Pennsylvania Zero-Emission Vehicle (ZEV) Roadmap

12/07/2023

DEPA Coalition Meeting

Opening Remarks

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About Us

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Transportation and Energy

Agenda

01 Vision

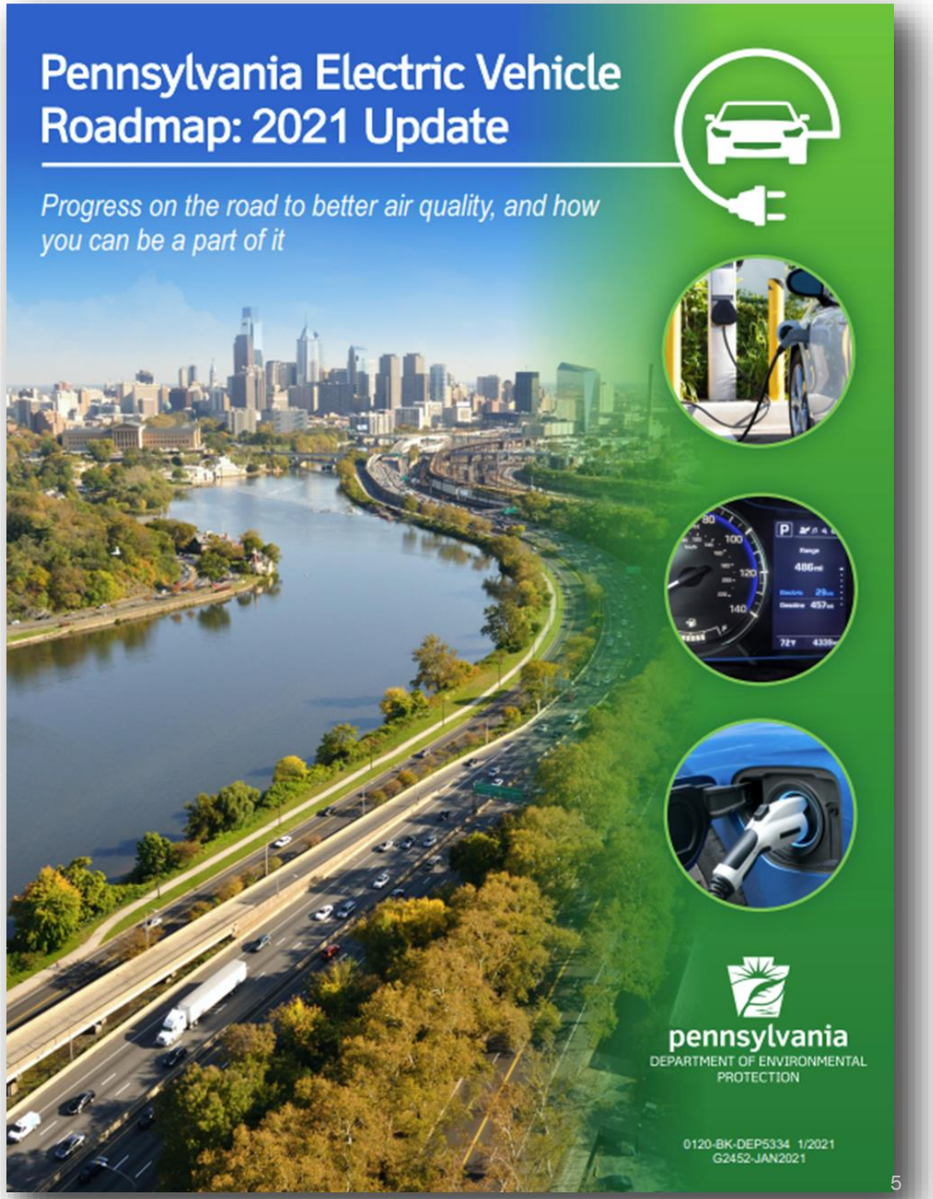
02 Scope of Work

03 Progress/Updates

04 Discussion

Pennsylvania Electric Vehicle (EV) Roadmap-Update

Recommendation from 2019 EV Roadmap	Progress/Actions Based on 2021 Update
Expand and improve consumer EV rebates	The DEP's Alternative Fuel Vehicles Rebate Program provided over **2,400 rebates**, totaling more than **$3.6 million** for new or used battery electric or plug-in hybrid vehicles for personal use in 2019. Low-income households received higher rebate amounts.
Establish EV sales goals in Pennsylvania	As of November 2020, there were more than **29,000 electric passenger vehicles** registered in the state, more than doubling the number since December 2017. Pennsylvania signed a multi-state agreement in 2020, committing to having at least **30% of new medium-duty and heavy-duty truck sales** as zero-emission vehicles **by 2030** and achieving **100% zero emission truck sales by 2050.**
Create incentives for others to invest in charging equipment	The DEP's Driving PA Forward program launched rebates to incentivize new Level 2 charging infrastructure, funding over **850 Level 2 charging plugs** and 11 projects installing more than **25 DC fast charging plugs**. Organizations, businesses, and government entities can apply for these rebates, with higher consideration given to projects in environmental justice areas.
Increase public knowledge about electric vehicles	The DEP and PennDOT coordinate the **Drive Electric Pennsylvania Coalition**, conducting public outreach through **webinars, ride and drive events, flyers,** and other materials to educate the public about electric vehicles and dispel common misconceptions.
Strengthen statewide EV supply equipment network planning, investment, and communications	PennDOT and DEP are working to develop electric vehicle **charging corridors** on main highways in Pennsylvania. The goal is to have chargers available every **50 miles**, located no more **than 5 miles** from the highway. Funding is being targeted towards charging projects in these corridors.



Pennsylvania ZEV Roadmap – Vision

Enhance our understanding of the existing ZEV landscape

Incorporate hydrogen fuel-cell EVs (FCEVs)

Revisit strategies for light-duty ZEVs and expand into medium and heavy-duty ZEVs

Engage key stakeholders to ensure effective strategies and recommendations to accelerate adoption of ZEVs in the State

Pennsylvania (PA) Zero-Emission Vehicle (ZEV) Roadmap

Scope of Work

PA ZEV Roadmap Overview

1. Existing Condition & Market Assessment

2. Fleet Modeling

3. Environmental & Economic Benefits

4. Infrastructure Needs

5. Barriers & Recommendations

6. Growth Strategies

PA ZEV Roadmap Overview

1. Existing Condition & Market Assessment

Objective

Conduct a comprehensive analysis of the existing conditions and market dynamics for EVs and FCEVs across light-duty (LD), medium-duty (MD), and heavy-duty (HD) sectors.

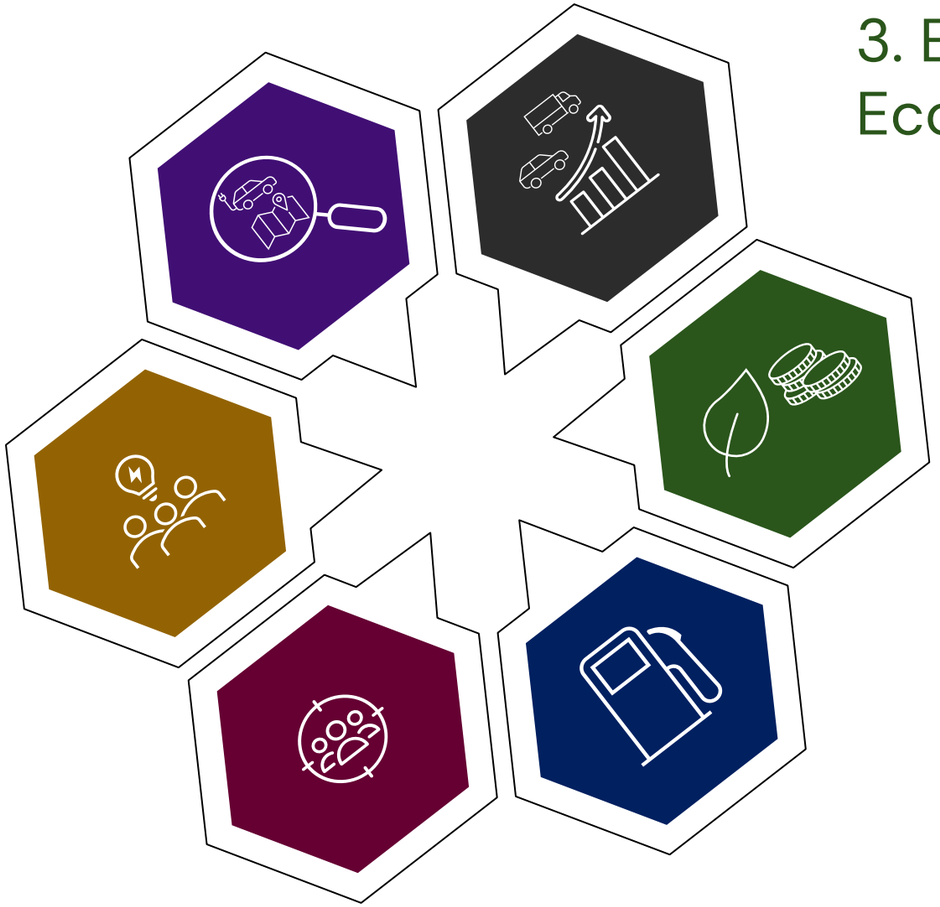
PA ZEV Roadmap Overview

2. Fleet Modeling

Objective

Conduct fleet modeling to project the adoption of ZEVs in LD, MD, and HD sectors, considering various policy scenarios.

PA ZEV Roadmap Overview



3. Environmental & Economic Benefits

Objective

Evaluate the environmental benefits of transitioning to ZEVs within the state, including reductions in greenhouse gas (GHG) emissions, criteria pollutants, and economic advantages.

PA ZEV Roadmap Overview

4. Infrastructure Needs

Objective

Determine the required number and types of EV charging and hydrogen fueling stations for supporting the adoption of ZEVs across all sectors

PA ZEV Roadmap Overview

5. Barriers & Recommendations

Detailed Barrier Overview:
Comprehensive understanding of challenges hindering ZEV adoption.

Segmentation based on Timeframes:
Near-term (0-2 years)
Medium-term (2-5 years)
Long-term (5+ years)

Comprehensive List of Recommendations ⟷ Growth Strategies
Tailored solutions for each barrier
Practicality through real-life examples

Drawing from Successful Practices
Showcasing proven strategies from other states.

Guiding Policy Decisions
Building a roadmap grounded in proven practices.

PA ZEV Roadmap Overview

6. Growth Strategies

Foundational Research

i. Analyze existing PA ZEV Roadmap
ii. Identify what has worked and evaluate changes in the landscape.
iii. Analyze successful practices in other regions/programs.

Collaboration with DEP

Engage DEP Energy Programs Office for insights and alignment with Pennsylvania's unique requirements.

Stakeholder Engagement

Leverage the Drive Electric PA Coalition for on-the-ground experiences and insights, including group discussions, surveys, and one-on-one interviews.

Strategy Formulation

Draft near, mid, and long-term strategies addressing goals, policies, regulations, planning, marketing and education.

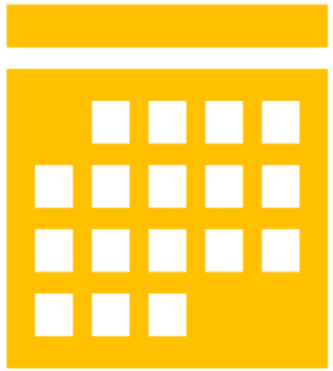
Iterative Refinement

Incorporate feedback from DEP and stakeholders for holistic and actionable strategies.

Drive Electric PA Coalition Meetings

3 DEPA Meetings

Prepare



- Develop agenda
- Confirm availability
- Plan effectively

Present

- Provide updates
- Facilitate open communication
- Seek input

Revise

- Incorporate feedback
- Ensure transparency
- Demonstrate collective efforts

Project Schedule

October 2023

Kick off meeting & notes

Oct-Nov 2023

Complete existing condition and market assessments

Summary memo to DEP

Nov-Dec 2023

Complete fleet modeling

Complete environmental and economic analysis

Summary memo to DEP

Dec-Jan 2023-2024

First DEPA meeting on Dec 7th

Completion of the EV charging and hydrogen fueling infrastructure assessment

Summary memo to DEP

Jan-Feb 2024

Identify barriers

Compile best practices

Start crafting growth strategies and recommendations

Feb-Mar 2024

Second meeting with Drive Electric PA Coalition

Mar-Apr 2024

Complete draft growth strategy development & recommendations

Detailed memo to DEP

Draft ZEV Roadmap outline to DEP

Apr-May 2024

Finalize growth strategy development & recommendations

Draft ZEV Roadmap to DEP

Summary PowerPoint presentation

May-Jun 2024

Third meeting with Drive Electric PA Coalition

Final ZEV Roadmap & report

Final presentation for educational outreach

Existing Condition & Market Assessment

PA ZEV Roadmap Overview

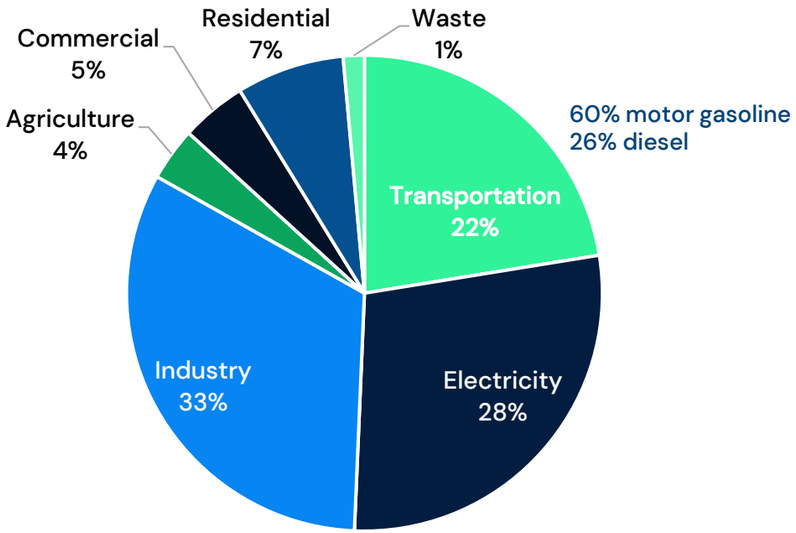
1. Existing Condition & Market Assessment

Objective

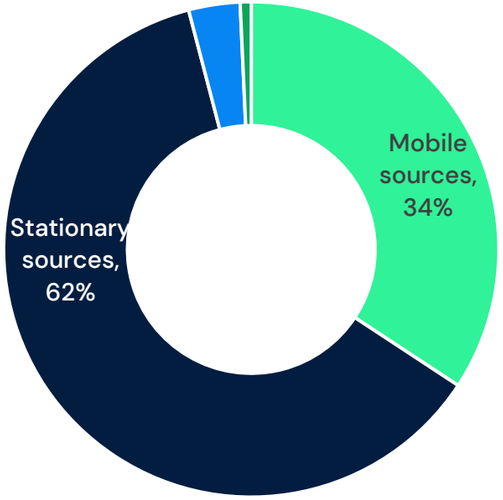
Conduct a comprehensive analysis of the existing conditions and market dynamics for EVs and FCEVs across light-duty (LD), medium-duty (MD), and heavy-duty (HD) sectors.

GHG Emissions and Criteria Pollutants in Pennsylvania (PA)

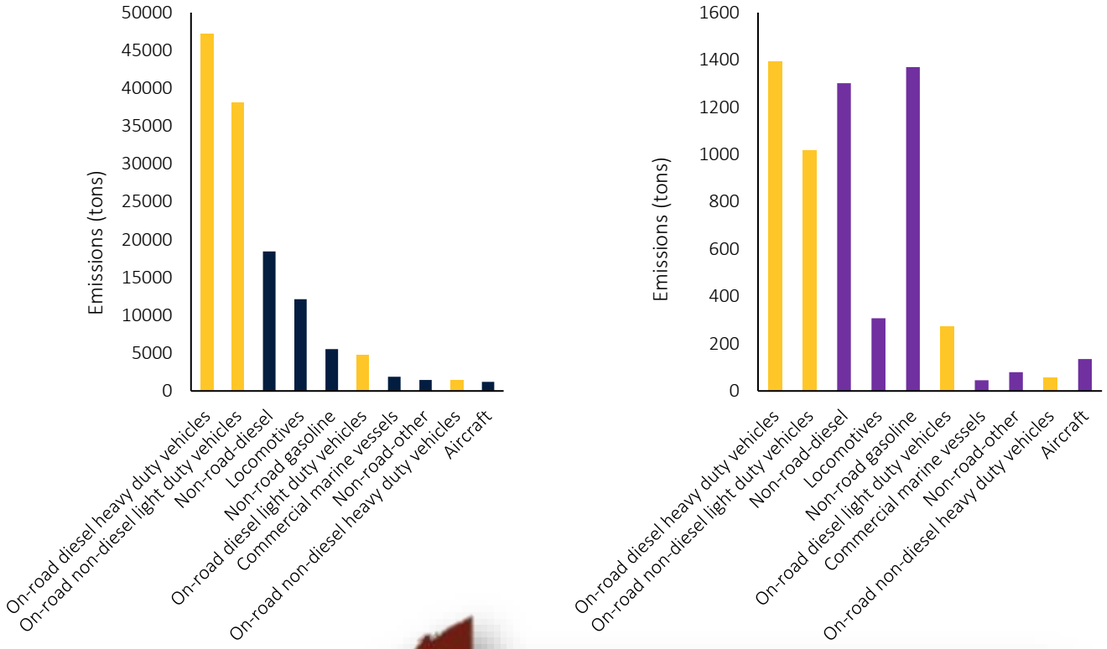
2019 Gross GHG emissions by sector

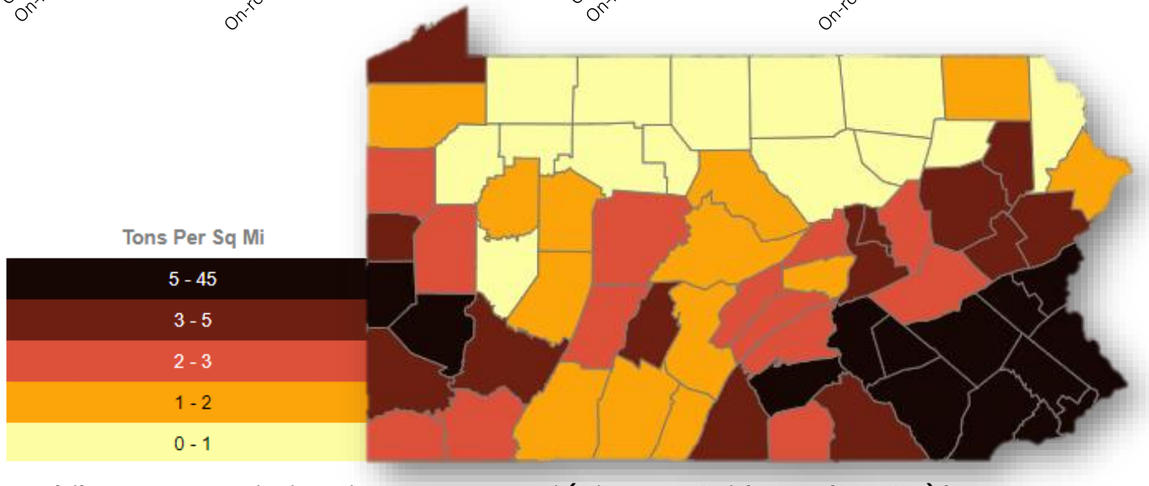


Sources of emissions (Nitrogen Oxides and PM 2.5) (2020)



Emissions in tons (Nitrogen Oxides and PM 2.5) by mobile source (2020)

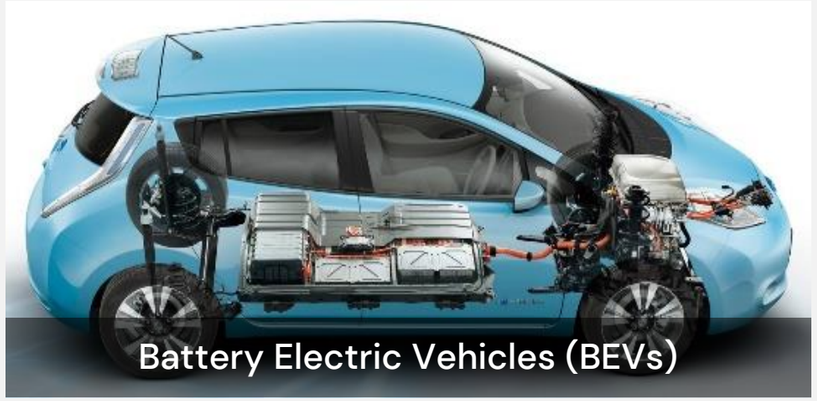




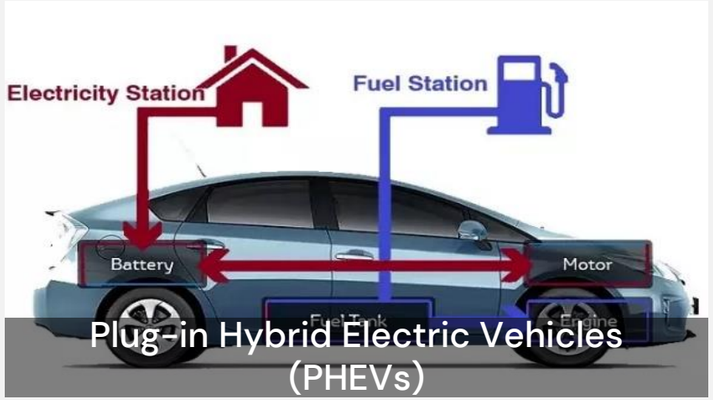
Mobile sources emissions in tons per sq mi (Nitrogen Oxides and PM 2.5) by county (2020) *[Allegheny County: statistics for PM 2.5 are above the level of the respective air quality standard (EPA Air quality statistics report, 2020)]*

Sources: *2022 PA GHG Inventory Report,* EPA's 2020 National Emissions Inventory

What are the different types of Zero Emission Vehicles (ZEVs)?



