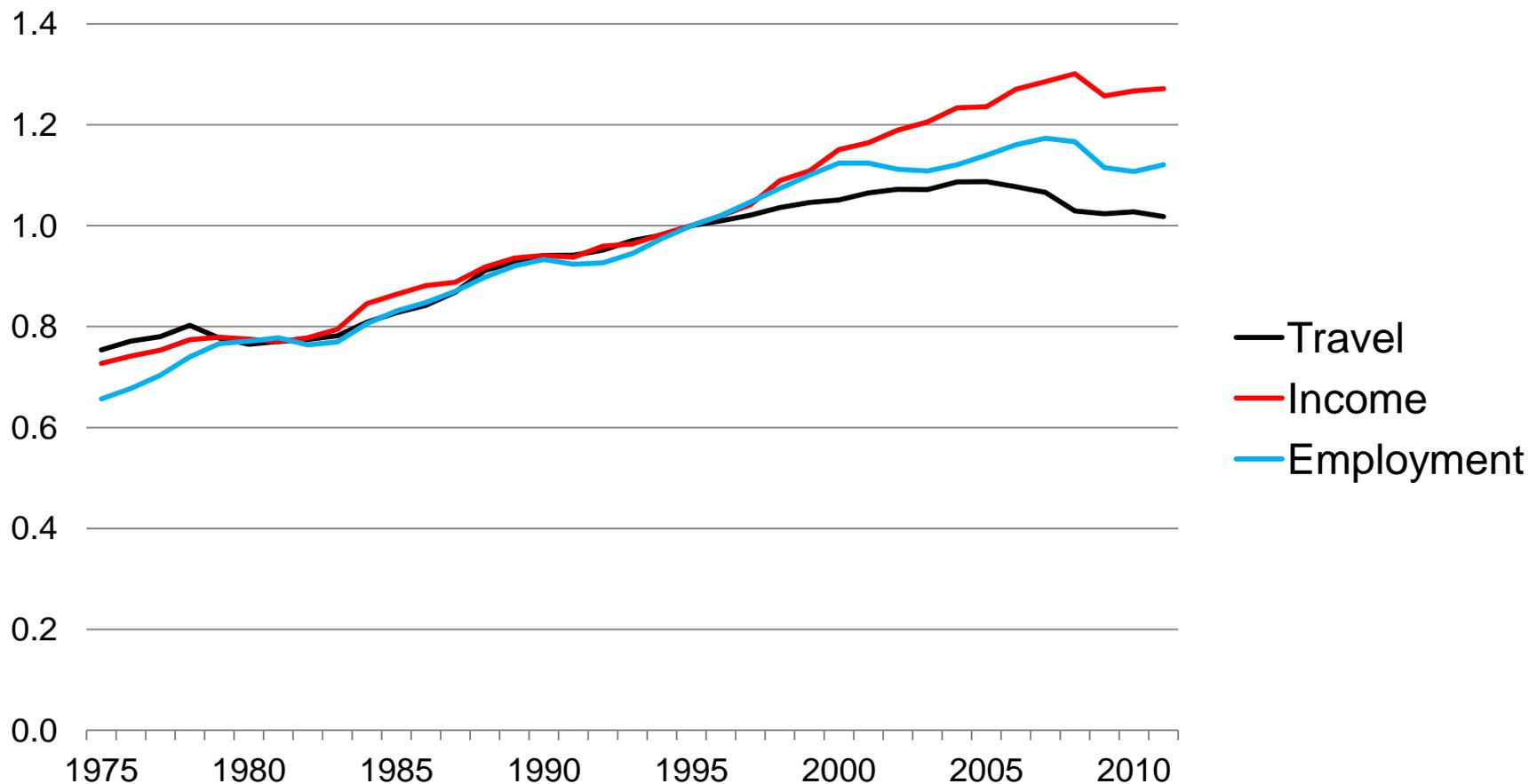
Light-duty vehicle

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
- Data limitations restrict ability to analyze current activity and behavior
- Goal will be to include age related travel element to projection

