Annual Energy Outlook 2025 Working Group Meeting

Transportation sector

Energy Consumption and Efficiency Modeling Team
May 22, 2024 | Virtual

Outline

- Recap of *Annual Energy Outlook 2023* (AEO2023)
- Planned data and modeling updates for the AEO2025 Transportation Sector Demand Model
  - Light-duty vehicles (LDV)
  - Heavy-duty vehicles (HDV)
  - Air
  - Other
- Discussion

AEO Reference case: Assumptions

- **Policy**: The AEO Reference case projects a future where current laws and regulations—those that are signed into law and are enforceable—persist until their sunset date (or through 2050, if no sunset date). Pending regulations are not modeled.

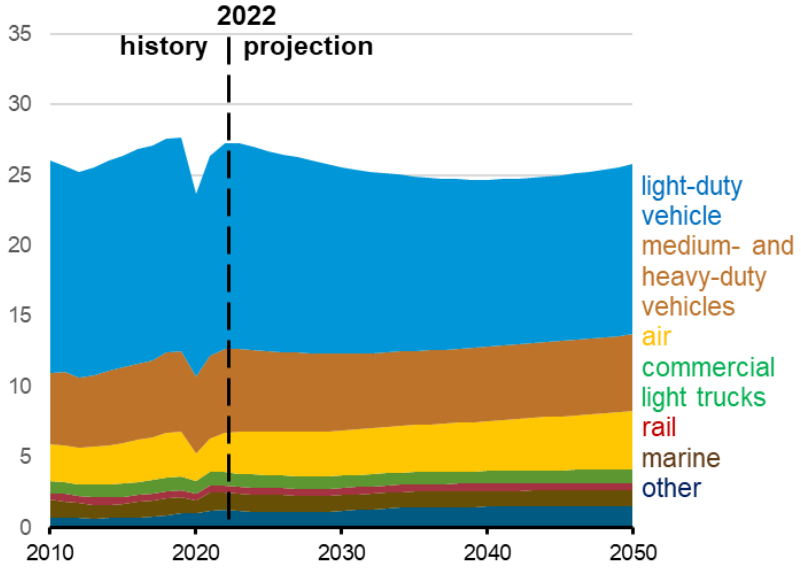
- **Technology**: The AEO Reference case projects technological evolution rather than revolution. For instance, we project significant cumulative reductions in battery costs due to incremental improvements and shifts in chemistry, but we *do not* explicitly include solid-state batteries, lithium-air batteries, or other as-yet-unproven technologies.

- **Industry**: We do not explicitly enforce any automaker announcements or aspirations regarding future electric (or other) vehicle sales shares.