Battery Electric Vehicles (BEVs)



Plug-in Hybrid Electric Vehicles (PHEVs)

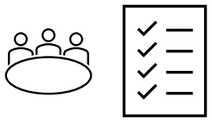
Hydrogen Fuel Cell Electric Vehicles (FCEVs)

Source: Alternative Fuel Data Center (AFDC). https://afdc.energy.gov/vehicles/electric_basics_ev.html

Key Existing ZEV Initiatives in Pennsylvania (PA)

Laws/regulations

- State EV Acquisition Requirements:
  Agencies must replace 25% of fleets with EVs by 2025. Green Government Council oversees emissions reduction.
- Medium- and Heavy-Duty ZEV Deployment:
  Multi-state agreement in 2020. At least 30% of new medium-duty and heavy-duty truck sales will be ZEVs by 2030 and 100% of these truck sales will be ZEVs by 2050.

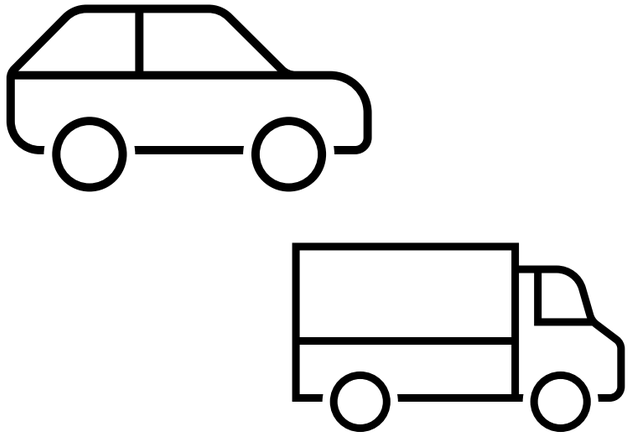


Planning & outreach

- Drive Electric Pennsylvania Coalition
- Electric Vehicle Roadmap
- Climate Action Plan
- Coordination across DEP, PennDOT & Drive Electric Pennsylvania Coalition for public outreach through webinars, ride and drive events, flyers, and other
- Pennsylvania's National Electric Vehicle Infrastructure (NEVI) Planning

Incentives

- Alternative Fuel Vehicle (AFV) Rebate
- Alternative Fuels Incentive Grant (AFIG) Program
- Diesel Emission Reduction Grants
- Heavy-Duty Emission Reduction Grants
- Medium- and Heavy-Duty (MHD) Zero Emission Vehicle (ZEV) Grant
- Hydrogen and Natural Gas Tax Credit
- Utility/Private Incentives

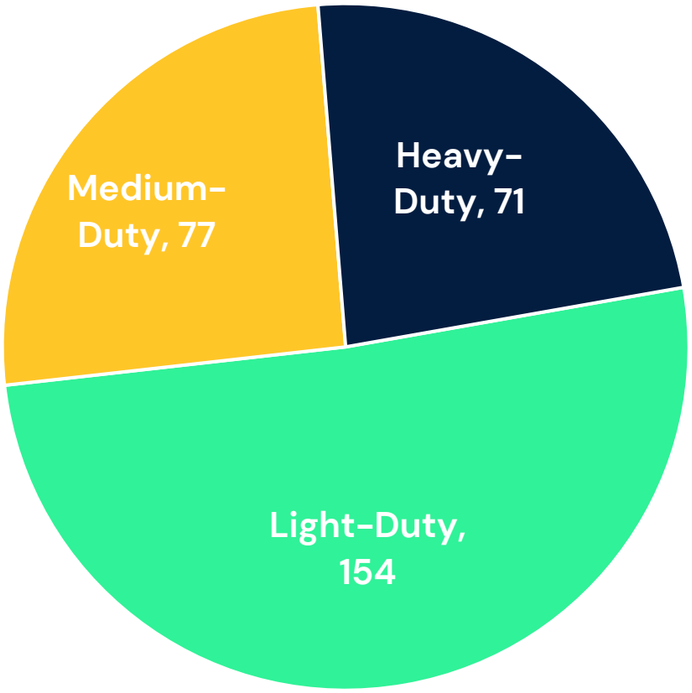


ZEV Market

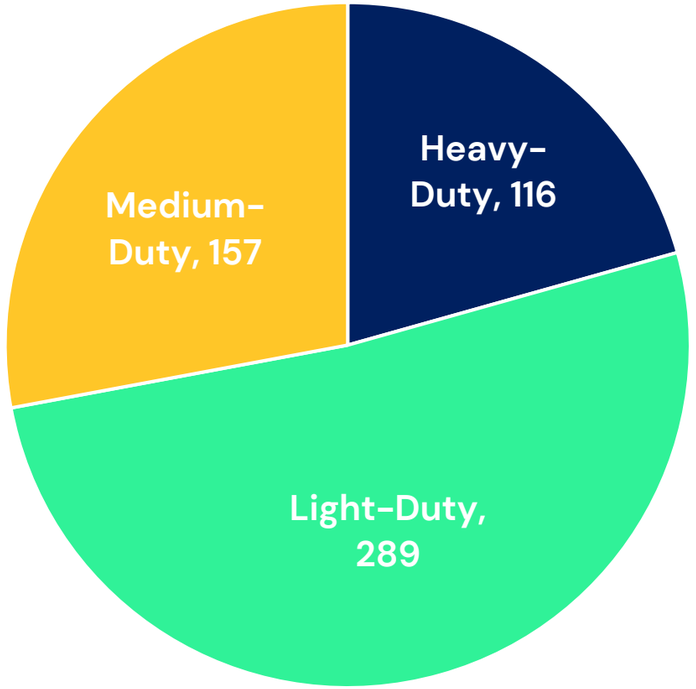
Model Availability

ZEV model availability by vehicle category

Unique Models



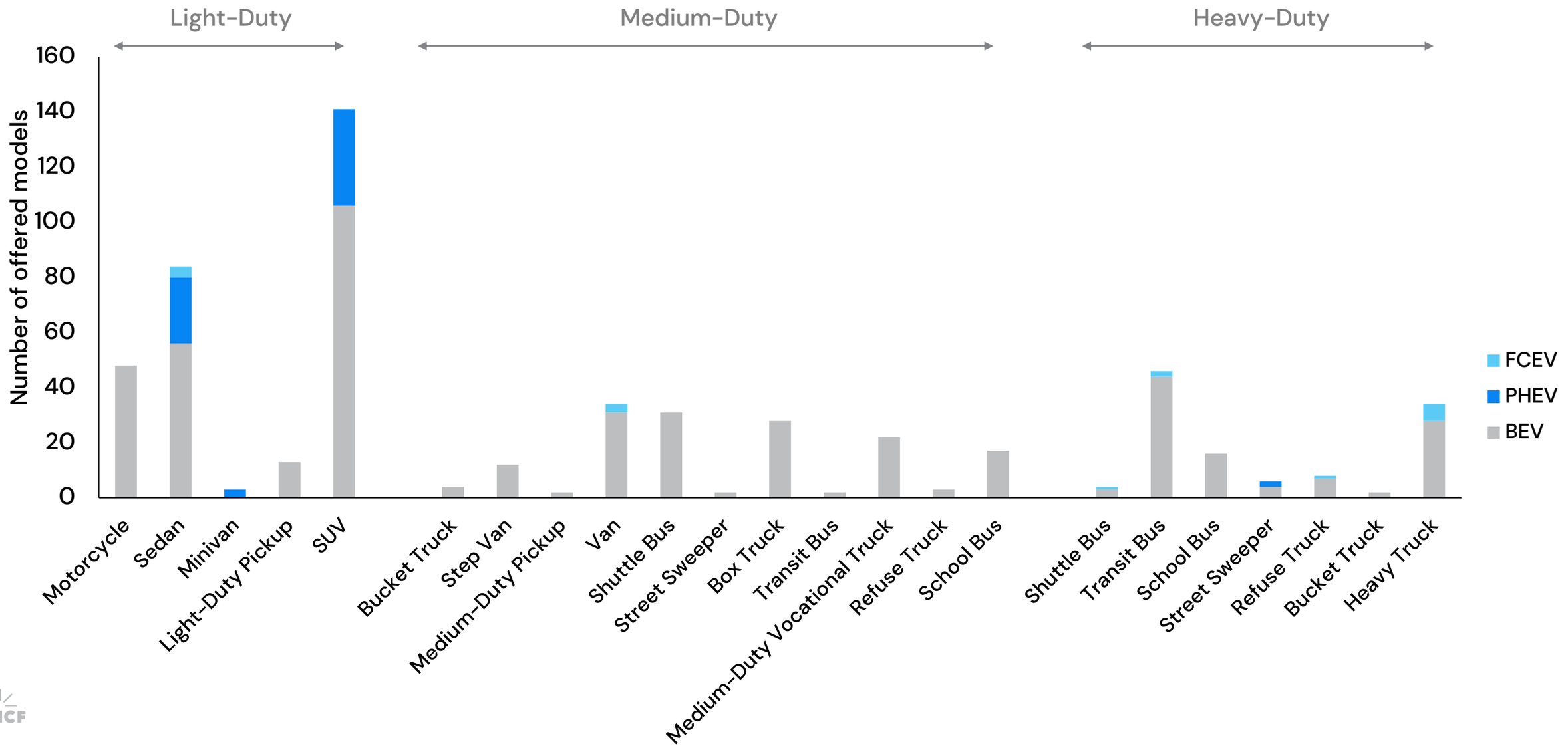
By Trim Level



Source:
ICF'S EV Library (as of October 2023)
FCEV-Light-Duty: Fueleconomy.gov, FCEV-Medium-/Heavy-Duty: Zero-Emission Technology Inventory tool

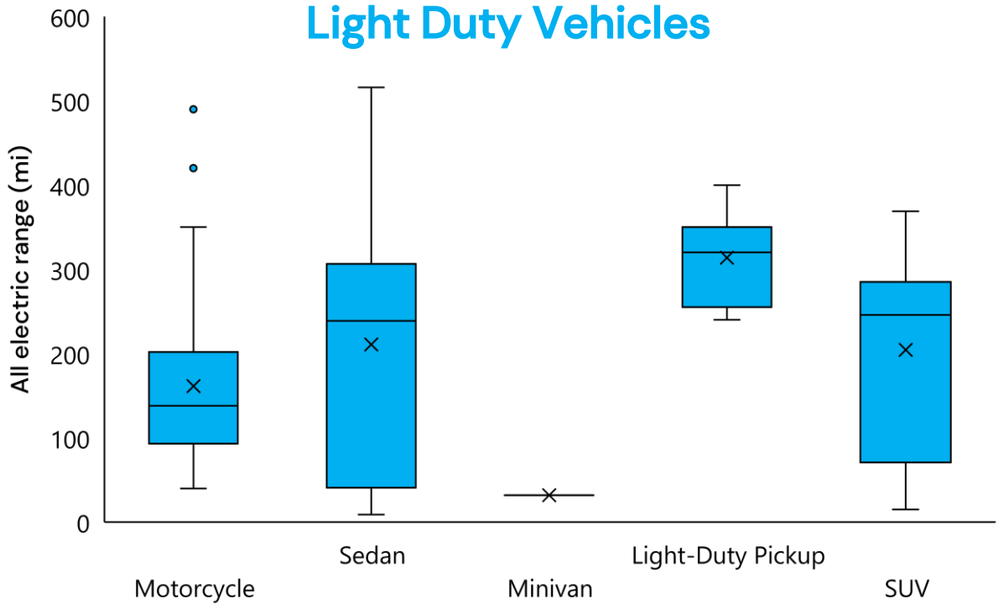
Model Availability

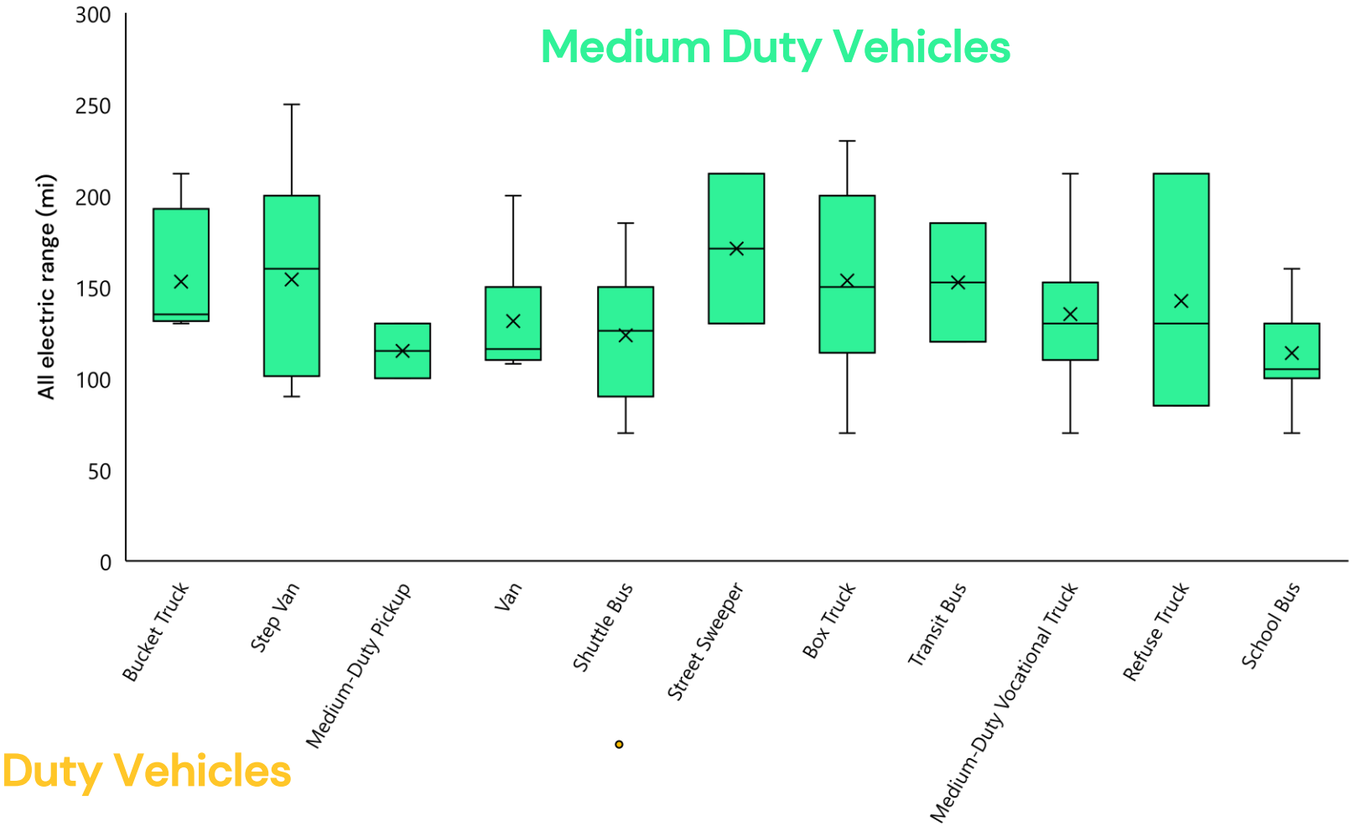
ZEV model availability by vehicle category and fuel type

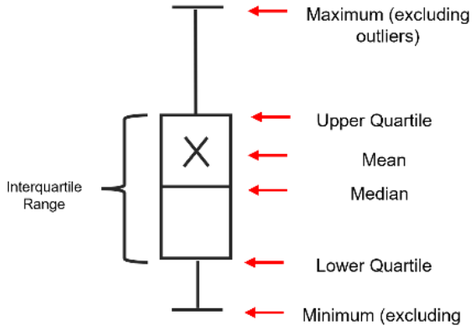


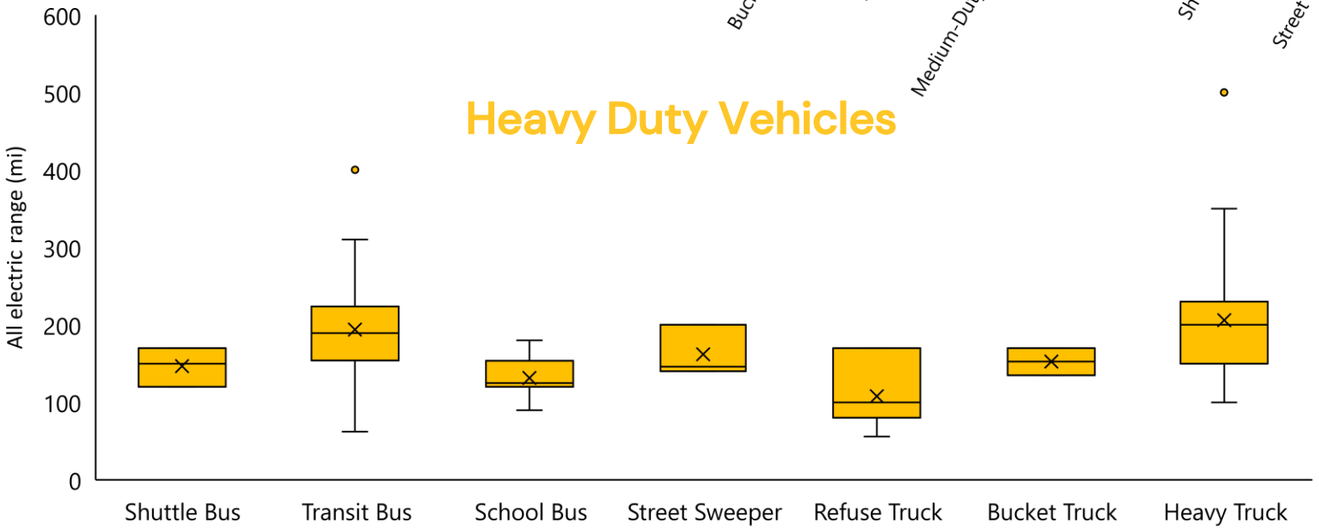
Sources:
ICF'S EV Library, FCEV-Light-Duty: Fueleconomy.gov, FCEV-Medium-/Heavy-Duty: Zero-Emission Technology Inventory tool