Growth trends in travel, income, and employment

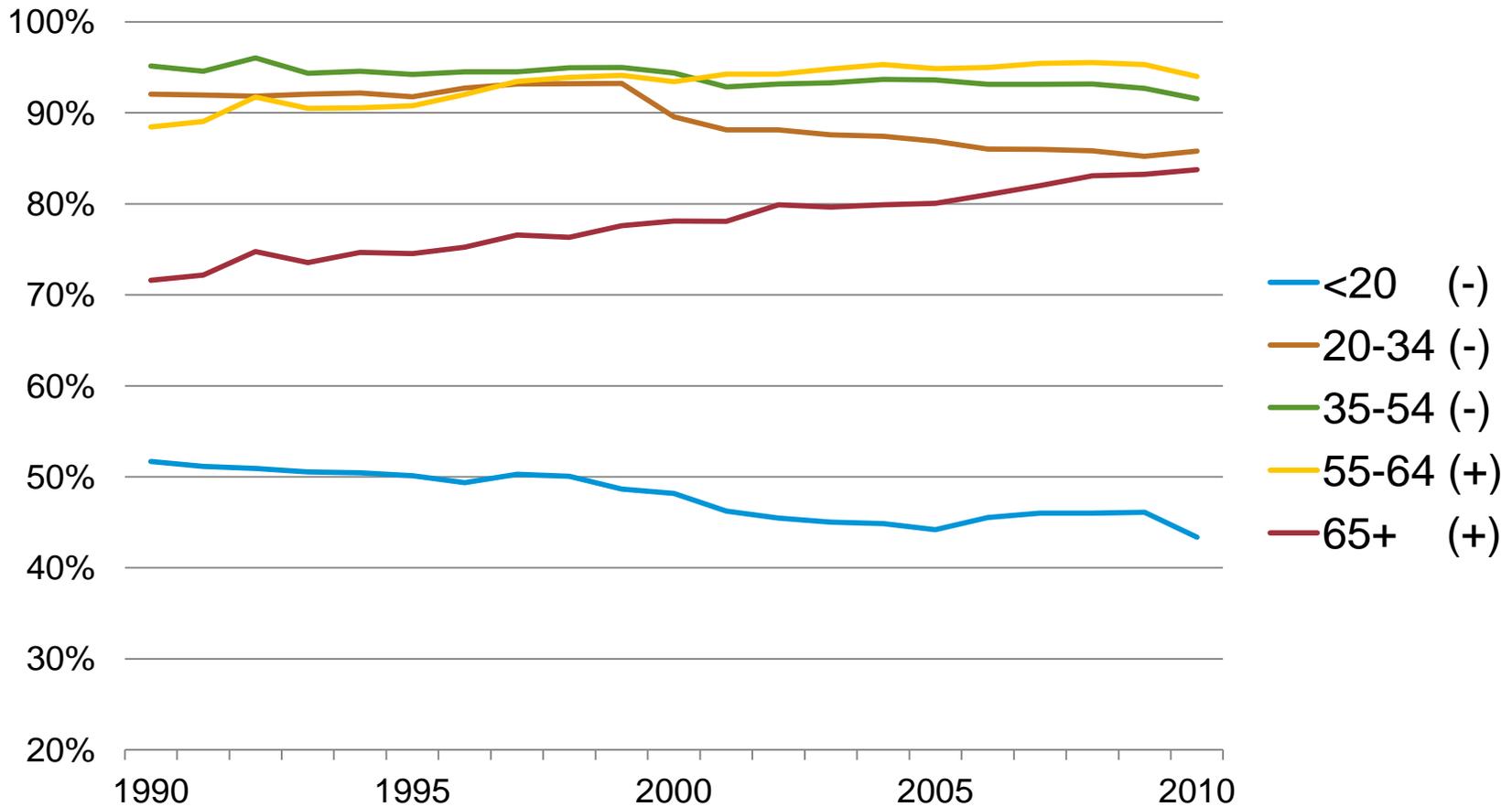
Indexed to 1995



— Travel
— Income
— Employment

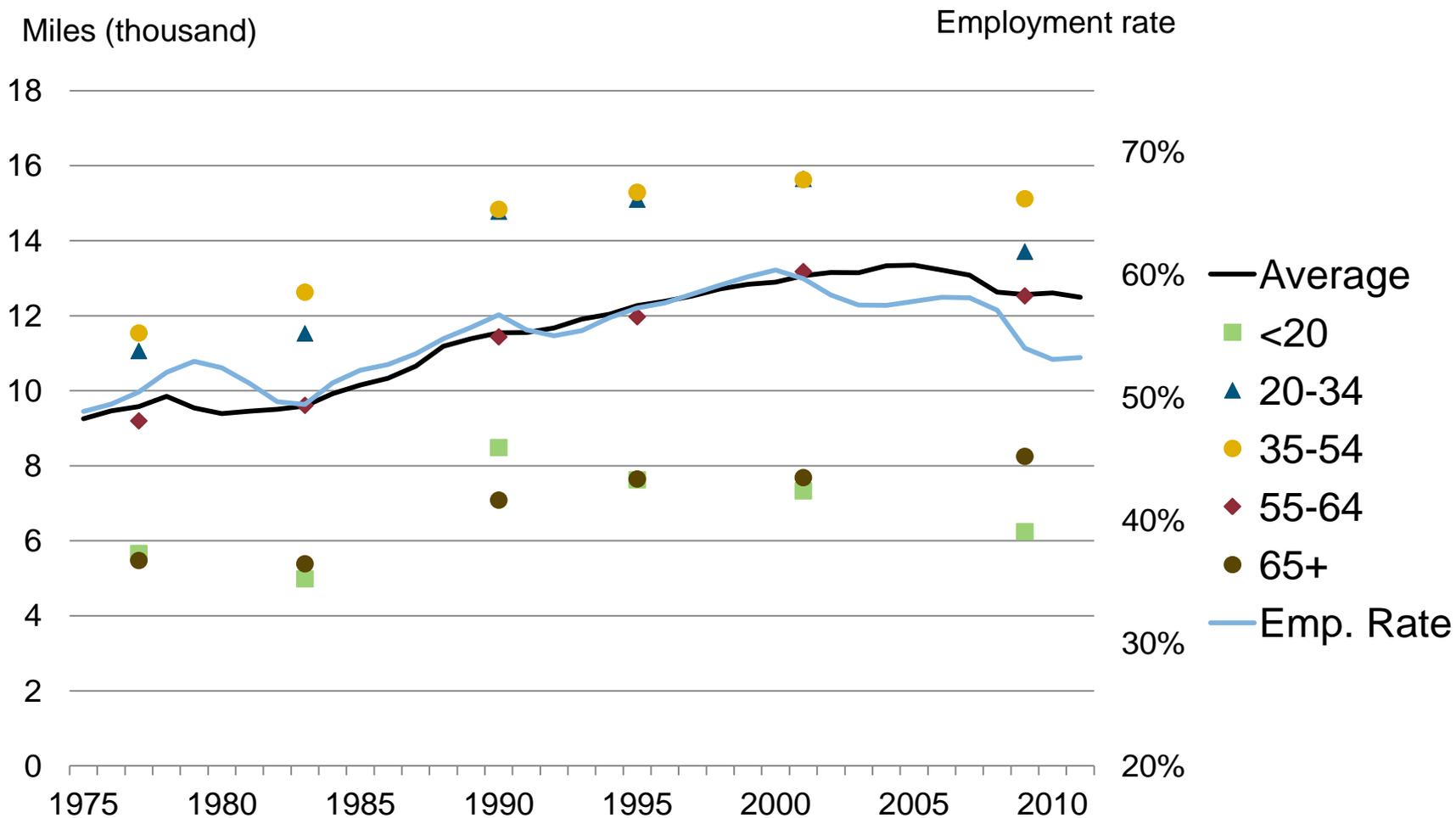
Licensing rates by age cohort