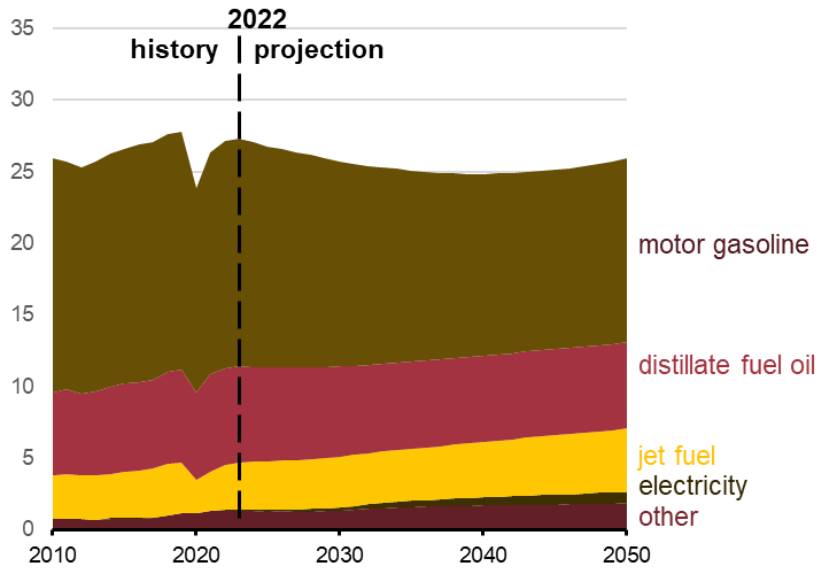
Annual Energy Outlook 2023 Recap

AEO2023: Transportation sector energy consumption

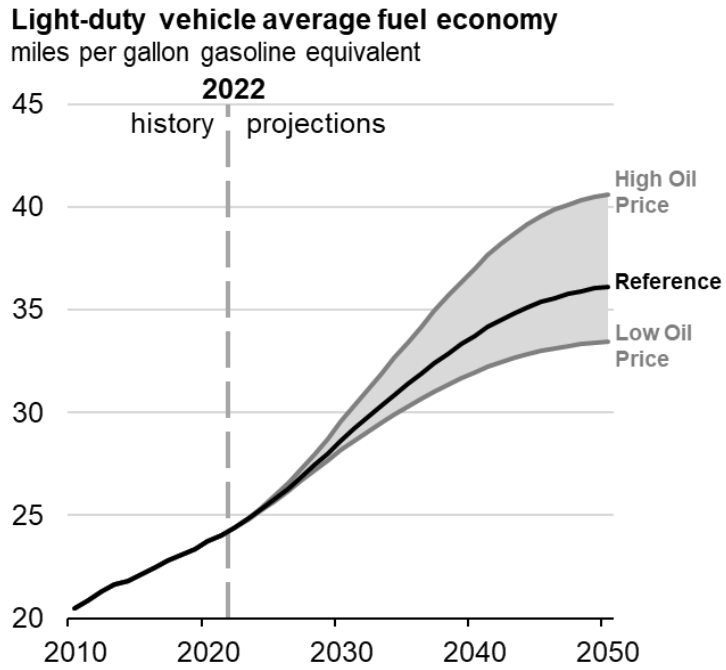
Transportation sector consumption by mode
AEO2023 Reference Case
quadrillion British thermal units

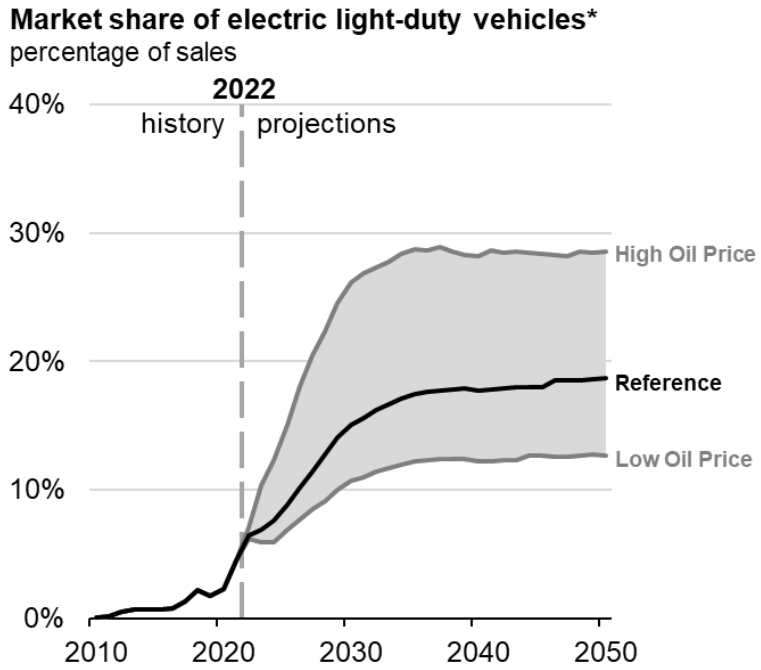


Transportation sector consumption by fuel
AEO2023 Reference Case
quadrillion British thermal units



AEO2023: EV market share and fuel economy





Data source: U.S. Energy Information Administration, *Annual Energy Outlook 2023* (AEO2023)
Note: *Includes battery electric and plug-in hybrid electric vehicles. Shaded regions represent maximum and minimum values for each projection year across the AEO2023 Reference case and side cases.