All Electric Ranges (miles) – EVs





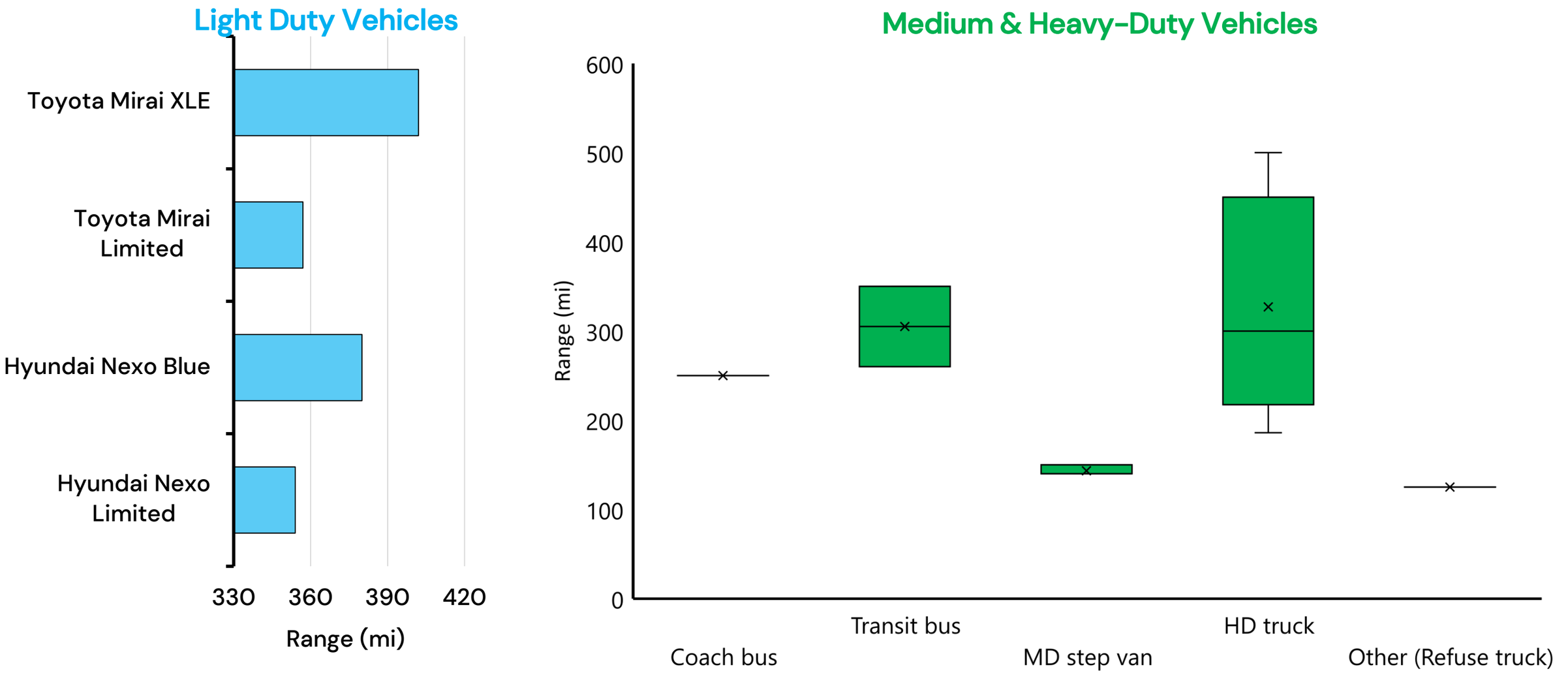




Source:
ICF'S EV Library

All Electric Ranges (miles) – Hydrogen Fuel Cell Electric Vehicles

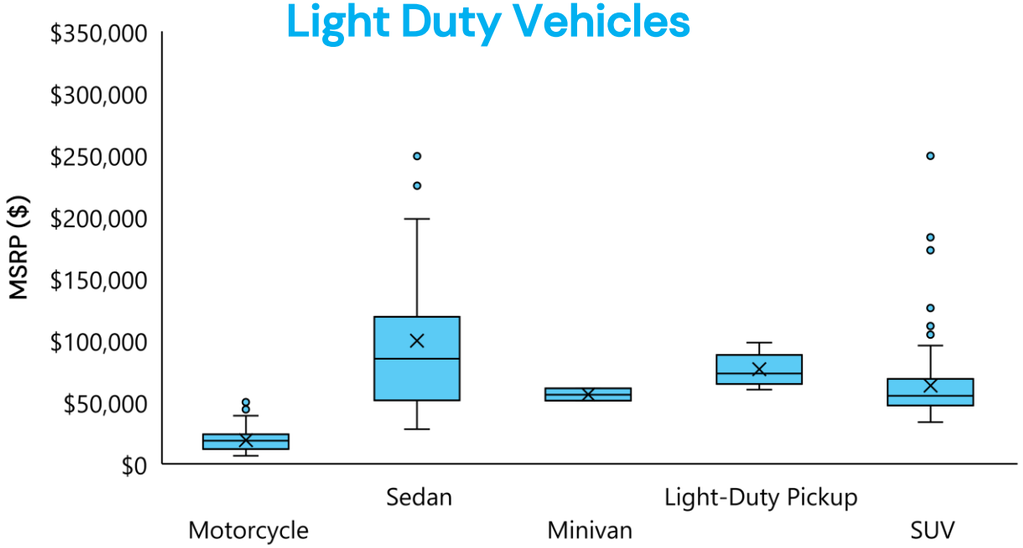
Range for (a) light-duty, (b) medium-duty (MD) and heavy-duty (HD) FCEVs



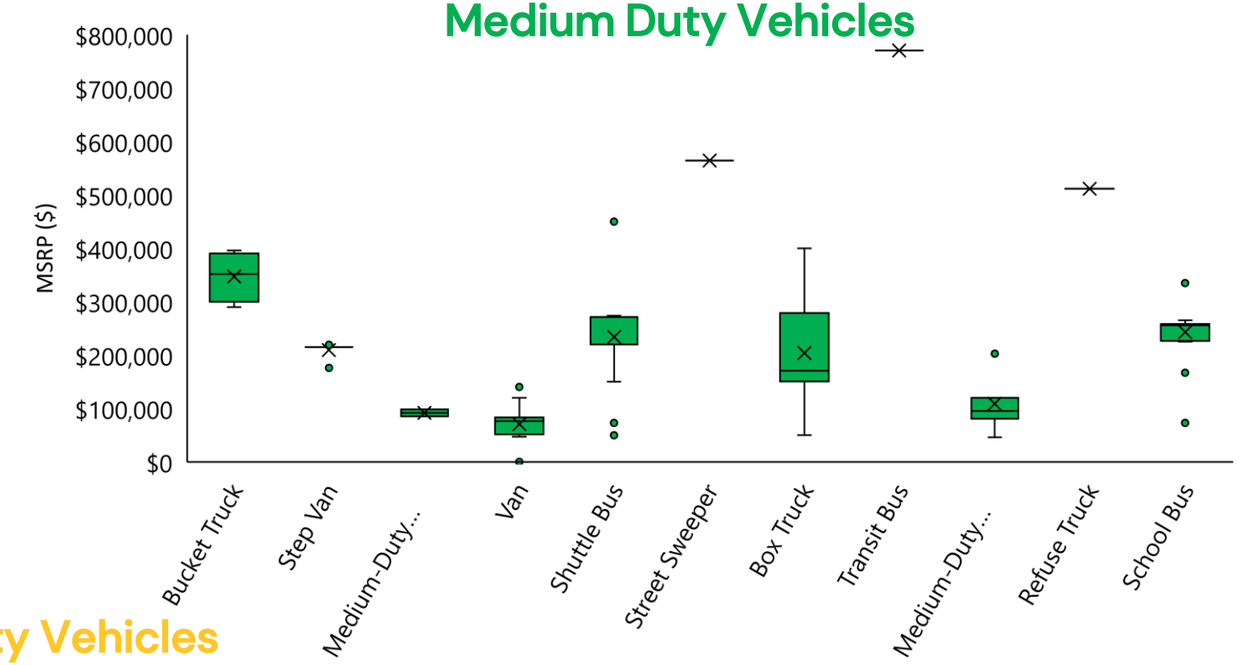
Sources:
Fueleconomy.gov

Vehicle Price ($) – Electric Vehicles

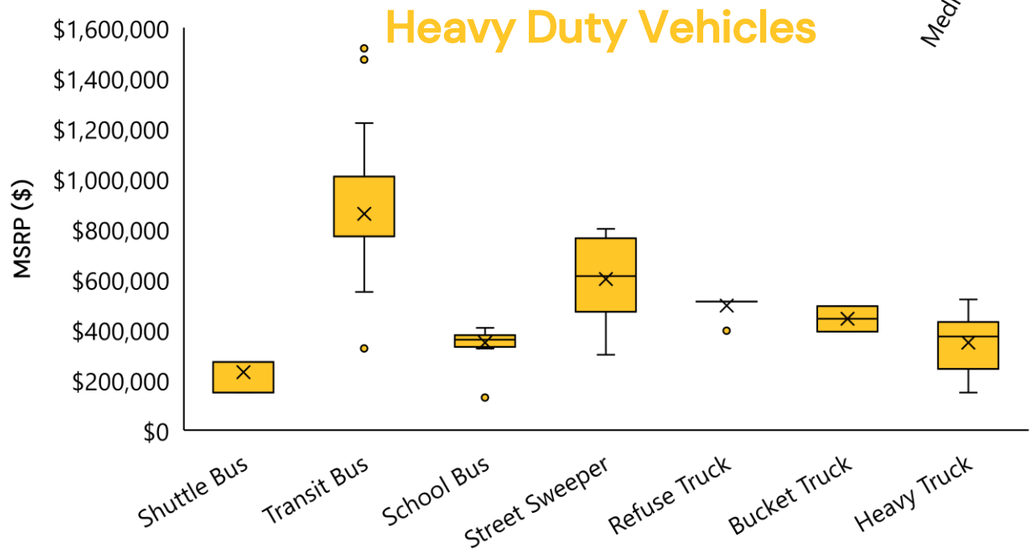
Light Duty Vehicles



Medium Duty Vehicles



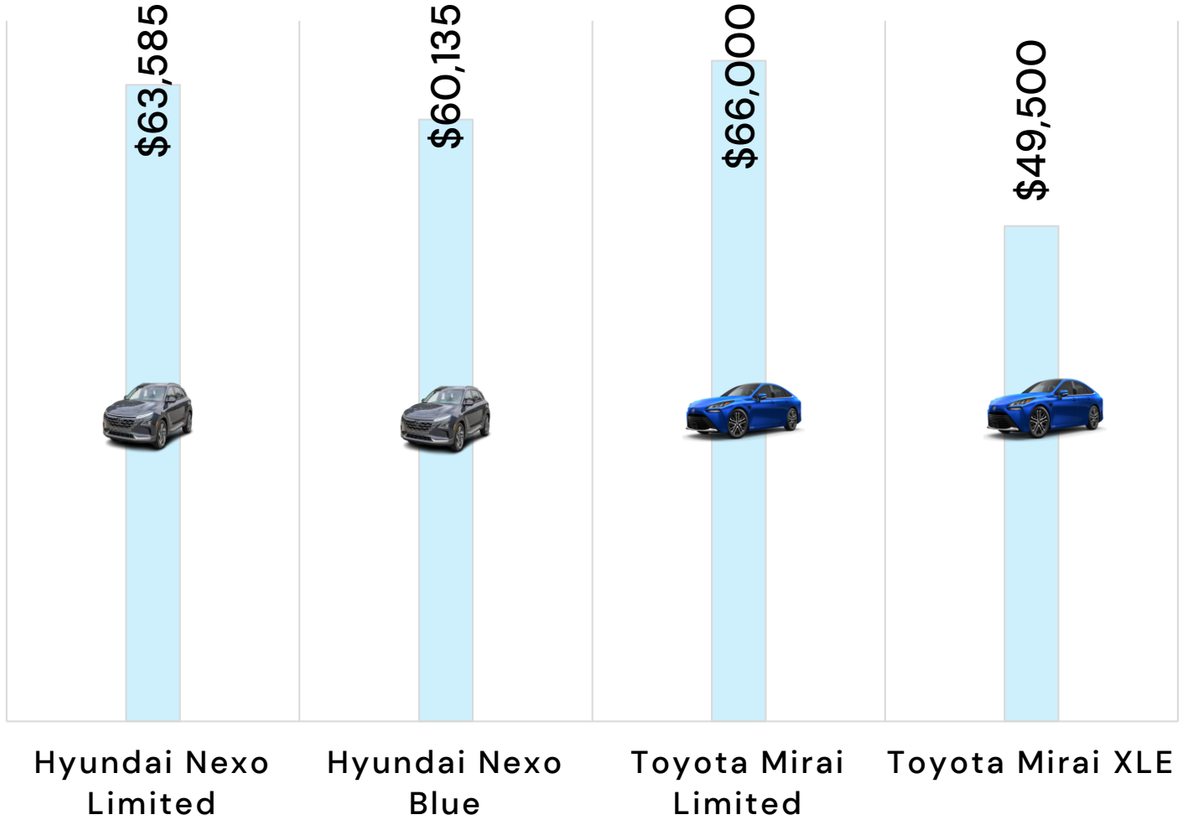
Heavy Duty Vehicles



Vehicle Price ($) – Hydrogen Fuel Cell Electric Vehicles

MSRP ($) for (a) light-duty, (b) examples for medium-duty and heavy-duty FCEVs (calls with dealerships)

Light Duty Vehicles



Heavy-Duty Vehicles

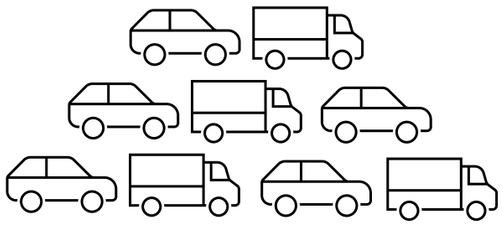
Nikola Tre FCEV
From $450,000

Hyundai Xcient
From $500,000

Hyzon HYHD8 110
From $640,000

ElDorado National Axess FC 40 ft bus
From $1,200,000

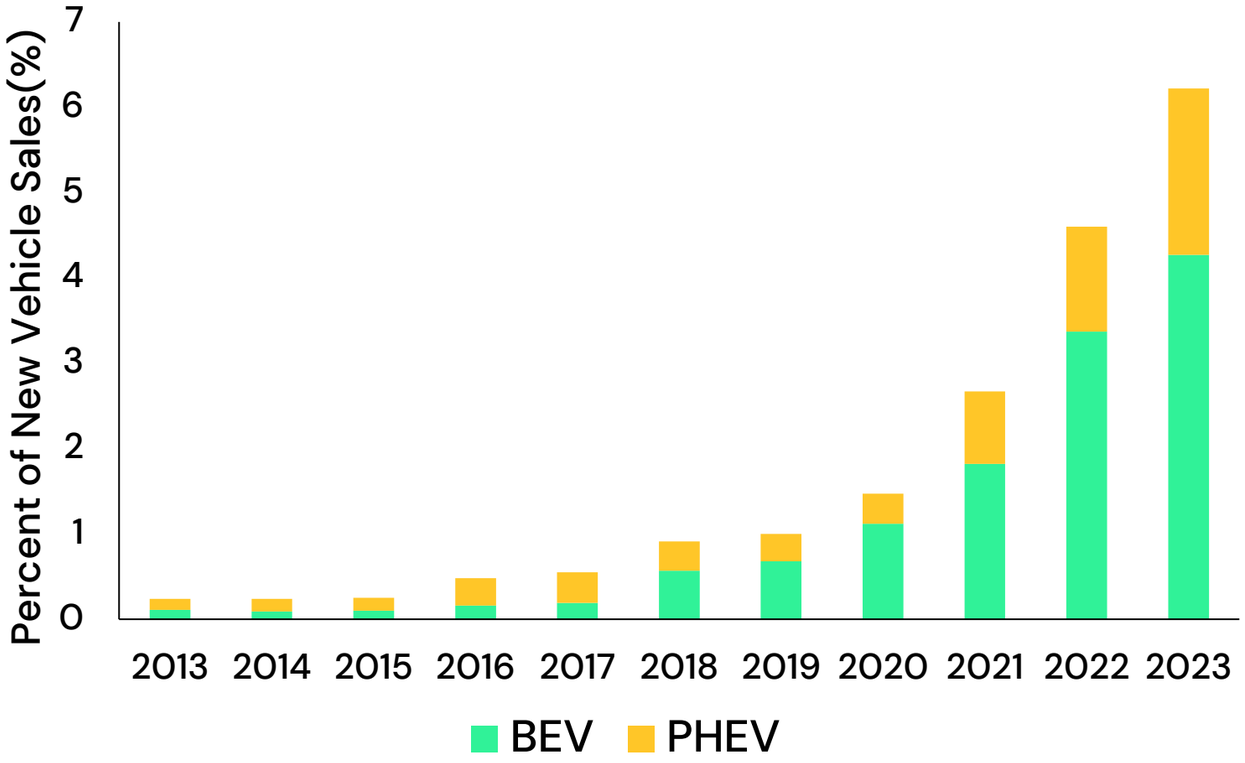
New Flyer Xcelsior CHARGE H2 Bus
From $1,235,000



