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AIR RESOURCES BOARD

Ride and Drive
Anaheim, CA

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New Technology Options and Q&A

Topics Covered

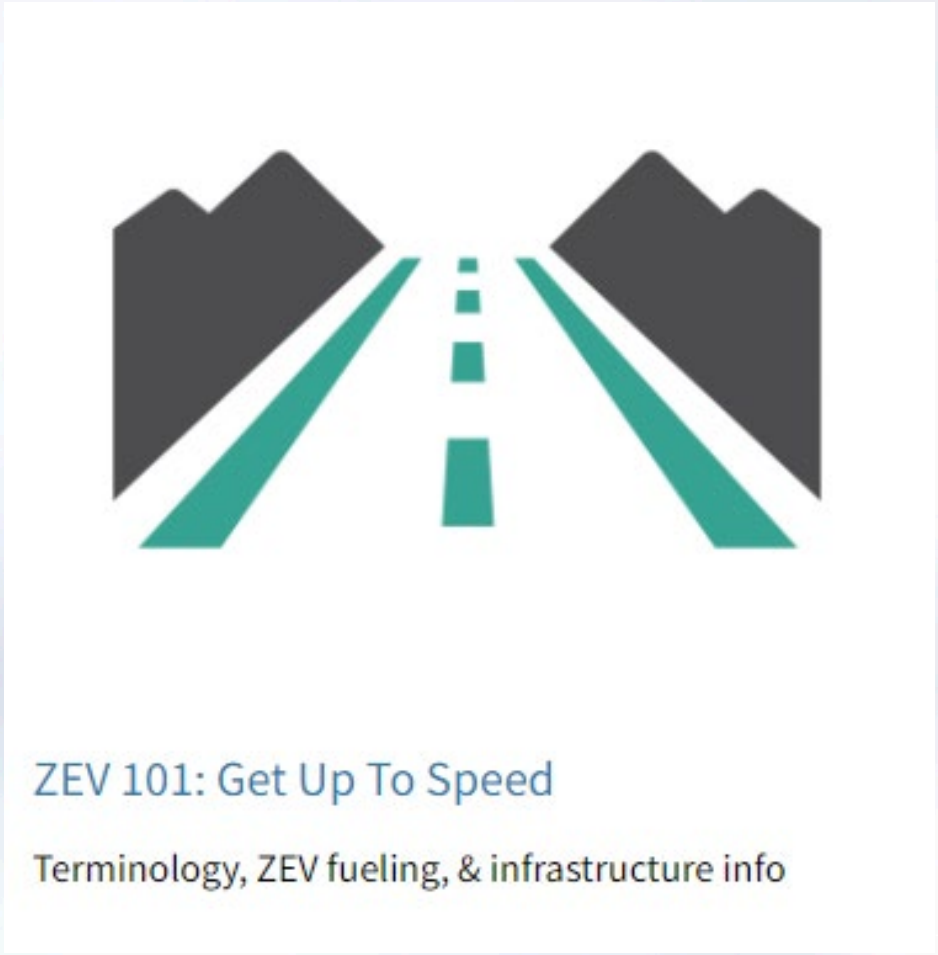
- Available Online Resources
  - ZEV TruckStop
- Basic Terminology
- Battery Electric Technology
- Hydrogen Fuel Cell Technology
- How to Choose a Vehicle
- Cal Fleet Advisor

ZEV TruckStop

- arb.ca.gov/ZEVTruckStop

ZEV 101: Get Up To Speed webpage

- Basic Terminology
- Battery Electric Technology
- Hydrogen Fuel Cell technology
- Steps to Transition



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Basic Terminology

- Zero-Emission Vehicles (ZEV)
- Battery-Electric Vehicles (BEV)
- Hydrogen Fuel-Cell Electric Vehicles (FCEV)
- Near-Zero Emission Vehicles (NZEV)
- Range
- Regenerative Braking
- Battery Pack
- Electric Drive Train
- Battery Management Systems
- Battery Capacity
- Voltage (Volts)
- Trucking as a Service (TaaS)
- Amperes (Amps)
- Kilowatt (kW)
- Kilowatt-Hour (kWh)
- Level 1 Charger
- Level 2 Charger
- Direct Current (DC) Fast Charger
- Depot Charging
- Opportunity Charging
- Fuel Cell
- Hydrogen Tank
- Charging as a Service (CaaS)
- ICE/ICEV (Internal Combustion Engine) Vehicles

