



EV Champion Training

Webinar 1: ZEV and EV Charging Fundamentals

Erin Nobler – Project Manager, NREL

Emily Kotz – Federal Fleet Team Lead, NREL

Julian Bentley – Bentley Energy Consulting

Joyce McLaren – Senior Energy Analyst, NREL

Thursday, August 29th 12-2PM ET

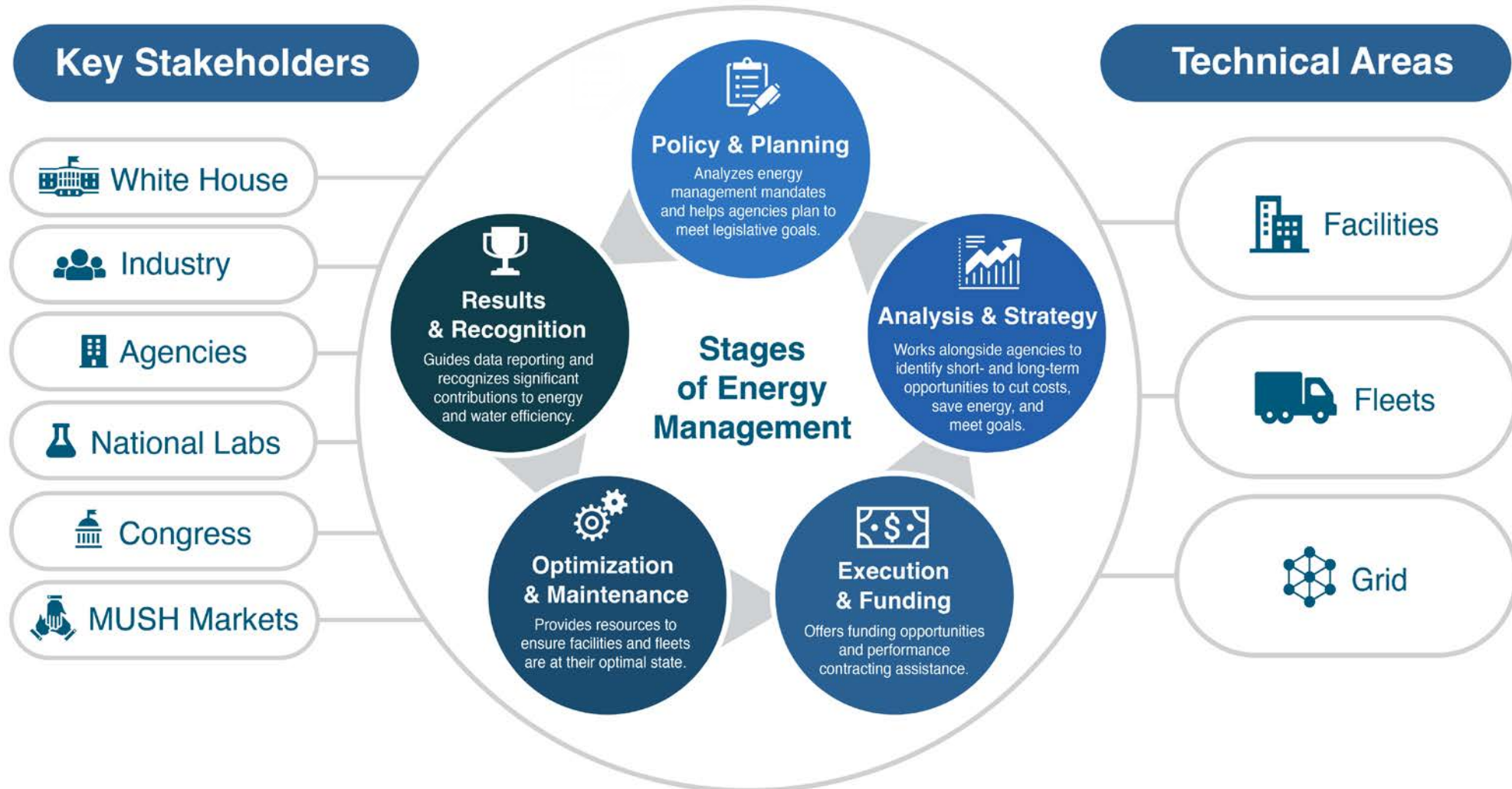
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FEMP Focuses on Federal Agency Support

FEMP works with **key stakeholders** to support **all stages of energy management** in federal agencies' **critical areas**



This Training Offers IACET CEUs

How to obtain your CEUs:

1. Visit the Whole Building Design Guide (WBDG) at wbdg.org to log in or create an account
2. Enroll in the training
3. Attend the training in full
4. Return to your WBDG account's Enrolled courses
5. Select the training's "Proceed to Course" button
6. Complete an assessment
7. Submit a training evaluation
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An International Association for Continuing Education and Training (IACET) continuing education unit (CEU) is a unit of credit equal to 10 hours of participation in an accredited program designed for professionals with certificates or licenses to practice various professions.



Register Today For Upcoming EV Champion Training

EV Champion Training Series	Date and Time
Training 1: ZEV and EV Charging Fundamentals	Thurs., Aug. 29, 12–2 p.m. ET
Training 2: ZEV and EV Charging Planning	Wed., Sept. 11, 2–4 p.m. ET
Training 3: EV Charging Site Assessments and Budgeting	Wed., Sept. 18, 2–4 p.m. ET
Training 4: EV and EV Charging Design and Implementation	Wed., Oct. 2, 2–4 p.m. ET



Training updates reflect current industry trends and business charging models. The training will follow the ZEV Ready Center framework.



Agenda

- 1 ZEV Ready Framework
- 2 Legislation Summary
- 3 Market Analysis
- 4 Vehicle and Charging Technology
- 5 Utility Basics
- 6 Wrap-Up/Q&A



Instructors



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Learning Objectives

- *Identify EV and EV charging technology fundamentals*
- *Recognize EV market and GSA Schedule options*
- *Identify utility basics, incentives, and rates as they relate to EV charging*
- *Identify methods to calculate life cycle costs for EVs and gasoline vehicles*



Electric Vehicle Key Terms

- **ICE:** Internal Combustion Engine
- **HEV:** Hybrid Electric Vehicle
- **PHEV:** Plug-In Hybrid Electric Vehicle
- **BEV:** Battery Electric Vehicle
- **EPA:** United States Environmental Protection Agency
- **ZEV:** Zero Emission Vehicle (includes BEV, PHEV, and Fuel Cell)
- **EVSE:** Electric Vehicle Supply Equipment



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Federal Fleet ZEV Ready Center

One-stop location to find resources on fleet electrification






Federal Fleet ZEV Ready Center – Planned Updates

Steps 1-6 being revised

Planning

Step 1	Step 2	Step 3	Step 4
Identify and coordinate team	Review training materials	Review requirements, goals, and data	Align headquarters strategy with site planning
 Team Ready	 Team Ready	 Commitment Ready	 Commitment Ready
Step 5	Step 6	Step 7	
Identify ZEV opportunities	Identify EVSE opportunities	Coordinate site financial planning with headquarters	
 Vehicle Ready	 Charging Ready	 Commitment Ready	

Design

Step 8	Step 9	Step 10	Step 11
Engage with key electrification stakeholders at site	Coordinate with local utility service	Complete site assessment and design EVSE	Identify EVSE at non-agency locations
 Team Ready	 Charging Ready	 Charging Ready	 Charging Ready
Step 12			
Work with leadership to secure EVSE funding			
 Commitment Ready			

ZEV Active

Step 13	Step 14	Step 15
Acquire ZEVs and EVSE	Install and activate EVSE	Support drivers in using ZEVs and EVSE
 ZEV Ready	 ZEV Ready	 ZEV Ready








Additional Planned Updates for Each Step:

- *Updated content and new subpages*
- *New icons with easy-to-find, relevant case studies, training, and tools*
- *New best practices section*
- *Revised Action Checklist at the end of the page*








Federal Fleet ZEV Ready Center

Planning

Step 1 Identify and train team  Team Ready	Step 2 Align HQ strategy with site planning  Commitment Ready	Step 3 Identify ZEV opportunities  Vehicle Ready	Step 4 Identify EVSE needs  Charging Ready
Step 5 Initial utility coordination  Charging Ready	Step 6 Quick site assessment  Charging Ready	Step 7 Coordinate site financial planning with headquarters  Commitment Ready	

Design

Step 8 Engage with key electrification stakeholders at site  Team Ready	Step 9 Coordinate with local utility service  Charging Ready	Step 10 Complete site assessment and design EVSE  Charging Ready	Step 11 Identify EVSE at non-agency locations  Charging Ready
Step 12 Work with leadership to secure EVSE funding  Commitment Ready			

ZEV Active

Step 13 Acquire ZEVs and EVSE  ZEV Ready	Step 14 Install and activate EVSE  ZEV Ready	Step 15 Support drivers in using ZEVs and EVSE  ZEV Ready
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Legislation and Review of Requirements

Requirements that guide federal fleet electrification

Administration priority: *Transitioning to a ZEV fleet*

Executive Order 14057



100% light-duty ZEV acquisitions by FY27



100% overall ZEV acquisitions by FY35

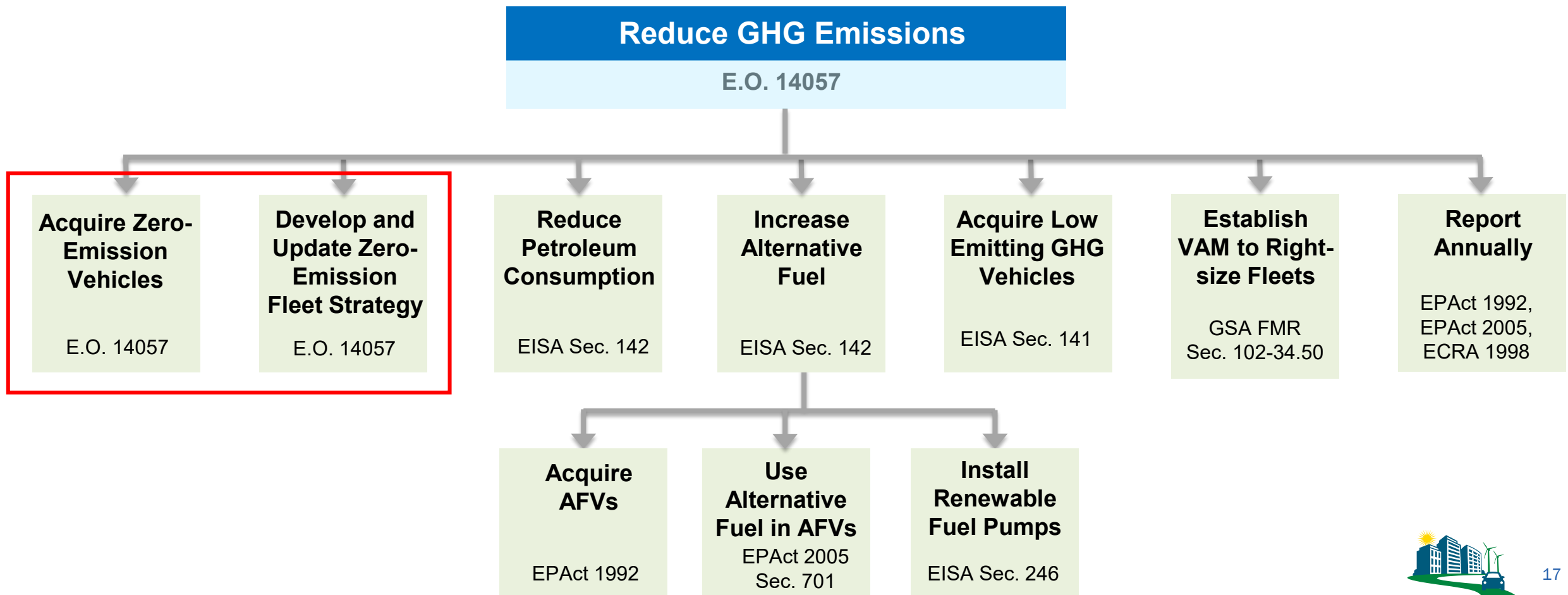


Update annual ZEV strategic plans



Federal Fleet sustainability requirements: overview

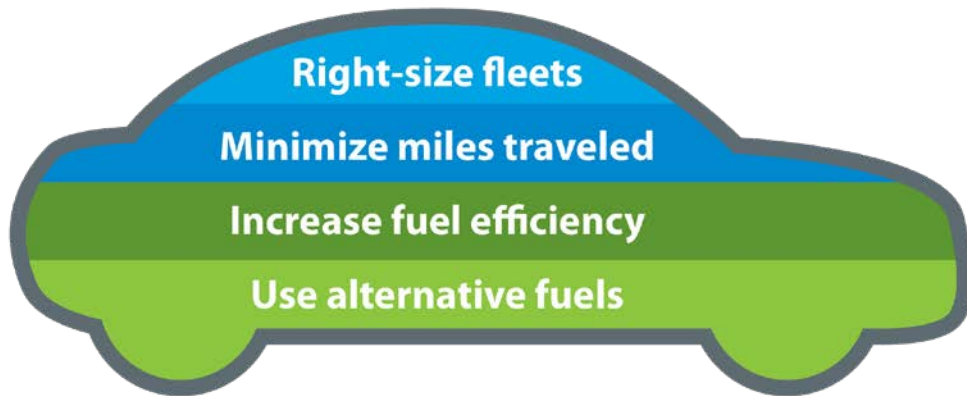
The overarching Federal fleet goals are to reduce fleet GHG emissions and transition to clean, zero-emission technologies



Core principles of sustainable fleet management

“Core Principles” help fleets reduce:

- Operational costs by lowering petroleum use
- Vehicle asset costs by right-sizing fleets and vehicles to mission



Right-size fleets & vehicles to mission

- Dispose of inefficient or unnecessary vehicles
- Replace with more fuel-efficient vehicles

Optimize/reduce vehicle miles travelled

- Eliminate and consolidate trips
- Use shuttles and mass transportation
- Implement transportation on demand

Replace with higher fuel economy vehicles

- Identify most efficient vehicle for mission
- Cost effective HEVs, PHEVs, and LSEVs

Cost effective operational changes

- Improved maintenance
- Drive more efficiently
- Avoid idling

Maximize alternative fuel use

- Electric vehicles and charging stations
- E85, CNG, & B20, AFVs and infrastructure support

Fleet electrification helps meet Federal fleet requirements

	Statute or EO	Requirement		Alignment with Fleet Electrification
Fuel Use	Petroleum Reduction <i>EISA §142</i>	Requires 20 percent total reduction from FY05	✓	All electricity used in ZEVs displaces petroleum use
	Alternative Fuel Use <i>EISA §142</i>	Requires 10 percent total increase from FY05	✓	All electricity used in ZEVs is counted towards alternative fuel use
Vehicle Acquisition	Optimum fleet inventory <i>FMR §102-34.50</i>	Establish a structured VAM to determine the appropriate size and number of motor vehicles	✓	Replacing inefficient vehicles with ZEVs yields ROI and sustainability benefits
	Acquisition of AFVs <i>EPAAct 1992</i>	At least 75% of LDVs acquired in MSAs/CMSAs must be AFVs	✓	ZEVs are classified as AFVs in meeting EPAAct 1992 requirements
	Acquisition of low GHG-emitting vehicles <i>EISA §141</i>	Prohibits agencies from acquiring vehicles that are not low-GHG-emitting vehicles	✓	Almost all ZEVs meet EPA's definition of a low-GHG-emitting vehicle
AF Use	Alternative fuel use in AFVs <i>EPAAct 2005 § 701</i>	All dual-fueled vehicles must use alternative fuel if reasonably available	✓	PHEVs are considered dual-fueled AFVs
	Alternative fuel infrastructure <i>EISA § 246</i>	Every federal fleet fueling center must install a renewable fuel pump	✓	EVSE qualify as renewable fuel pumps if the electricity is from renewable sources

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Market Analysis

Where is the market today and where is it heading

Current EV Market

Global sales slowing, but continue to be strong

U.S:

- Grew 10% in H1 2024
- Grew 52% in 2023
- Grew 52% in 2022
- Grew 90% in 2021



1,402,000 EVs (2023)
926,000 EVs (2022)
608,000 EVs (2021)

Market Share:

9.3% (H1 2024)

9.1% (2023)
6.8% (2022)
4.0% (2021)

Europe:

- Grew 1% in H1 2024
- Grew 16% in 2023
- Grew 15% in 2022
- Grew 63% in 2021



3,017,000 EVs (2023)
2,602,000 EVs (2022)
2,262,000 EVs (2021)

Market Share:

21% (H1 2024)

24% (2023)
23% (2022)
19% (2011)

China:

- Grew 32% in H1 2024
- Grew 36% in 2023
- Grew 85% in 2022
- Grew 141% in 2021



8,060,000 EVs (2023)
5,916,000 EVs (2022)
3,202,000 EVs (2021)

Market Share:

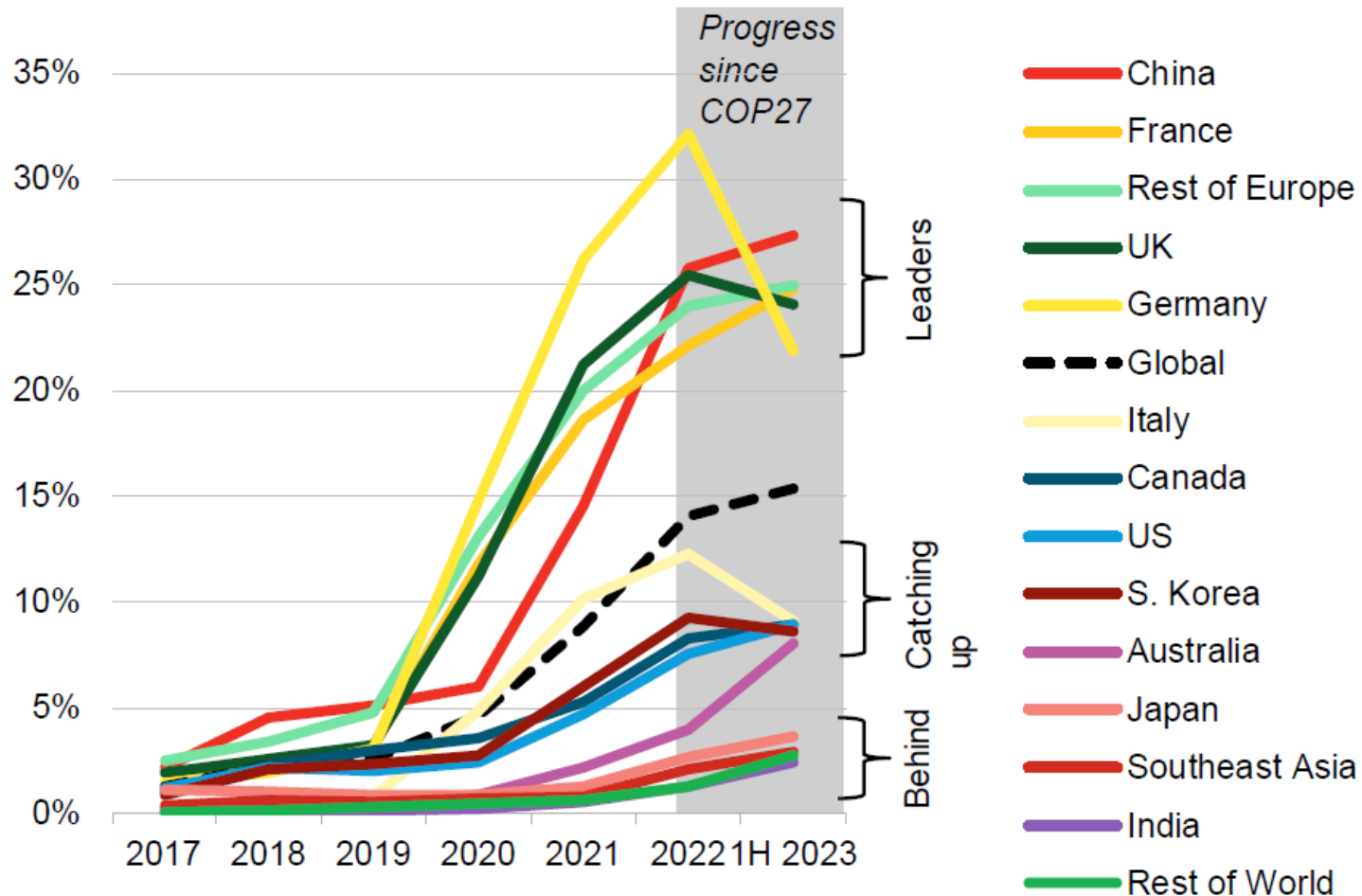
42% (H1 2024)