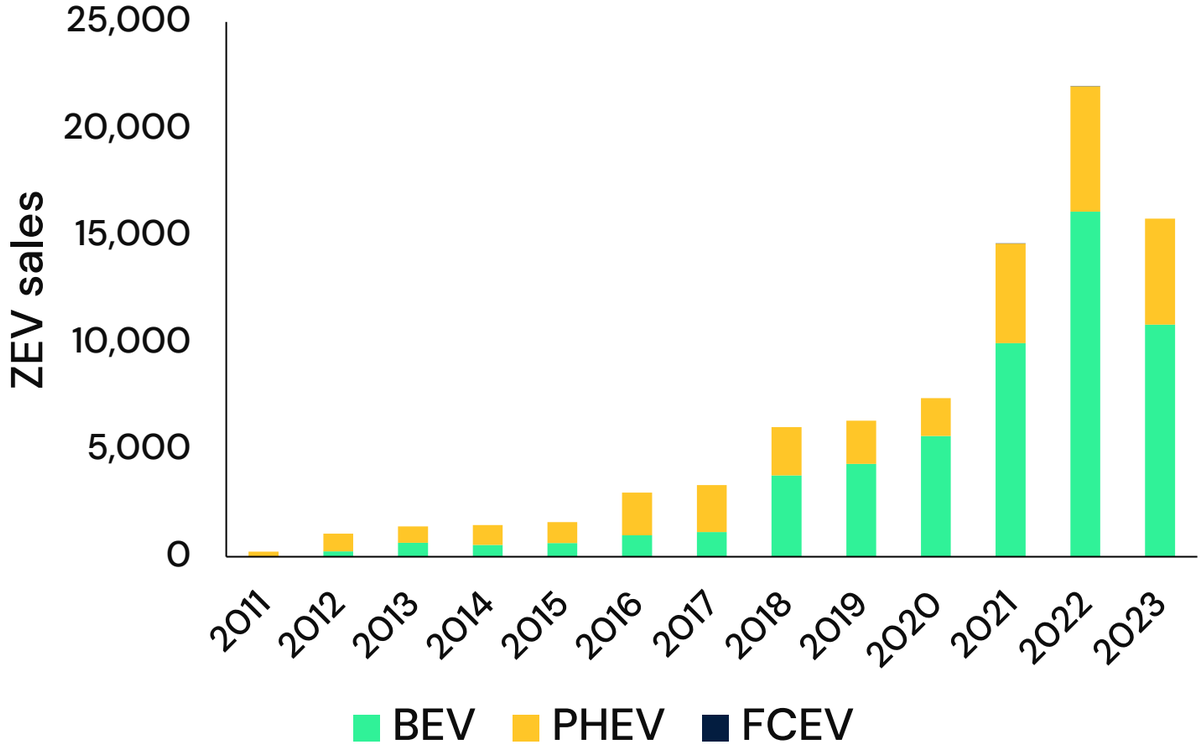
ZEV Adoption in Pennsylvania

ZEV Sales

Annual ZEV market share (% of new vehicle sales)



Annual ZEV sales



Important Caveat

2023 data is only for Q1 and Q2 (until June 2023)

Source: https://www.autosinnovate.org/EVDashboard

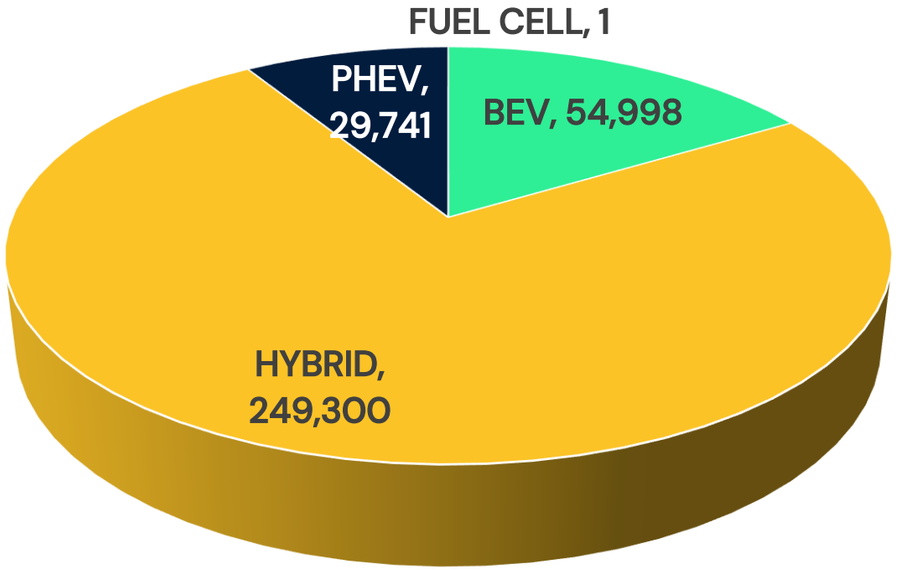
ZEV Population

ZEV share (Percent of vehicle registrations)

Year	BEV	PHEV	Total
2016	0%	0.1%	0.1%
2017	0%	0.1%	0.1%
2018	0.1%	0.1%	0.2%
2019	0.1%	0.1%	0.2%
2020	0.2%	0.1%	0.3%
2021	0.3%	0.2%	0.5%
2022	0.5%	0.2%	0.7%

Source: TransAtlas – Alternative Fuels Data Center

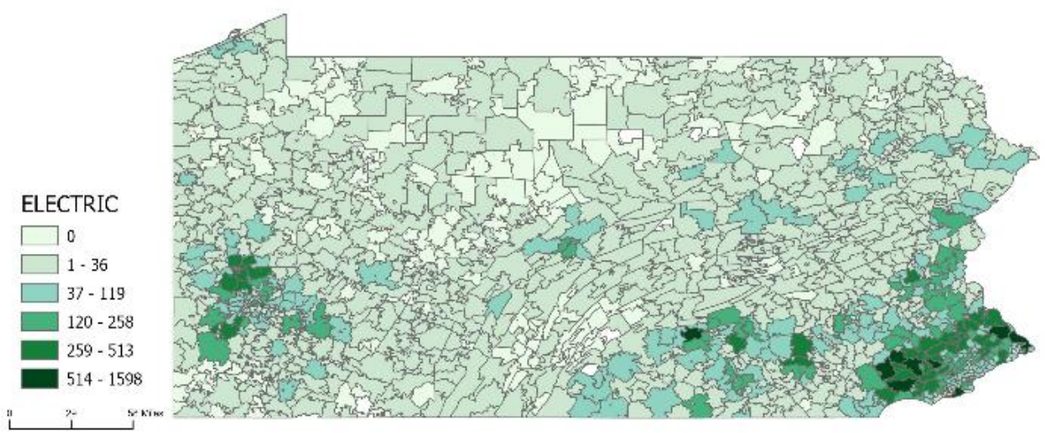
ZEV Population (as of Sep 2023)

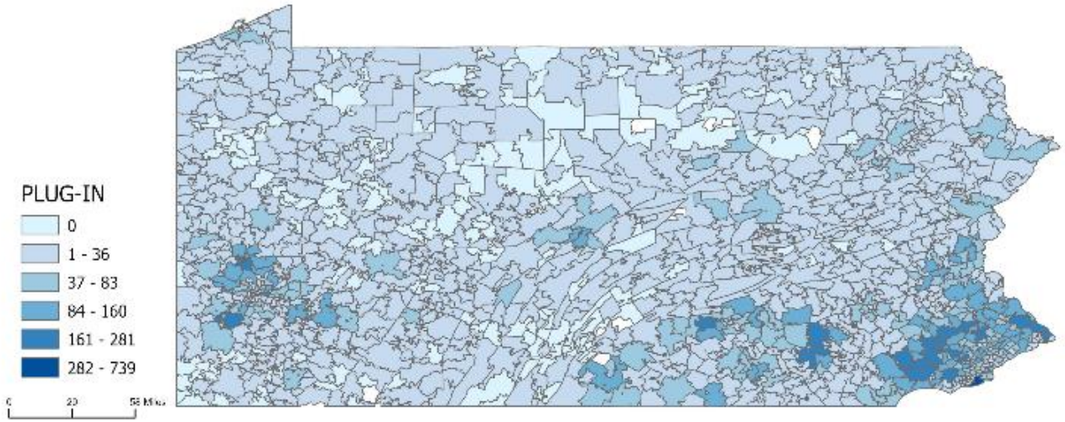


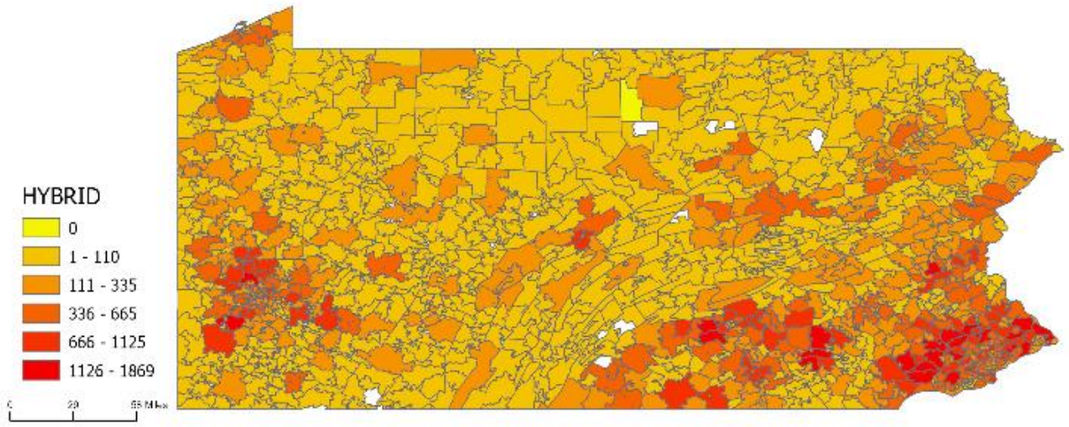
Source: PennDOT

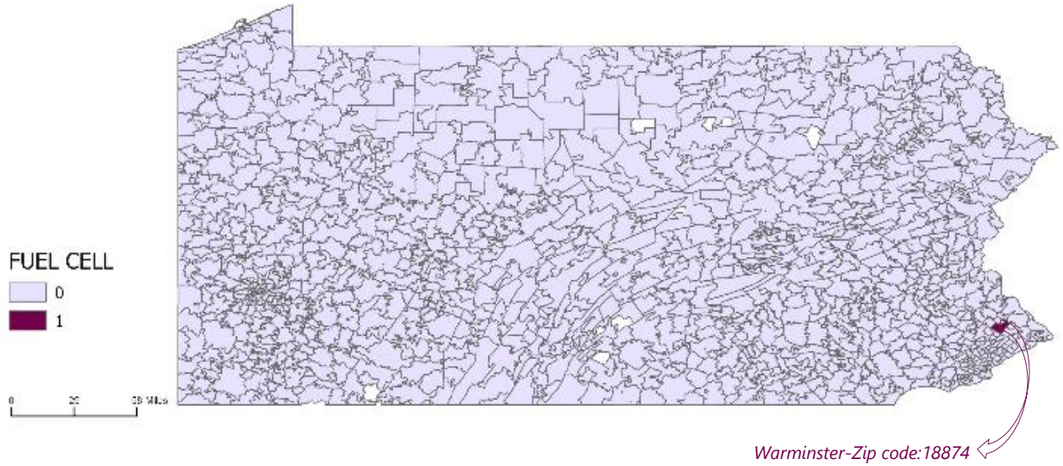
Geographical Distribution of ZEV Ownership in PA

ZEV and hybrid vehicle registrations by fuel type and zip code
(missing/unknown data is indicated with white color)





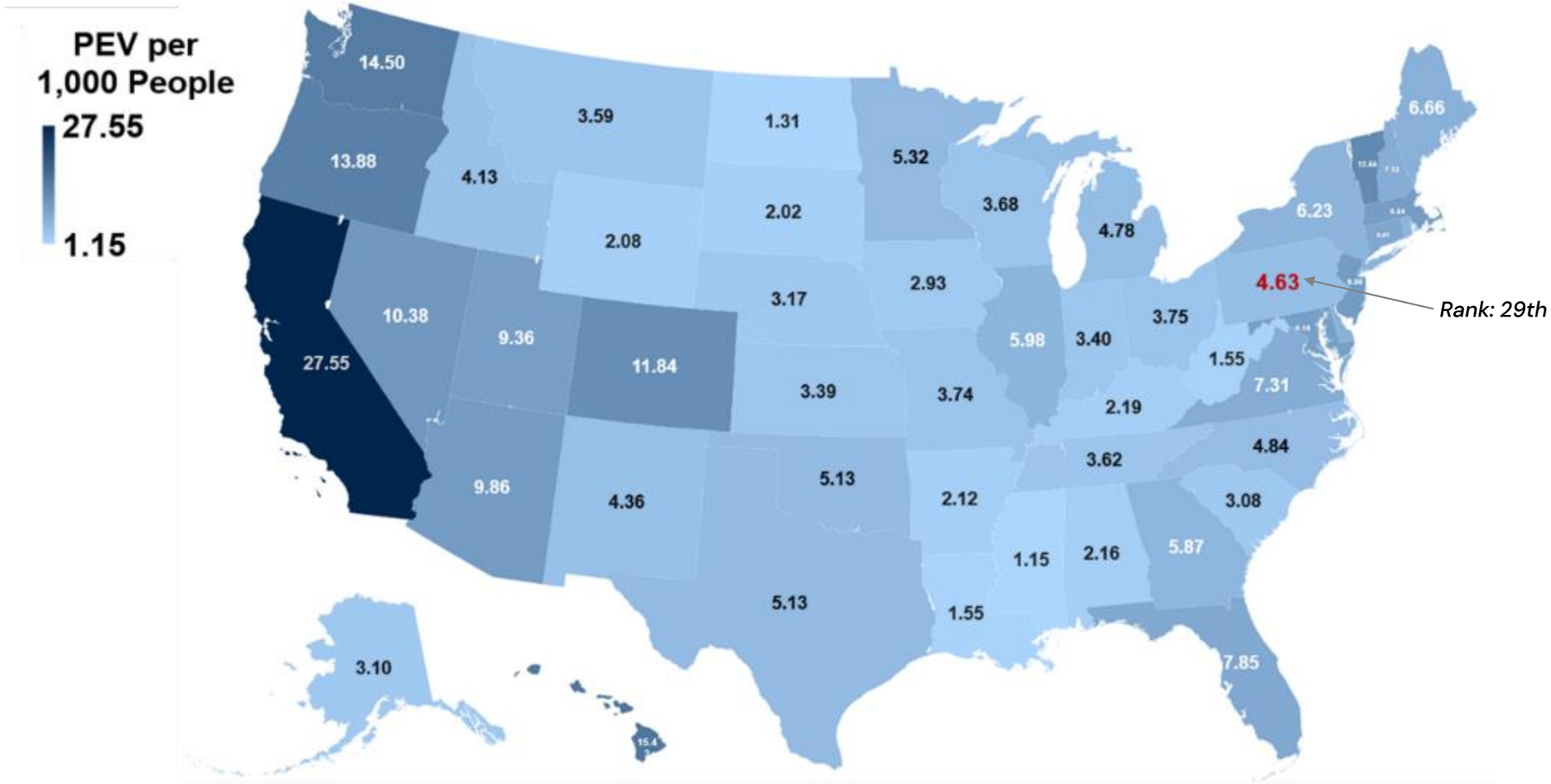




Source:
Alternative Fuel Vehicle (AFV) data by zip code: PennDOT
ZIP code boundaries: Esri Data and Maps

ZEV Population in PA vs. Other States

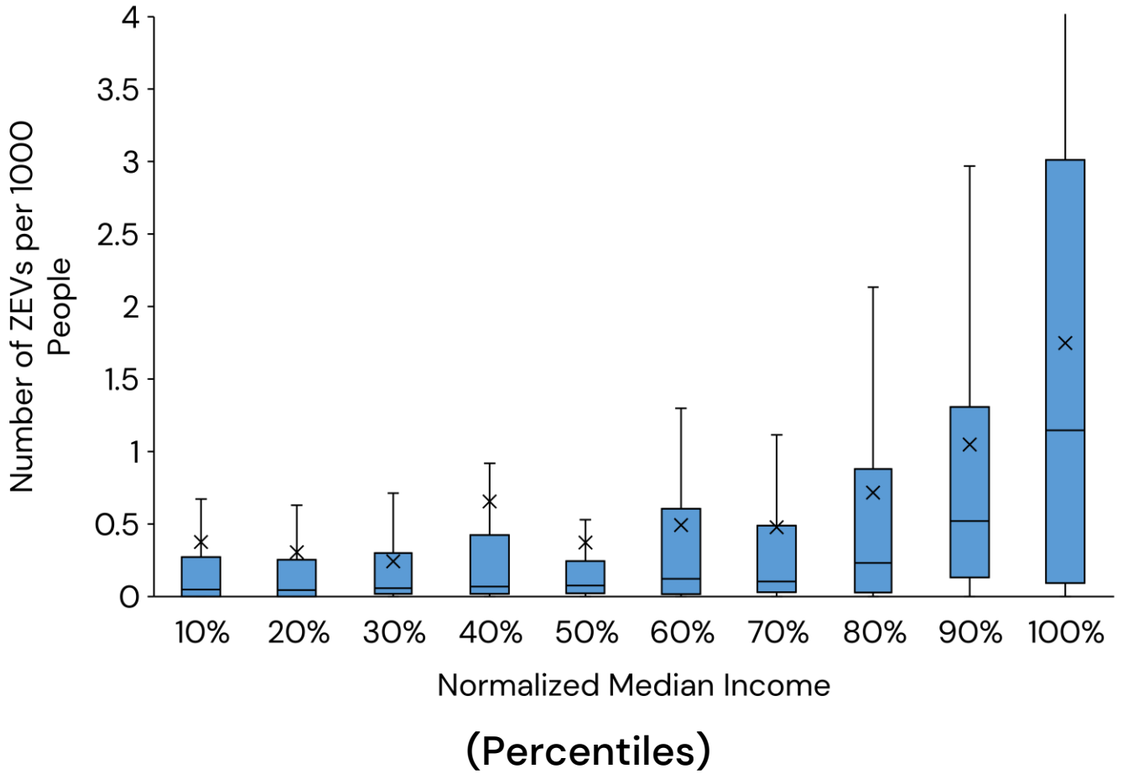
Plug-in EVs (PEVs) per 1,000 people by state (2022)



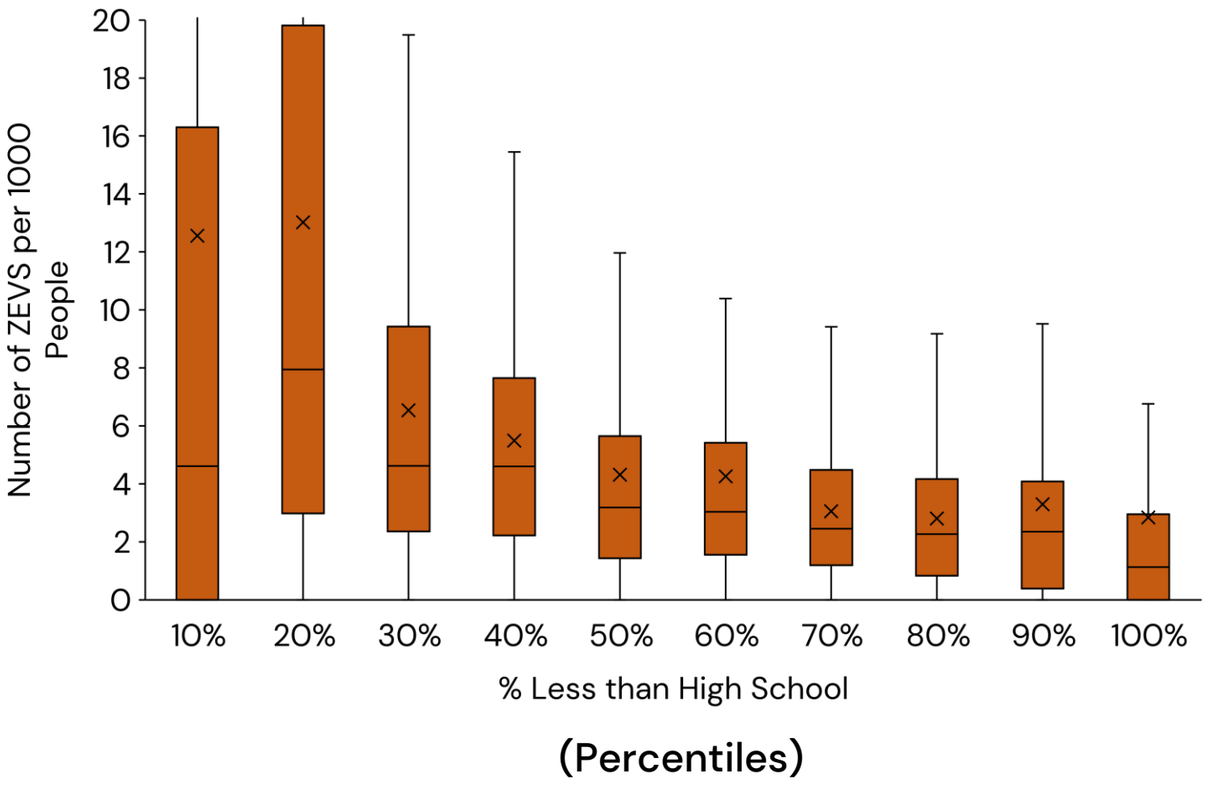
Source: https://www.energy.gov/eere/vehicles/articles/fotw-1279-february-27-2023-seven-states-and-district-columbia-had-more-10.
PEV registration data – Experian Automotive data analyzed by Argonne National Laboratory. Population – U.S. Census Bureau, Population Division, Annual Estimates of the Resident Population for the United States.