Annual Energy Outlook 2025 Modeling Update

Light-duty vehicles

LDV data updates

Data	Last historical year AEO2023	Last historical year AEO2025	Source	NEMS input file
On-road stock by census division, car/light-truck, fleet type, powertrain, and vintage	2021	2023	Polk (S&P)	trnstockx
Scrappage/survival by region and car/light truck	2021	2023	Polk (S&P)	trnldvx
Annual VMT per vehicle by vintage, powertrain, region, fleet, and car/light-truck	2021	2023	Polk (S&P)	trnldvx
Sales and attributes by size class, powertrain, and manufacturer	2020	2022 (maybe 2023)	EPA CAFE compliance database	trnldvx, trnfemx, trnhtsax
Sales and attributes by powertrain and manufacturer	2022 and prelim 2023	2023 and preliminary 2024	Wards Intelligence	For model calibration
Battery prices (dollars per kWh)	2022	2023 (maybe 2024)	BNEF	trnldvx

Note: VMT=vehicle miles traveled; EPA=U.S. Environmental Protection Agency; CAFE=Corporate Average Fuel Economy; NEMS=National Energy Modeling System

LDV new datasets and inputs

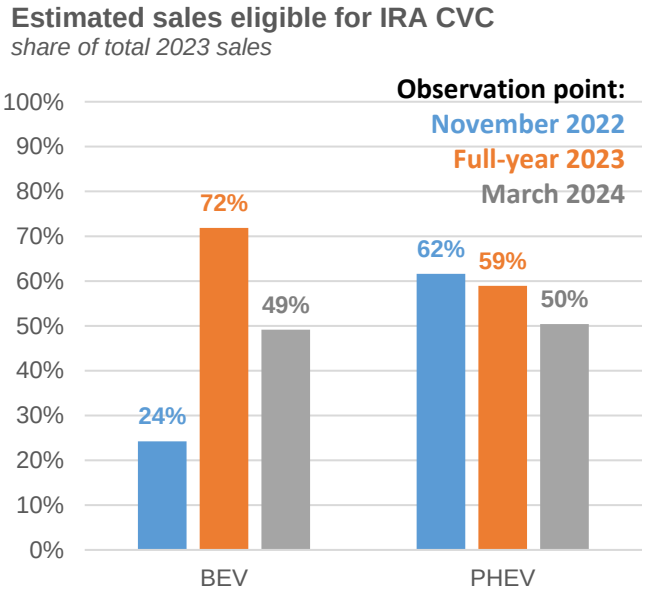
- Regional average EV registration fees (stock-weighted from state-level)
- EV charging ports by region and type (L1, L2, DCFC), based on AFDC data processed for EIA's *Monthly Energy Review* Appendix F
- Comprehensive model years 2010–2018 historical FEGuide/CAFE compliance/Wards attribute dataset. **National** sales and sales-weighted average attributes by size class, manufacturer, powertrain.
- Crosswalk Polk, Ward's, and EPA nameplates to merge all three datasets for model years 2019–2022. **Regional** sales-weighted average attributes by size class, manufacturer, powertrain

LDV model development

- Develop new consumer powertrain choice model
  - Move **from** coefficients that vary across our 16 size classes **to** coefficients that vary across region, manufacturer group, and size class
- Rebuild *trnfemx* and *trnhtsax* input files and related code to use new historical databases rather than attribute multipliers
- Breakout EV electricity demand by type (home, public L2, public DCFC) to send to the Electricity Market Module (EMM).
  - We will use sector-specific electricity prices from EMM; that is, rather than using the *transportation* electricity price, TRAN will use *residential* for home charging and *commercial* for public.
  - EMM will apply different load curves depending on charging type and mode, which will then affect residential and commercial electricity prices across all of NEMS.

LDV policy: IRA Section 30D Clean Vehicle Credit

- The IRS' interpretation of the Clean Vehicle Credit (CVC) changed significantly after AEO2023 modeling was frozen (Nov 2022).
- We revised the share of BEV and PHEV sales that were eligible in 2023 and are building a projection of eligibility through the life of the regulation (will be revised closer to model freeze).
- We anticipate a drop in eligibility in January 2025 (because of critical mineral sourcing requirements) followed by a slow increase as EVs percolate into the mass market, limited by increasing domestic/free-trade-agreement content requirements.



