ZEV 101
GSA Fleet & National Renewable Energy Laboratory
Agenda

- What is a ZEV?
- Current Offerings / Market trends
- Operating my ZEV
- Charging
- Maintenance
- Weather Effects
- Upcoming Trainings
- Question and Answer
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).
Types of ZEVs

**BEVS**

100% Electricity & Battery

- Ranges 100-350
- 0 emissions
- LD Acquisition Cost 50% more
- Charging plentiful & growing

**FCEVS**

100% Hydrogen & Battery

- Ranges 350-450
- 0 emissions
- LD Acquisition Cost 190% more
- Charging Limited
- Models Limited (likely to take off in trucking)

**PHEVS**

Gasoline + Electricity

- All electric range 20-40
- Total Range (on gas) 310-640
- Optimal for missions >200 miles/day
- 15%-55% less tailpipe CO₂
- LD Acquisition Cost 50% more
- Models Limited
How does a battery electric car work?

There are 5 major components of the battery electric vehicle.
How does a battery electric car work?

The **battery pack** is made up of lithium ion cell batteries with coolant running through the pack to keep it from overheating.
The **inverter** converts the power from direct current to alternating current to power the motor.
How does a battery electric car work?

The \textit{induction motor} uses the alternating current to produce a rotating magnetic field causing it to turn.
How does a battery electric car work?

The drivetrain distributes power from the motor to the wheels.
How does a battery electric car work?

The charging system allows you to transfer energy from the grid to the battery pack.
Regenerative Braking

When you take your foot off the accelerator or press on the brakes, the electric motor is operated in reverse. This recaptures some of the vehicle’s kinetic energy and recharges the battery. Regenerative braking increases efficient, but should not take the place of charging at a station.

Regenerative braking modes vary with each vehicle make and model.
One-pedal Driving

Brake
- press the brake pedal to stop quickly
- regenerative braking

Slow Down
- release the accelerator*

Speed Up
- press the accelerator

*depending on vehicle model, when you release the accelerator the brake light may or may not activate.
Dashboard Displays & Other Features

- Adaptive Cruise Control
- Automatic Emergency Braking
- Lane Departure Warning/Lane Keep Assist
- Self-Parking Technology
ZEV Market Trends

- Government policies promote and mandate ZEV Market Development
- Investment & Mass production ramp up for all classes of electric vehicles
- “Overselling” of vehicles by automakers & new/enhanced attention on ZEVs
- Supply Chain Disruptions (especially microchips) will continue into 2023

Limited Availability | Longer Lead Times & Delays | More ZEV Models | Longer Ranges | More public charging & fleet card acceptance
What are the Benefits?

- Zero Emissions (potential)
- More Efficient
- Less Maintenance
- Fuel Savings
- Enhanced Performance
Aside from the benefits, why are we electrifying the Fleet?
E.O. 14057 Catalyzing America’s Clean Energy Economy Through Federal Sustainability (Signed 12/8/21)

100 percent zero-emission light-duty vehicle acquisitions by 2027 and 100 percent zero-emission vehicle acquisitions by 2035

Each agency with a fleet comprising at least 20 vehicles shall develop and annually update a zero-emission fleet strategy that shall include:

- Optimizing fleet size and composition
- Deploying zero-emission vehicle re-fueling infrastructure
- Maximizing acquisition and deployment of zero-emission light-, medium-, and heavy-duty vehicles where the General Services Administration (GSA) offers one or more zero-emission vehicle options for that vehicle class.

Accompanying memo requires strategic ZEV plan development to set intermediary targets, Agency-owned vehicle consolidations to leasing program, and deployment of telematics to collect operational data to inform fleet decisions.

E.O. Fact Sheet, Official Release, & Memo
### Federal Support for ZEV Deployment

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- **Offerings Match Commercial Marketplace**: Provides matching funding for commercial marketplace offerings.
- **Charging Station Offerings & Install Support**: Offers support for installing charging stations.
- **ChargePoint RFID Cards**: Provides RFID cards for charging stations.
- **Unique Financing Options**: Offers unique financing solutions.
- **Training**: Provides training resources.
- **Planning Resources & Assistance**: Offers planning resources and assistance.
57 ZEV Offerings

- Sedans
- SUVs
- Pickups
- Cargo Vans
- Stake trucks
- Tractors
- Shuttle Buses
- Transit Buses
- School Buses
- Work Buses
- Ambulances

- 46 Battery Electric
- 7 Plug-in Hybrid
- 4 Hydrogen Fuel Cell
Download the FY22 ZEV Fact Sheet at gsa.gov/afv to see all of the current offerings.
ZEV Purchases

ZEVs make up 7.86% of FY22 Purchases!
Charging 101

“Level 1”
- NEMA 15
- 3-4 RPH

“Level 2”
- J1772
- 16-25 RPH

“DC Fast”
- Tesla SAE Combo CHAdeMO
- 200-500 RPH

No single standard
Charging

Plugging in

Charging best practices

Finding a charger plugshare.com or DOE Alternative Fueling Station Locator
EV Charging: More Networks Accept WEX & Voyager!