Disparities in ZEV Ownership

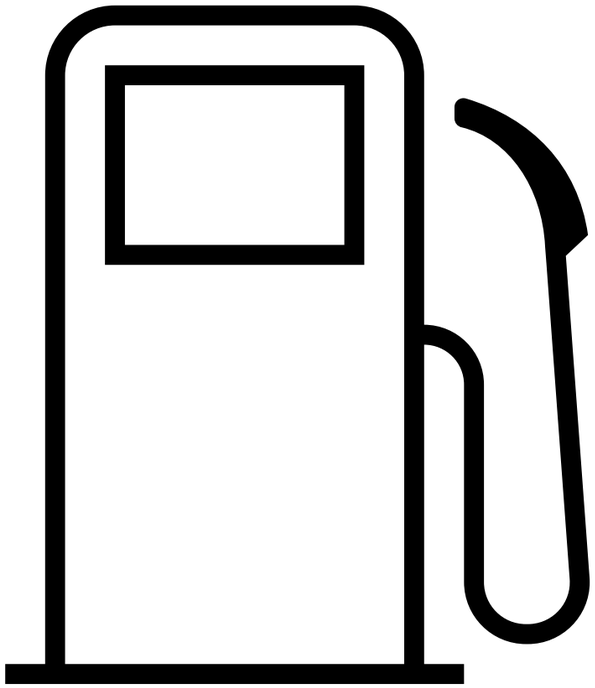
ZEV ownership compared to income by zip code



ZEV ownership compared to education by zip code



Sources:
PennDOT (ZEV population by zip code)
U.S. Census Bureau's American Community Survey. https://data.census.gov/advanced?g=010XX00US$8600000_040XX00US42



Clean Fueling Infrastructure

Fueling Infrastructure in PA

0 **Hydrogen Stations**

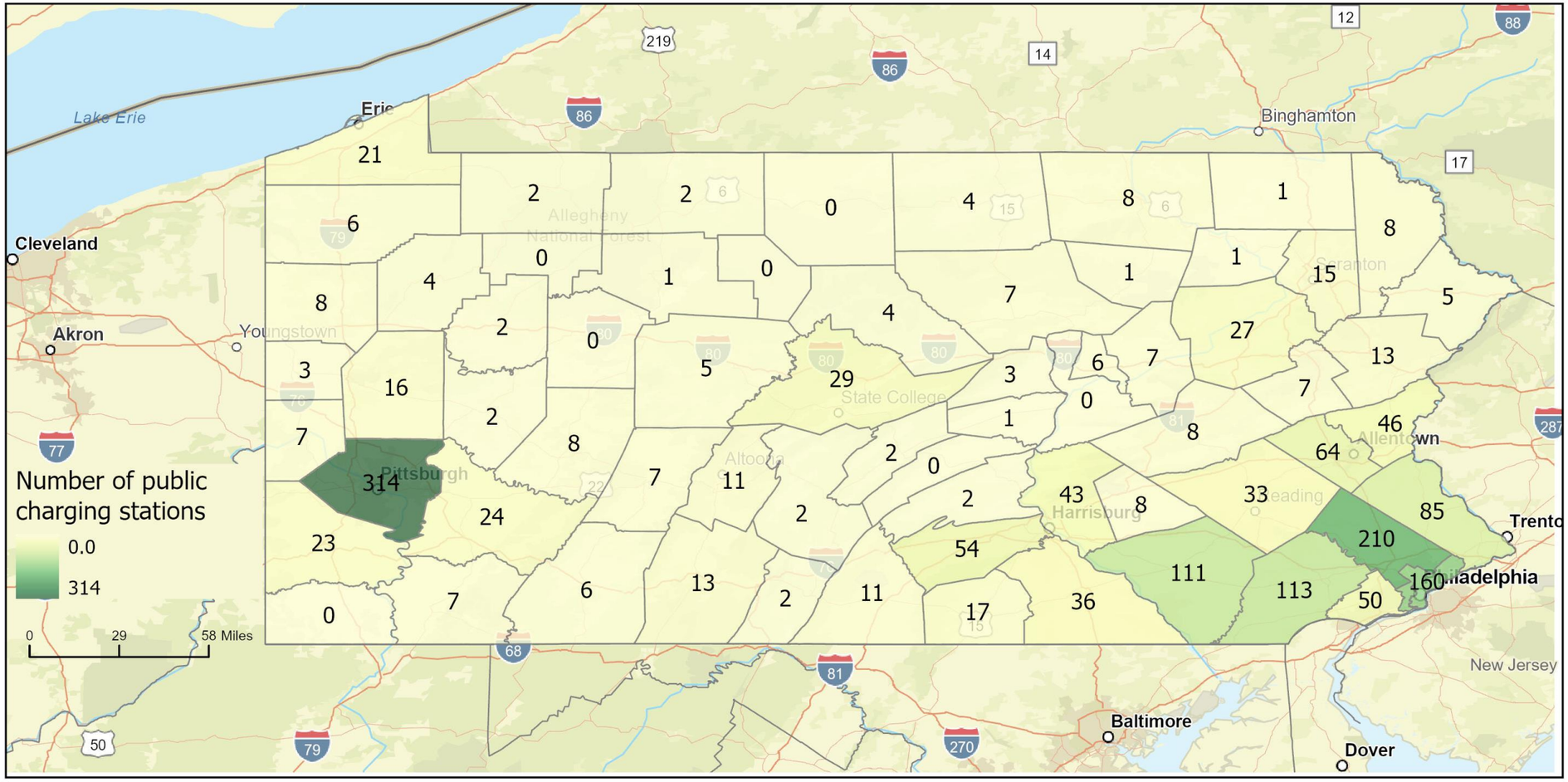
1763 **EV Charging Stations**

Access type	Number of stations
Private	**67**
Available	67
Planned/temporarily unavailable	0
Public	**1696**
Available	1585 (121 Tesla)
Planned	1
Temporarily unavailable	110
Total	**1763**

Source: Alternative Fuel Data Center (AFDC) Station Locator (Nov 2, 2023)

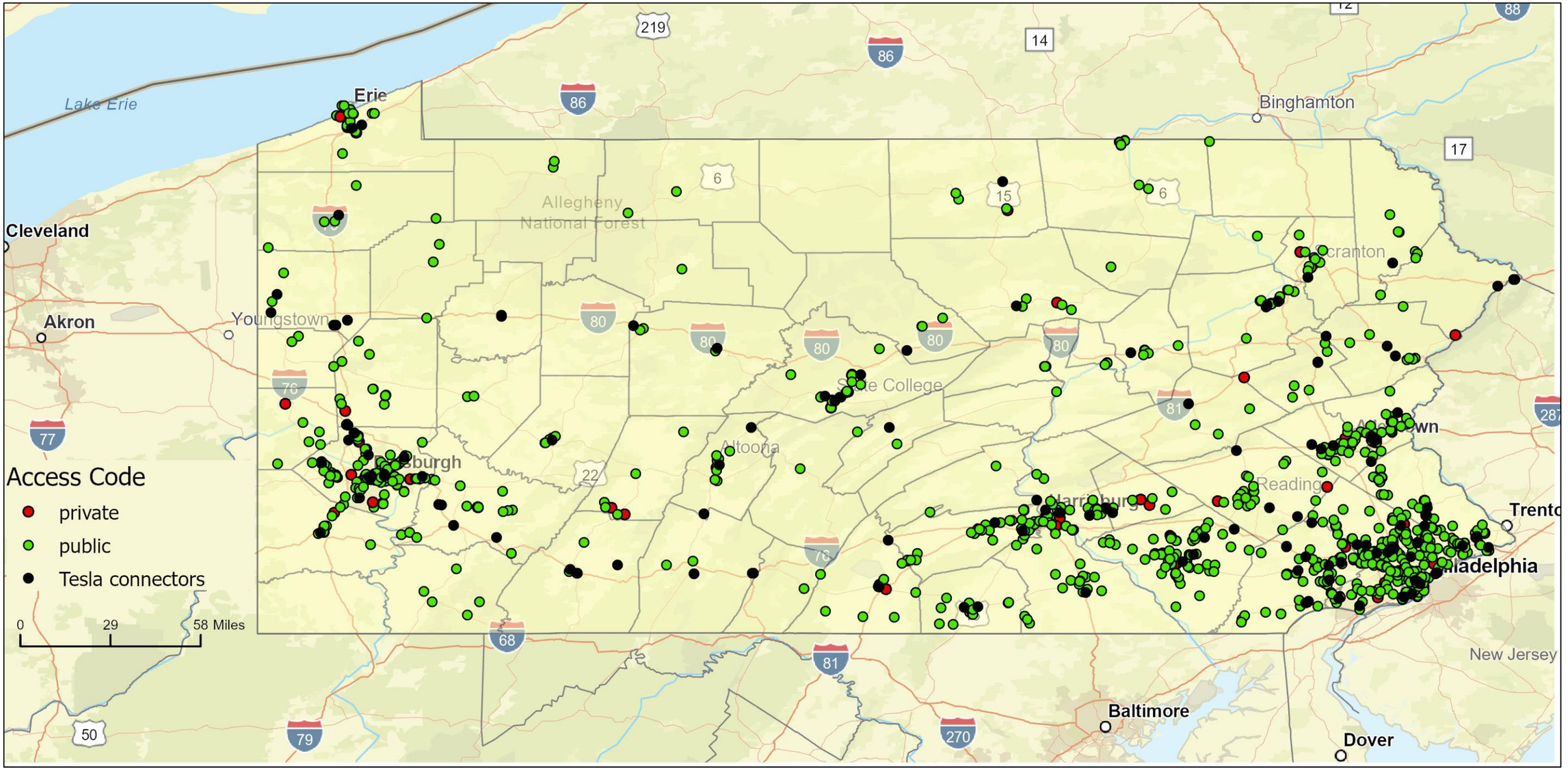
Charging Stations by County

Number of public charging stations by County



Sources:
Alternative Fuel Data Center (AFDC) Station Locator (Nov 2, 2023)
County boundaries: Esri Data and Maps

EV Charging Infrastructure–Access



Available charging stations by access: public, private, Tesla (public) (number of stations: 1652)

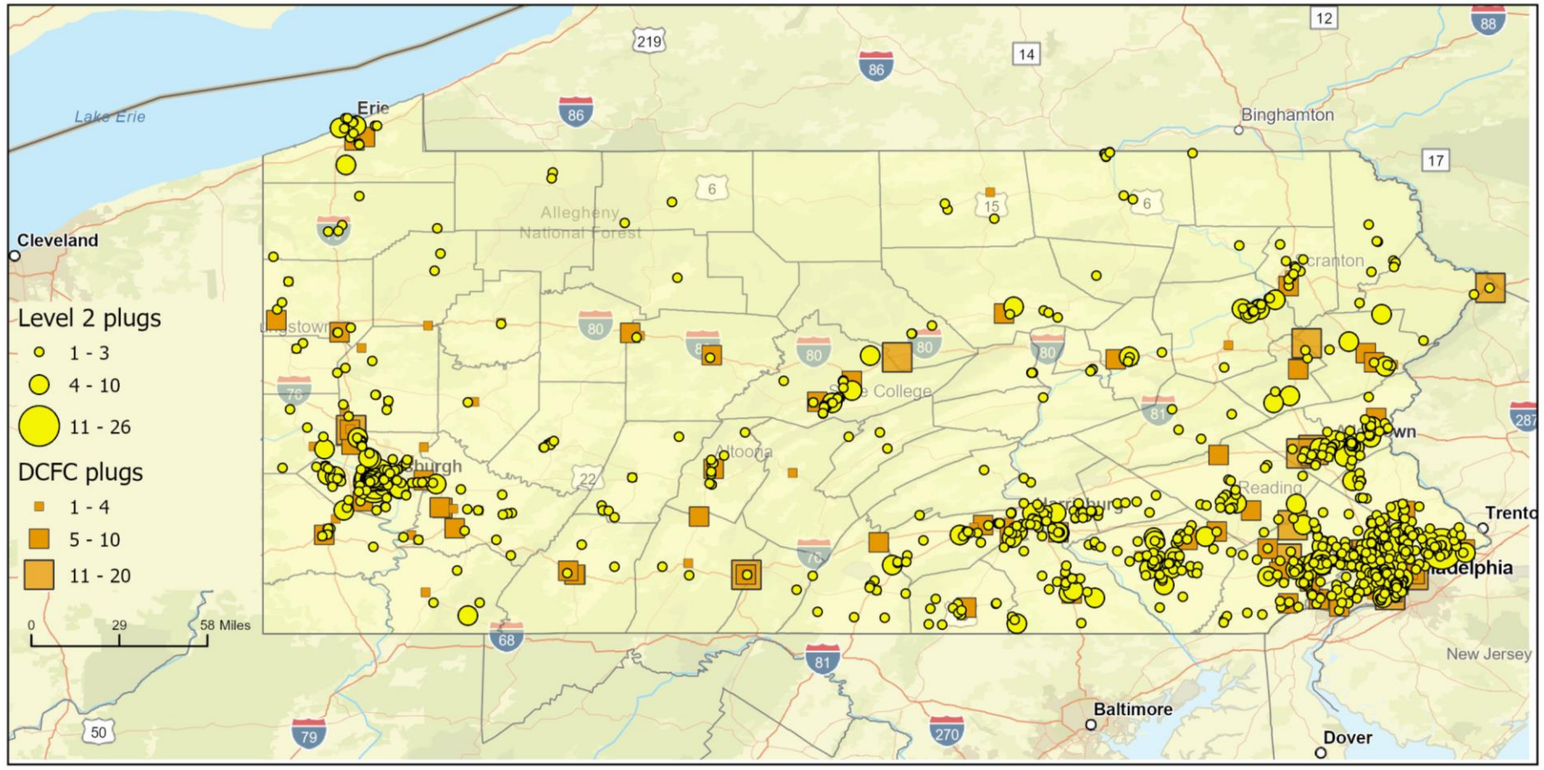
Source: Alternative Fuel Data Center (AFDC) Station Locator (Nov 2, 2023)

Charging Levels–Public Charging

Distribution of public stations' ports by EV network charging level

EV Network	Number of level 2 plugs	Number of DCFC plugs
AMPUP	12	
Blink Network	485	7
CHARGELAB	11	6
ChargePoint Network	1593	60
Electrify America		86
EV Connect	62	19
EVGATEWAY	4	
EVgo Network	1	84
FLASH	75	
FLO	52	
Non-Networked	371	18
OpConnect	14	
RIVIAN_ADVENTURE		6
RIVIAN_WAYPOINTS	4	
SHELL_RECHARGE	29	2
SWTCH	8	
Tesla		642
Tesla Destination	270	
UNIVERSAL	36	
Volta	169	6
Total	3196	936

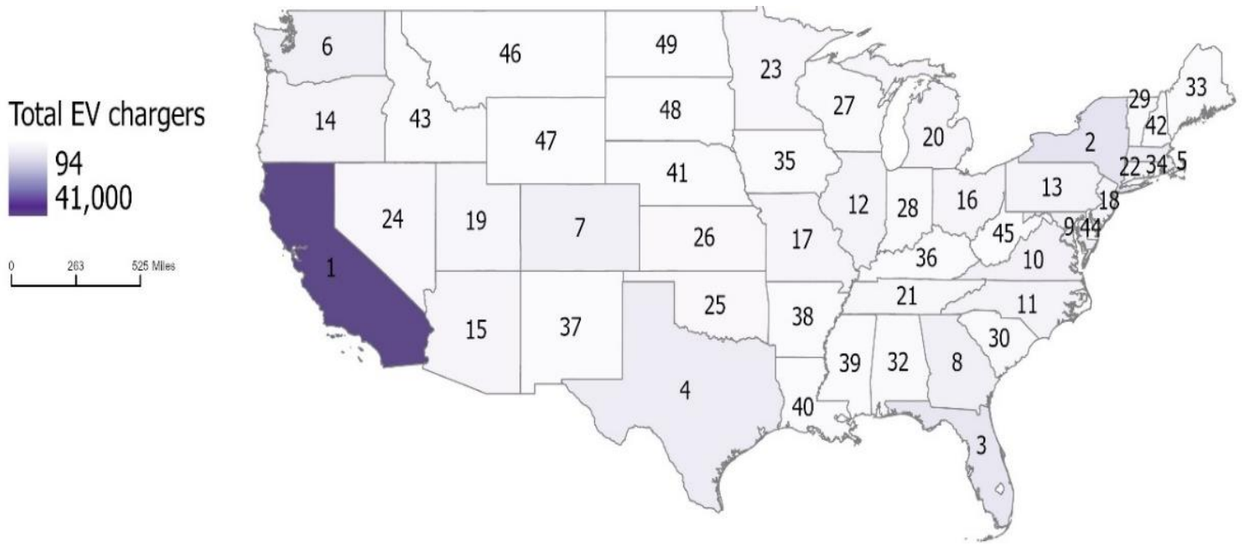
Distribution of public charging stations by charging level



Source: Alternative Fuel Data Center (AFDC) Station Locator (Nov 2, 2023)

EV Charging Infrastructure in PA and Other States

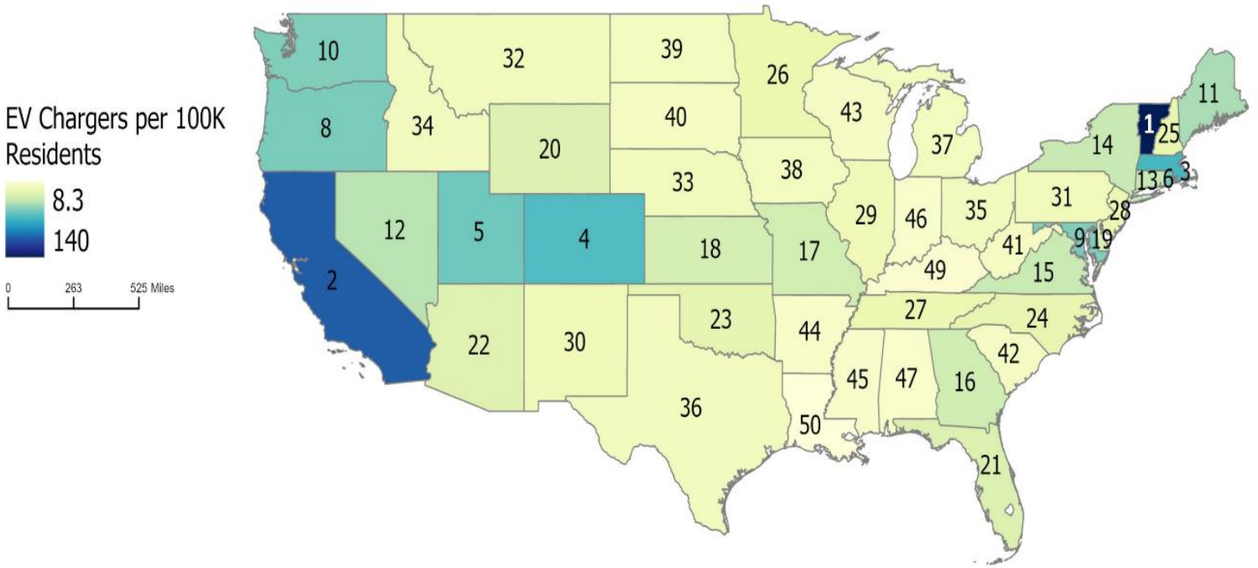
Number of EV Chargers



The ranking is based on the total number of EV chargers; a rank of 1 reflects more charging stations

PA rank: 13th

EV Chargers Per Capita Across the U.S.