Percent of age cohort with a drivers license



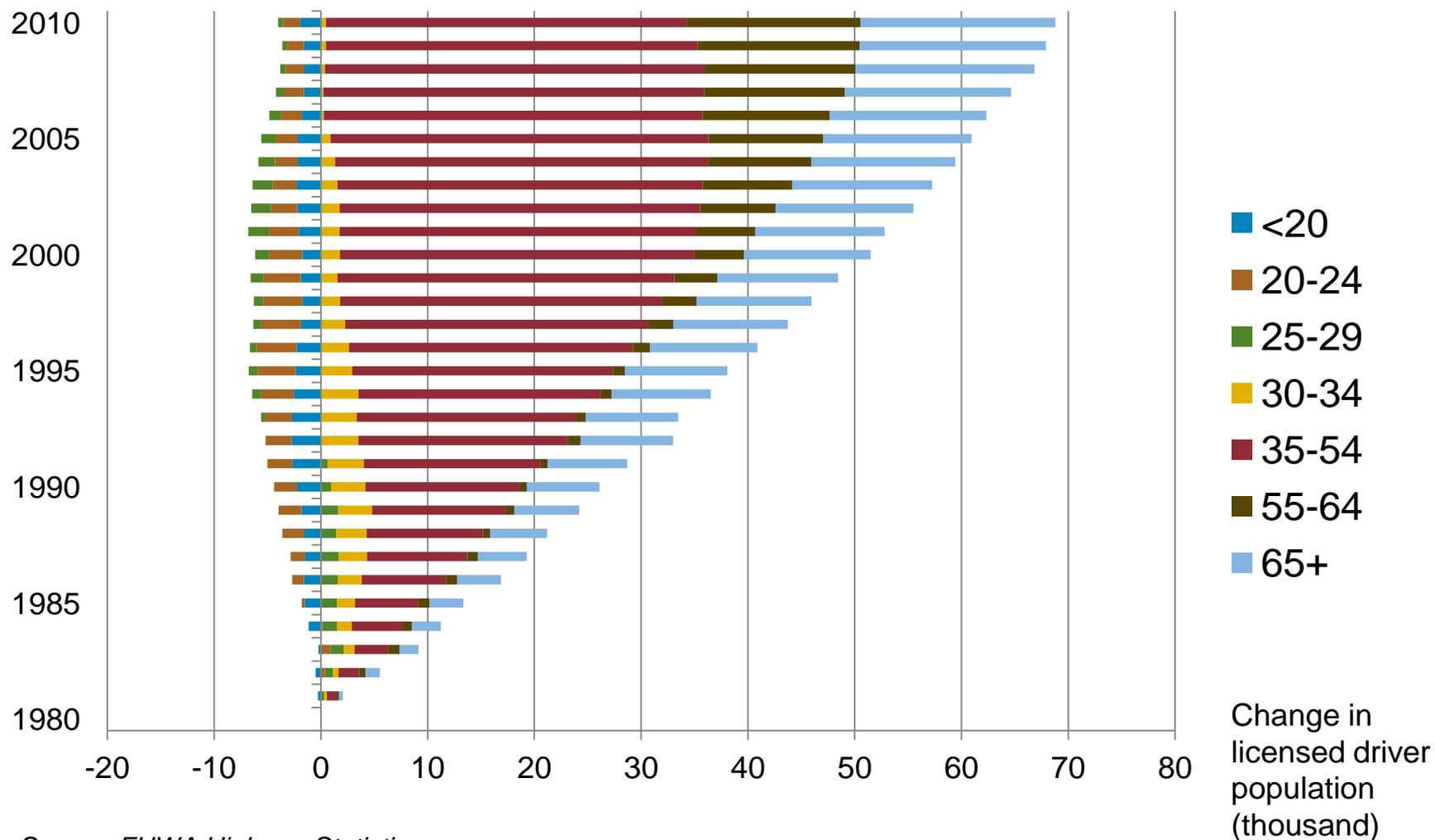
Source: FHWA Highway Statistics

Annual vehicle miles traveled by licensed drivers



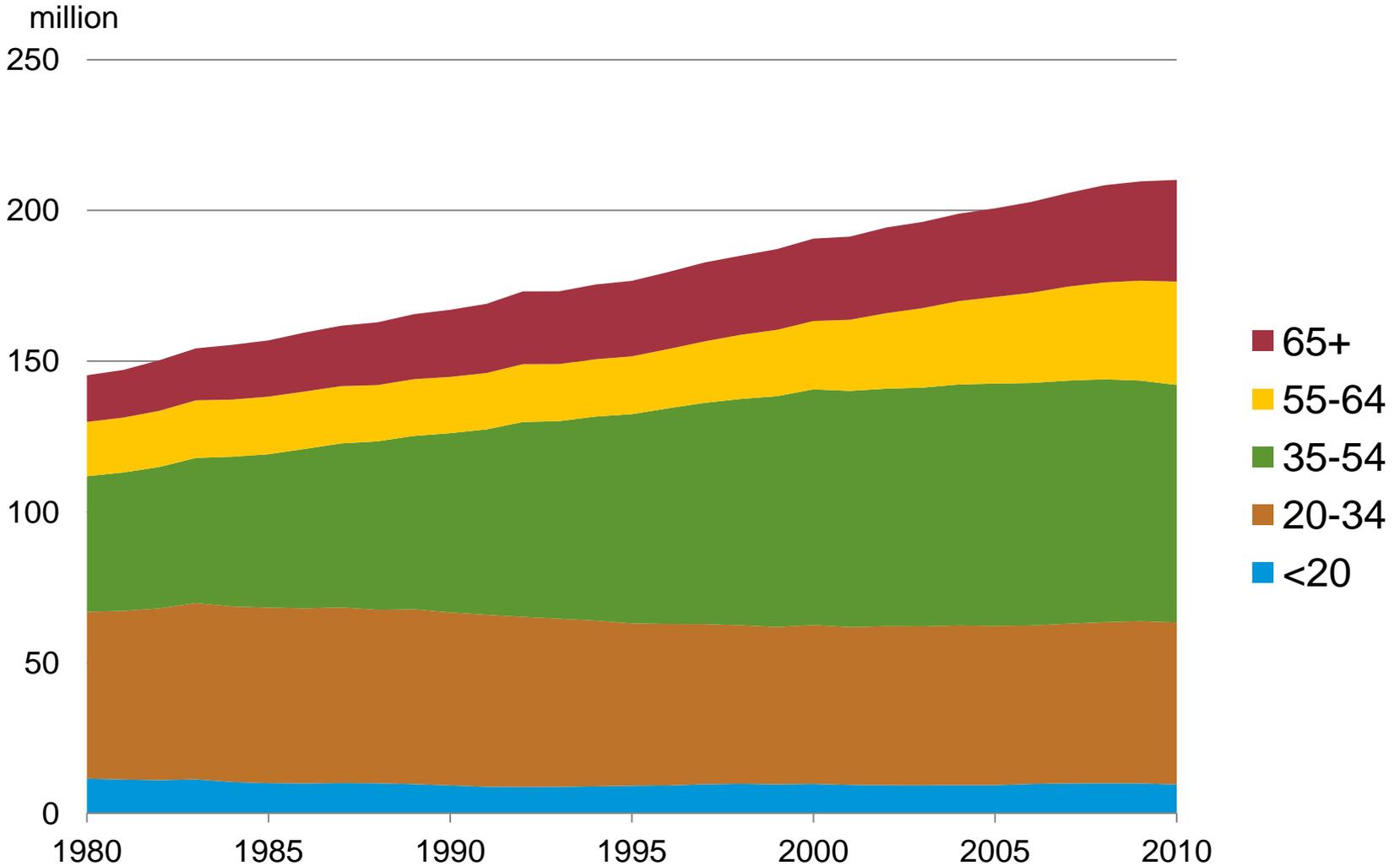
Source: NHTS and FHWA Highway Statistics