Basic Technology Overview

- Hydrogen Fuel Cell Electric (FCEV)

- Battery Electric (BEV)

FCEV – Refueling

- FCEVs are electric vehicles – they use electricity to power an electric motor
- The hydrogen powers a fuel cell to produce the electricity
- Hydrogen is stored in an on-board tank, and is refueled in a similar fashion to conventional ICE vehicles

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FCEV - Benefits

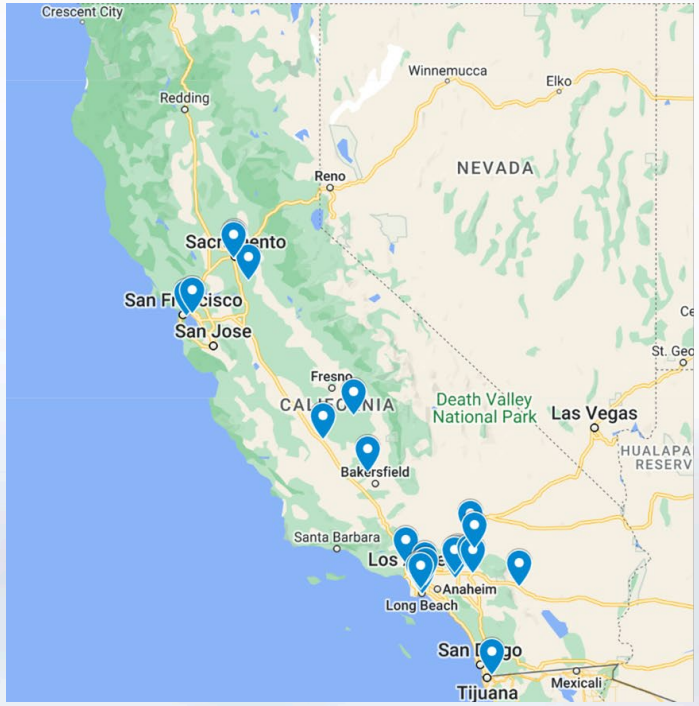
- Zero-emission - only produces water vapor and warm air
- Can be produced domestically
- Faster to refuel compared to charging BEVs
- Can handle tough conditions and environments
- Safe
- Lower operational costs
- Potential for shared fueling

FCEV - Limitations

- High up-front costs
- Currently limited refueling infrastructure availability
- Fuel production process is complex, and hydrogen prices are still higher today than conventional fuels

The Future of Hydrogen

- 200 new hydrogen stations by 2025
- 13 to offer heavy-duty services
- Federal Programs Underway
  - EnergIIZE Commercial Vehicles
  - Low Carbon Fuel Standard
  - Hydrogen Shot



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FCEV – Safety Considerations

- Myth – hydrogen is more dangerous than conventional fuel
- Fact – hydrogen is safer than conventional fuels like gasoline and diesel

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BEV – Charging

- Need to be plugged into an electric energy source
- Time needed to charge depends mostly on power output of the charging station
- Three categories of chargers:
  - Level 1 (110/120V)
  - Level 2 (208/240V)
  - Level 3 (DCFC) (200+V)

BEV – Charging, cont…

- Charge speed vary based on
  - Ambient temperatures
  - Battery capacity
  - Battery charge level
- Different charging solutions and strategies are available
- Different charger connectors:
  - SAE J1772
  - CCS Type 1
  - SAE 3068

BEV - Benefits

- Lower cost of ownership
- Higher fuel efficiency
- Less maintenance, fewer repairs
- Promotes US energy security
- Zero tailpipe emissions
- Quieter ride, more responsive motor, less vibration

BEV – Limitations

- Limited range
- Higher up-front costs
- Rely on charging infrastructure

BEVs – Overcoming Limitations

- Charging schedule
- Fleet management strategies
- Route planning
- Opportunity charging

BEVs - Charging Efficiency

- Many factors affect charging efficiency
  - Battery capacity
  - Charger level
  - Charger output power rate
  - Vehicle charging max power rate
  - Access to chargers
  - Down time available to spend at charger
  - Ambient temperature
  - Battery temperature
  - Battery charge level