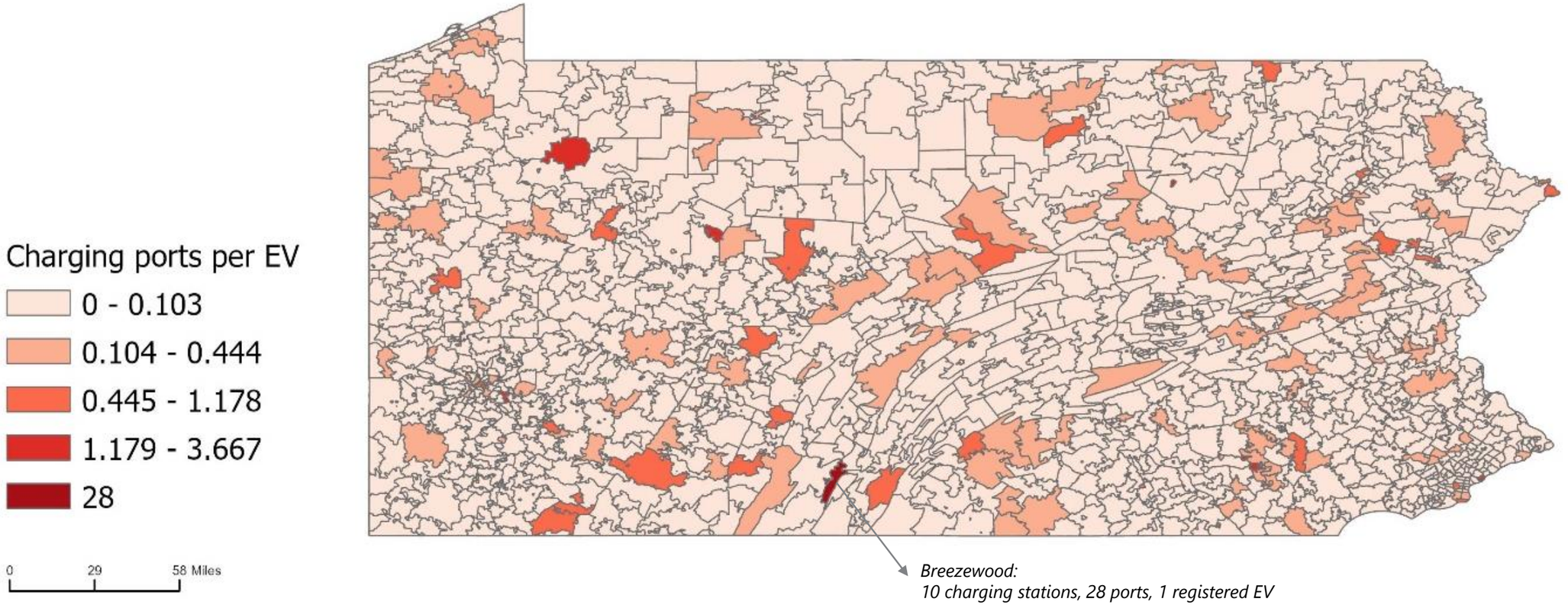
Ranking based upon EV charger per capita; a rank of 1 reflects the most-dense

PA rank: 31st

Sources: U.S. DOE, Vehicle Technologies Office. Fact of the Week #1169; Manzanetti, Z. (2022) (Governing); CoPilot (2022)

Charging Ports per EV Registration

Ratio of public charging ports (Level 2 and DCFC) and EV registrations by zip code



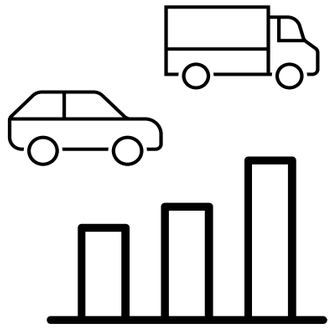
Source:
Charging stations/ports: Alternative Fuel Data Center (AFDC) Station Locator (Nov 2, 2023)
AFV data by zip code: PennDOT
ZIP code boundaries: Esri Data and Maps

NEVI Program

- Effort to fill existing DCFC gaps
- DCFC along AFCs to facilitate long-distance travel and medium-and heavy-duty travel
- High-priority groups strategically concentrated near major metropolitan centers and interstates (EV Mobility Plan)
- Charging infrastructure gaps: rural areas, regions with lower EV registrations, or those situated farther from interstates, particularly in north PA
- PA has indicated existing creditable sites, providing a foundation for future considerations

NEVI round 1A priority locations

Sources:
PennDOT. https://experience.arcgis.com/experience/6696d9749a124136b9d28a7507f300d5
Alternative Fuel Data Center (AFDC) Station Locator (Nov 2, 2023)



Fleet Modeling

PA ZEV Roadmap Overview

2. Fleet Modeling

Objective

Conduct fleet modeling to project the adoption of ZEVs in LD, MD, and HD sectors, considering various policy scenarios.

ZEV Adoption Modeling Scenarios in PA

Three scenarios are considered

Light Duty Regulations

- EPA Proposed Multi-Pollutant Standards → National ZEV Adoption
- EPA Proposed Multi-Pollutant Standards with FCEVs → National ZEV Adoption w/ FCEVs
- CARB Advanced Clean Cars II → High ZEV Adoption (Bookend scenario)

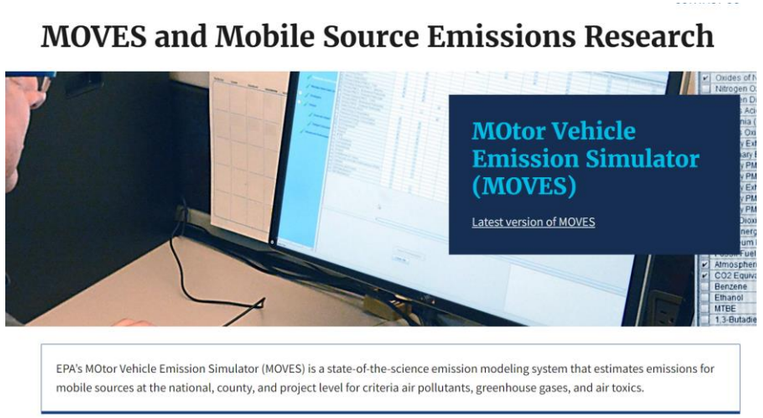
Medium- and Heavy-Duty Regulations

- EPA Phase-3 Proposed Standards → Low ZEV Adoption
- CARB Advanced Clean Trucks → Mid ZEV Adoption
- CARB Advanced Clean Fleets → High ZEV Adoption (Bookend scenario)

Electricity and hydrogen demand from ZEV adoption

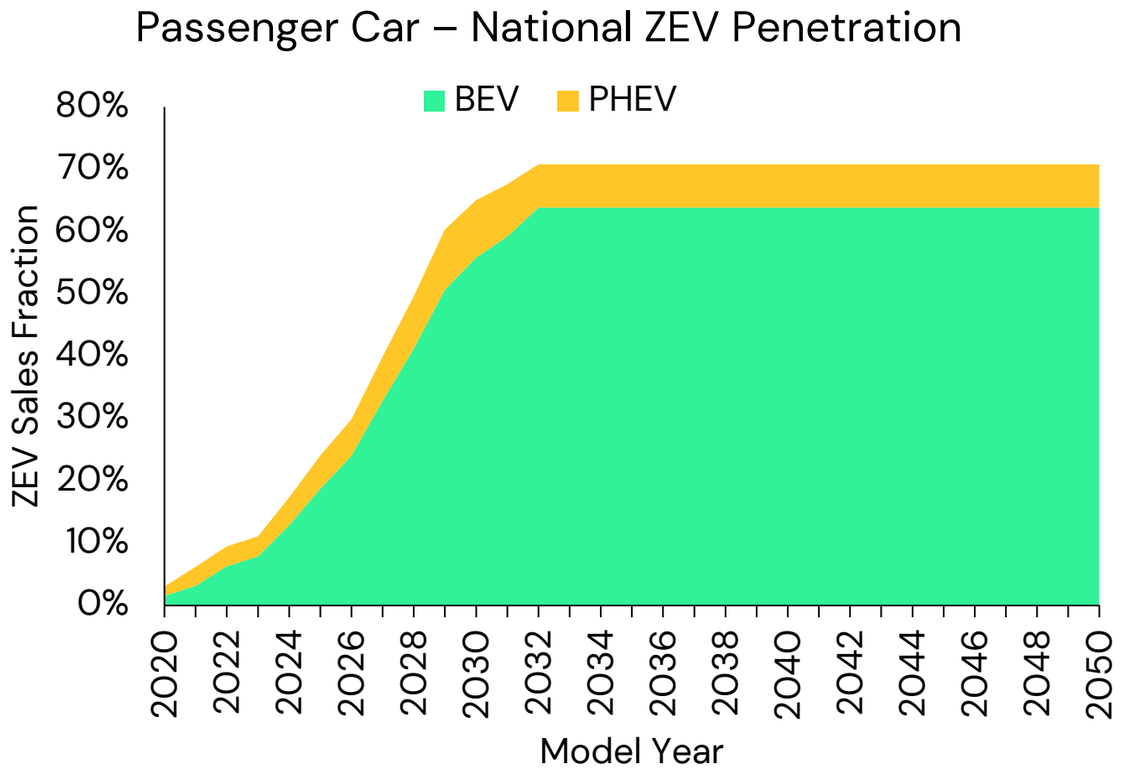
ZEV adoption scenarios, aligned with the EPA regulatory requirements or other regional programs

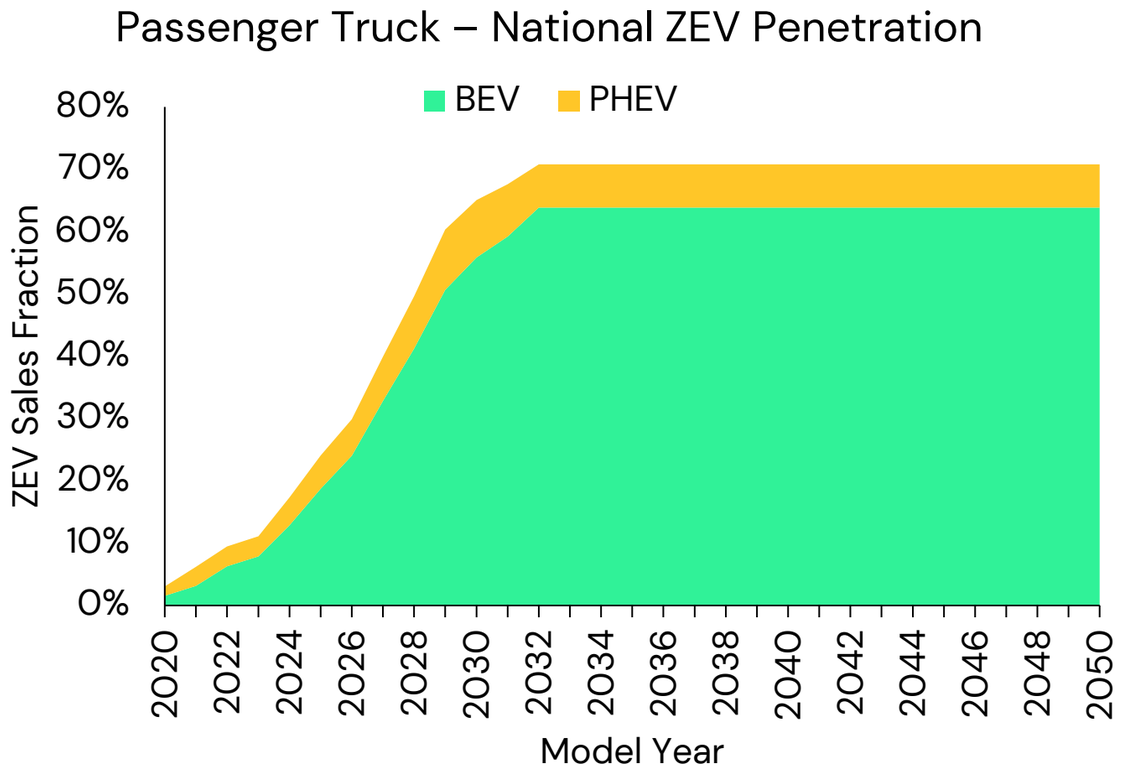
"Business-as-usual" vehicle stock and sales



Light-Duty Scenario I: EPA Multi-Pollutant Emissions Standards

ZEV fractions are in line with the Proposed EPA Multi-Pollutant Emissions Standards for MY2027. The fleet average BEV penetration will reach 67% by 2032. The EPA proposed rule only considered BEV penetration. We adjusted technology mix to account for PHEV using California ACC II assumptions. No FCEV penetration is assumed in this scenario

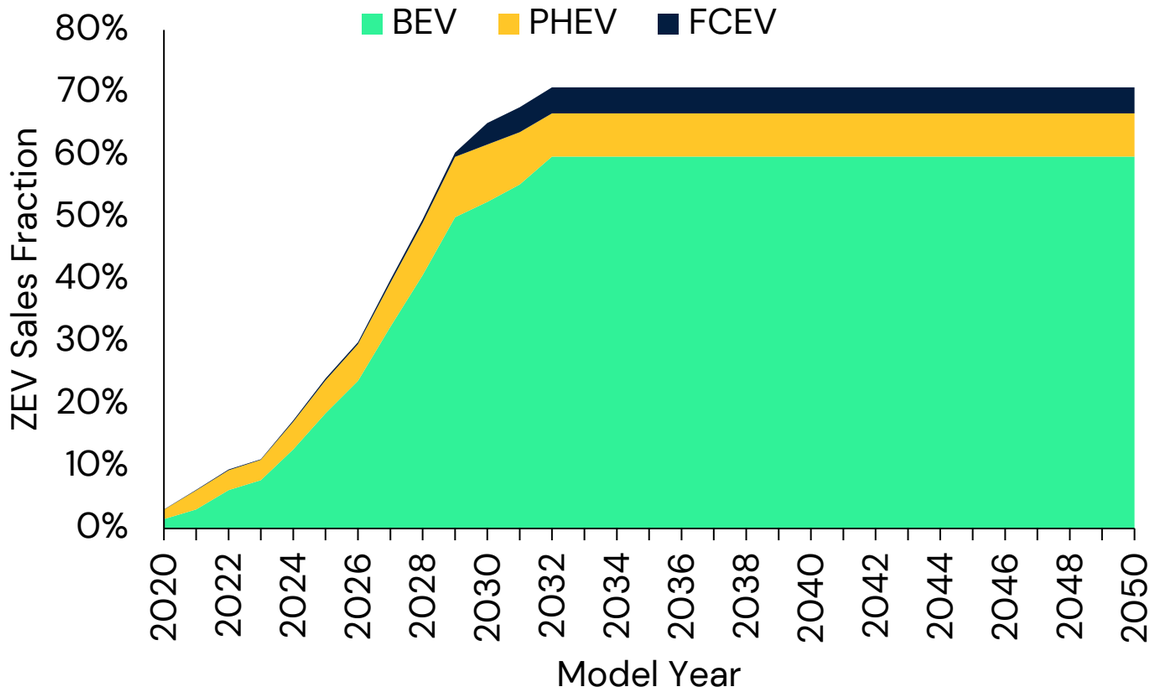




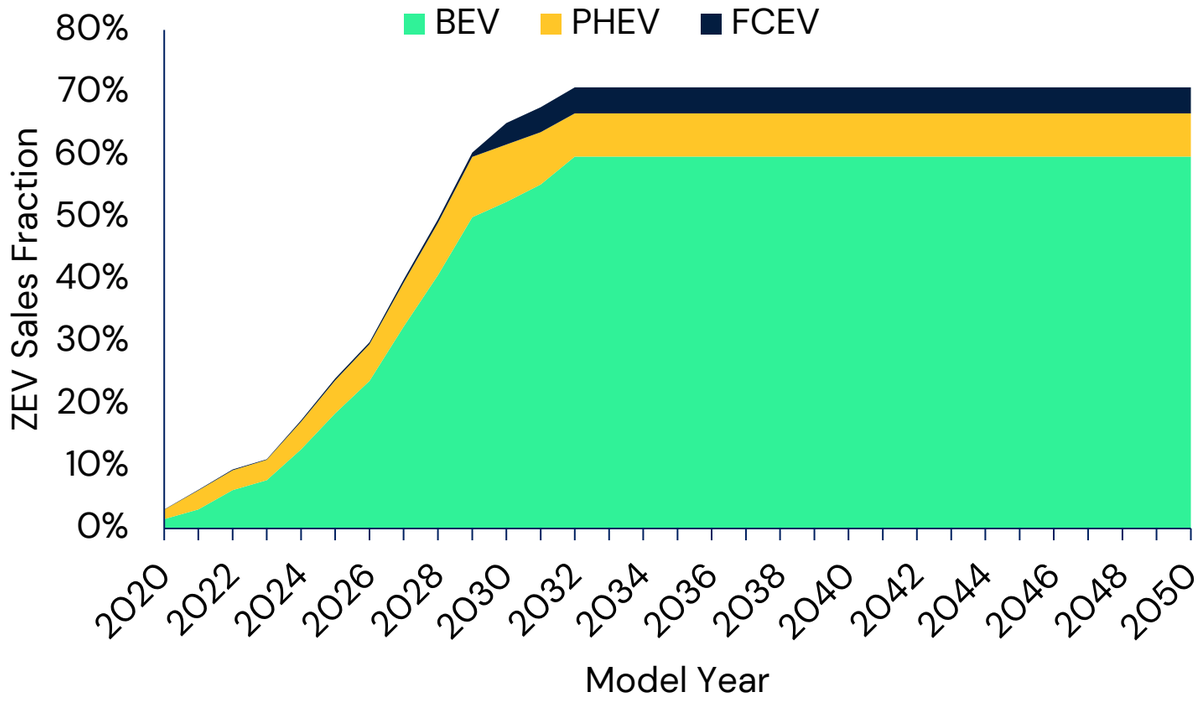
Light-Duty Scenario II: EPA Multi-Pollutant Emissions Standards with FCEVs

ZEV fractions are in line with Light-Duty Scenario I. However, here we consider FCEV penetration, following CARB's ACCII technology mix assumptions.