37% (2023)
30% (2022)
15% (2021)



Adoption and growth rates vary across major countries

EV Market Share by Country (2017-2023)

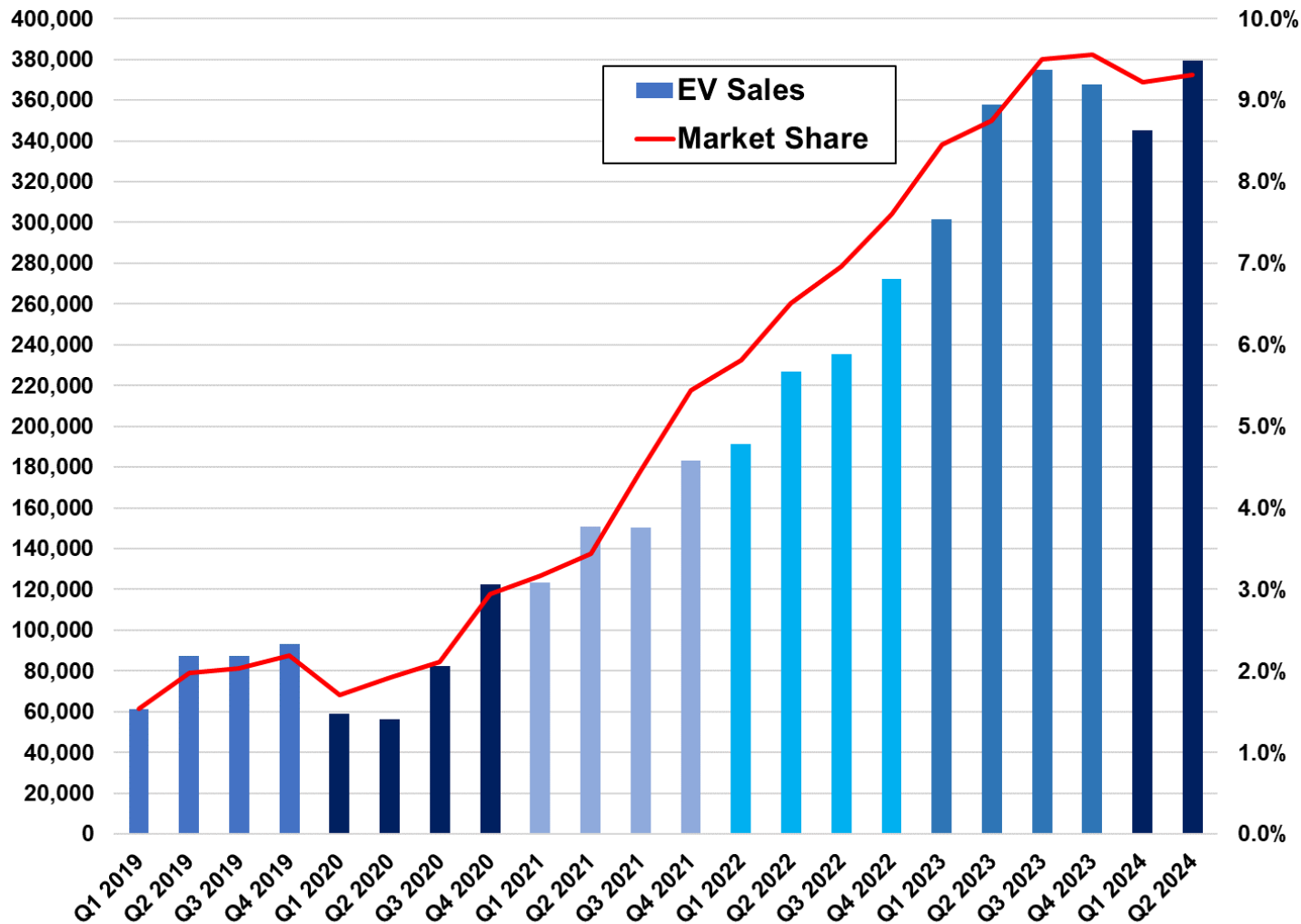


- Adoption is **greatest in China and most European countries**
- In **over half** of the global car market, **EV adoption is still below 10% of sales**, and in **30%** of the car market, **EV adoption is still below 5%**
- Issues include:
 - lack of low-priced vehicles
 - EV model availability
 - charging infrastructure
 - unreliable grids
 - lack of policy support



U.S. EV sales beginning to stagnate in early 2024

U.S. Electric Vehicle Sales by Quarter (2019 to 2024)



- EV sales have remained **relatively flat over the last 5 quarters**
- **EVs sales in 1st half of 2024 grew 10%** over same period in 2023
- **EV sales of 1.47M over last 12 months grew by 26%** over 1.17M EVs sold in prior 12 months
- **Since Q2 2022, market share consistently over 9%**
- **Shift towards PHEVs, increasing from 19% to 23% of sales**



Recent EV Market Developments

Growing current of anti-EV media

The Washington Post

Car shoppers aren't electrified by electric vehicles

America passed the EV 'tipping point' — but many buyers still want gas

Bloomberg

Why America's Car Buyers Are Rethinking EVs

Forbes

EV Sales Pace Is Running Short Of Power Going Into 2024

THE WALL STREET JOURNAL.

Automakers Have Big Hopes for EVs; Buyers Aren't Cooperating

Money

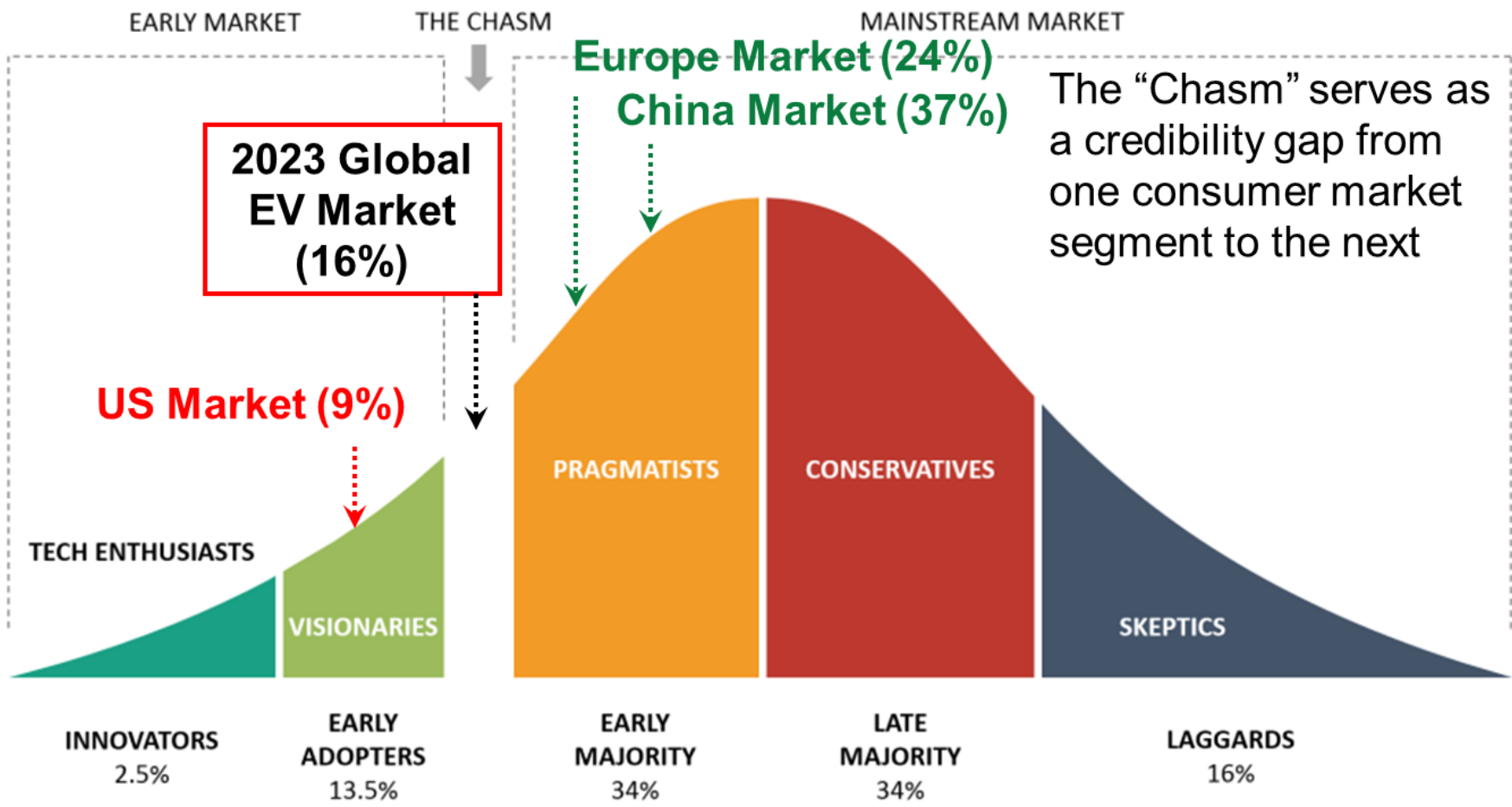
EV Sales Are in a Slump — Why Aren't More Car Buyers Going Electric?

NEW YORK

A Once Unthinkable Question: Could Electric-Vehicle Sales Decline This Year?



The EV market and the technology adoption life cycle



Crossing the chasm is expected to occur when the cost of EVs reaches cost parity with the ICEV

- **Innovators:** Pursue new technologies. Assures other consumers that the product works.
- **Early Adopters:** Looking for revolutionary breakthrough. High-risk and least price-sensitive
- **Early Majority:** Mainstream market seeking revolutionary technology. Needs to see technology perform well.
- **Late Majority:** Like traditional products. Wait until something has become an established standard.

Challenges expected as U.S. EV market transitions through the chasm

“As the initial wave, powered by tech-savvy ‘early adopters’ has become saturated, automakers and dealers need to turn their attention to more reluctant consumers”

Sam Fiorani, AutoForecast Solutions

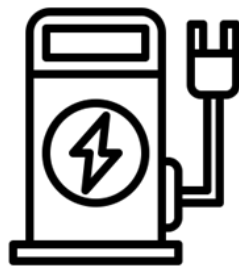
“The next great growth area for EVs is said to be a more mainstream crowd: lower- and middle-income buyers, people who want practical everyday cars and total newcomers to the electric world”

InsideEVs

Automakers need to appeal to consumers concerned about:



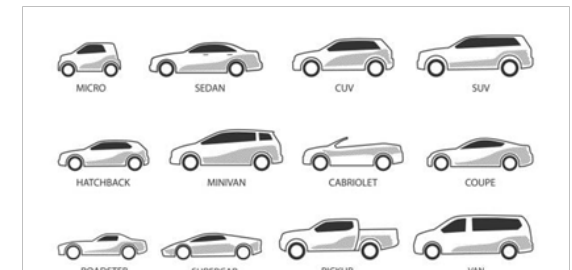
Affordability



Lack of Charging Infrastructure



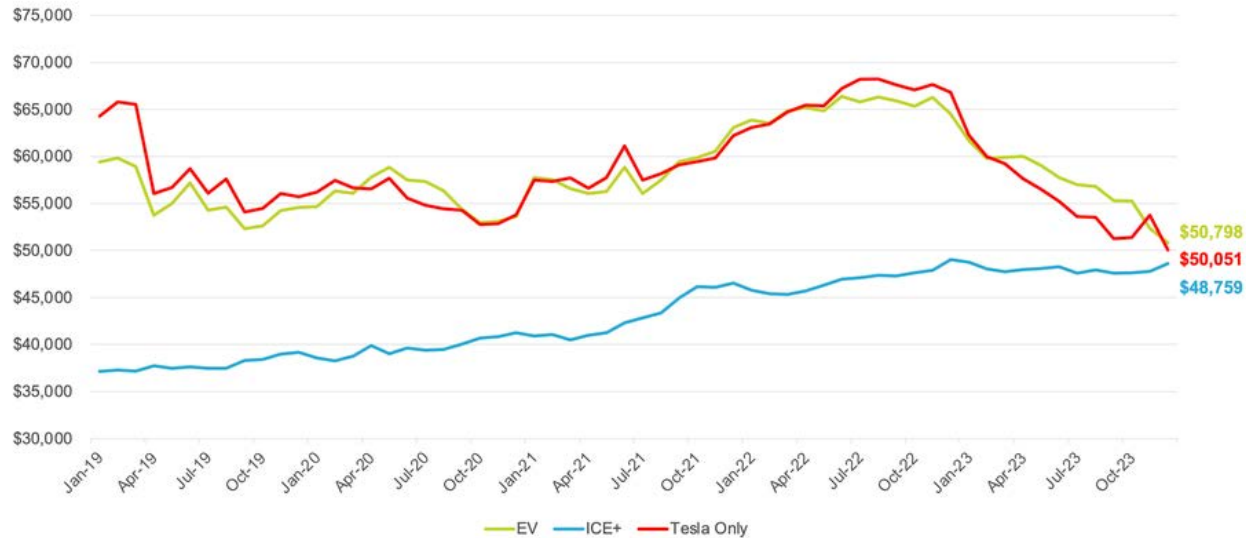
Range Anxiety



EV Model Availability

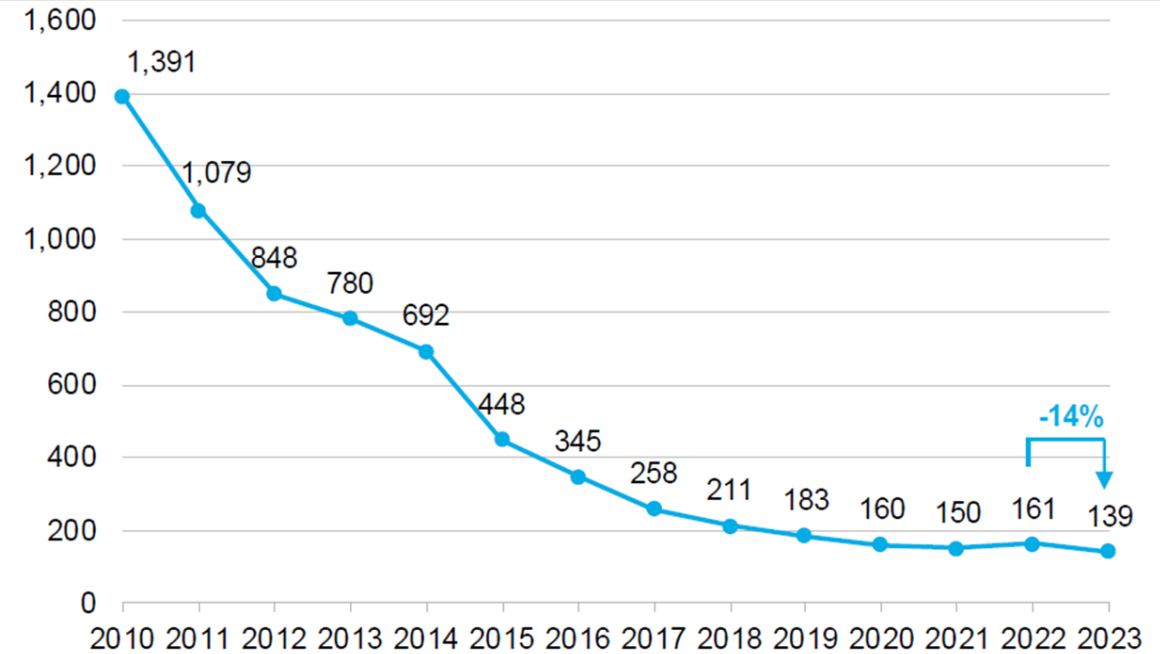
Cost parity: EVs have been too expensive

Average Vehicle Transaction Price (2019-2023)



EV prices are slowly approaching parity with ICEVs, but still a lot of work to do

Battery Pack Price per kWh (real \$2023)

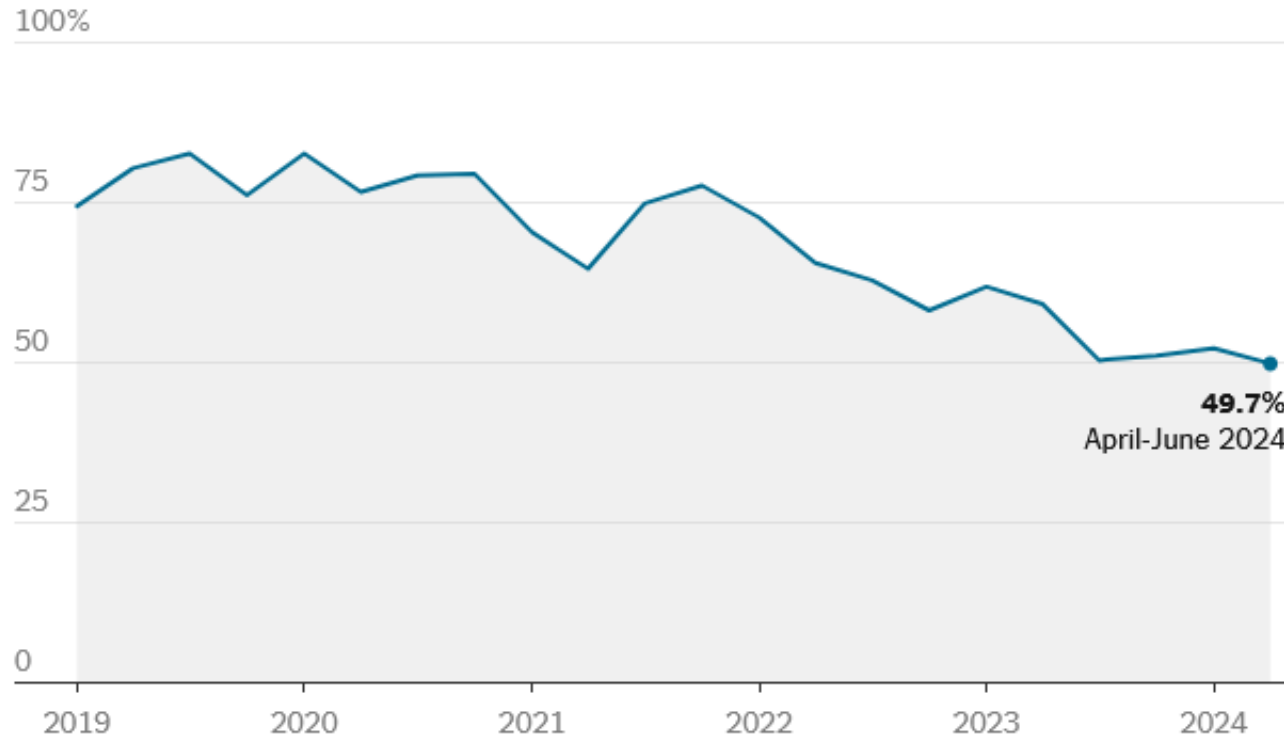


Source: Bloomberg New Energy Finance

Falling battery prices will help BEVs achieve acquisition cost parity with conventional vehicles

Availability: Non-Tesla BEVs increasing share of market

Tesla's Share of US EV Sales by Quarter



Source: Cox Automotive • By The New York Times

- **Tesla sales fell below 50%** of US EV sales for the first time in Q2 2024
- EVs from **established OEMs** are **providing similar range and capabilities** to Tesla
- Established OEMs offer **large dealer networks, and provide maintenance and repairs**
- **Increased competition** in the EV market is creating price pressure and helping to **push overall EV adoption higher**



Availability: Non-Tesla BEVs increasing share of market

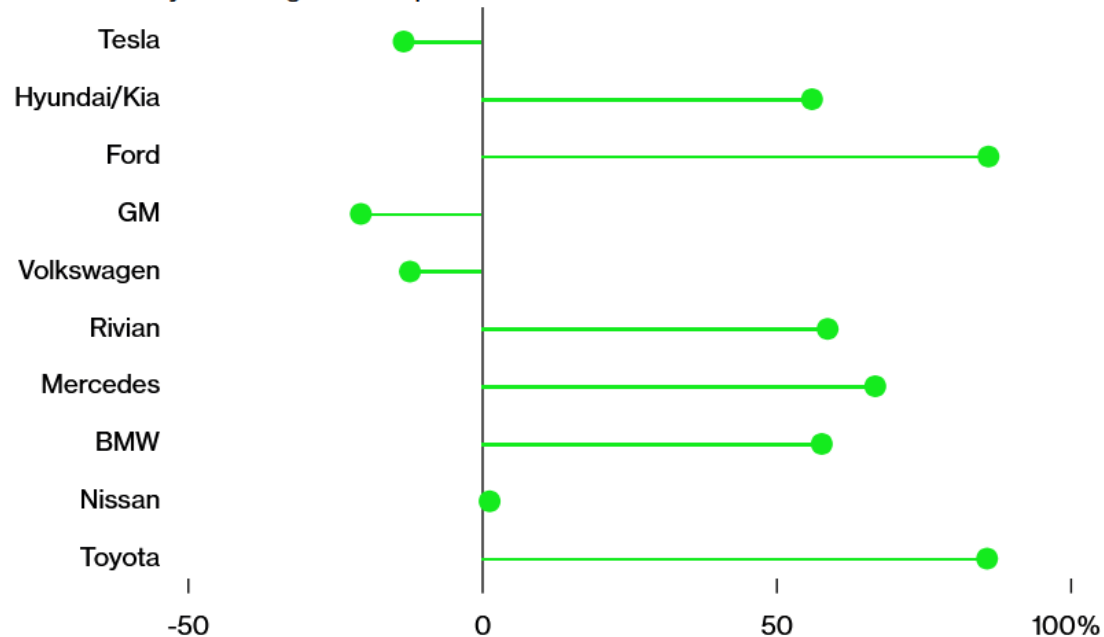
“It’s a tale of two EV markets, where consumers are flocking to some brands in record numbers while turning their backs on those with inferior battery range, slower charging and high prices.”