Growth in driver licensing by age cohort



Source: FHWA Highway Statistics

Driver licenses by age cohort



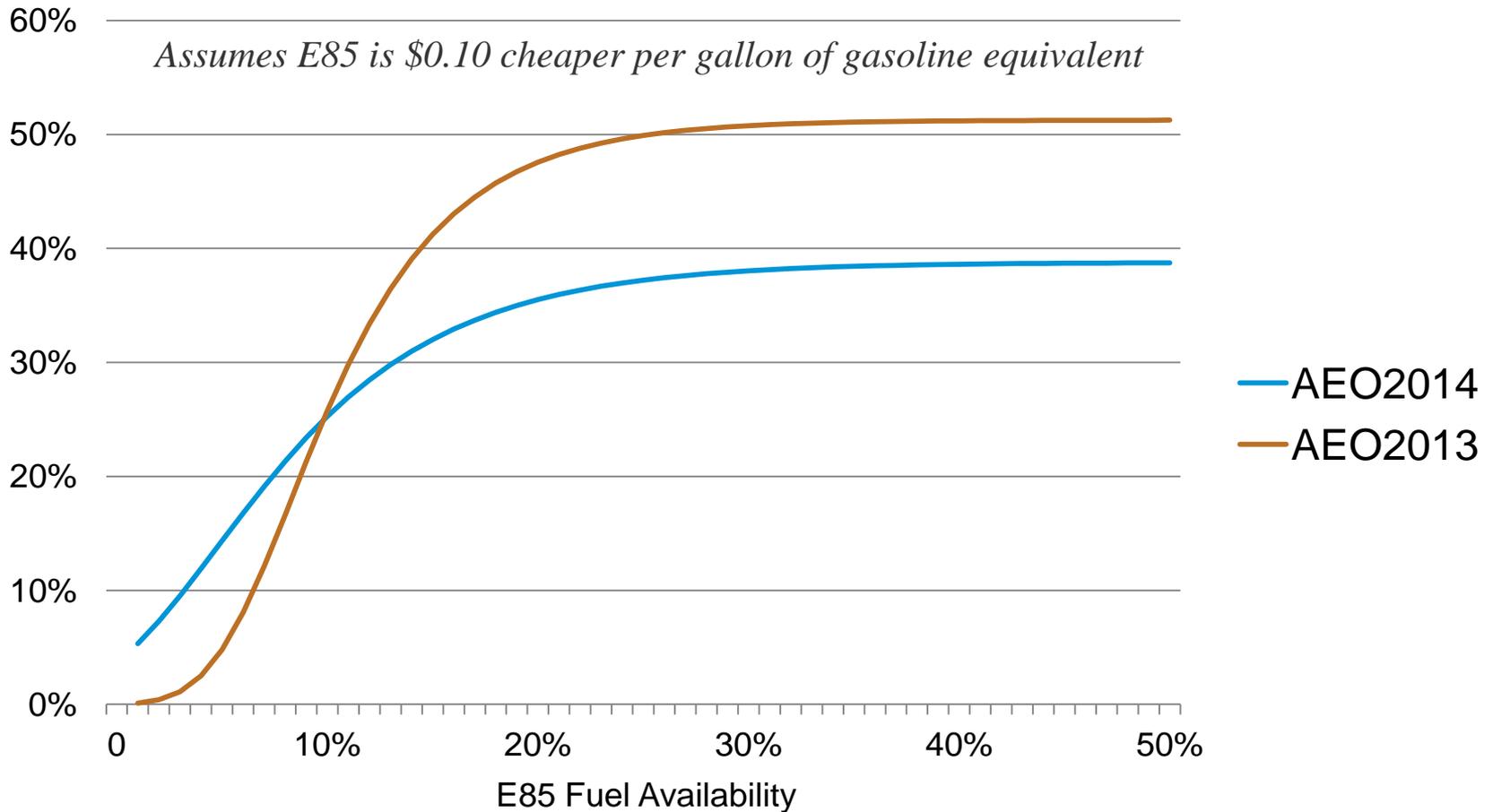
Source: FHWA Highway

Consumer preference for E85

- E85 demand determined using a probability model developed by Greene at ORNL
 - Market share determine by fuel prices and E85 availability
- Current model assumes single consumer behavior across census divisions the 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