LDV policy: other

- **National Highway Traffic Safety Administration (NHTSA) CAFE** (pending) and **EPA LDV Multi-Pollutant Emissions Standards** (enacted)
- DOE **petroleum equivalency factor** update: apply changes to *fuel content factor* and *gasoline-equivalent fuel economy of electricity* between 2026 and 2030 according to the final March 2024 rule

Model year	Fuel content factor (FCF)	Gasoline-equivalent fuel economy of electricity (E_g)	Compliance mpg (210 watthours/mile tested efficiency)
2024-2026	1/0.15	12,307	391
2027	1/0.3625	28,996	381
2028	1/0.575	28,996	240
2029	1/0.7875	28,996	175
2030+	1.00	28,996	138

- **Zero-emission vehicle mandate** credit bank update (ACC I, not ACC II)

LDV battery cost methodology

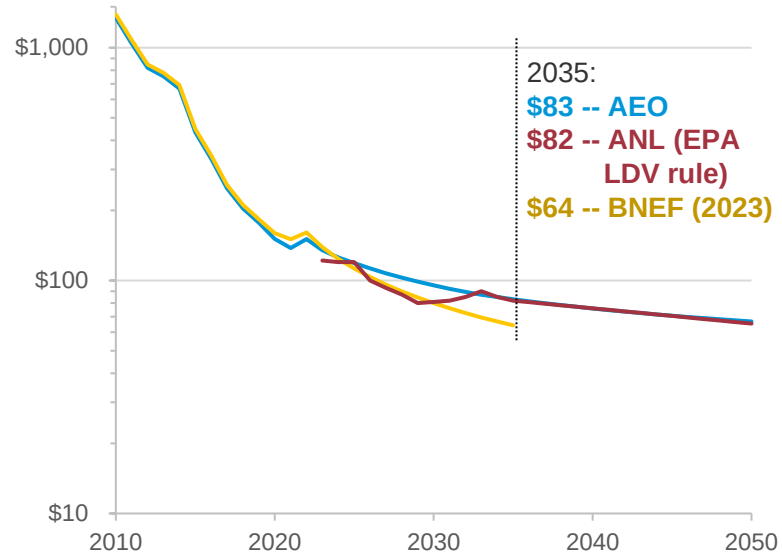
NEMS TRAN assumes battery costs decline over time as a function of cumulative production, a relationship represented by a two-stage learning curve model:

$$Li\_ion\_cost_{year} = pack\_a_{ildv} * \left(cumulative\_gwh_{year-1}\right)^{-\frac{\ln(1-LR\_a)}{\ln(2)}} + mat\_a_{ildv} * \left(cumulative\_gwh_{year-1}\right)^{-\frac{\ln(1-LR\_b)}{\ln(2)}}$$

where
LR_a = 16.5%
LR_b = 3.5%

The first stage estimates the battery *pack* production cost, while the second applies a minimum threshold for *active materials* cost.

Light-duty BEV battery direct manufacturing cost projection
2022 USD/kWh



Hsieh, I-Yun Lisa, Sam Pan Menghsuan, Yet-Ming Chiang, and William Green. "Learning Only Buys You so Much - Practical Limits on Battery Price Reduction." Applied Energy, 2019, 7.

Heavy-duty vehicles

Heavy-duty vehicle data updates

Data	Last historical year AEO2023	Last historical year AEO2025	Source	NEMS input file
Sales and stock by vintage, powertrain, region, fleet, and size class	2021	2023	Polk (S&P)	trnstockx
Annual VMT per vehicle by vintage, powertrain, size class, and type	2002	2021/2022	2021VIUS, Polk (S&P)	trnhdvx
Scrappage/survival curves by powertrain, region, size class, and type	2021	2023	Polk (S&P)	trnhdvx
New vehicle fuel economy by vintage, powertrain, and size class	2021	2023	2021VIUS, Polk (S&P), CARB, Fuelly (2b/3)	trnhdvx

Note: VMT=vehicle miles traveled; VIUS = Vehicle Inventory and Use Survey; CARB = California Air Resources Board