Stephanie Valdez-Streaty, Cox Automotive

EVs Still Booming for Most US Automakers

For six of the top 10 brands, growth topped 50% in Q1

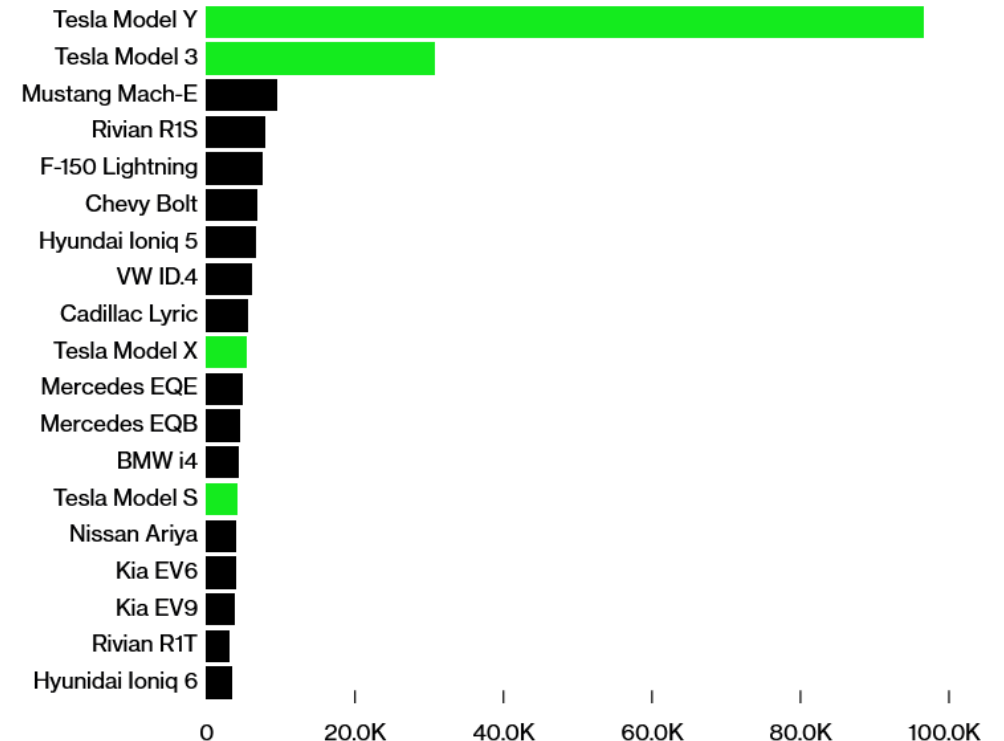
● Year-over-year change in first-quarter EV sales



Source: Cox Automotive, Bloomberg Green
Note: Company sales include branded subsidiaries

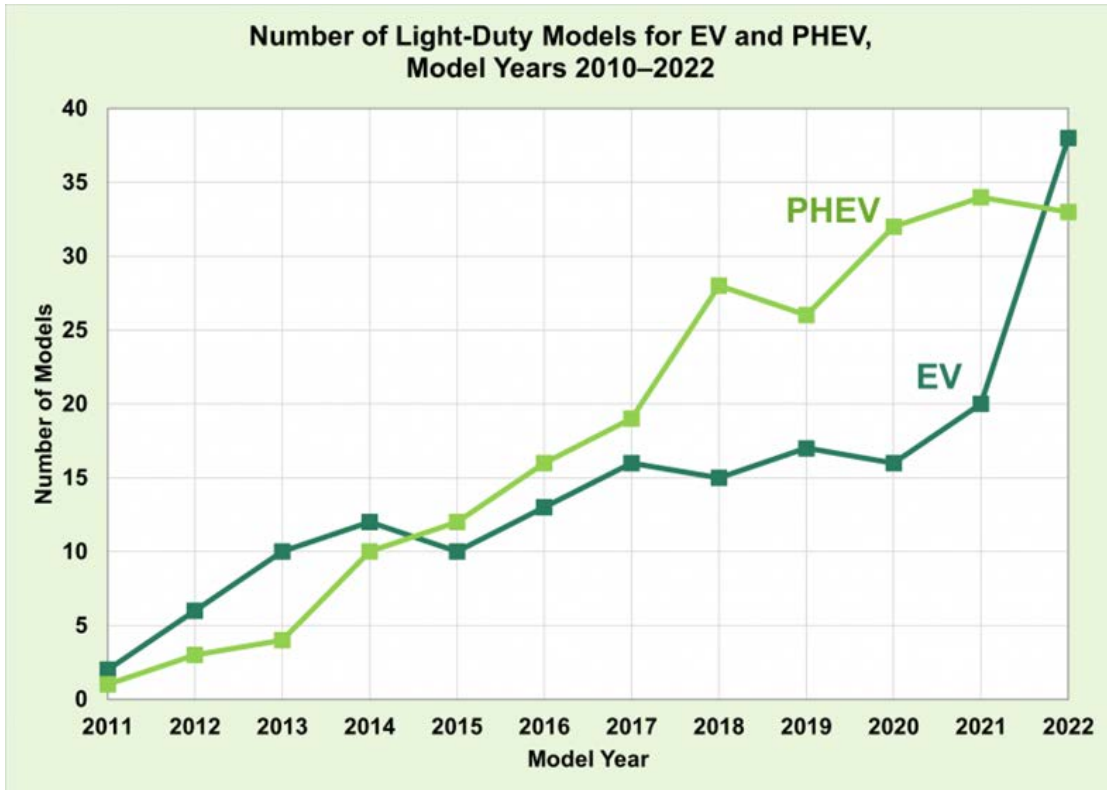
Tesla Is Still the Only High-Volume EV Maker

US first-quarter sales by model

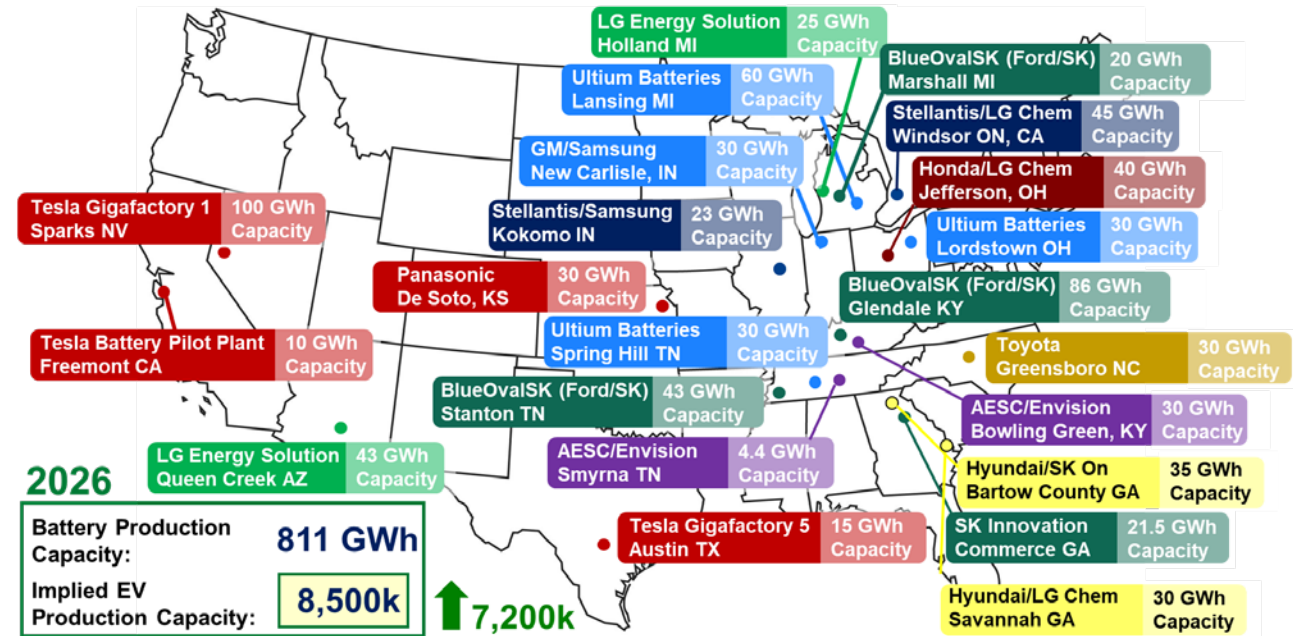


Source: Cox Automotive

Availability: Models increasing across brands and segments



Source: Dept. of Energy, Vehicle Technologies Office, March 20, 2023



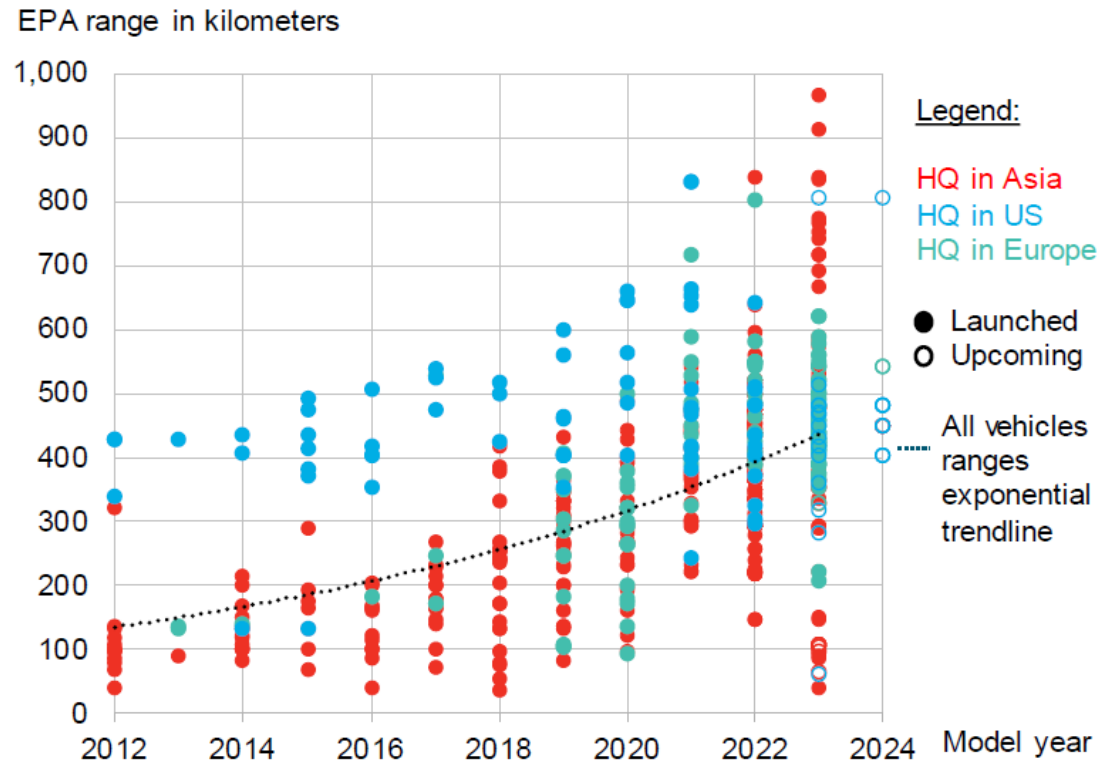
EV market sales growth driven by consumer choice across manufacturers and segments

Huge growth in planned U.S. battery manufacturing capacity, from 1.3M ('23) to 8.5M EVs ('26)

EV Capabilities: Improving towards an ICEV experience

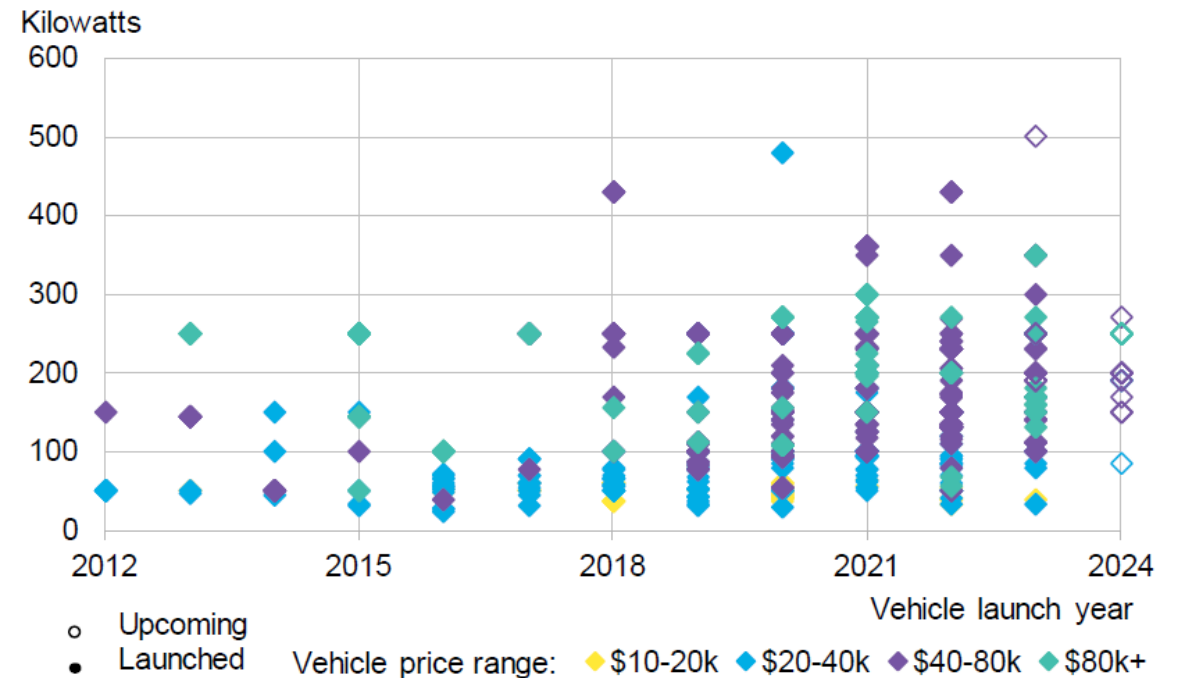
The average range of newly launched BEV models improves each year...

Range of launched and upcoming BEV models, by launch year



... as does the charging capability of BEVs

Maximum charging capability of selected BEV models, by year of launch



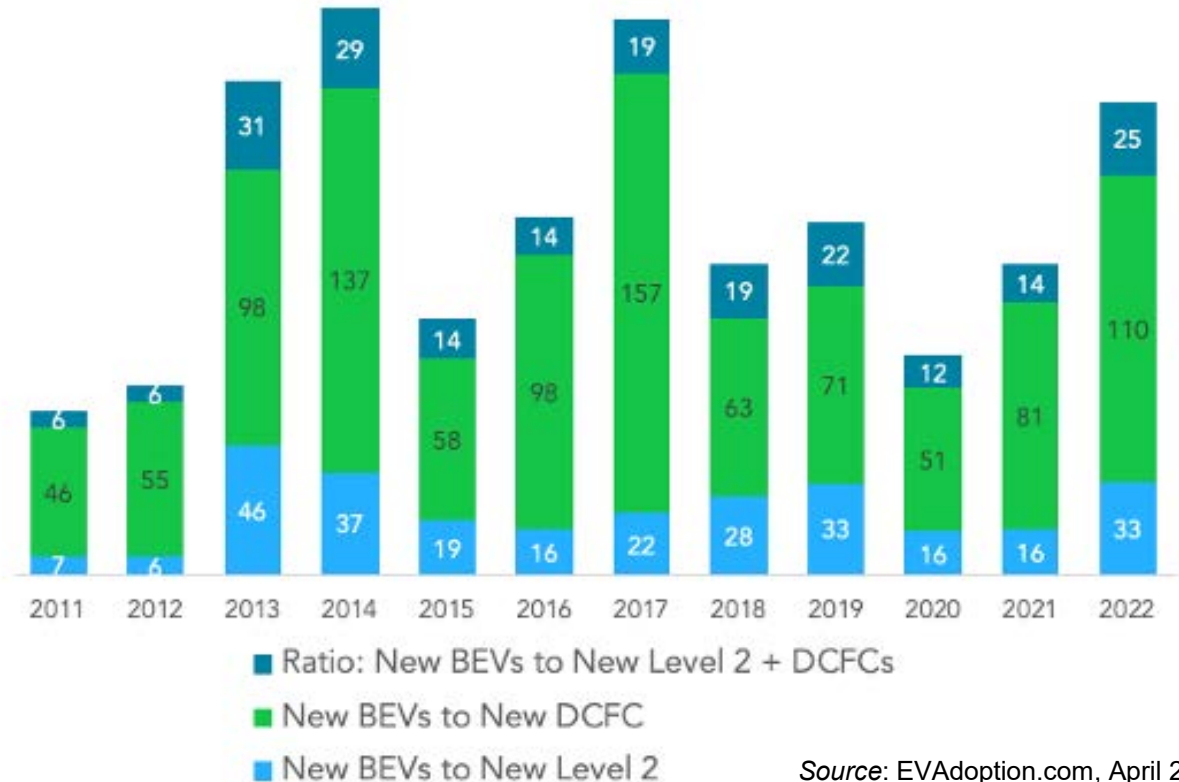
Source: Bloomberg New Energy Finance, Zero-Emission Vehicles Factbook, December 2023

Charging Infrastructure: Not keeping up with sales

New BEV sales are outpacing the rate of new DC fast chargers

- **Ratio of 110 new BEVs to new DC fast chargers** more than double the ratio in 2020 and highest since 2017
- **Overall ratio** of 25 new charging ports to new BEVs **highest since 2014**