Consumer choice for E85

E85 market share



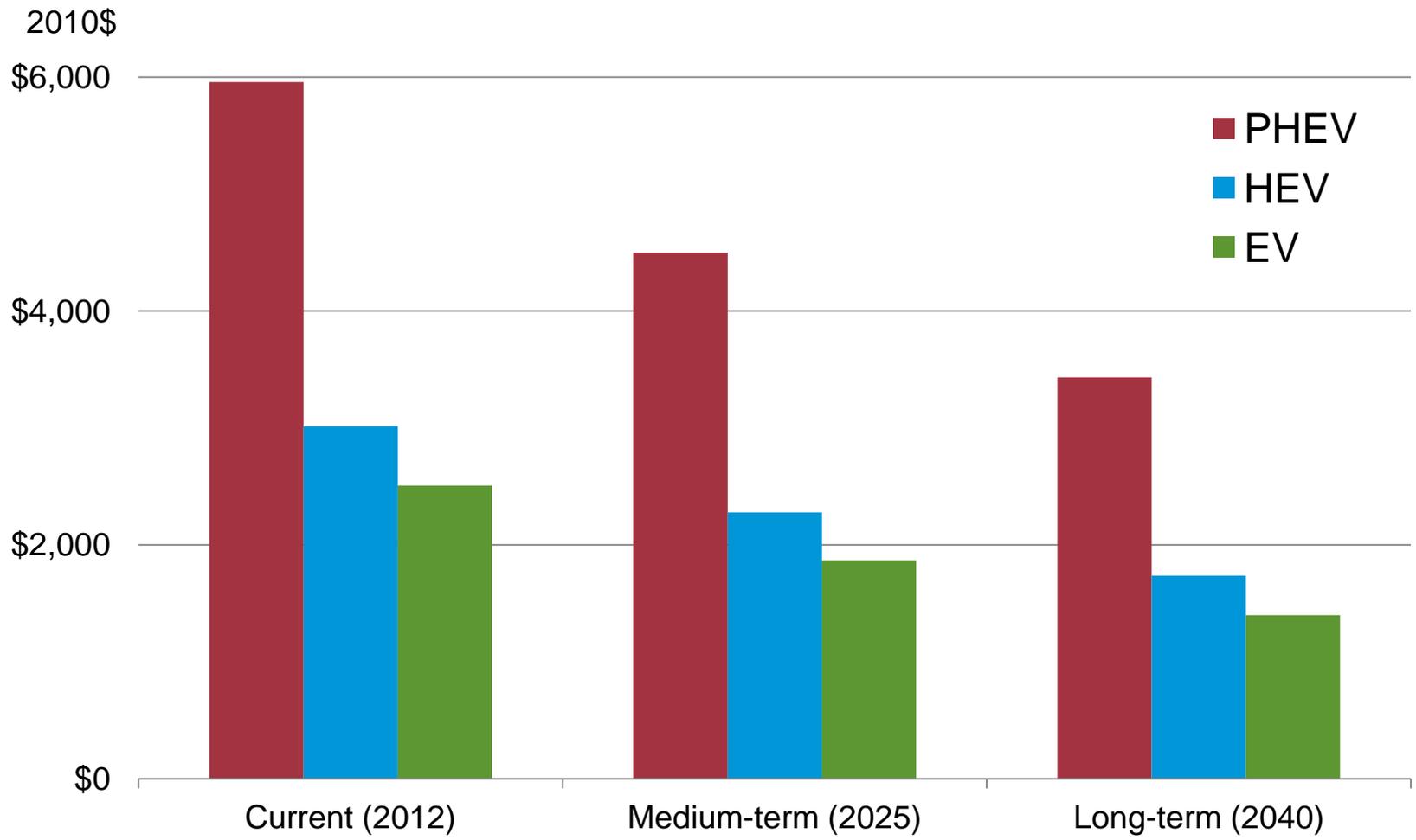
Battery electric vehicle modeling updates

- Battery size (kWh)
 - OEM manufacturer websites have model year 2012 and 2013 data on battery size (kWh):
 - HEV: Toyota Prius hybrid (1.7 kWh NiMH)
 - Volkswagen Jetta hybrid (1.1 kWh lithium-ion)
 - PHEV10: Toyota Prius plug-in hybrid (4.4 kWh lithium-ion)
 - PHEV40: Chevy Volt plug-in hybrid (16.5 kWh lithium-ion)
 - EV100: Nissan Leaf plug-in electric (24.0 kWh lithium-ion)
 - EV200: Tesla Model S 200 mile plug-in electric (60.0 kWh lithium-ion)
- 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

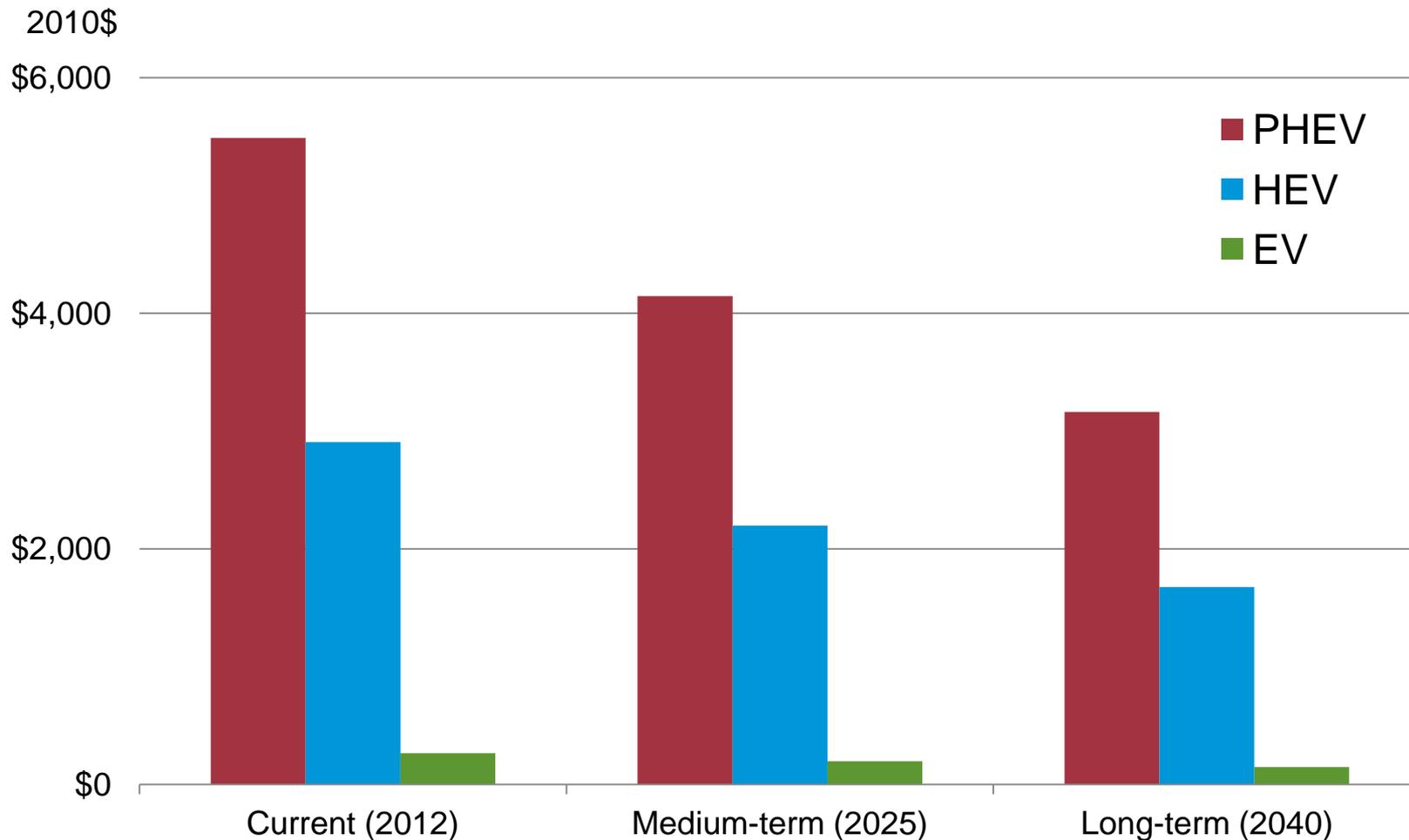
Battery electric vehicle modeling updates (continued)