Heavy-duty vehicle new datasets and inputs

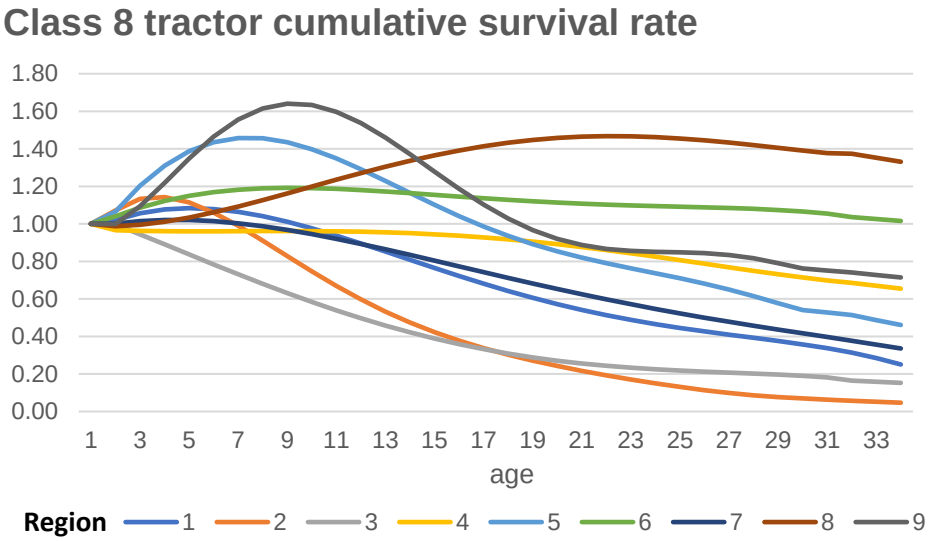
- **Developed analysis pipeline for 2021 VIUS data**

- Regional scrappage/survival curves (for each region: 11 different curves based on size class and tractor/vocational) [VIUS, Polk]

- Financial horizon / payback period requirements [length of ownership from VIUS and Polk]

Heavy-duty vehicle new datasets and inputs

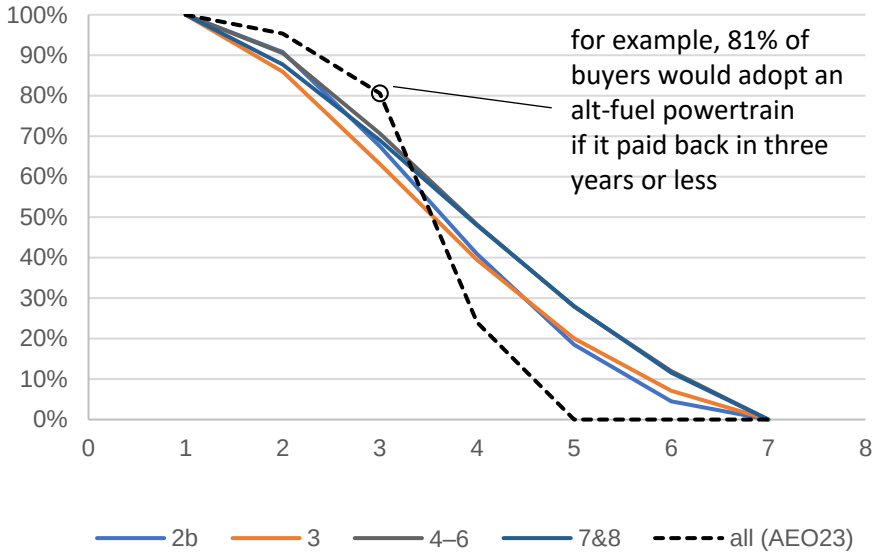
- Developed analysis pipeline for 2021 VIUS data
- **Regional scrappage/survival curves (for each region: 11 different curves based on size class and tractor/vocational) [VIUS, Polk]**
- Financial horizon / payback period requirements [length of ownership from VIUS and Polk]



Heavy-duty vehicle new datasets and inputs

- Developed analysis pipeline for 2021 VIUS data
- Regional scrappage/survival curves (for each region: 11 different curves based on size class and tractor/vocational) [VIUS, Polk]
- **Financial horizon / payback period requirements [length of ownership from VIUS and Polk]**

Share of vehicle buyers that would switch powertrains, by payback period



Heavy-duty vehicle model development

- New hydrogen fuel cell powertrain choice module with more detail
- Breakout EV electricity demand by type (depot/over-the-road) to send to EMM; will use different load shapes than other modes
- Add structure for Hydrogen Market Module (HMM) transportation sector hydrogen pricing

Heavy-duty vehicle policy

- EPA Phase 3 (enacted) and NHTSA CAFE Phase 3 (pending)
- Advanced Clean Truck rule (California and Clean Air Act Section 177 states)
- IRA Section 45W Commercial Vehicle Credit
  - $7,500 for Class 2b–3 trucks
  - $40,000 or battery cost, whichever is less, for Class 4–6 trucks
  - $40,000 for Class 7–8 trucks