Ratio of New BEVs to New Charging Stations, 2011-2022



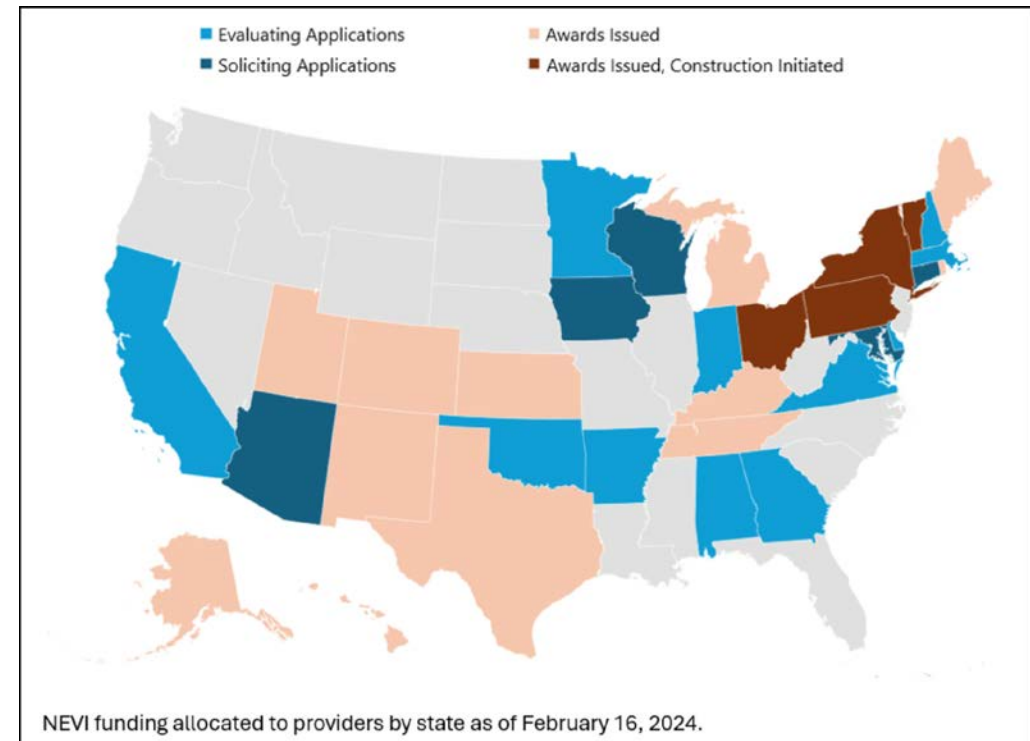
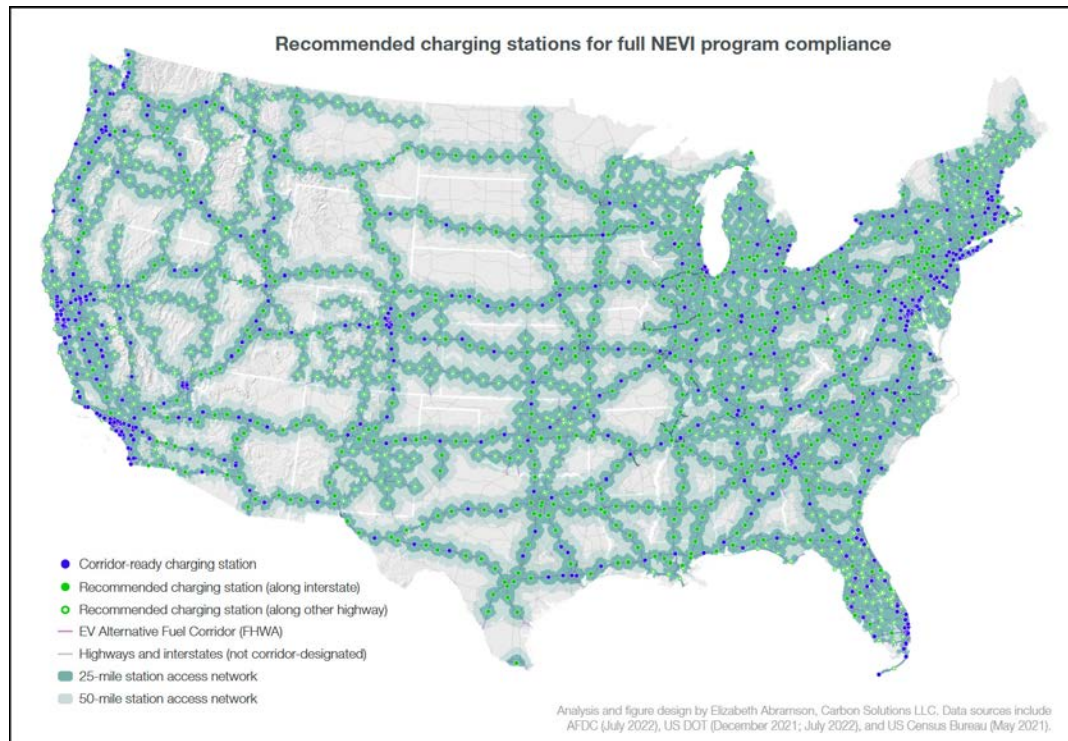
Source: EVAdoption.com, April 2023



Charging Infrastructure: Initiatives to meet charging needs

" We're moving more and more into a generation of buyers that rely much on public charging infrastructure. They probably use their car very similar to the way they've used a car before, just by going to public infrastructure." Philipp Kampshoff, McKinsey

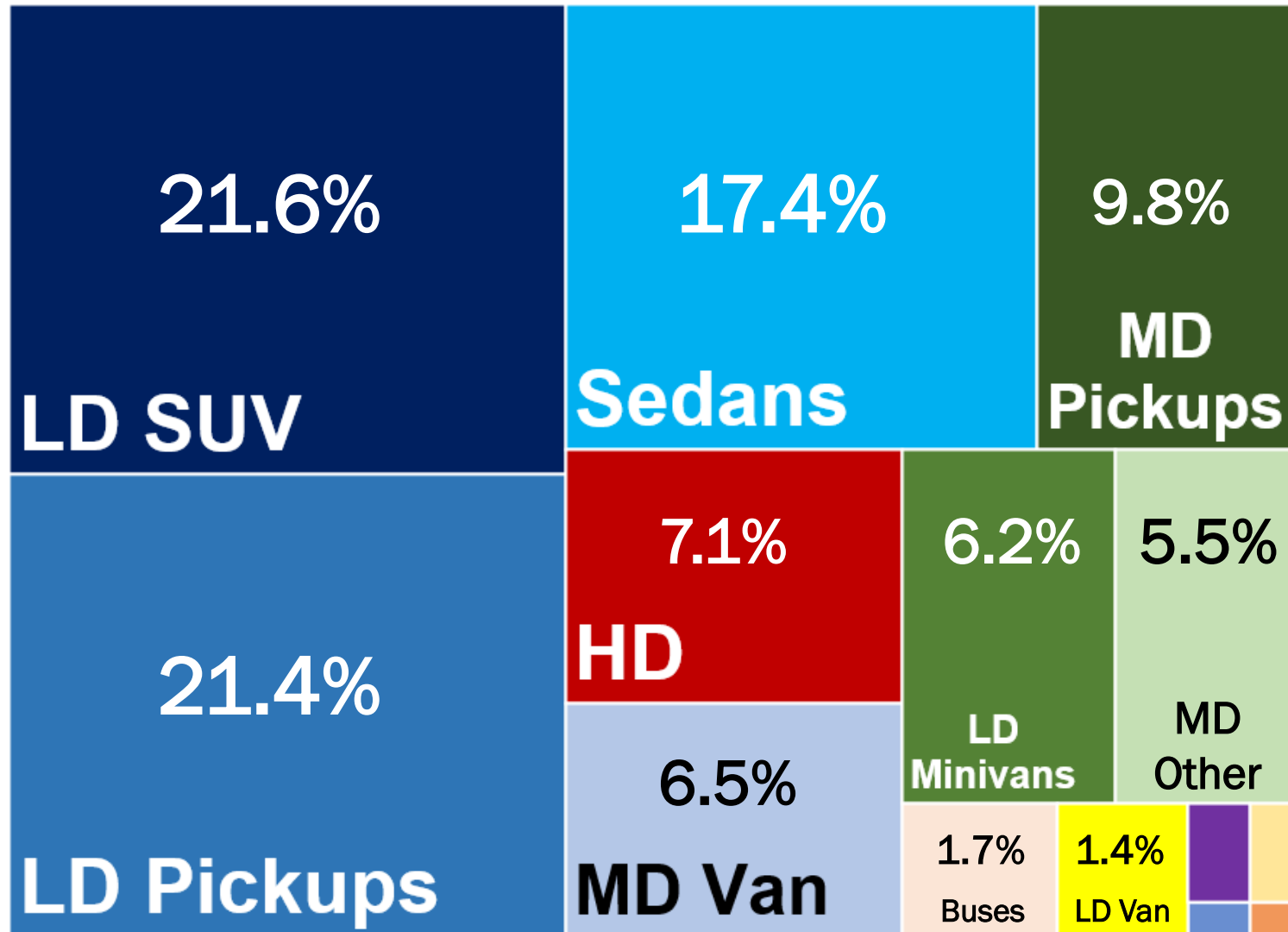
Infrastructure bill included \$7.5 billion to build out a national network of EV chargers



Federal Fleet Electrification

What types of vehicles comprise the Federal Fleet?

FY23 Federal Fleet Composition by Vehicle Type (Excluding USPS)



Three primary vehicle types (*LD SUVs, LD Pickups, and Sedans*) represent ~60% of non-USPS fleet



Current available EVs from GSA by vehicle type

17.4%
Sedans



Sedan BEVs

Nissan Leaf	\$27,715	149 mi.
Nissan Leaf+	\$35,875	212 mi.
Tesla Model 3	\$49,591	272 mi.
Hyundai Ioniq 6	\$37,698+	240/361 mi.

21.6%
LD SUV



LD SUV BEVs

Hyundai Kona	\$34,235	261 mi.
Ford Mach-E	\$35,162+	230/320 mi.
Kia Niro BEV	\$40,749	253 mi.
Hyundai Ioniq 5	\$40,785+	220/303 mi.
Nissan Ariya	\$41,560+	205/304 mi.
Chevy Equinox	\$41,655+	285/319 mi.
VW ID.4	\$42,490+	263/291 mi.
Kia EV6	\$45,398+	232/282 mi.
Subaru Solterra	\$47,207	227 mi.
Chevy Blazer	\$48,689+	270 mi.
Tesla Model Y	\$51,166+	244/279 mi.



LD SUV PHEVs

Kia Niro PHEV	\$35,996+	34 mi.
Ford Escape	\$37,388	37 mi.
Hyundai Tuscon	\$38,035	33 mi.
Mits. Outlander	\$42,192	38 mi.
Kia Sorento	\$50,855	32 mi.
Lincoln Corsair	\$52,867	27 mi.
Grand Cherokee	\$56,607	26 mi.
Wrangler Rubicon	\$61,762	22 mi.

21.4%
LD Pickups



Light-duty Pickup BEVs

Ford F150 BEV	\$46,379+	240/320 mi.
Chevy Silverado	\$74,677+	393/450 mi.



Current available EVs from GSA by vehicle type

6.2%

LD Minivans



LD SUV PHEVs

Chrysler Pacifica \$51,444 32 mi.

6.5%

MD Van

1.4%
LD Van



Van BEVs

Ford E-Transit	\$47,744+	126 mi.+
RAM Promaster	\$75,791	162 mi.
Merc. eSprinter	\$76,452+	173/252 mi.

1.7%

Buses



Buses BEVs

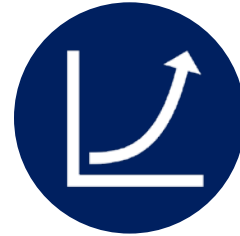
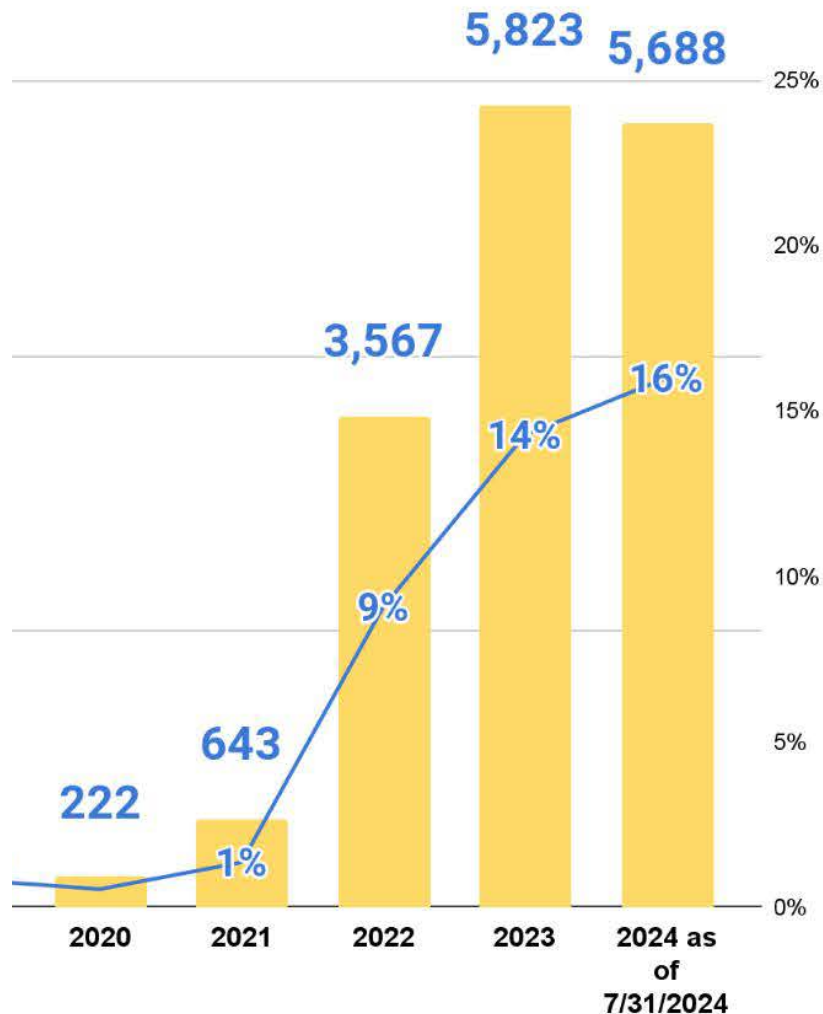
Various

EVs currently available for more than 76% of Federal Fleet (*Excluding USPS*)



Ramping up EV acquisitions through FY 2027

Federal Fleet ZEV Orders (2020-Present)



What is the “right” ramp rate towards 100% LDV acquisitions in FY 2027?



What vehicle/types can be electrified today and will be available by FY 2027?



How to plan for deployment of charging infrastructure to support future EV acquisitions?



How can Federal fleets move towards transforming their fleets to ZEVs (*ZEV Ready*)?



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Vehicle Technology

EV fundamentals

Vehicle Overview



Federal Fleet Training Video 1

Electric Vehicle Technology Overview

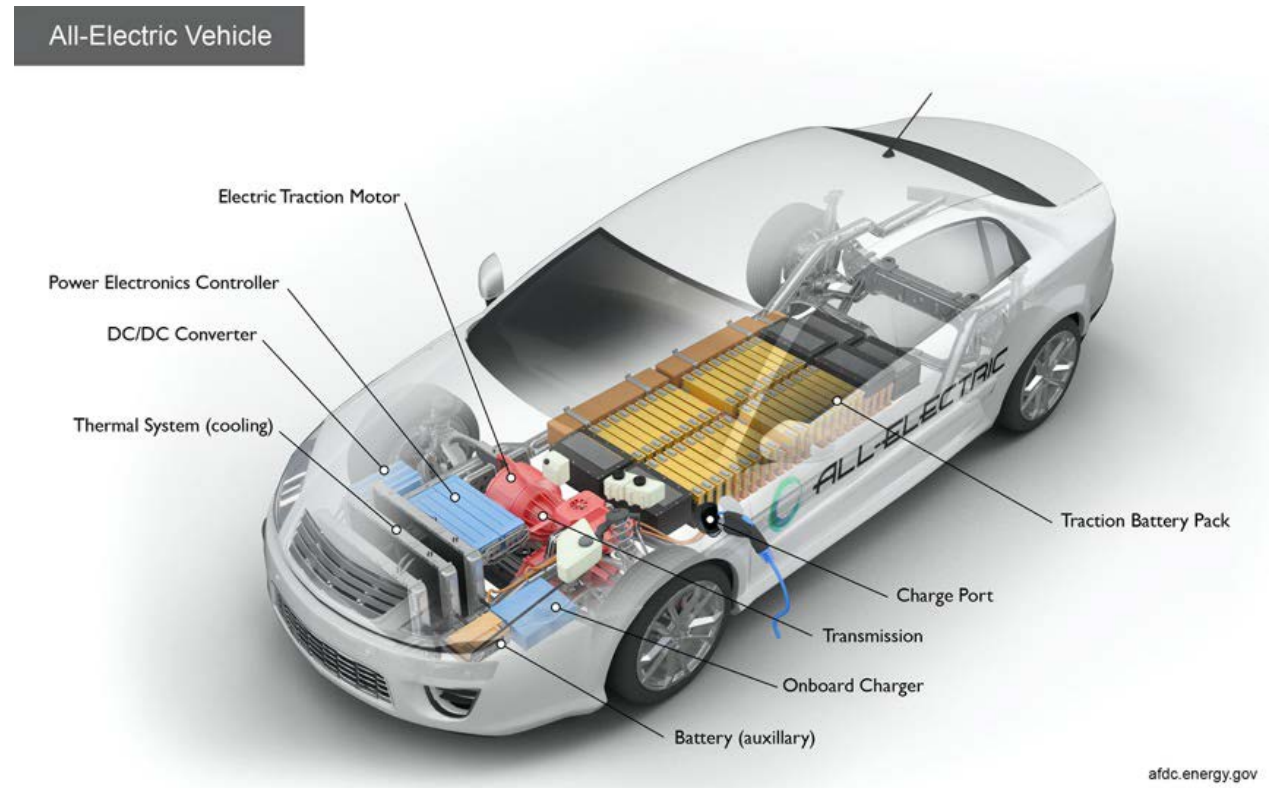
<https://youtu.be/UgUAFU3rCHU>

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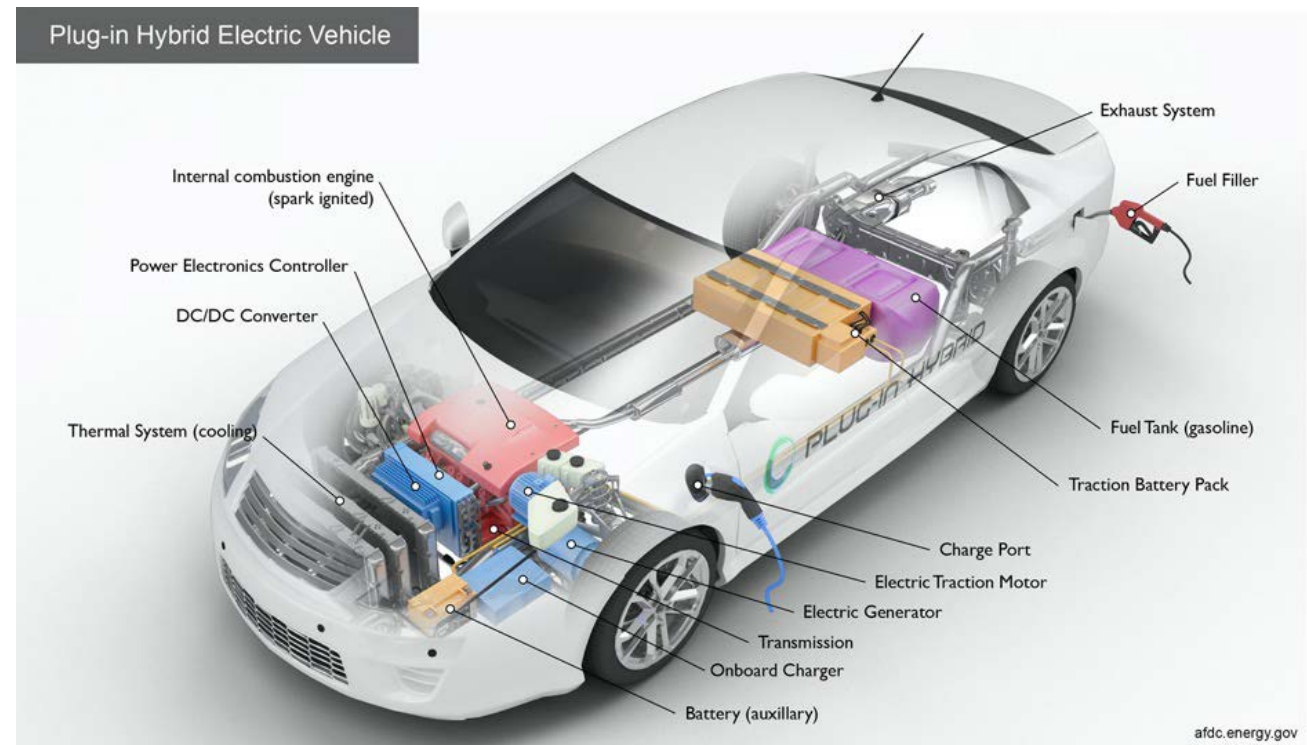
Vehicles: EVs

- Battery stores electrical energy that powers the motor
- Battery charged by plugging in to outside electric power source
- Zero tailpipe emissions, but air pollution may be produced through electricity generation
- Driving range of 100 to over 400 miles