- 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, examples:
 - Midsize: Toyota Prius Plug-in (PHEV10), 2013
 - Compact: Ford Focus EV (EV100), 2012
 - Large: Tesla Model S (EV200), 2013
- Fuel economy equivalent
 - All-electric fuel efficiency calculated using battery size and vehicle all-electric range

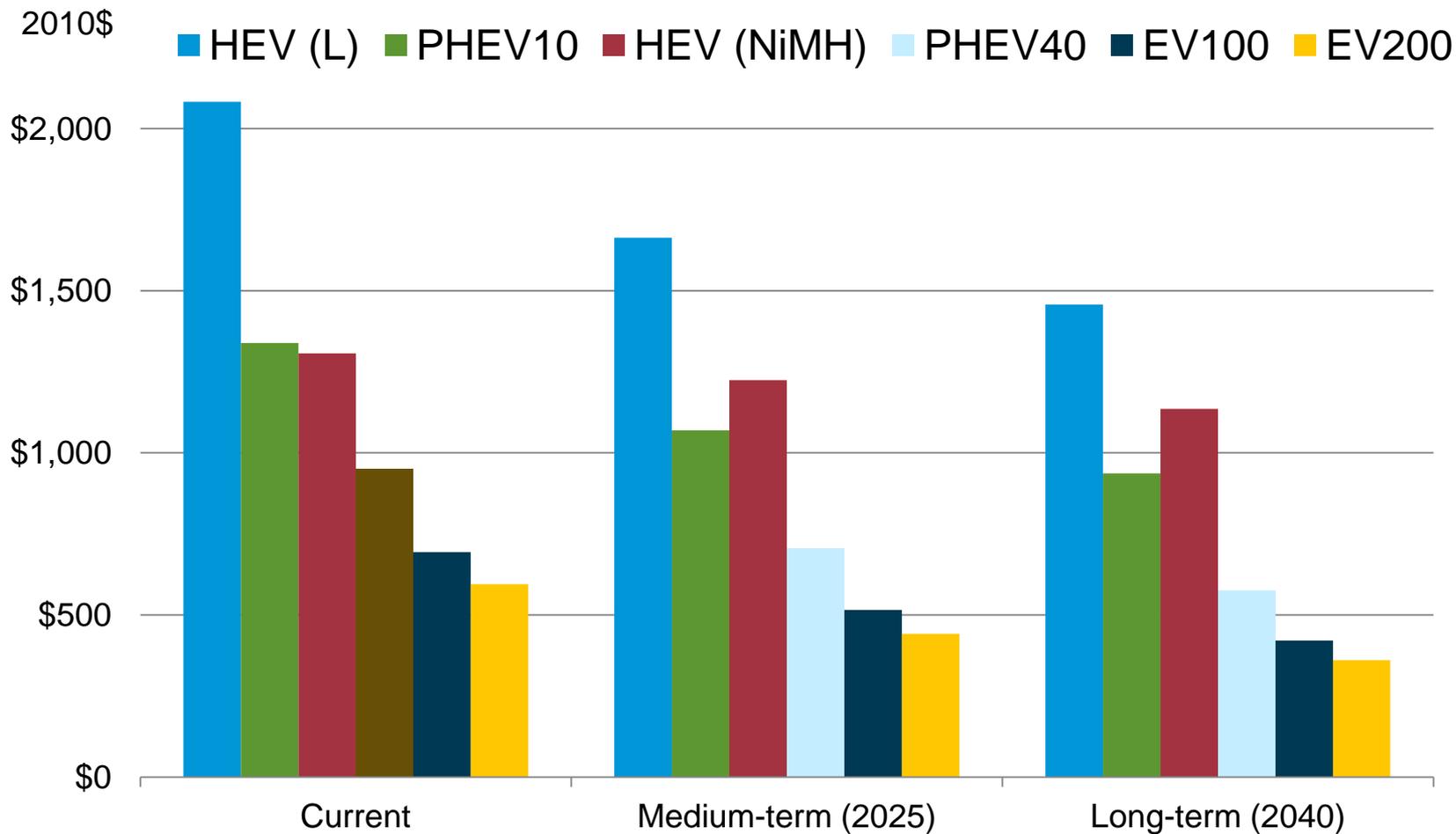
Midsize passenger car non-battery incremental (net) cost to consumer



Small sports utility vehicle non-battery incremental (net) cost to consumer



Battery cost to consumer (\$/kWh)