Other modes

Air data updates

Data	Last historical year AEO2023	Last historical year AEO2025	Source	NEMS input file
Sales and stock by vintage, flag region, body type, and passenger/freight	2021	2023	World Jet Inventory	trnairx
Revenue passenger miles, freight ton-miles, load factors by airport pair, body type, and passenger/freight	2020	2022	ICAO Traffic by Flight Stage	trnairx
U.S.-only revenue passenger miles and freight ton-miles by domestic/international	2021	2023	Bureau of Transportation Statistics T100	trnairx
Operational parameters – belly freight share, MTOW by body type, efficiencies (gallon per ton-mile)	2021	2023	Bureau of Transportation Statistics T2	trnairx

Note: ICAO = International Civil Aviation Organization; MTOW = Maximum total operating weight

Other data updates

Mode	Data	Last historical year AEO2023	Last historical year AEO2025	Source	NEMS input file
Transit	Passenger miles, efficiency, fuel shares by mode (rail and bus) and region	2020	2022	Federal Transit Administration National Transit Database	trnldvx
Military	Distillate and jet fuel consumption	2021	2023	Defense Logistics Agency	trnldvx

Key on–road transportation policies in NEMS

- **2021**: NHTSA repeals SAFE I (12/21/2021)
- **2022**: EPA reinstatement of California's CAA waiver (3/14/2022)
- **2022**: NHTSA CAFE update (3/21/2022)
- **2022**: Inflation Reduction Act [IRA] (partially included) (8/16/2022)
- **2023**: CA Advanced Clean Truck rule (+ CAA 177 states) (4/6/2023)
- **2024**: IRA Section 30D Clean Vehicle Credit eligibility
- **2024**: IRA Section 45W Commercial Clean Vehicle Credit
- **2024**: Petroleum equivalency factor update (MY2027+) (3/18/2024)
- **2024**: EPA LDV GHG (4/18/2024) and Phase 3 HDV (4/22/2024)
- **Pending**: NHTSA LDV and HDPUV CAFE Standards (MY2027-2032)
- **Pending**: NHTSA Phase 3 HD CAFE Standards
- **Pending**: California Advanced Clean Fleets (ACF) rule
- **Pending**: California Advanced Clean Cars II (ACC II) rule

Included in AEO2023 and AEO2025

Included in AEO2025

Not in AEO2025 unless finalized

Summary of major projects

- Re-estimate LDV consumer choice model at a more disaggregate level
- Model updates to accommodate new and updated LDV and freight-related policy
- Enhance linkage with Electricity Market Module to better represent variation in electricity consumption (load curves, sectors) across different transportation modes
- Update LDV, freight truck, air, and transit historical datasets
- Significant code restructuring and rewriting

Discussion

Topics	Date	Time
Introduction to the Carbon Capture, Allocation, Transportation, and Sequestration Module	6/5/2024	11:00 a.m.
Introduction to the Hydrogen Market Module	6/12/2024	2:00 p.m.
Intro to the Hydrocarbon Supply Module	7/11/2024	1:00 p.m.
Petroleum and Natural Gas	7/17/2024	11:00 a.m.

Contact information

Monica Abboud | phone: 202-586-2518
| email: monica.abboud@eia.gov

Michael Dwyer (presenter) | phone: 202-586-8406
| email: michael.dwyer@eia.gov

John Maples (lead) | phone: 202-586-1757
| email: john.maples@eia.gov

Catherine Prendergast | phone: 202-586-5117
| email: catherine.prendergast@eia.gov

For more information

U.S. Energy Information Administration home page | www.eia.gov

Annual Energy Outlook | www.eia.gov/aeo

AEO2025 Resources https://www.eia.gov/outlooks/aeo/resources/

Annual Energy Outlook Working Group materials https://www.eia.gov/outlooks/aeo/workinggroup/

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

International Energy Outlook | www.eia.gov/ieo

Monthly Energy Review | www.eia.gov/mer

Today in Energy | www.eia.gov/todayinenergy

State Energy Profiles | www.eia.gov/state

Drilling Productivity Report | www.eia.gov/petroleum/drilling/

International Energy Portal | http://www.eia.gov/international/overview/world