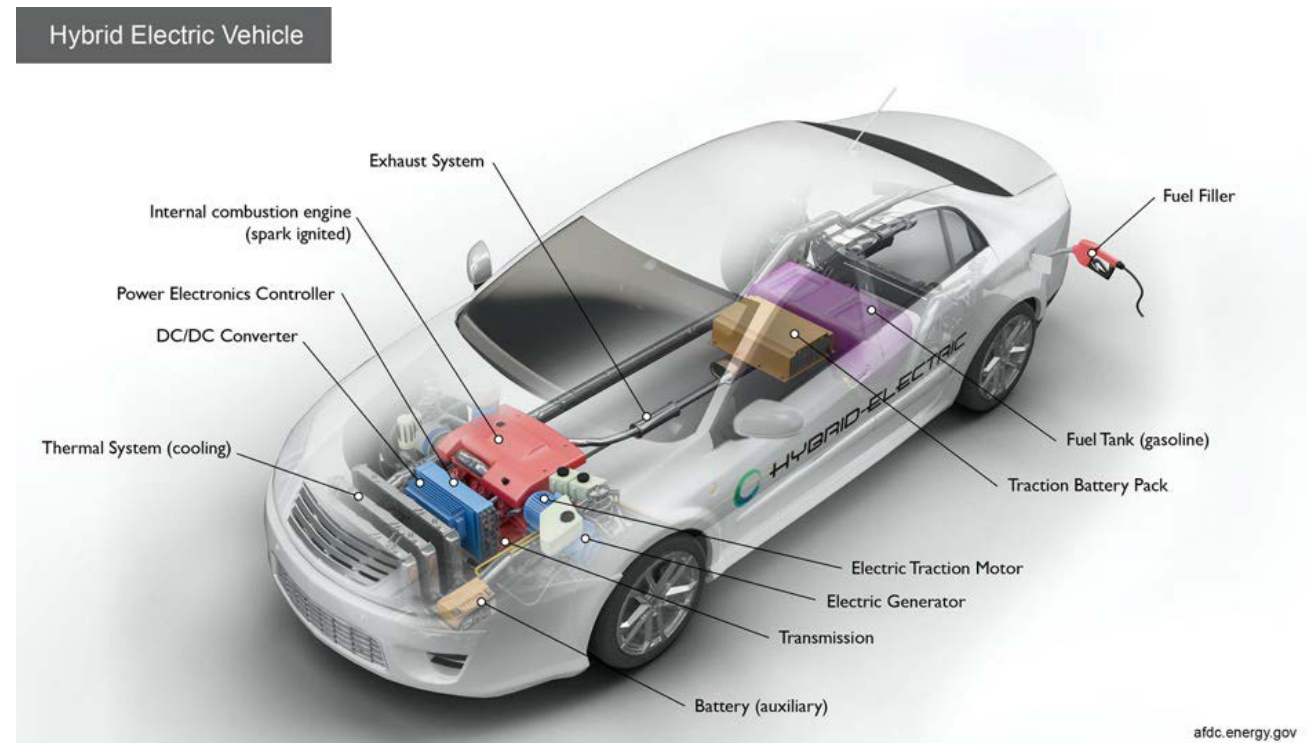
Vehicles: PHEVs

- Internal combustion engine uses alternative or conventional fuel
- Battery charged by outside electric power source, engine, and regenerative braking
- During urban driving, most power comes from stored electricity

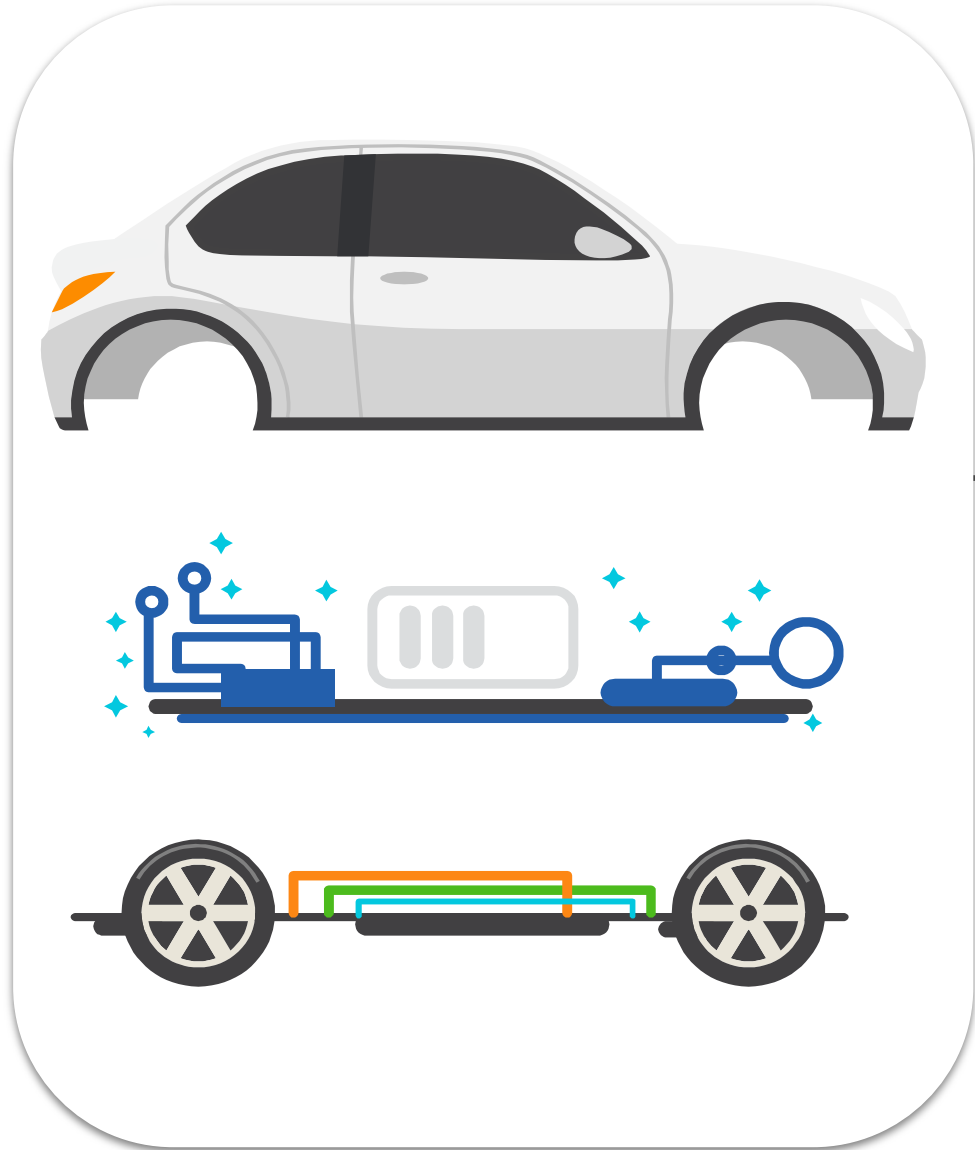


Vehicles: HEVs

- Battery is charged by the engine and regenerative braking
- Power from electric motor allows smaller engine and better fuel economy
- Fuel-efficient system design
 - **Mild hybrid:** Cannot power vehicle using electric motor alone
 - **Full hybrid:** More powerful electric motor, larger batteries can drive vehicle on just electric power for short distances and at low speeds



What is a ZEV?



(potential for) **ZERO** Scope 3
Greenhouse gas emissions



(potential for) **ZERO** smog forming
particles



Includes Battery-Electric Vehicles (BEV),
Plug-in Hybrids (PHEV), and hydrogen
powered Fuel Cell Vehicles (FCEV).



EV Technology and Drivetrain Options: Vehicle Technology

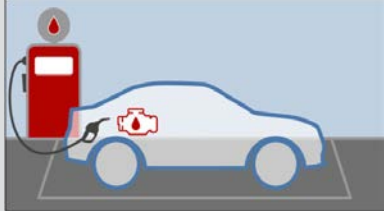
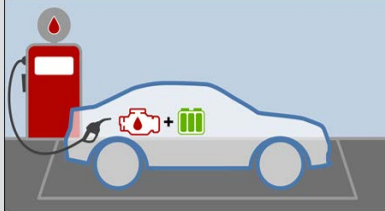
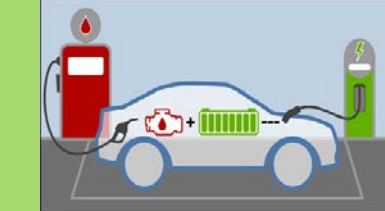
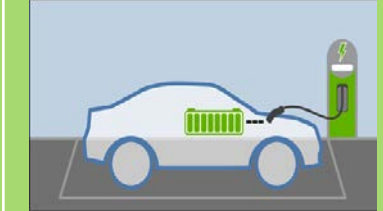
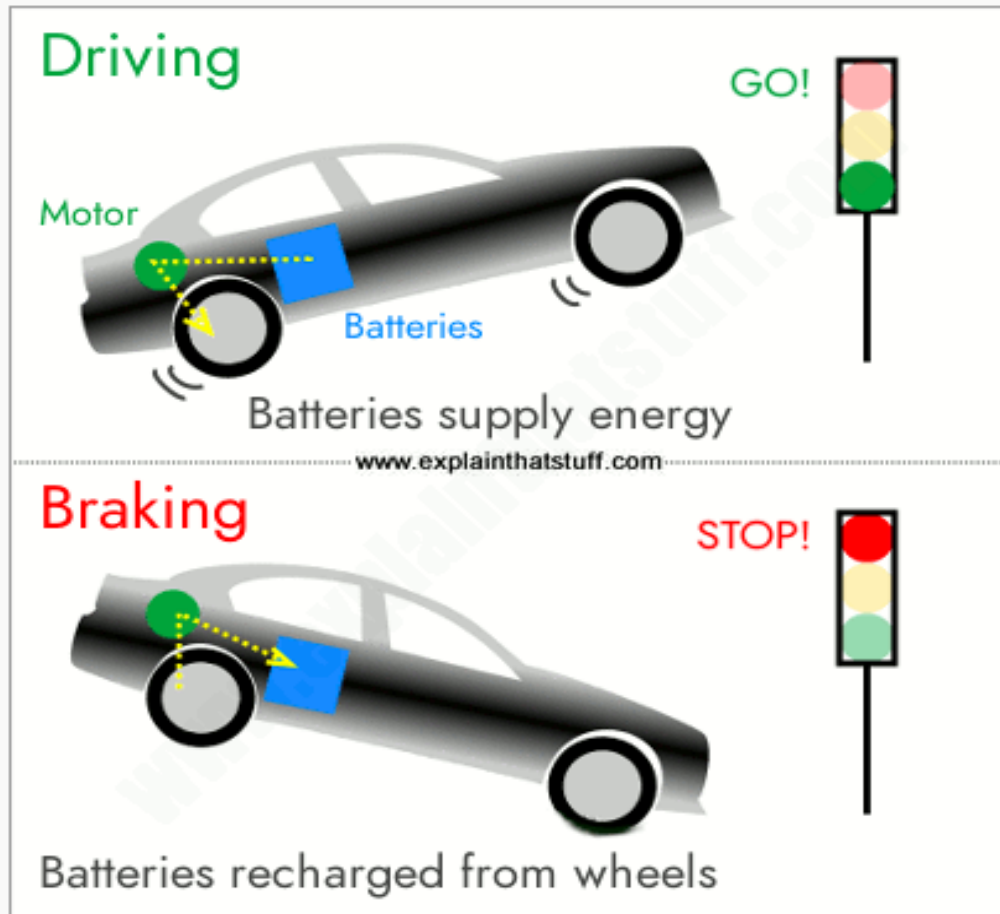
	ICE	HYBRID	PHEV	BEV
Vehicle Type				
Energy Source	Fuel Tank	Fuel Tank & Battery	Fuel Tank & Battery	Battery
Fuel	Gasoline	Gasoline	Gasoline Electricity	Electricity
Power Source	Gas Engine	Gas Engine & Electric Motor	Gas Engine & Electric Motor	Electric Motor
Fuel Economy Units	MPG	MPG	MPGe or kWh/100 miles	MPGe or kWh/100 miles

Image: <https://evolution.es.anl.gov>

MPGe: Miles per gallon of gasoline equivalent
kilowatt-hours (kWh) per 100 miles



EV Technology and Drivetrain Options: Regenerative Braking



Regenerative braking uses an electric vehicle's motor as a generator to convert much of the kinetic energy lost when decelerating back into stored energy in the vehicle's battery.

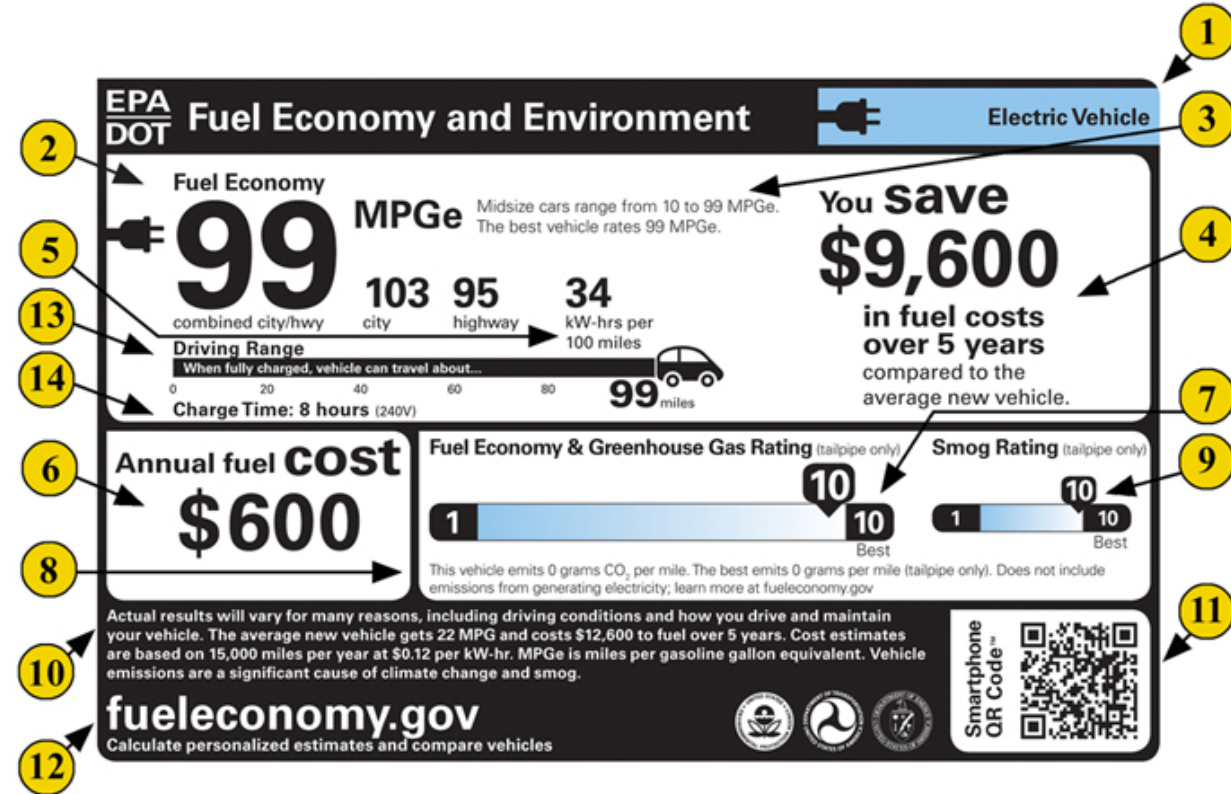


EV Technology and Drivetrain Options: EPA Fuel Economy Label

EPA/DOT FuelEconomy.gov

- Label Details for PHEVs and EVs

1. Vehicle Technology & Fuel
2. Fuel Economy
3. Fuel Economy Comparison
4. Fuel Savings Over 5 Years
5. Fuel Consumption Rate
6. Estimated Annual Fuel Cost
7. Fuel Economy
8. GHG Emissions
9. Smog Related Emissions
10. Fine Print
11. QR Code
12. Fueleconomy.gov
13. Driving Range
14. Charge Time



<https://www.epa.gov/fueleconomy/text-version-electric-vehicle-label>



Vehicle Ranges



Federal Fleet Training Video 1

Electric Vehicle Technology Overview

<https://youtu.be/UgUAFU3rCHU>

2:50 – 4:16



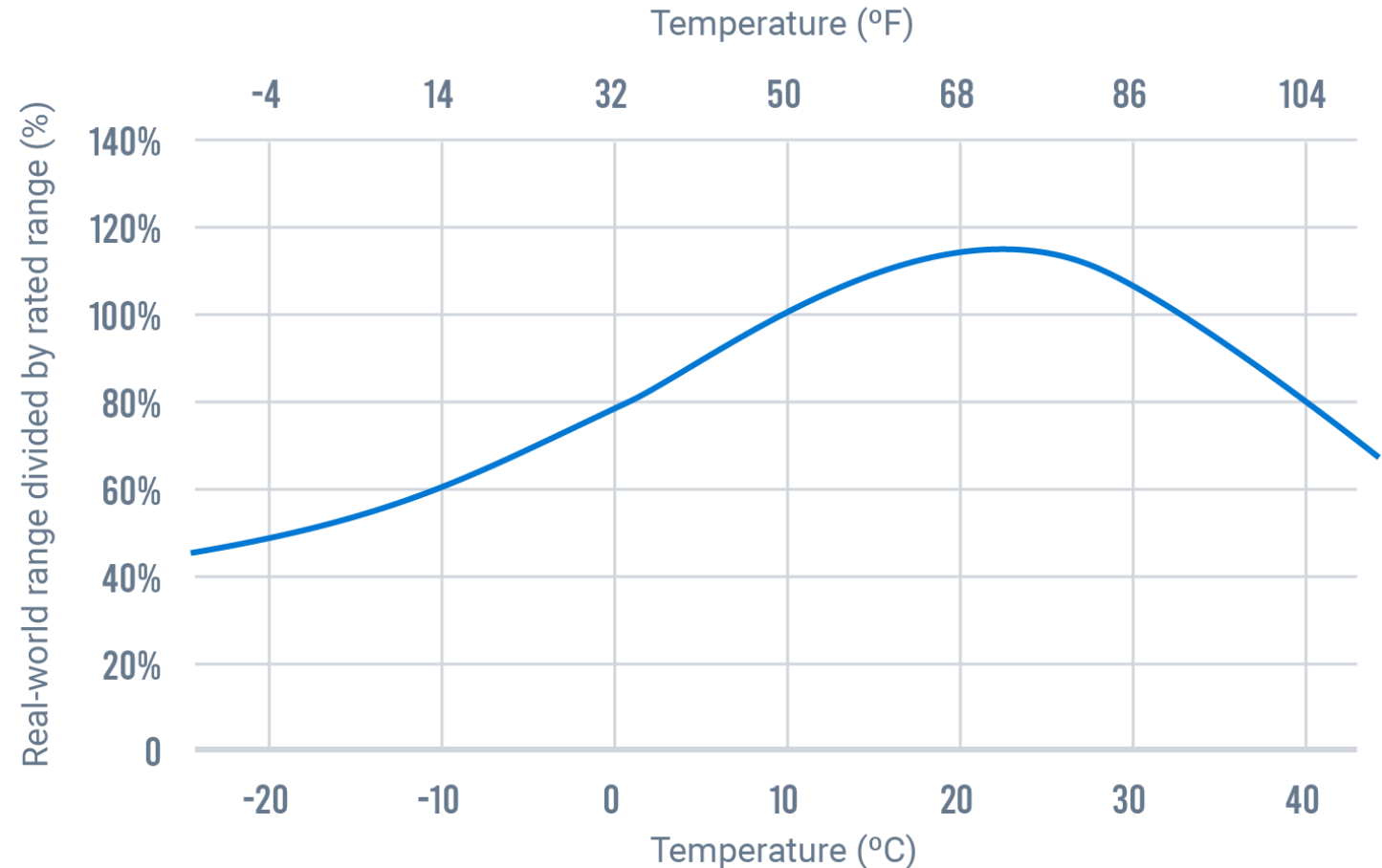
Weather Impact on Range

Optimal operating temperature is $\sim 70^{\circ}$

Temperature impacts are vehicle dependent

During extreme cold weather, EV range may decrease $\sim 50\%$ of the rated range