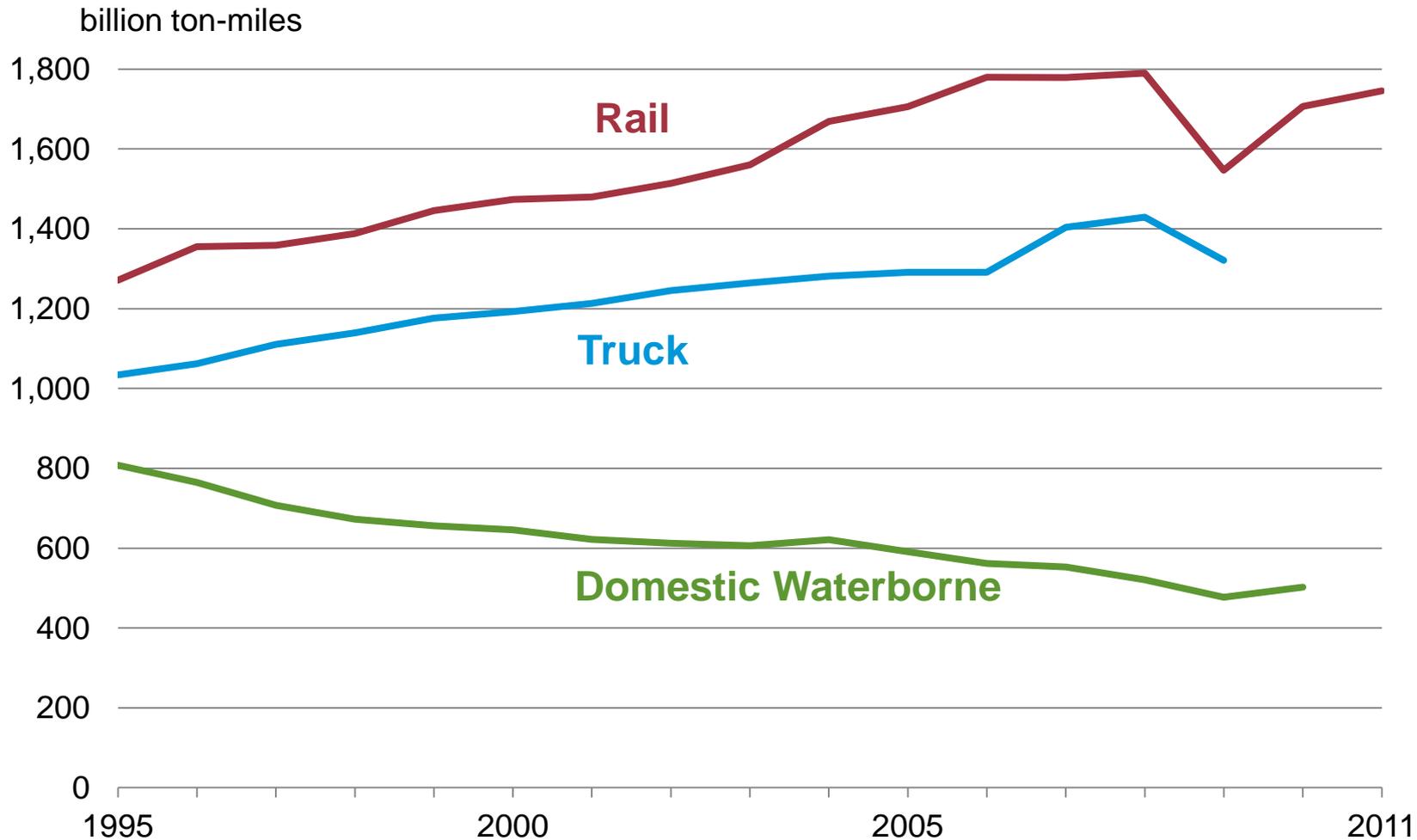


Heavy-duty vehicle, rail, marine

Regionalizing freight movement by mode (truck, rail, marine) 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 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
- Ton-mile and truck vehicle miles projected using ton-mile/\$output by mode, by census division, by commodity

Historical ton-mile data by mode



Updated freight modes to incorporate regionalization by commodity using CFS ton-mile shares: Rail 2007

Census Division	chemicals rubber plastic	primary metals	processed food	paper products	petroleum products	stone, clay, glass, concrete	metal durables	other manu	agriculture	mining	Total
1	0.1%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.1%	0.0%	0.1%	0.4%
2	0.5%	0.1%	0.2%	0.1%	0.3%	0.0%	0.0%	0.2%	0.3%	1.1%	2.7%
3	1.2%	0.5%	0.3%	0.2%	0.4%	0.1%	0.2%	0.2%	0.9%	10.1%	14.0%
4	0.3%	0.1%	0.8%	0.1%	0.1%	0.1%	0.0%	0.3%	2.5%	6.6%	10.9%
5	1.0%	0.1%	0.1%	0.2%	0.1%	0.1%	0.1%	0.1%	0.5%	9.1%	11.5%
6	0.7%	0.3%	0.0%	0.2%	0.1%	0.0%	0.0%	0.0%	0.1%	5.9%	7.4%
7	3.2%	0.3%	0.3%	0.4%	1.1%	0.1%	0.0%	0.2%	1.3%	9.8%	16.8%
8	0.3%	0.0%	0.1%	0.1%	0.4%	0.1%	0.0%	0.2%	0.2%	30.1%	31.5%
9	0.5%	0.2%	0.6%	0.4%	0.4%	0.0%	0.1%	0.7%	1.0%	0.8%	4.8%
Total	7.7%	1.8%	2.5%	1.7%	2.9%	0.5%	0.5%	2.1%	6.7%	73.6%	

Industrial output shares by census division and industrial sector in 2007 (2005\$)

Census Division	chemicals rubber plastic	primary metals	processed food	paper products	petroleum products	stone, clay, glass, concrete	metal durables	other manu	agriculture	mining	Total
1	0.5%	0.1%	0.3%	0.2%	0.0%	0.1%	1.9%	0.6%	0.1%	0.0%	3.7%
2	2.5%	0.7%	1.0%	0.3%	0.1%	0.2%	2.7%	1.4%	0.3%	0.2%	9.3%
3	3.6%	1.5%	2.1%	0.6%	0.1%	0.4%	10.5%	1.9%	0.6%	0.2%	21.5%
4	1.0%	0.1%	2.0%	0.2%	0.0%	0.2%	3.3%	0.8%	0.6%	0.2%	8.5%
5	3.0%	0.4%	1.5%	0.6%	0.0%	0.4%	4.4%	3.0%	0.8%	0.4%	14.5%
6	1.1%	0.6%	0.7%	0.4%	0.0%	0.2%	3.4%	0.9%	0.3%	0.4%	7.9%
7	3.6%	0.5%	1.1%	0.3%	0.1%	0.3%	4.1%	0.8%	0.6%	3.9%	15.4%
8	0.3%	0.1%	0.5%	0.1%	0.0%	0.2%	1.6%	0.6%	0.5%	1.4%	5.2%
9	1.3%	0.1%	1.5%	0.3%	0.1%	0.3%	5.5%	1.9%	1.7%	1.1%	13.9%
Total	16.8%	4.1%	10.8%	3.1%	0.5%	2.2%	37.4%	11.9%	5.4%	7.8%	