- ChargePoint roaming agreements mean more pay-for-use or free public charging -
  - Available at ChargePoint, EVBox, evconnect, EVgo, Greenlots and Flo connected Stations
- Reporting in Fuel Use Report in Drive-thru & billed through mileage rate
- Request a WEX connected ChargePoint card at GSAFleetAFVTeam@gsa.gov
- Can be used with Tesla vehicle charging as well

Find a station on https://www.plugshare.com/
Maintenance

- 8 Years 100,000 miles battery pack warranty
- No oil changes for BEVs; tire pressure, rotate tires, flush corrosive materials, replace the cabin air filter and wiper blades, and topping off the washer fluid
- Will vary depending on climate
Most ZEVs will be delivered to dealerships

ZEVs come 75% charged

Delivered to EV-certified dealerships

Customers notified when vehicle is ready for pick-up
NREL
Temperature Effects on EV Batteries

Leidy Boyce
Engineering Researcher
NREL
Objectives

• Key Terms
• Battery Capacity General Concepts
• The Role of Battery Management System
• Common Factors Impacting Battery Life and Driving Range
• Tips for Avoiding Range Loss and EV Storage
How Much Does Temperature Affect an Electric Vehicle’s Driving Range?

It all depends, BUT...

Picture source: https://thenextweb.com/news/ev-battery-basics-kw-kwh-electric-vehicle-charging-lingo
Key Terms

- **Battery Capacity**: The amount of electricity (electric charge) stored in batteries, measured in \textit{ampere-hours}, with the total energy often measured in \textit{kilowatt-hours}.

- **State Of Charge (SOC)**: The ratio of the present \textit{residual capacity} to the overall available capacity.

- **State Of Health (SOH)**: How much capacity the battery pack stores relative to the brand-new capacity.

- **Vehicle Range**: Distance the vehicle can travel on a single charge.
BEV and PHEV are EV

**BEV (All-electric)**
Between 24.0 kWh and 100 kWh

**PHEV (Plug-in hybrid)**
Between 4.4 kWh and 34 kWh


(2012 Toyota Prius Plug-in Hybrid)

Pictures from: https://afdc.energy.gov/vehicles/how-do-all-electric-cars-work
Battery SOH Degrades Over Time

SOH: State Of Heath

Battery Management System (BMS) Role: Safe & Reliable Operations

Most plug-in hybrids and all-electric vehicles use lithium-ion batteries like these.

State Of Charge (SOC)
State Of Health (SOH)
Safe Operating Area of a Battery

Figure 1: Schematic summary of the key components of a battery pack after [17].

**Safe Operation Area**

- $V_{MAX} = 4.2 \, V$
- $V_{MIN} = 2.5 \, V$
- $T_{MAX} = 55 \, ^{\circ}C$
- $T_{MIN} = -20 \, ^{\circ}C$

**Safety Conditions**

- **Overcharge**: $OV$
- **Under Temperature**: $UT$
- **Over Discharge**: $OD$
- **Over heating**: $OT$

**Legend**

- **Safe Operation Area**

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*Note: Images and diagrams are not included in the text representation.*
Common Factors Impacting Battery Life and Driving Range

- Extreme Temperatures
- Terrain
- Anything Extreme
- Real World Driving Conditions

- Temperate (fewer than 5 days per year over 80°F (27°C) or under 23°F (-5°C))
- Hot (more than 5 days per year over 80°F (27°C))

Source: https://www.geotab.com/uk/blog/ev-battery-health/
Hot and Cold Temperatures Reduce Range of EVs

Overall Cabin Temperature

- **20-30% reduction in range**
- **Cabin heating draws power** (varies based on driver)
- **Cabin AC draws power** (varies based on driver)
- **20-46% reduction in range**

Overall Outdoor Temperature

- **15-21% lower at 20°F**
- **Lower component efficiency in cold weather** (varies based on drive cycle)
- **Lower range in cold weather** (highly variable)
- **Lower range in hot weather** (highly variable)

Component Efficiency

Source: fleetscarma
Ideal Operating Temperature is 70 °F

*Driving range data from Geotab-equipped Chevrolet Bolts

https://www.geotab.com/uk/blog/ev-battery-health/
Tips to Minimize Range Loss

1. Park your car in a garage.
2. Precondition car.
3. Heat the passenger, not the car.
4. Inflate your tires.
5. Activate the “eco” mode
6. Smooth driving habits.
Tips on How to Store an EV for Long Periods

1. Right storage location.
2. Consider leaving your EV plugged in.
3. Recommend charge of between 20% and 80%.
4. Avoid Parasitic Drain.

https://newsroom.aaa.com/2019/02/cold-weather-reduces-electric-vehicle-range
Take Away Points

• High vehicle use **does not equal** higher battery degradation.
• Store vehicle in a **weather control environment**.
• EVs on **average lose 20%** of their range in colder climate.
• EVs **charge more slowly** in cold temperatures.
• EV drivers use **lower-power charging methods** whenever they can to promote longer battery health.
References


• https://inl.gov/article/electric-vehicles/

• https://www.recurrentauto.com/research/winter-ev-range-loss

• https://www.naf.no/elbil/aktuelt/elbiltest/ev-winter-range-test-2020/
ZEV Future Predictions

- OEMs more vertically integrated
- Upgrades through OTA and Vehicle Software Drives Profits
- Light-Duty ZEVs reach price parity with ICE vehicles 2025-26
- More autonomous features
Upcoming Training

➔ **NREL’s EV Champion Training** (April 12 10AM)
  wbdg.org/continuing-education/femp-courses/femplw04122022

➔ **2022 FedFleet** (May 17-19)
  gsa.gov/fedfleet
Questions & Answers

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