Real-world range vs. rated range



Source: Geotab <https://www.geotab.com/blog/ev-range/>

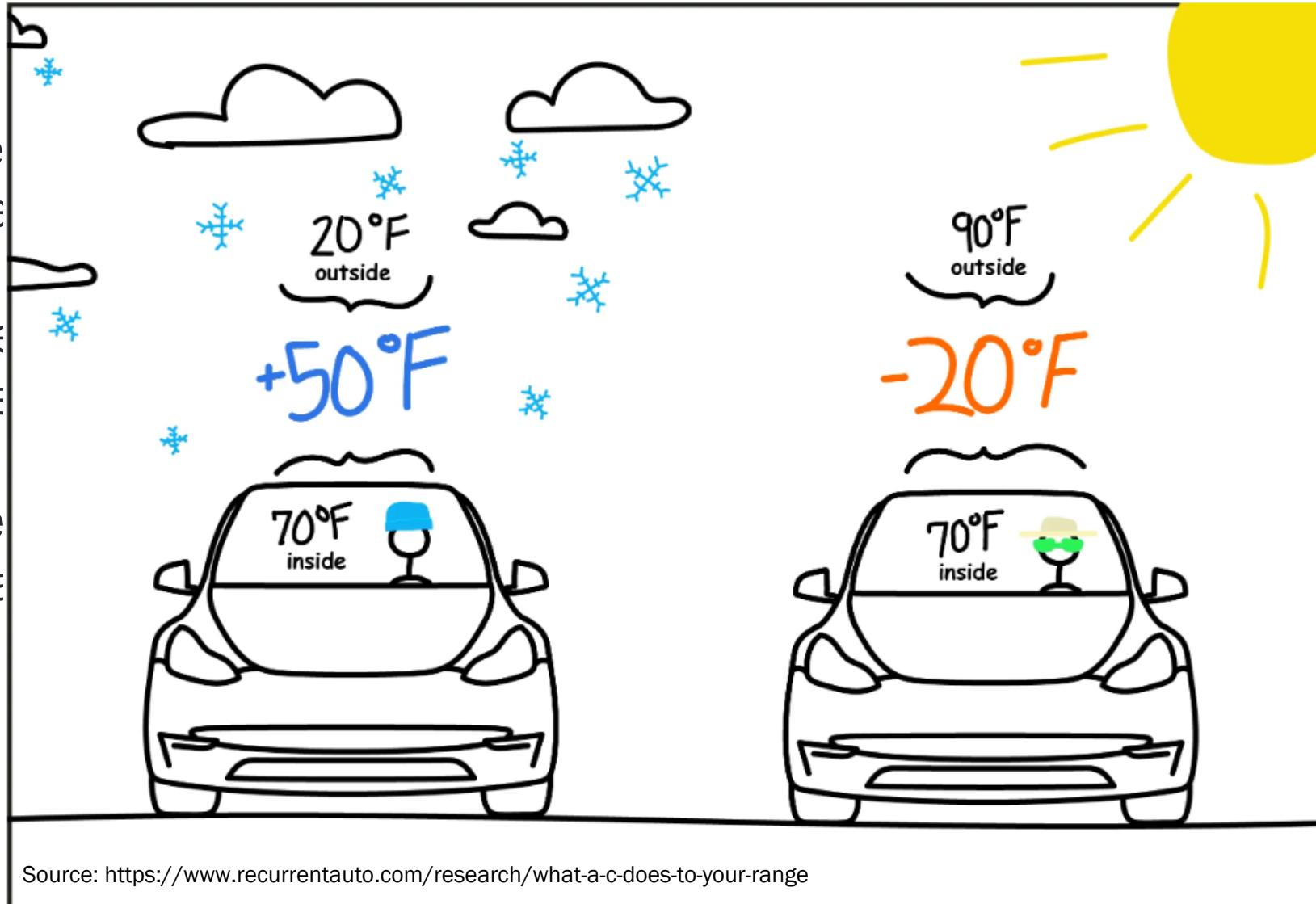


Weather Impact on Range

Optimal operating temperature

Temperature vehicle dependent

During extreme weather, EV range may be as low as 30% of the rated range



Source: <https://www.recurrentauto.com/research/what-a-c-does-to-your-range>



Vehicles: Batteries

- Energy storage systems, such as batteries, are essential for electric-drive vehicles
- All original equipment manufacturer EVs made today use **lithium-ion** batteries.
- Other energy storage options:
 - Lead-acid batteries
 - Ultracapacitors



EV Benefits and Financial Considerations

EV Technology and Drivetrain Options : Benefits of Fleet Electric Cars



Zero Emissions (potential)



More Efficient



Less Maintenance



Fuel Savings



Enhanced Performance



GSA ZEV Offerings

Transportation and logistics services

Overview

Transportation Audits

Transportation programs

Fleet management

Vehicle purchasing

Vehicle leasing

Fleet electrification

Alternative fuel vehicles

EVSE purchasing resources

Governmentwide EVSE-related design-build and construction IDIQ contracts

Electrification resources and training

GSA charging ports

Alternative fuel vehicles

We help you [lease](#) or [purchase](#) alternative fuel vehicles so you can meet [federal sustainability requirements](#).

Resources

- The [AFV product guide](#) [XLSX - 400 KB] has all available configurations.
- The fiscal year [2024 Zero Emission Vehicle fact sheet](#) [PDF - 1 MB] lists ZEV offerings in all classes.
- Our [Welcome to Your ZEV](#) [PDF - 139 KB] one-pager helps GSA customers get their ZEVs on the road!
- Our [Tesla one page guide](#) [PDF - 121 KB] is a brief overview on using Tesla vehicles and our [GSA Tesla Guide](#) [PDF - 849 KB] provides a more in-depth overview of operating and maintaining Tesla vehicles.
- The [alternative fuels data center](#) has locations for fueling stations in the United States and Canada.
- The [cost comparison tool](#) uses basic information about your driving habits to calculate total cost of ownership and emissions.
- [Fueleconomy.gov](#) has downloadable data sets for fuel economy, an EPA Green Vehicle Guide, and a SmartWay Vehicle List.

For accessibility help email us at fleetbusinessoversight@gsa.gov



Last updated: Jul 3, 2024

<https://www.gsa.gov/buy-through-us/products-and-services/transportation-and-logistics-services/fleet-management/fleet-electrification/alternative-fuel-vehicles>



EV Technology and Drivetrain Options: FY24 GSA Fleet Zero Emission Vehicle

Pickup Truck Offerings

SIN, Make & Model	55E Ford F150 Lightning (BEV)	56E Ford Lightning SSV (BEV)	57E Chevrolet Silverado (BEV)
Availability	OPEN Qty Restriction: 2,000	OPEN Qty Restriction: 2,000 NOT PURSUIT RATED NO CENTER CONSOLE	OPEN
Acquisition Price	\$48,623 \$55,763 (XEVR)	\$49,995	\$76,398 \$81,498 (XEVR)
Incremental Cost	\$4,907	\$6,265	\$27,105
GSA Lease Rate	\$213/mo. & \$0.100/mi. \$288/mo. & \$0.100/mi. (XEVR)	\$339/mo. & \$0.140/mi.	\$261/mo. & \$0.142/mi. \$313/mo. & \$0.142/mi. (XEVR)
Range	240 miles 320 miles (XEVR)	240 miles	393 miles 450 miles (XEVR)
Charging Time	L1: 72+ hours L2: 10-14 hours DC Fast: 41-122 min.	L1: 72+ hours L2: 10-14 hours DC Fast: 41-122 min.	L1: 90+ hours L2: 15+ hours DC Fast: 40-60 min.
Contract Ship Days	180	180	450
Passengers	5	5	5
Pass. Volume (cu. ft.)	-	-	-
Rear Legroom (inches)	43.6	43.6	44.3
Cargo Capacity (cu ft.)	5.5 ft. bed 52.8 cu. ft. cargo box 14.1 cu. ft. in trunk	5.5 ft. bed 52.8 cu. ft. cargo box 14.1 cu. ft. in trunk	5.9 ft. bed 10.7 cu. ft. in trunk



Vehicle Energy Needs and Cost

*Fueling Cost = Fuel Consumption Rate * Fuel Price*

20 MPG
combined city highway
5.0 gal/100mi

68 MPGe
combined city highway
49 kWh/100 mi

	Model	Fuel Economy	Fuel Cost	Fueling Cost
ICE	Ford F150 (ICE)	20 Mi/Gal 0.05 Gal/Mi	\$3.00/Gal	15¢ per mile
BEV	Ford F150 Lightning (BEV)	68 Mi/Gal Eq. 0.49 kWh/Mi	10¢/kWh	4.9¢ per mile

$$Fueling\ Cost_{ICE} = \frac{5\ gal}{100\ mile} \times 3.00\ \frac{US\$}{gal} = 0.15\ \frac{US\$}{mile}$$

$$Fueling\ Cost_{BEV} = \frac{49\ kWh}{100\ mile} \times 0.1\ \frac{US\$}{kWh} = 0.05\ \frac{US\$}{mile}$$



Total Cost of Ownership – Step by Step (GSA-Leased Vehicle)

Step 1: Gather vehicle data from GSA

	Fuel Economy	Fuel Price	Fuel Cost	Incremental Cost	Lease Rate	Mileage Rates
Ford F150 (ICE)	20 Mi/Gal 0.05 Gal/Mi	\$3.00/Gal	\$0.15/Mi	\$0.00	\$209/mo	\$0.25
Ford F150 (BEV)	68 Mi/Gal Eq. 0.49 kWh/Mi	\$0.10/kWh	\$0.05/Mi	\$4,533	\$213/mo	\$0.10

Step 2: Consider incremental cost

\$0

\$4,533

Step 3: Calculate annual costs

$$\begin{aligned} \text{Annual Cost}_{ICE} &= (12 \text{ months} \times \$209) + (12,000 \text{ mi} \times \$0.25) \\ &= \$5,508/\text{year} \end{aligned}$$

$$\begin{aligned} \text{Annual Cost}_{BEV} &= (12 \text{ months} \times \$213) \\ &+ (12,000 \text{ mi} \times \$0.10 + \$0.05) = \$4,344/\text{year} \end{aligned}$$

Step 4: Calculate payback period

$$\text{Payback Period}_{EV} = \frac{(\$4,533 - \$0)}{(\$5,508 - \$4,344)} = \sim 4 \text{ years}$$



EV Technology and Drivetrain Options: The Role of Telematics



Vehicle Travel Data

- Daily VMT (max/average)
- Annual VMT
- Typical dwell period
- Parking locations



Vehicle Details

- Make/Model
- Mission/Use case
- Engine faults, such as faulty oxygen



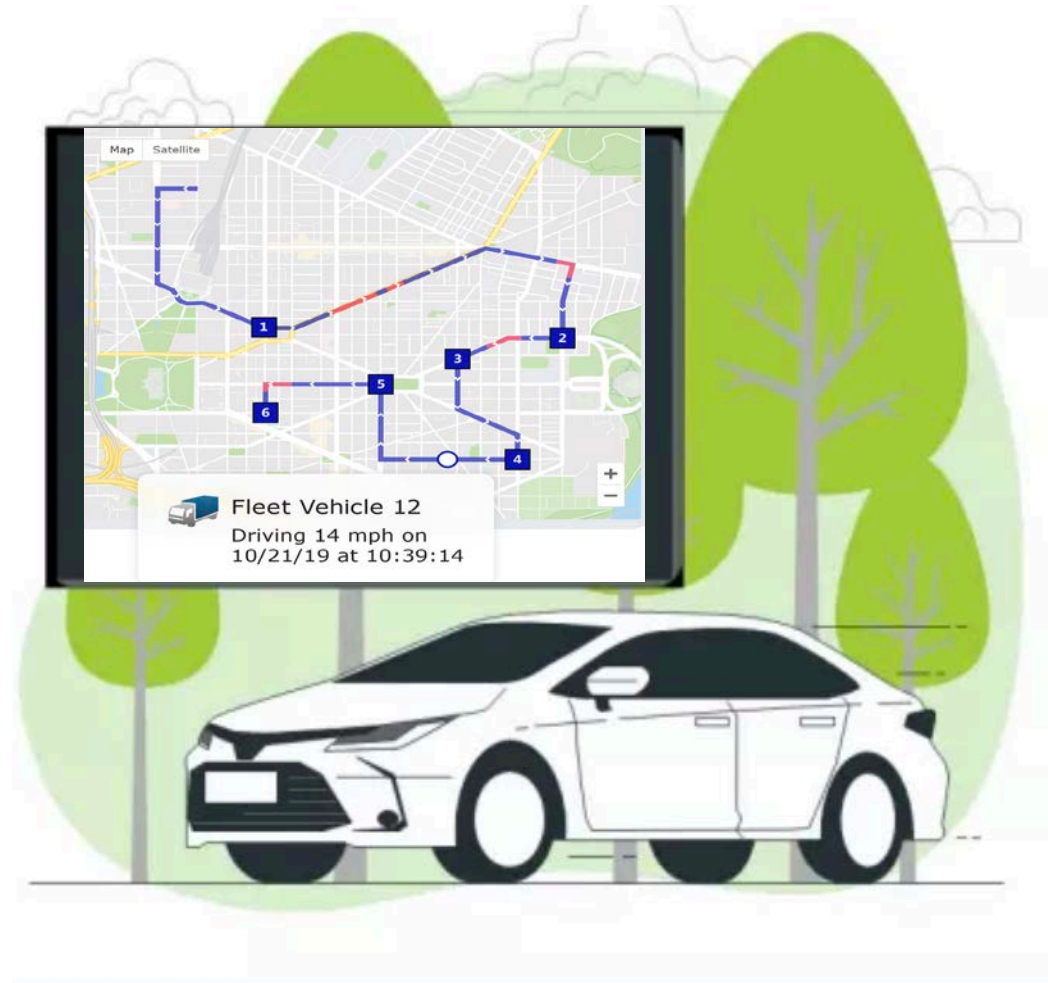
Fuel Use

- Maintenance
- Fuel



Safety

- Speed profiles
- Driver behavior

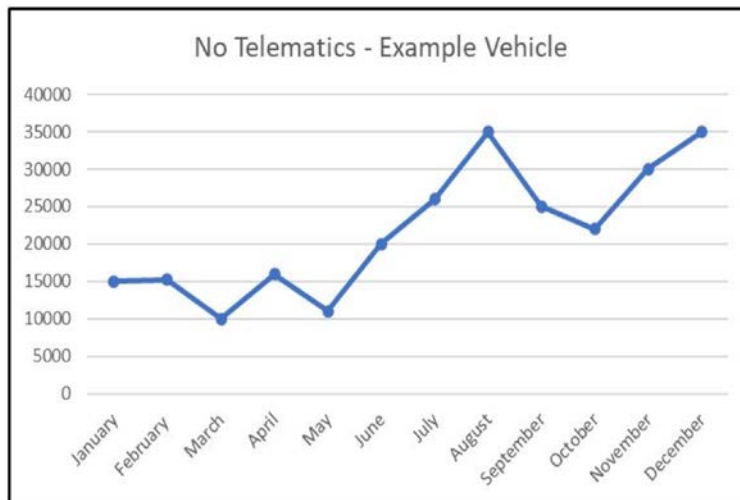


Geotab was awarded BPA as GSA Fleet's sole provider of telematics services

Using Telematics Data for Fleet Management (Vehicle Miles Traveled Example)

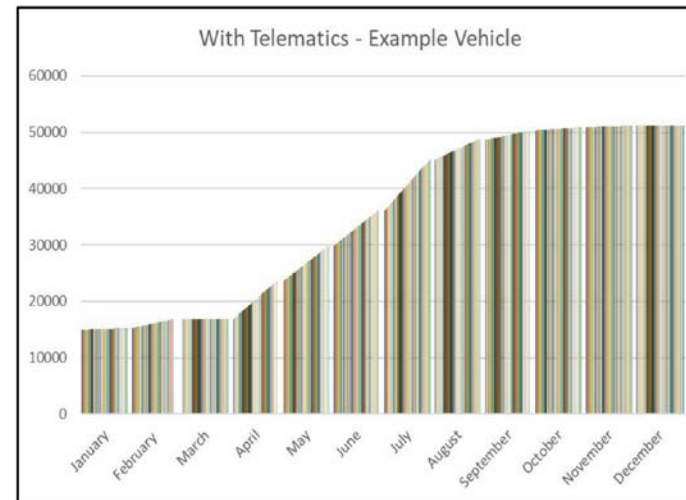
Without Telematics

- Some fluctuations as reported
- Only a monthly snapshot of utilization
- Estimates when mileages go unreported



With Telematics

- Time savings through automation
- No monthly mileage estimates
- More reliable projected replacement dates/criteria
- **DAILY** utilization



ZEV Considerations

- Which vehicles in your fleet are good candidates for electrification?
 - Consider daily vehicle miles traveled (VMT) and assess travel consistency
 - Estimate the daily energy needs for each vehicle
 - Review BEV and PHEV options while considering each vehicle's rated electric range



Consistent parking locations create opportunities for daily charging

BEVs are ideal for use cases with a majority of daily VMT less than the rated range (e.g., 98% of days within the 250-mile Chevrolet Bolt range)

Extreme temperature days can negatively impact driving range and may require mid-day charging

PHEVs are great for vehicles with varying travel and garage locations where frequent mid-day charging would be a challenge



EV Charging Infrastructure

EVSE Fundamentals

EV Charging Station Types



Federal Fleet Training Video 1

Electric Vehicle Technology Overview

<https://youtu.be/UgUAFU3rCHU>

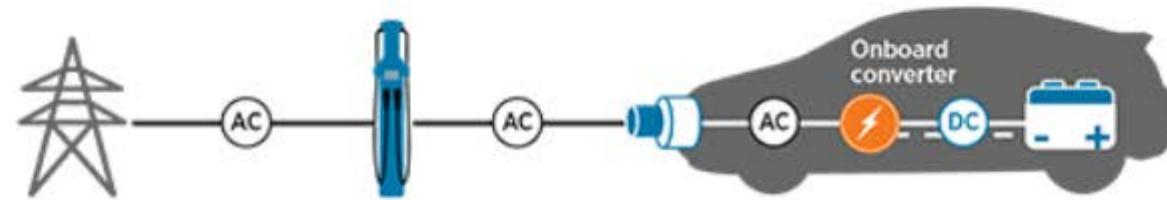
7:43 – 9:15



AC vs. DC Charging

AC charging

AC charging, sometimes called “Level 2,” delivers electric power to the car, which the vehicle then converts to DC — or battery — power using an onboard converter.



DC charging

With DC charging, or “DC fast,” the charger itself converts AC power to DC before delivering it straight into the vehicle’s battery.



-chargepoint+

EV Charging Infrastructure



Level 1



Level 2

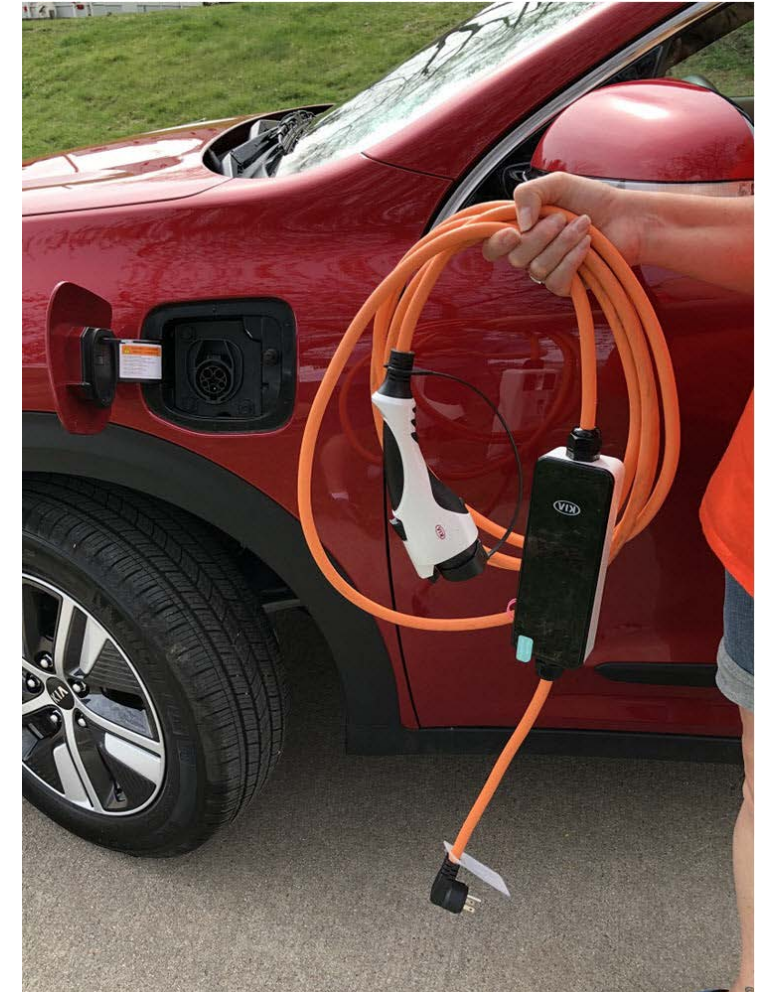


DC Fast



EV Charging Infrastructure

	Input Voltage (V)	Output Power (kW)	LDV Charge Rate	Primary Fleet Use
Level 1	120	1.4–1.9	2 to 5 miles of range per hour of charging	PHEVs and low mileage BEVs
Level 2	208 or 240	2.9–19.2	10 to 40 miles of range per hour of charging	BEVs that don't require a quick recharge
DC Fast	Typically 480	25–350	100 to 200+ miles of range in 30 minutes of charging	BEVs that need a quick recharge