Passenger Car – National Scenario with FCEVs

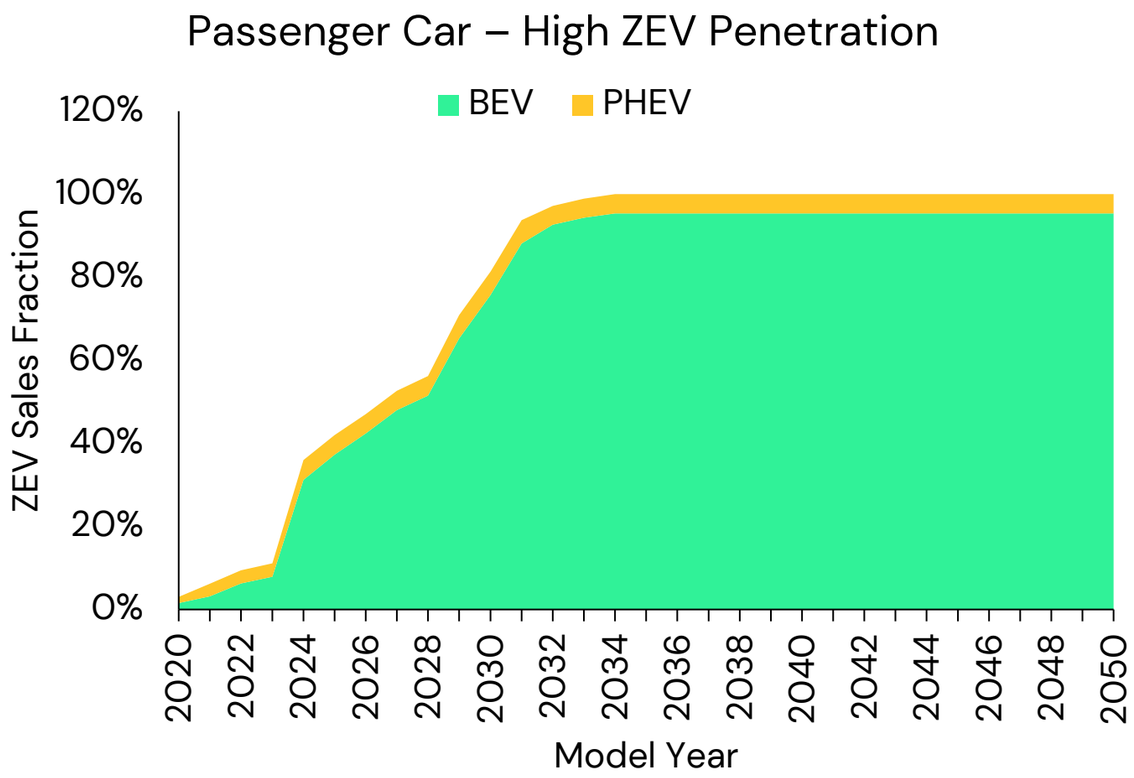


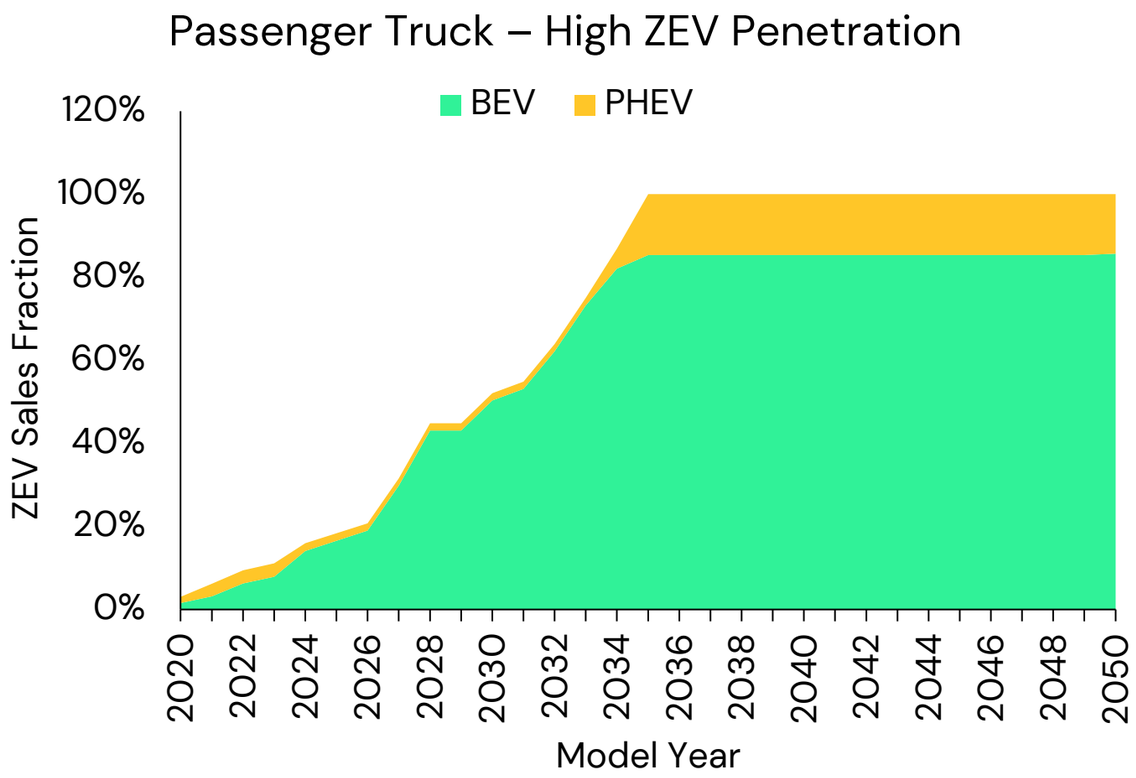
Passenger Trucks – National Scenario with FCEVs



Light-Duty Scenario III: California Advanced Clean Cars II

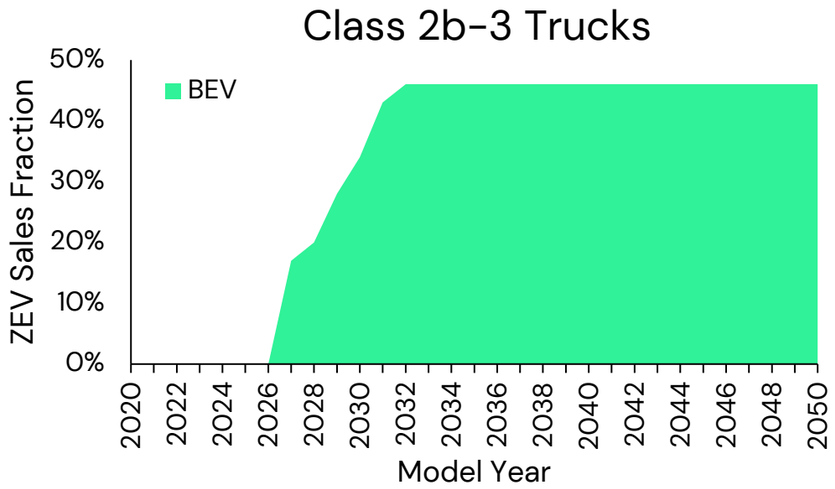
ZEV fractions and technology mix are in line with California Advanced Clean Cars II (ACCII) Regulation that all new passenger cars, trucks and SUVs sold in these states will be zero-emission by 2035. Currently we do not consider LD FCEV penetration.

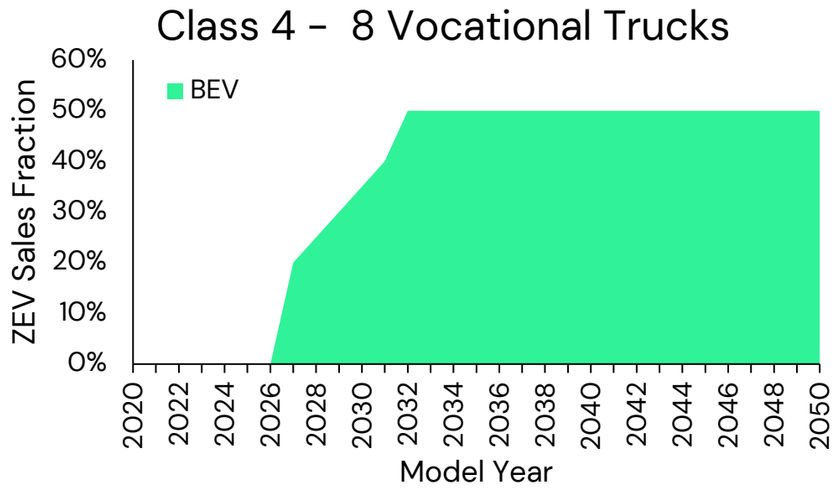


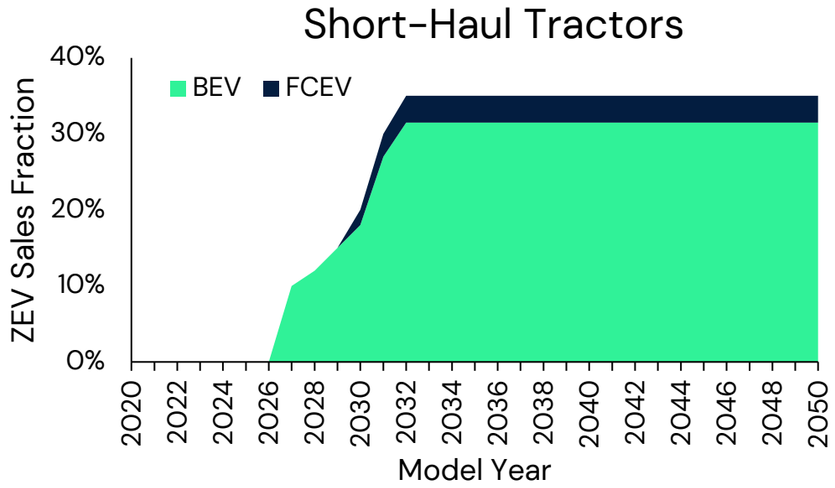


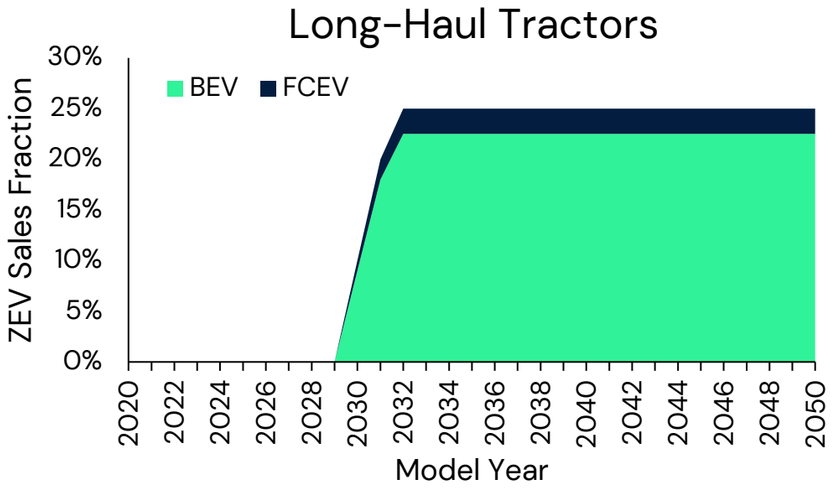
Medium & Heavy-Duty Scenario I: EPA Phase 3 Standards

Class 2b-3 for will follow the proposed EPA Multi-Pollutant Emissions Standards while Class 4 – 8 trucks will follow the ZEV penetration rates, as proposed in the GHG emissions standards for Heavy-Duty Vehicles—Phase 3.



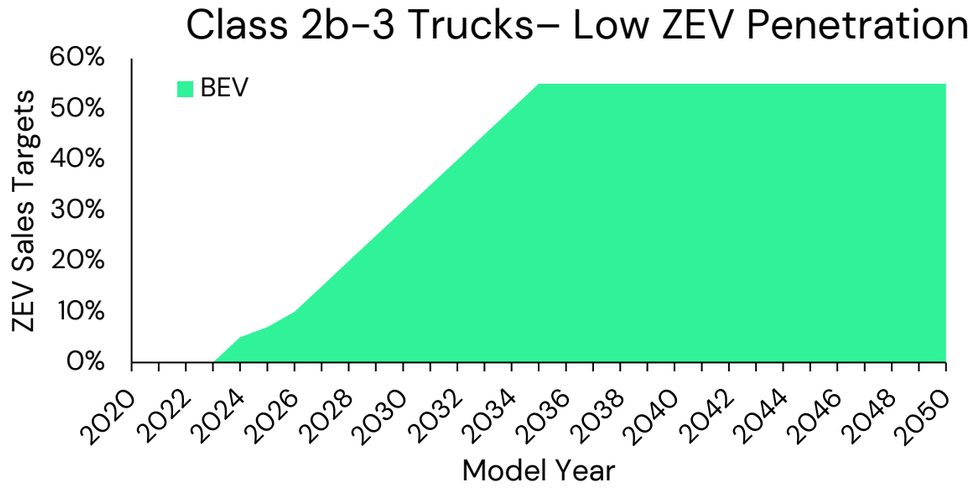


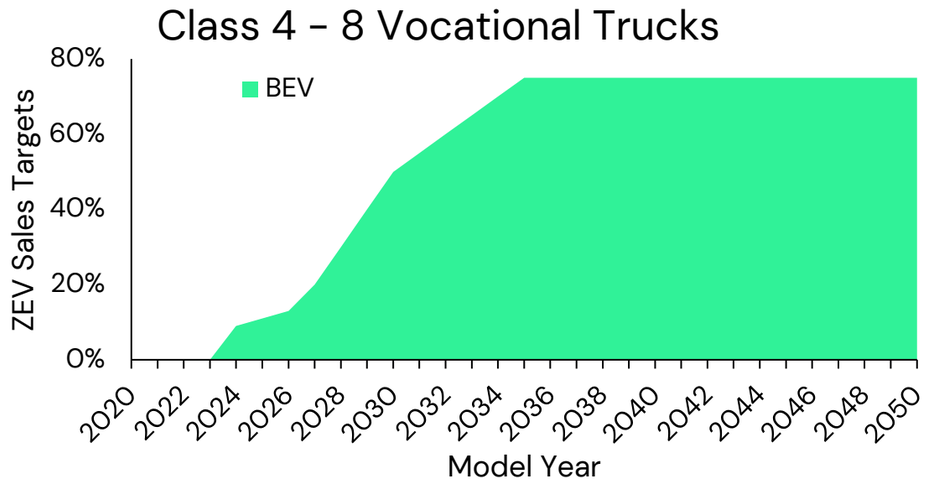


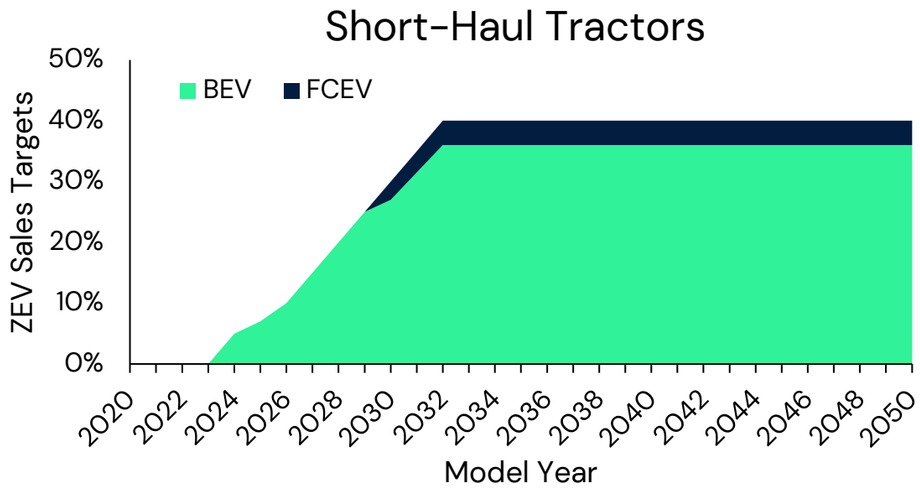


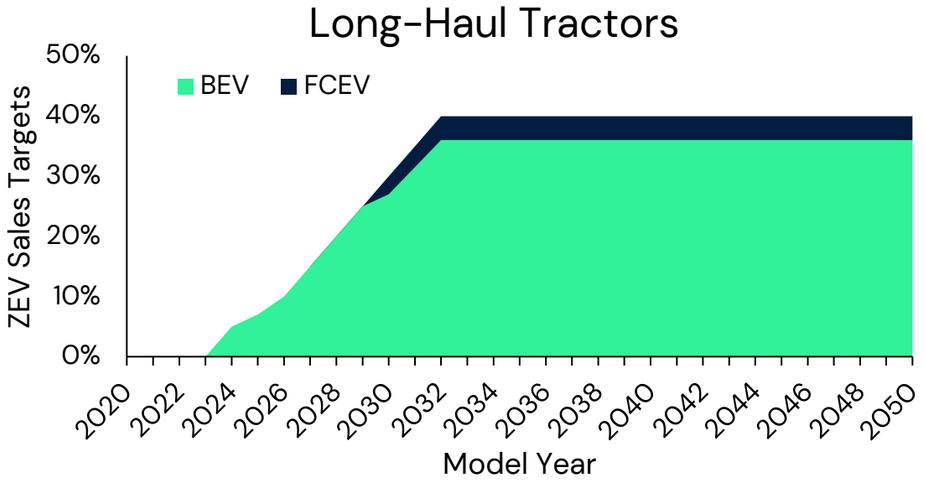
Medium & Heavy-Duty Scenario II: California Advanced Clean Trucks

MHD ZEV fractions are to follow California's Advanced Clean Trucks regulation while technology mix assumptions were kept consistent with ACT (10% FCEV – 2030 phase in timeframe as stated in the EPA latest heavy-duty rule making document).