Regionalizing historical ton-mile data by mode and by commodity

- Commodity flow survey allows regionalization of ton-miles by mode and by commodity
- Historical industrial output data available by commodity from NEMS Macroeconomic Module (2005\$)
- These data used to calculate ton-miles per dollar of industrial output by mode, by census division, and by commodity

Rail—ton-miles per dollar industrial output 2007

Census Division	Chemicals rubber plastic	primary metals	processed food	paper products	petroleum products	stone, clay, glass, concrete	metal durables	other manu	agriculture	mining
1	0.07	0.10	0.02	0.15	0.26	0.00	0.00	0.05	0.05	2.62
2	0.06	0.06	0.06	0.08	1.02	0.01	0.00	0.05	0.30	2.35
3	0.11	0.11	0.04	0.11	1.68	0.08	0.01	0.04	0.53	15.68
4	0.11	0.76	0.14	0.09	1.13	0.17	0.00	0.11	1.45	10.02
5	0.11	0.14	0.03	0.13	1.42	0.08	0.01	0.01	0.19	7.72
6	0.21	0.15	0.02	0.19	2.18	0.05	0.00	0.01	0.16	5.47
7	0.30	0.22	0.10	0.38	3.06	0.08	0.00	0.09	0.75	0.85
8	0.38	0.23	0.05	0.28	43.73	0.17	0.00	0.13	0.15	7.51
9	0.13	0.46	0.13	0.36	1.49	0.03	0.01	0.13	0.20	0.26

Projecting regional ton-miles by mode, census division, and commodity

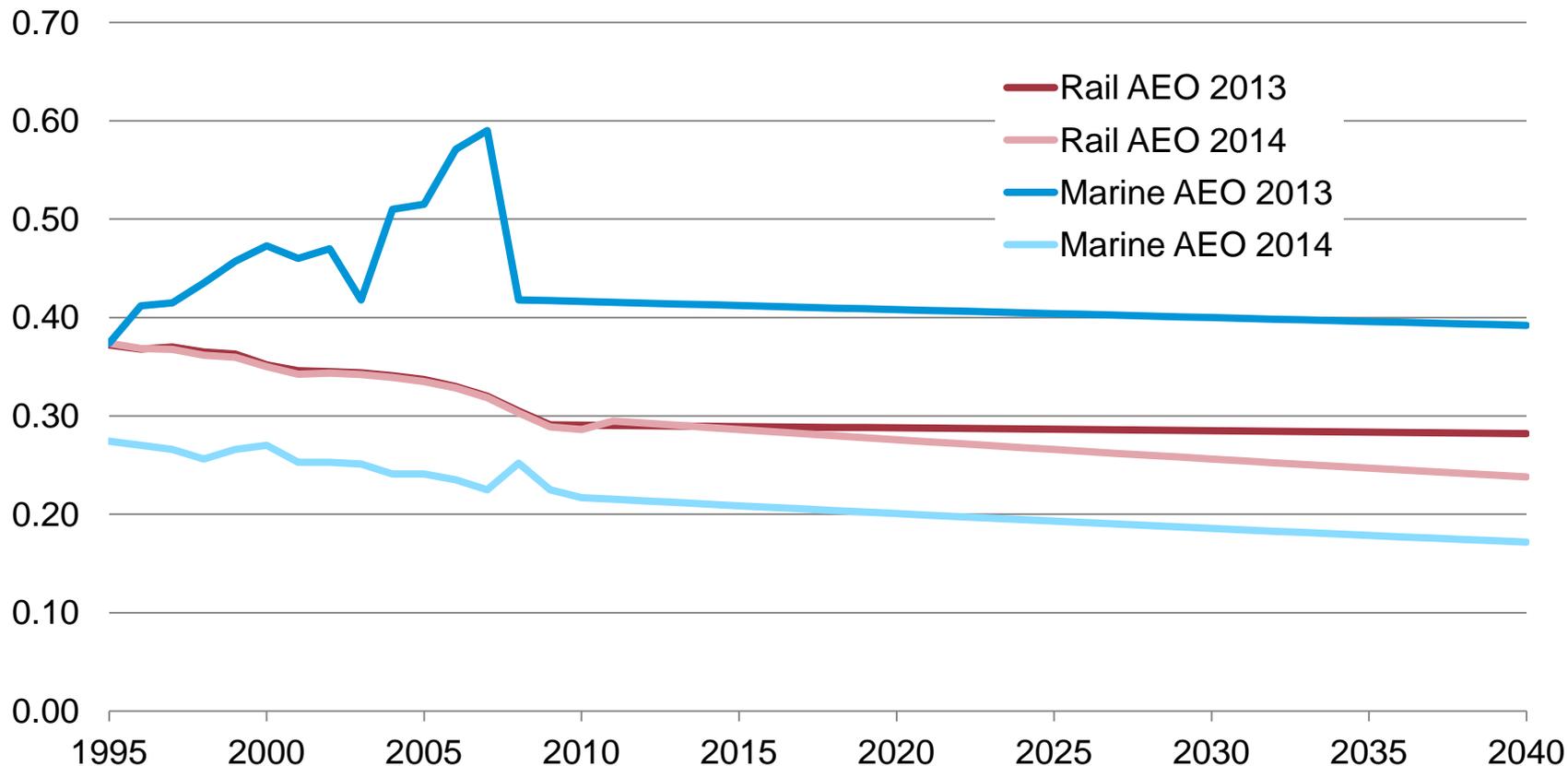
- For each mode, census division, and commodity grouping
 - $\text{Ton-miles}(\text{year-1}) + (\text{Industrial Output}(\text{year}) * \text{ton-miles per } \$ \text{ output})$
- Ton-miles vary as industrial output rises or declines (ton-miles per \$ output vary by mode)

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
- 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

Proposed freight rail and domestic marine efficiencies

Btu / 1,000 ton-miles



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

Future modeling updates

- Further study and update to heavy-duty vehicle technology attributes and penetration, vehicle market representation, and modeling of HD National Program (Polk data)
- Regionalization of international shipping energy demand (U.S. Army Corps of Engineers PDSTATE data)
- Natural gas as a fuel choice for locomotives and marine vessels

Discussion/questions

Nicholas Chase / phone: 202-586-8851
/ email: nicholas.chase@eia.gov

Patricia Hutchins / phone: 202-586-1029
/ email: patricia.hutchins@eia.gov

John Maples / phone: 202-586-1757
/ email: john.maples@eia.gov

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