Common Types of EV Connectors

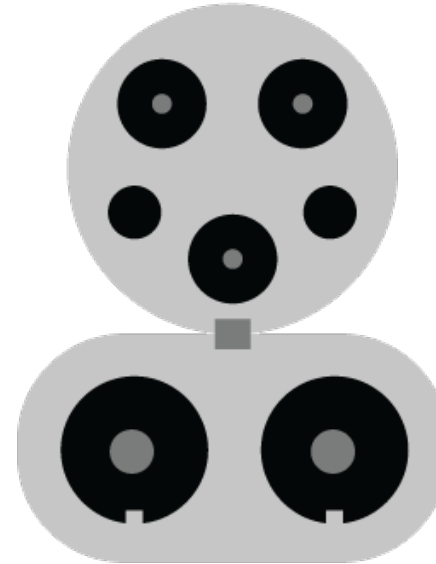
DC Fast Charging



J1772 connector



J3400 (NACS)
connector



CCS connector



CHAdeMO
connector

Level 1 and 2 Charging



Standards and Codes

EV/EVSE Standards and Codes Ensure Safety

Installation Requirements



Federal Fleet Training Video 3
Electric Vehicle Supply Equipment Infrastructure

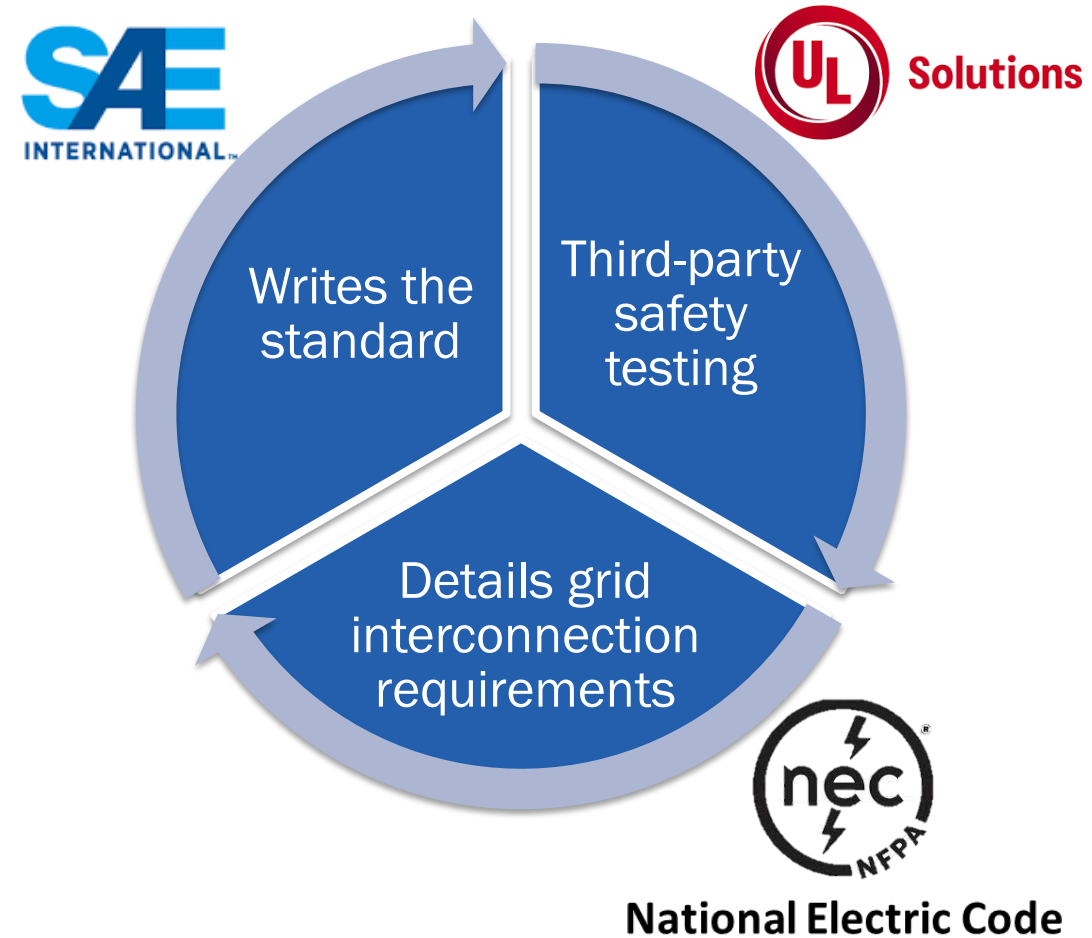
<https://youtu.be/TjKwOhKBtNc>
4:35 – 6:08



Standards and Codes

Standards and codes govern the design, construction, and installation of EVSE

- SAE Standard
 - EV connector plugs, such as: J1772 (CCS Combo) and SAE J3400 (NACS)
- UL Solutions
 - Third-party safety tests
- NEC 625
 - Outlines EVSE installation requirements



Electric Vehicle Supply Equipment: NEC Code



NEC § 625.40 states that each outlet used to charge EVs needs to be connected by an **individual branch circuit**. For Level 1 this requires one dedicated breaker, for Level 2 it requires two vertically adjacent dedicated breakers.

NEC § 625.21 Overcurrent Protection

Overcurrent protection for feeders and branch circuits supplying electric vehicle supply equipment shall be sized for continuous duty and shall have a rating of not less than **125%** of the maximum load of the electric vehicle supply equipment.

$$32 \times 1.25 = 40 \text{ A Circuit Breaker}$$

$$\frac{32 \text{ A}}{40 \text{ A}} = 0.8 \times 100 = 80\%$$

“80% rule” for charging stations?



Electric Vehicle Supply Equipment: NEC Code



NEC § 625.42 describes how to rate the load of EV charging.

It states that

“Electric vehicle charging loads shall be considered to be continuous loads.”

NEC § 625.42 also states:

“Where an *automatic load management system* is used, the maximum equipment load on a service and feeder shall be the maximum load permitted by the automatic load management system.”



EV Charging Station Power Levels

Determining the Right EVSE Power Level for Your Project

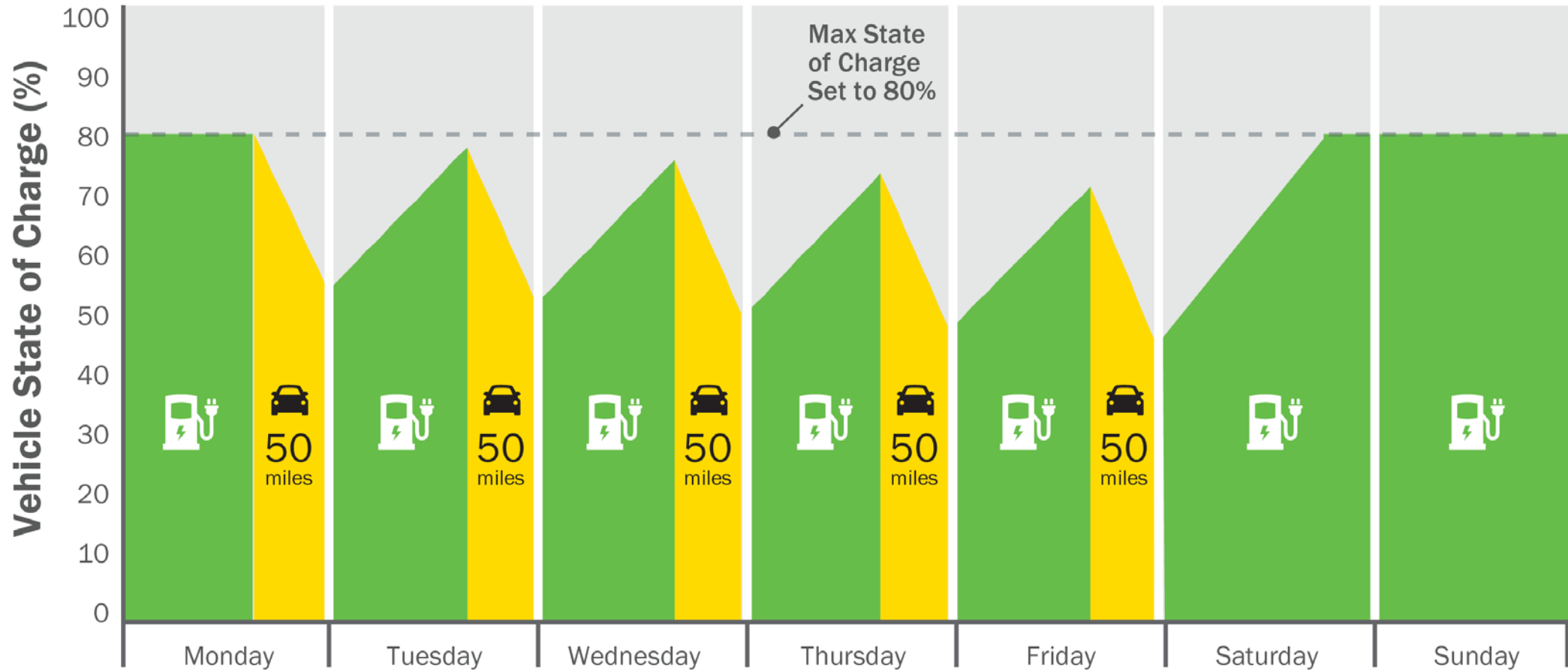
Level 1 Charging Considerations

- Adds 2-5 miles of range per hour of charging
- GSA vehicles come with a cordset
- Consider Level 1 when there is an existing outlet, or one could be easily installed
 - 120V outlet should be on a dedicated breaker



Example of a Vehicle Using a Level 1 Charger Overnight

Example Week - Level 1 Charging (250 miles)



Cost Considerations

- Installing a 120V/240V outlet is typically lower cost than installing a pedestal or wall mounted Level 2 EV charging station
- If trenching and/or updating electrical, likely makes sense to install Level 2 EV charging stations



Level 2: Power Level (kW) = Volts X Amps / 1000

NEC 80% Rule – margin of safety to ensure circuits operate within a safe range

Panel Breakers	EVSE Power Rating	208V	240V
40 Amps	32 Amps	6.7 kW	7.7 kW
50 Amps	40 Amps	8.3 kW	9.6 kW
60 Amps	48 Amps	10.0 kW	11.5 kW
80 Amps	64 Amps	13.3 kW	15.4 kW
100 Amps	80 Amps	16.6 kW	19.2 kW



Level 2: Power Level (kW) = Volts X Amps / 1000

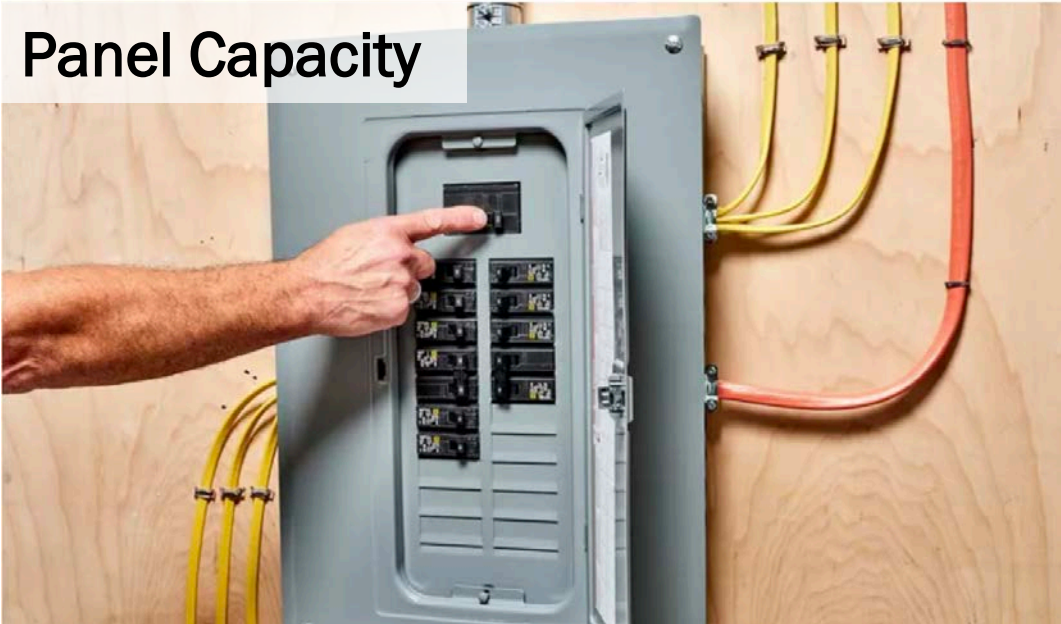
NEC 80% Rule – margin of safety to ensure circuits operate within a safe range

Panel Breakers	EVSE Power Rating	208V	240V
40 Amps	32 Amps	6.7 kW	7.7 kW
50 Amps	Most vehicles available today cannot charge above 11.5 kW		9.6 kW
60 Amps			11.5 kW
80 Amps	64 Amps	13.3 kW	15.4 kW
100 Amps	80 Amps	16.6 kW	19.2 kW

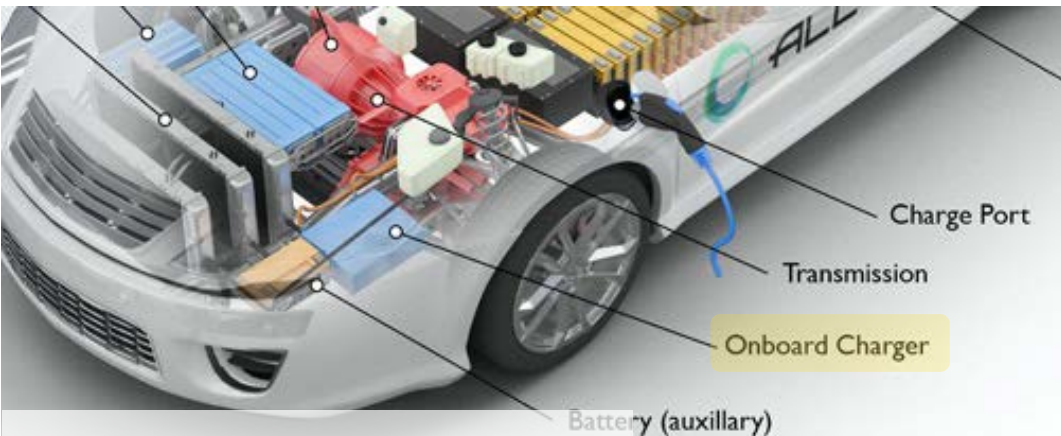
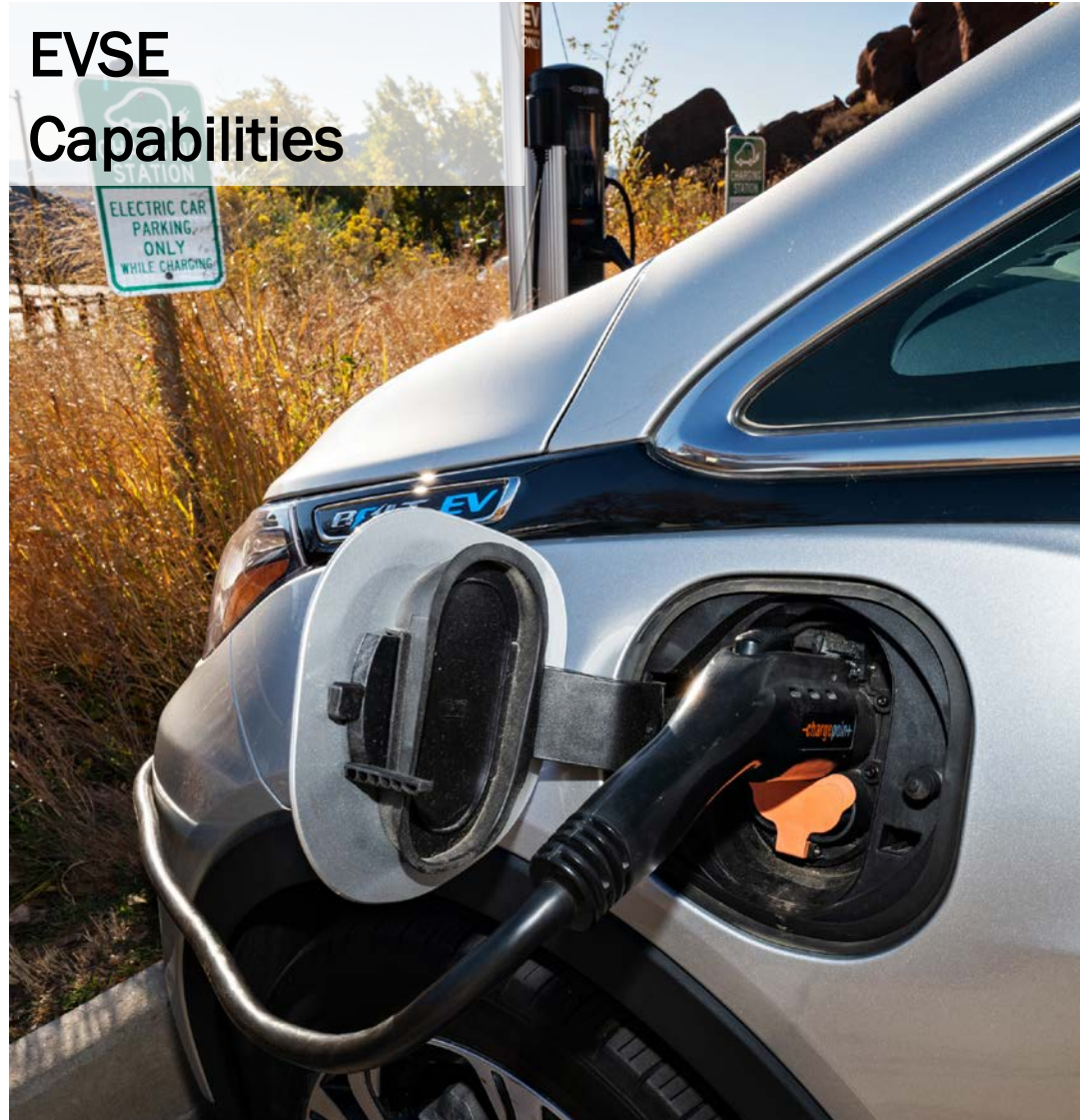


Considerations for Selecting Level 2 Power Rating

Panel Capacity



EVSE Capabilities

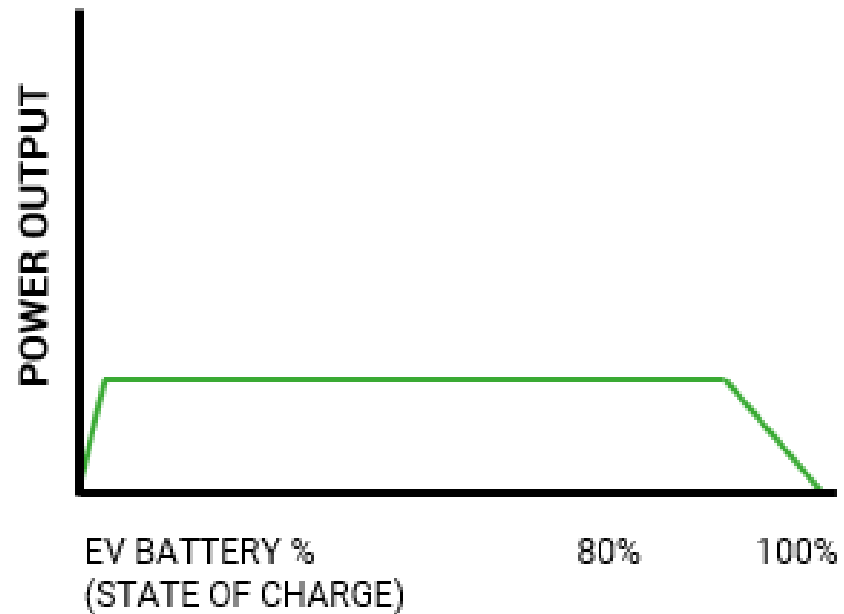


ZEV Onboard Charger

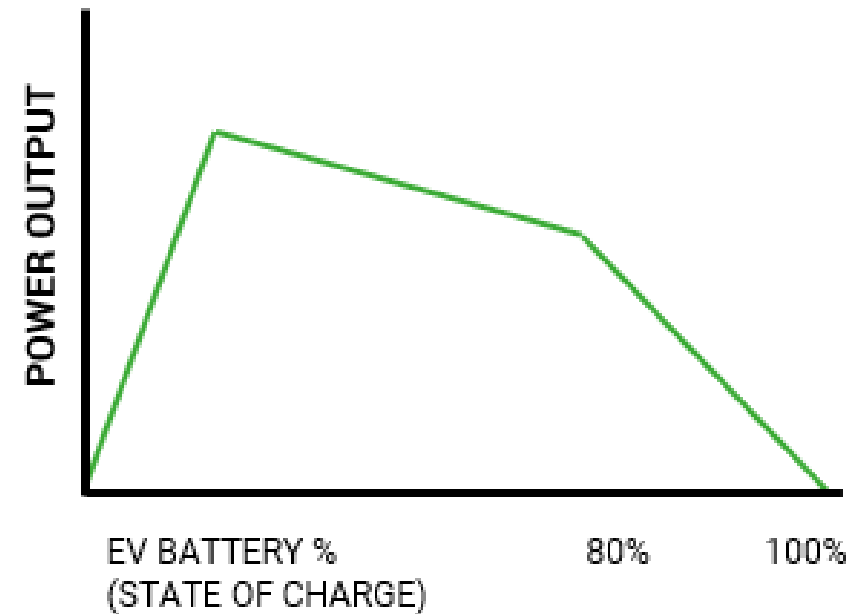


Understanding the DC Fast Charging Curve

AC charging station



DC fast charging station



Source: Evesco



Agenda

- 1 ZEV Ready Framework
- 2 Legislation Summary
- 3 Market Analysis
- 4 Vehicle and Charging Technology
- 5 Utility Basics**
- 6 Wrap-Up/Q&A