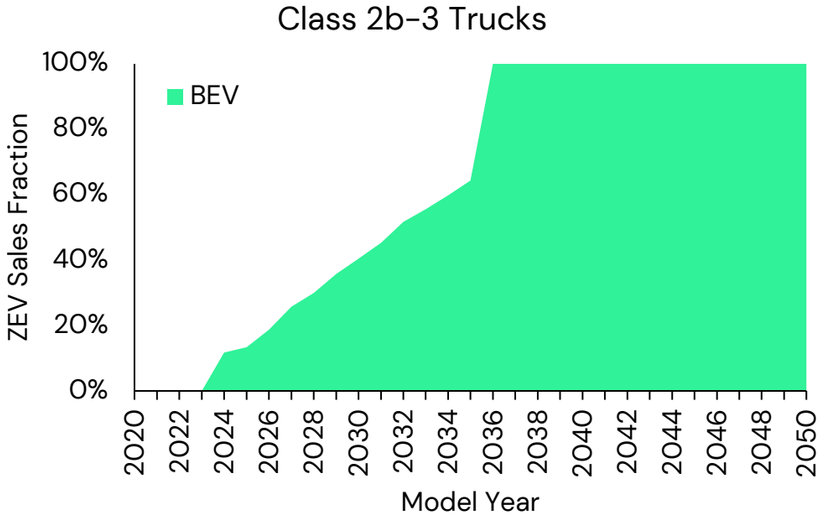


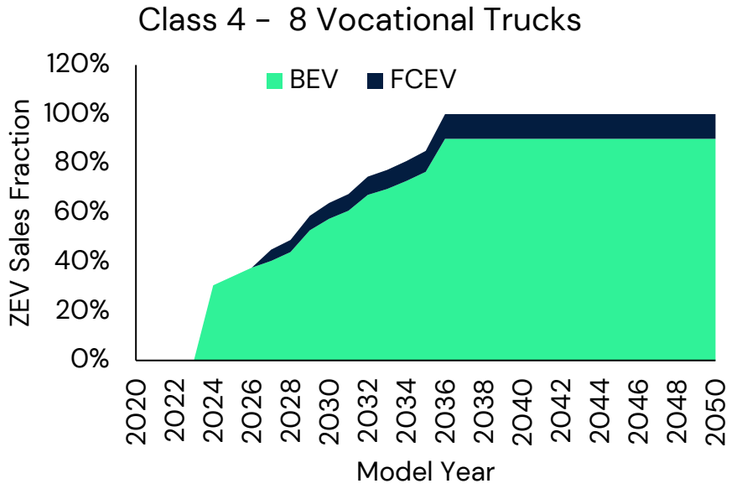


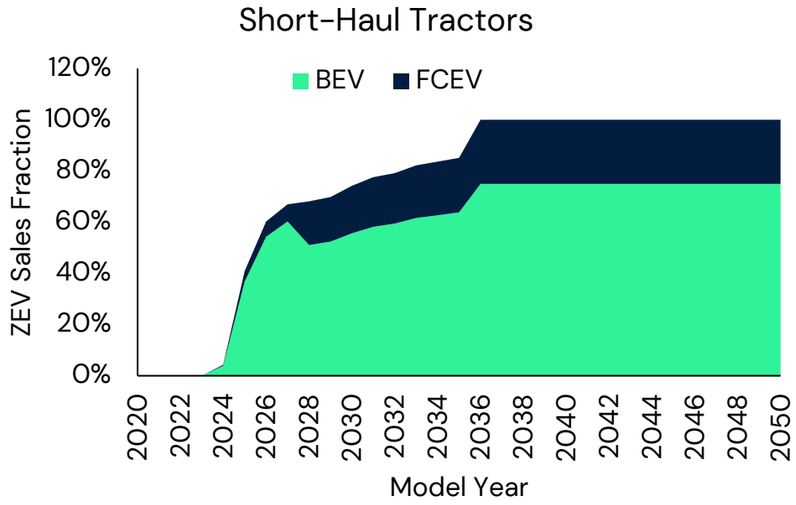


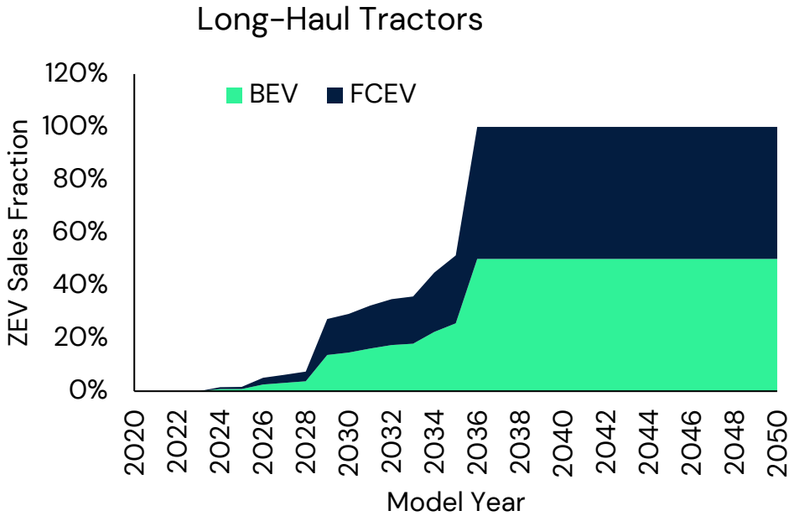
Medium & Heavy-Duty Scenario III: California Advanced Clean Fleets

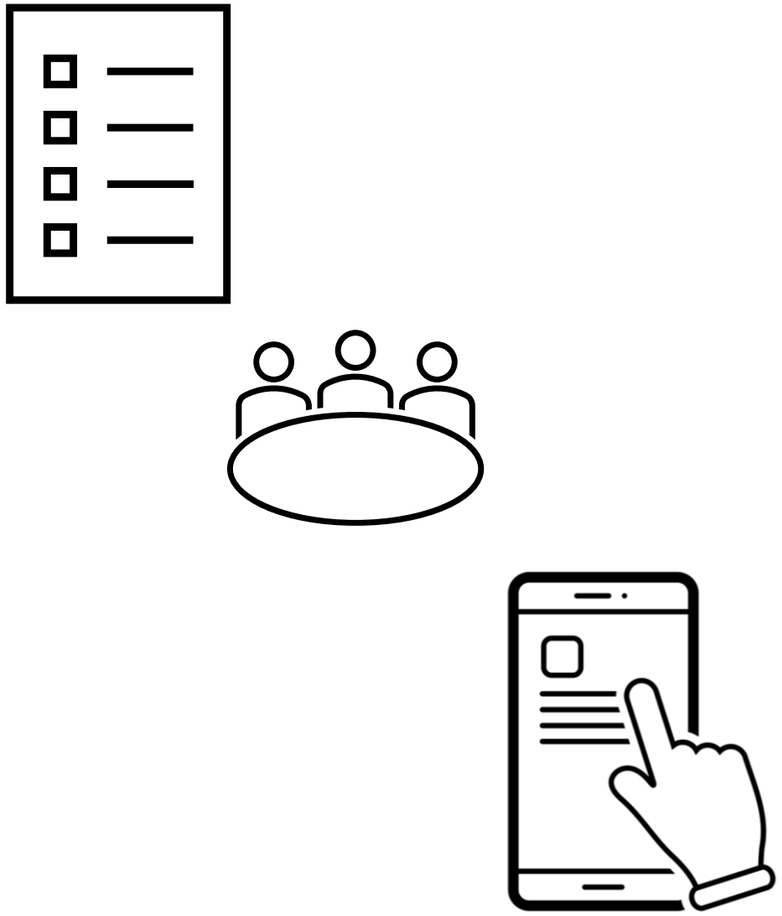
California is so far the only state that has set 100% sales target for medium- and heavy-duty truck sales through the recently adopted Advanced Clean Fleets (ACF) regulation. In addition, ACF has also established fleet purchase requirement that goes above and beyond the manufacturer sales targets that were originally set by the Advanced Clean Trucks regulation. Technology mix was kept consistent with ACF rulemaking assumptions as well.











Discussion

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Appendix

Report & Presentation

❑ Final Report

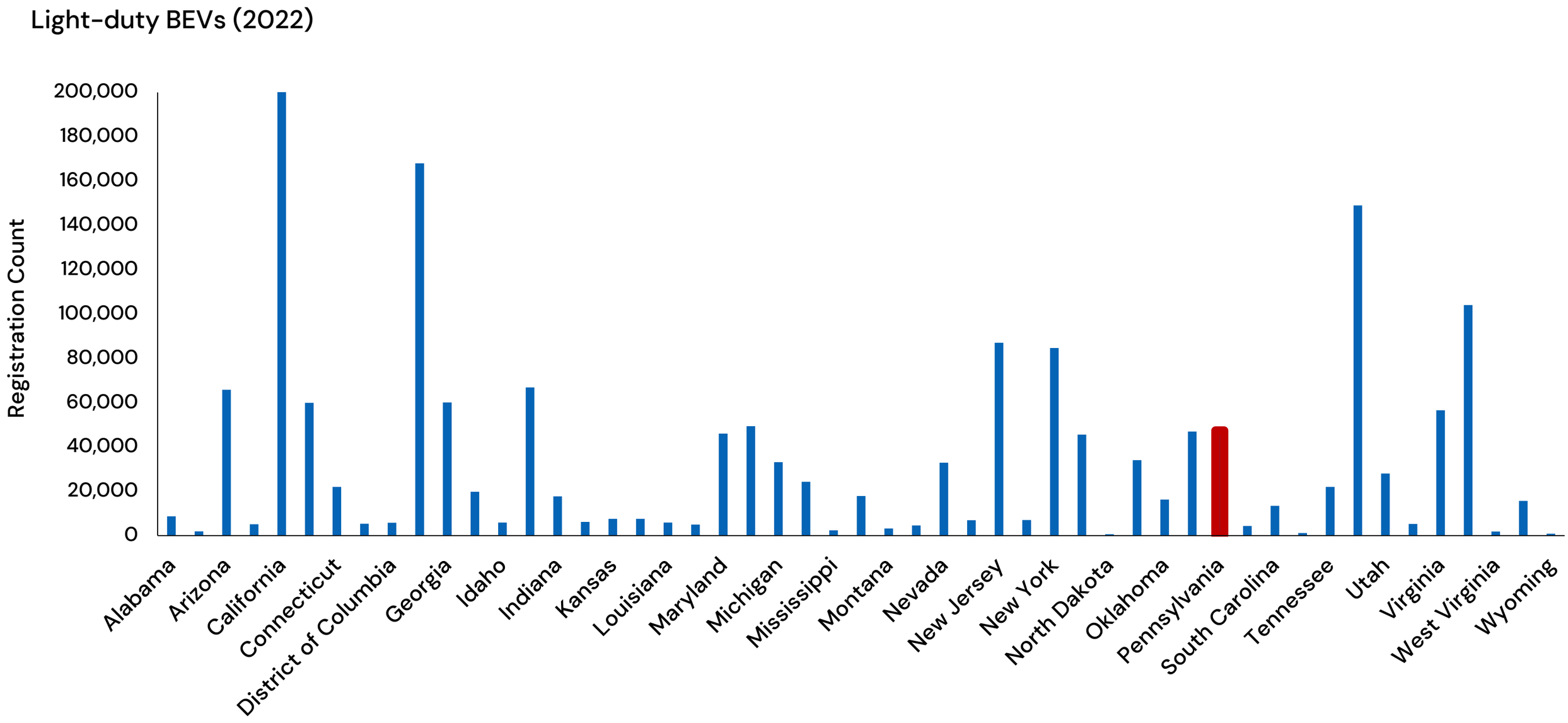
❑ Presentation for Educational Outreach

Model Availability

Medium-/heavy-duty vehicle manufacturer commitments to ZEV sales and carbon neutrality

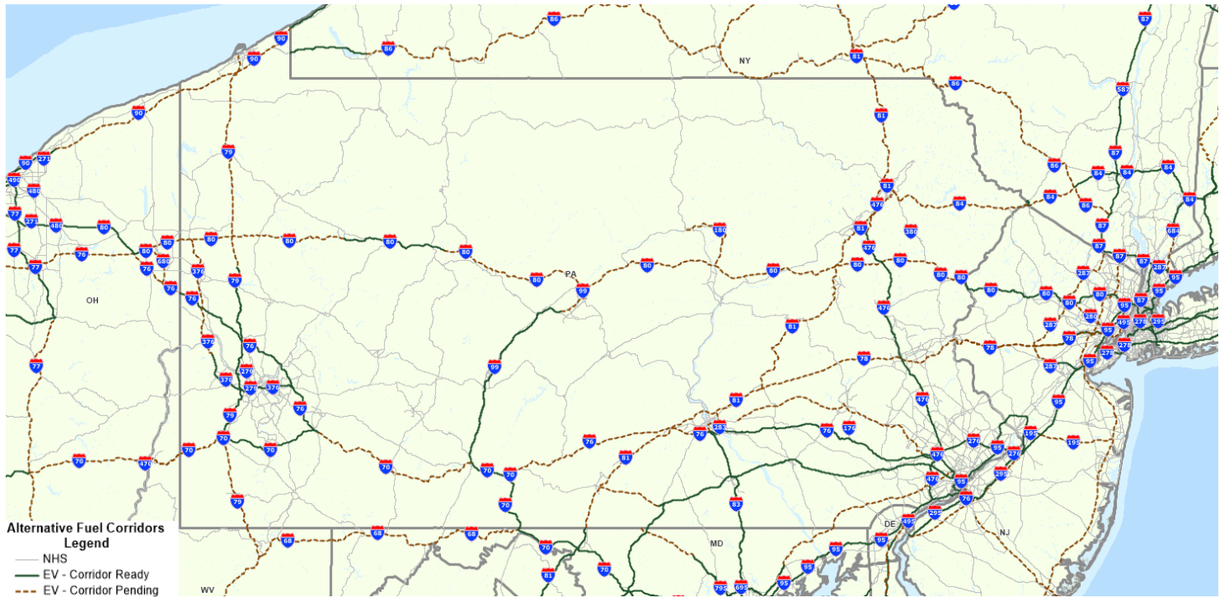
Manufacturer	Commitment	Date
Scania	At least 90% of zero-emission vehicle sales worldwide, with remainder powered by 100% fossil-free energy	2040
GM group	100% carbon neutral in global products and operations	2040
Stellantis	70% low-emission vehicle sales in Europe, and 40% in the US	2030
Ford Group	100% fossil free new vehicle sales	2040
Daimler Group	100% carbon neutral in driving operation in Europe, North America, and Japan	2039
Toyota Group	100% carbon neutral in lifecycle by 2050	2050
Changan	100% electric vehicle sales	2025
Great Wall Motor	100% carbon neutral with interim target of 80% new vehicle sales by 2025	2025
Mahindra & Mahindra	100% carbon neutral in operations	2040
VW Group	100% carbon neutral in operations	2050
Renault	100% carbon neutral worldwide, with interim target of 100% CO2 neutral in Europe by 2040	2050
Nissan	100% carbon neutral across operations and product lifecycle	2050
Mitsubishi	100% carbon neutral, with 50% EV sales by 2030	2050
Isuzu	100% carbon neutral in vehicle operation and plants sheet	2050
Paccar	100% fossil free new vehicle sales	2040
Suzuki	90% reduction in CO_2 emissions in driving operation	2050
Volvo Trucks Group	100% fossil free new vehicle sales	2040
CNH Industrial	100% fossil free new vehicle sales	2040
Honda	100% battery-electric and fuel cell electric vehicle sales in North America, with interim targets of 40% by 2030 and 80% by 2035	2040
Mazda	90% reduction in CO_2 emissions in driving operation and energy production	2050
Hyundai Kia	100% carbon neutral in all operations	2050

ZEV Population in PA and Other States



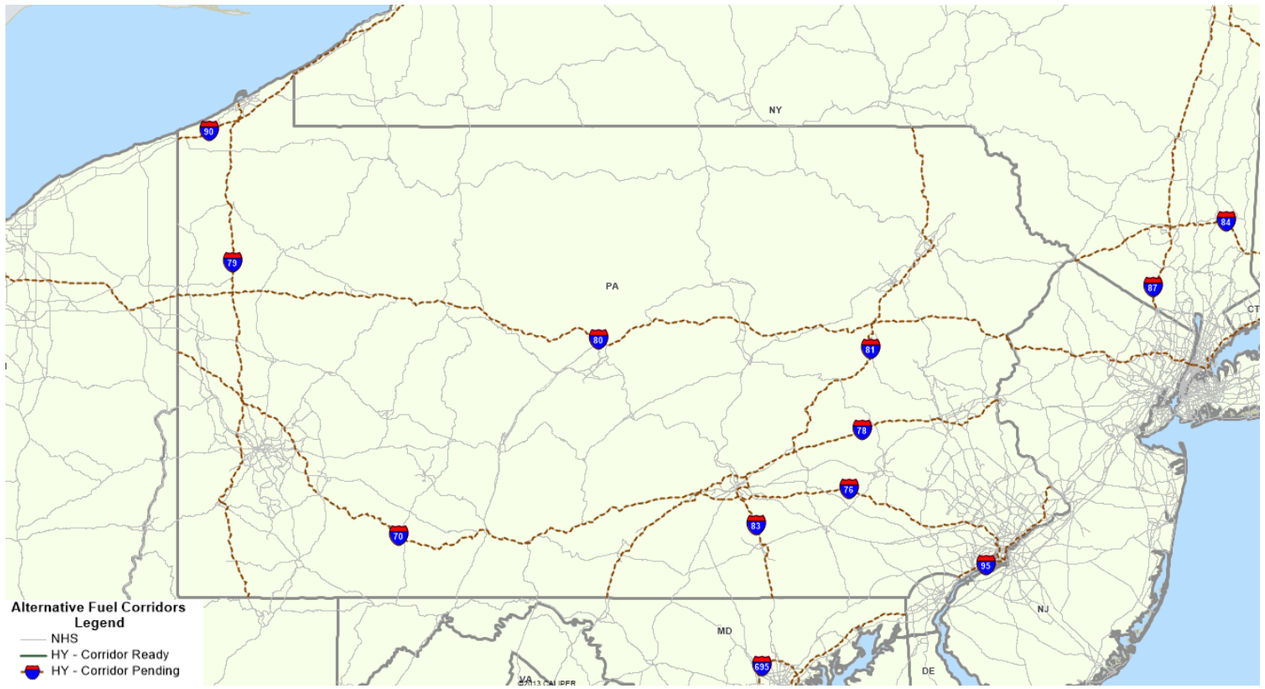
Sources:
Alternative Fuels Data Center (AFDC): Vehicle registration counts derived by the National Renewable Energy Laboratory with data from Experian Information Solutions

Alternative Fuel Corridors

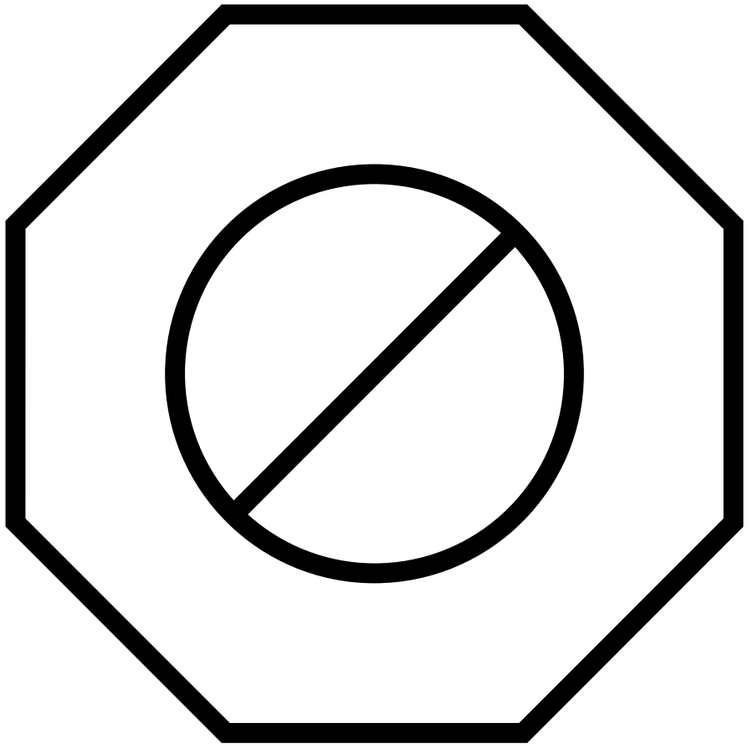


⇦ Alternative Fuel Corridors- Electric Vehicle (EV-Round 1,2,3,4,5,6 and 7)

Alternative Fuel Corridors- Hydrogen (HY-Round 1,2,3,4,5,6 and 7) ⇨



Source: FHWA



Barriers to ZEV Adoption and Deployment

Groups of Barriers

Existing literature and examination of ZEV landscape

ZEV Adoption & Deployment

Lack of Fueling Infrastructure

Technology Readiness

Lack of Awareness

Regulatory and Policy Barriers