Utility Basics

Coordinating With Your Utility and Understanding
the Utility Rate Structures

Connecting EVSE to the Utility Grid

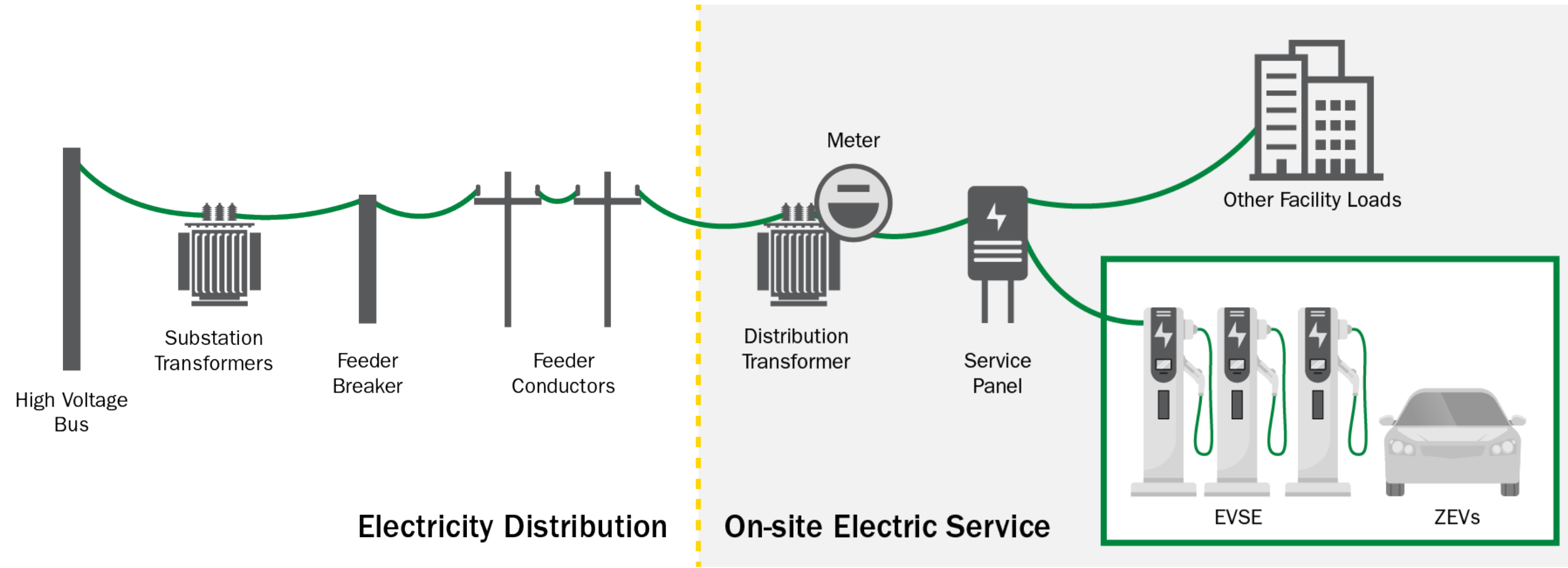


Federal Fleet Training Video 3
Electric Vehicle Supply Equipment Infrastructure

<https://youtu.be/TjKwOhKBtNc>
3:33 – 4:35



Elements of the Electricity Grid



Installing EVSE: Utility Metering of EV Charging Load

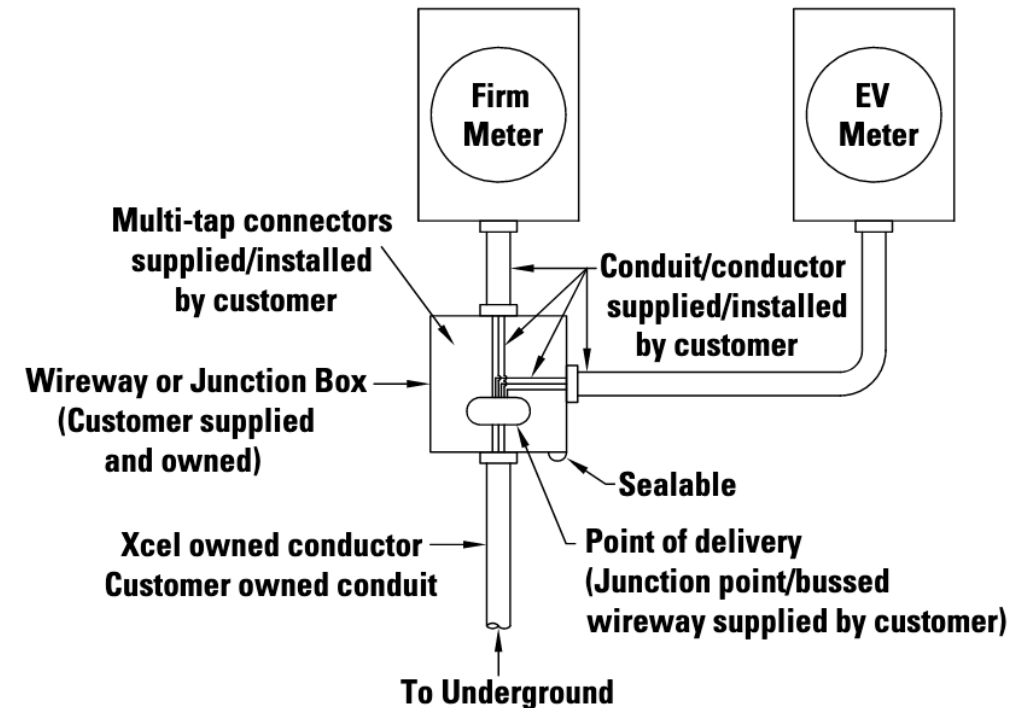
- Ask your utility representative about connecting your EVSE and metering options for your specific site and use case
- Utility may offer more than one configuration option
- Equipment may include meter sockets, meter, junction box, service panel, conduit, and conductors
- Understand which items are the customer's responsibility
- EVSE may be metered separately or share a building meter
- Consider what other loads will be on the same meter

Example of EV meter configuration

<https://www.xcelenergy.com>

DRAWING EV-30

UNDERGROUND SERVICE



NOTES:

1. Need to coordinate disconnect/reconnect with Xcel builders line.
2. Point of delivery in wireway, conductors after that point supplied by customer.
3. Junction point or bussed wireway supplied by customer.

EVs and Your Utility Bill



Federal Fleet Training Video 2

Electric Vehicle Financial Considerations

https://youtu.be/Xdi7T_rz75Q
4:23 – 6:32



Anatomy of a Utility Rate

Each utility rate is constructed of components. Each is intended to allow the utility to recover different types of costs of providing electricity to the customer.

Fixed Charge (aka Customer Charge, Base Charge)	Designed to recover administrative costs, customer service, local distribution
Energy Charge (\$/kWh)	Designed to recover variable costs (e.g., fuel purchases, energy purchases, operations and maintenance, regulatory fees and taxes, environmental initiatives)
Demand Charge (\$/kW)	<p>If the demand charge is \$20/kW and your highest kW usage during the month is 100 kW, then $20 \times 100 = \\$200$ is added to your monthly bill</p> <p>Designed to recover capacity and infrastructure costs (e.g., building transmission, generating stations, and technology necessarily to ensure reliability)</p> <p>Standard in commercial/industrial rates; less common in residential</p>



Types of Rate Structures

Utility rates are used to encourage customer behaviors that reduce system costs.

Most Common Rate Structures

- Demand Charge Rate
 - A demand charge is a \$/kW rate applied to the highest kW use during a billing period
 - Demand charge is added to the energy charge and fixed charge
- Time-of-Use (TOU) Rate
 - \$/kWh changes with time of day, day of week, and/or by season
 - May or may not include a demand charge
 - Designed to encourage customers to shift use to off-peak times to reduce strain on the grid

Other structures include:

- Block Rates
- Subscription Rates



EV Charging Rate Structures

Ask the utility if they offer special EV charging rate structures.

Options may include:

- Time of Use (TOU) rate incentives for charging during off-peak hours (nights and weekends).
 - ❖ [Green Mountain Power EV Rate 74](#): Peak M–F, 1–9 p.m.
 - ❖ [PG&E TOU Business EV Rate](#): Peak 4–9 p.m.; Super Off-Peak 9 a.m.–2 p.m. (when solar production is high)
- Utility Managed Charging Rates
 - ❖ [Xcel Colorado EV Rate](#): Utility may cut charging during peaks (~5–7 times/month, lasting a few hours, usually around 5 or 6 p.m.). Customer can override and pay higher kWh prices during peaks.
- Low-Usage or High-Usage Rates
 - ❖ [PG&E Business EV Block Plans](#)
- Demand-Charge Holiday Rate



Case Studies

Federal EV Truck Charging



Photo credit: ford.com

Montana Electric Bus Charging



Photo credit: missoulaclimate.org

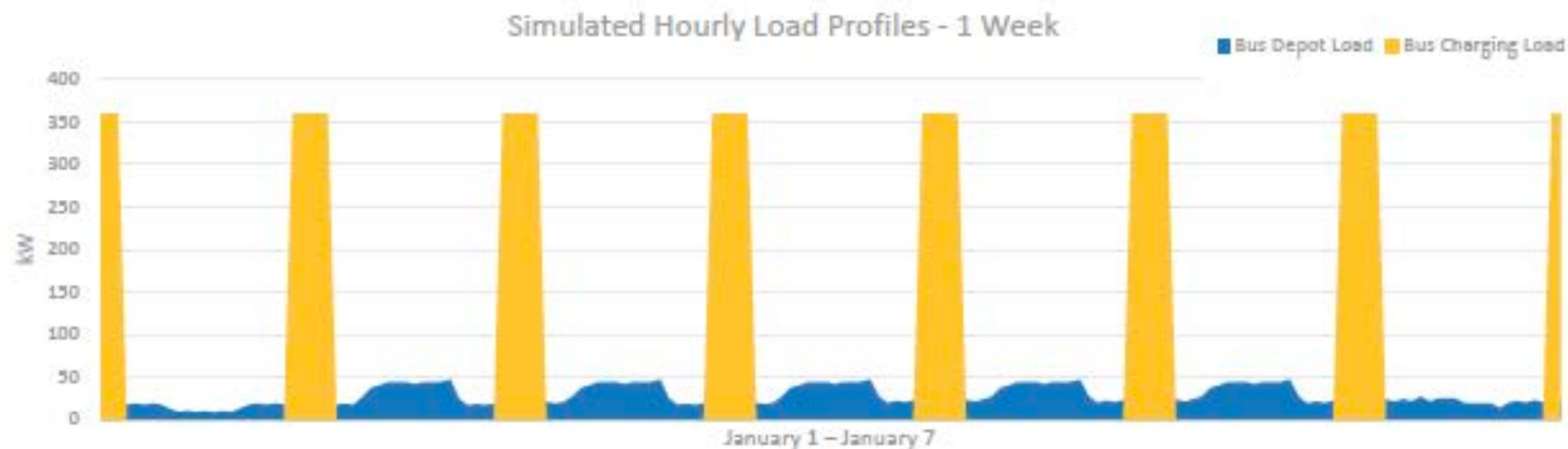


Use Vehicle and EVSE Management Systems to Reduce Cost

Vehicles and EVSE have management systems to control and track charging.

Use EVSE and vehicle management systems to:

- Limit charging during high-cost periods
- *Track the cost of electricity from EV charging (for reporting purposes)*
- *Stagger charging across vehicles to ‘flatten’ kW demand to reduce demand charges*



Relationship Building

Task 1: Build a partnership with the utility.

- Communicate with utility *early and often* about your project goals and plans
 - Identify the appropriate point of contact within the utility
- When met with resistance:
 - Seek to understand the utility perspective and priorities (safe, reliable system)
 - Employ the phrase: “What will it take to.....”

FLEET ELECTRIFICATION ADVISORY PROGRAM

**ELECTRIC VEHICLE PROCUREMENT
AND CHARGING INFRASTRUCTURE SUPPORT**

*Utilities may offer information or advisory
services to facility managers deploying EVSE*



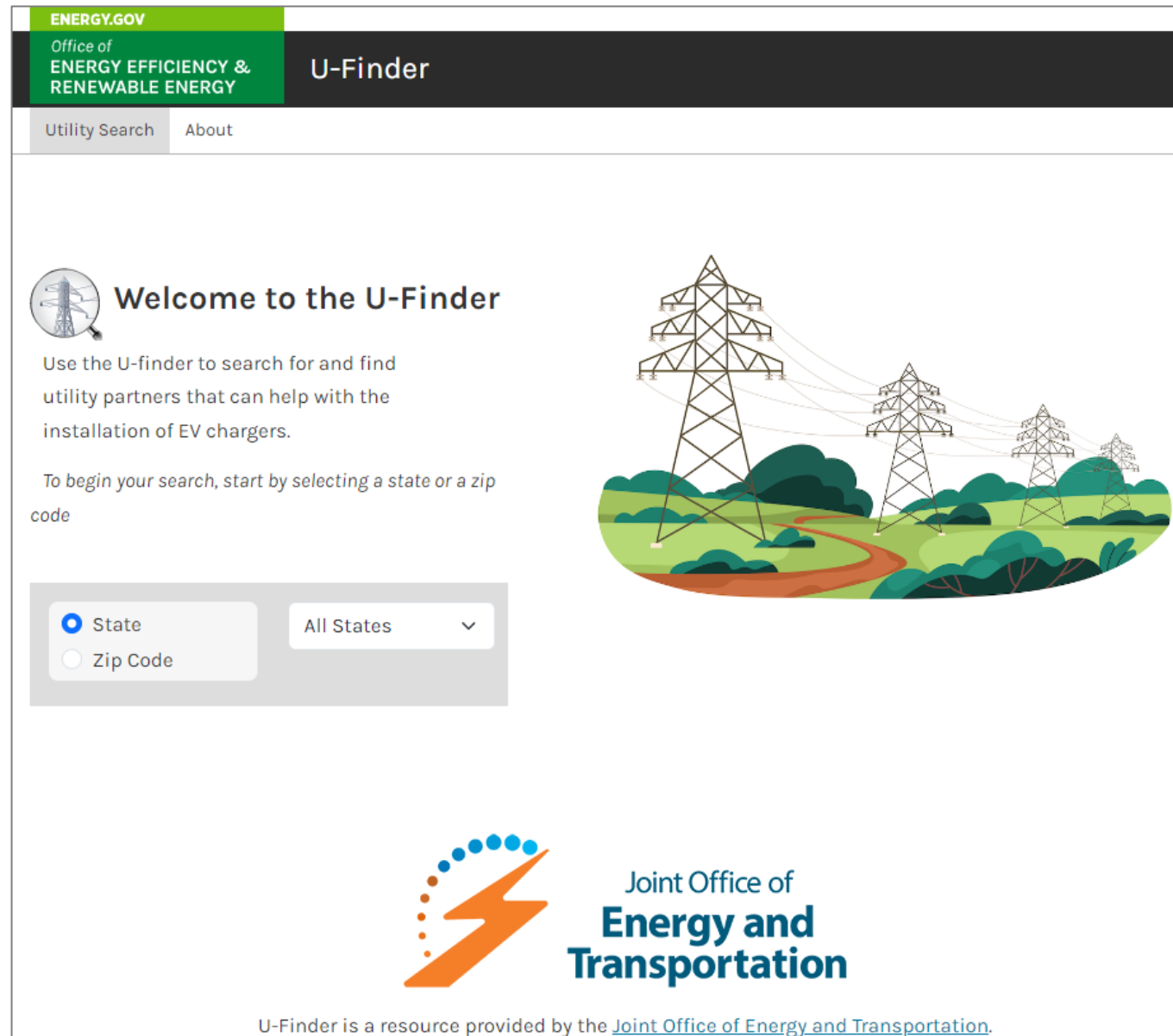
Connect With Your Utility With U-Finder

Primary goal: Enable EVSE planning efforts to connect with local utilities.

Primary message: Contact your utility early in the process!

Secondary goal: Raise awareness of available local utility incentives.

<https://afdc.energy.gov/utility-finder>



The screenshot shows the U-Finder website interface. At the top, there is a green header with "ENERGY.GOV" and "Office of ENERGY EFFICIENCY & RENEWABLE ENERGY". To the right of the header is the title "U-Finder". Below the header, there are two tabs: "Utility Search" (which is active) and "About". The main content area features a circular icon of a power line tower on the left, followed by the heading "Welcome to the U-Finder". Below this heading is a paragraph: "Use the U-finder to search for and find utility partners that can help with the installation of EV chargers." Underneath is another paragraph: "To begin your search, start by selecting a state or a zip code". Below the text is a search form with two radio buttons: "State" (which is selected) and "Zip Code". To the right of the radio buttons is a dropdown menu currently showing "All States". On the right side of the main content area, there is a large illustration of several power line towers in a landscape with green hills and a winding path. At the bottom right of the page is the logo for the "Joint Office of Energy and Transportation", which consists of a stylized orange lightning bolt with a blue arc above it. Below the logo is the text "Joint Office of Energy and Transportation". At the very bottom of the page, a small line of text reads: "U-Finder is a resource provided by the [Joint Office of Energy and Transportation](#)."

Agenda

- 1 ZEV Ready Framework
- 2 Legislation Summary
- 3 Market Analysis
- 4 Vehicle and Charging Technology
- 5 Utility Basics
- 6 **Wrap-Up/Q&A**



Questions?

NREL/PR-5400-90973

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Notable Tools and Resources

FEMP Fleet Electrification and Optimization website

- <https://www.energy.gov/femp/fleet-electrification-and-optimization>

Federal Fleet ZEV Ready Center

- <https://www.energy.gov/femp/federal-fleet-zev-ready-center>

Federal Fleet EV Training

- https://www.youtube.com/playlist?list=PLmIn8Hncs7bEa_NOG5Y8EZY0NoxJtTOEF

GSA 2024 Zero Emission Vehicle Fact Sheet

- https://www.gsa.gov/system/files/FY2024%20GSA%20ZEV%20Fact%20Sheet_3.18.2024_508.pdf

DOE's AFDC Electric Vehicles

- <https://afdc.energy.gov/vehicles/electric.html>

U-Finder

- <https://afdc.energy.gov/utility-finder>

EVI-LOCATE

- <https://evi-locate.nrel.gov/>

FuelEconomy.Gov

- <https://fueleconomy.gov/>



Register Today For Upcoming EV Champion Training

EV Champion Training Series	Date and Time
Training 1: ZEV and EV Charging Fundamentals	Thurs., Aug. 29, 12–2 p.m. ET
Training 2: ZEV and EV Charging Planning	Wed., Sept. 11, 2–4 p.m. ET
Training 3: EV Charging Site Assessments and Budgeting	Wed., Sept. 18, 2–4 p.m. ET
Training 4: EV and EV Charging Design and Implementation	Wed., Oct. 2, 2–4 p.m. ET



Training updates reflect current industry trends and business charging models. The training will follow the ZEV Ready Center framework.



This Training Offers IACET CEUs

How to obtain your CEUs:

1. Visit the Whole Building Design Guide (WBDG) at wbdg.org to log in or create an account
2. Enroll in the training
3. Attend the training in full
4. Return to your WBDG account's Enrolled courses
5. Select the training's "Proceed to Course" button
6. Complete an assessment
7. Submit a training evaluation
8. Download your certificate.

What's an IACET CEU?

An International Association for Continuing Education and Training (IACET) continuing education unit (CEU) is a unit of credit equal to 10 hours of participation in an accredited program designed for professionals with certificates or licenses to practice various professions.



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Thank You

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