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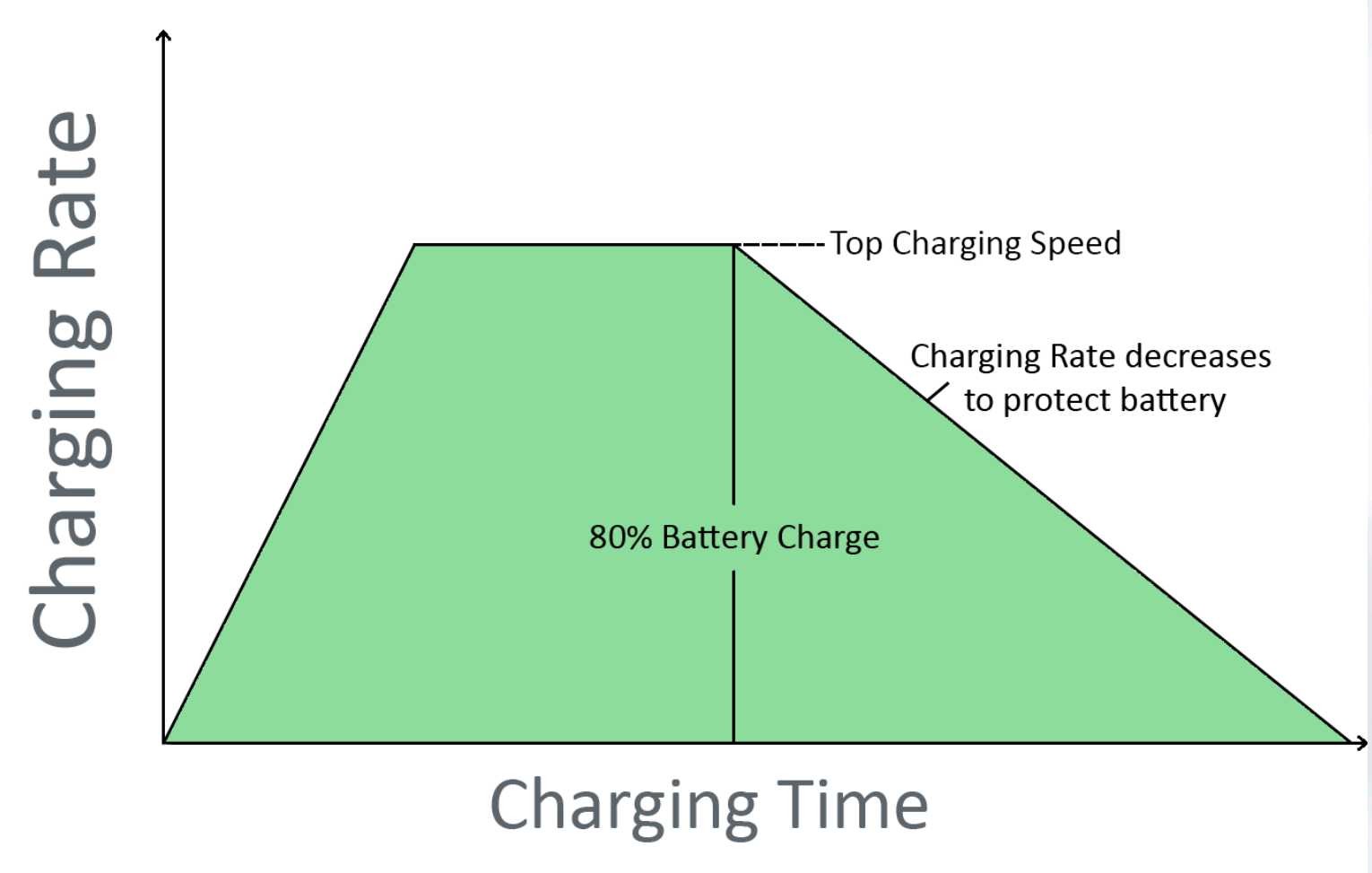
BEVs – General Charging Curve



BEVs – Factors Affecting Range

- Route conditions/ topography
- Vehicle speeds
- Weather – AC/Heater use
- Driving habits
- Load weight
- Wind
- Tire condition/pressure

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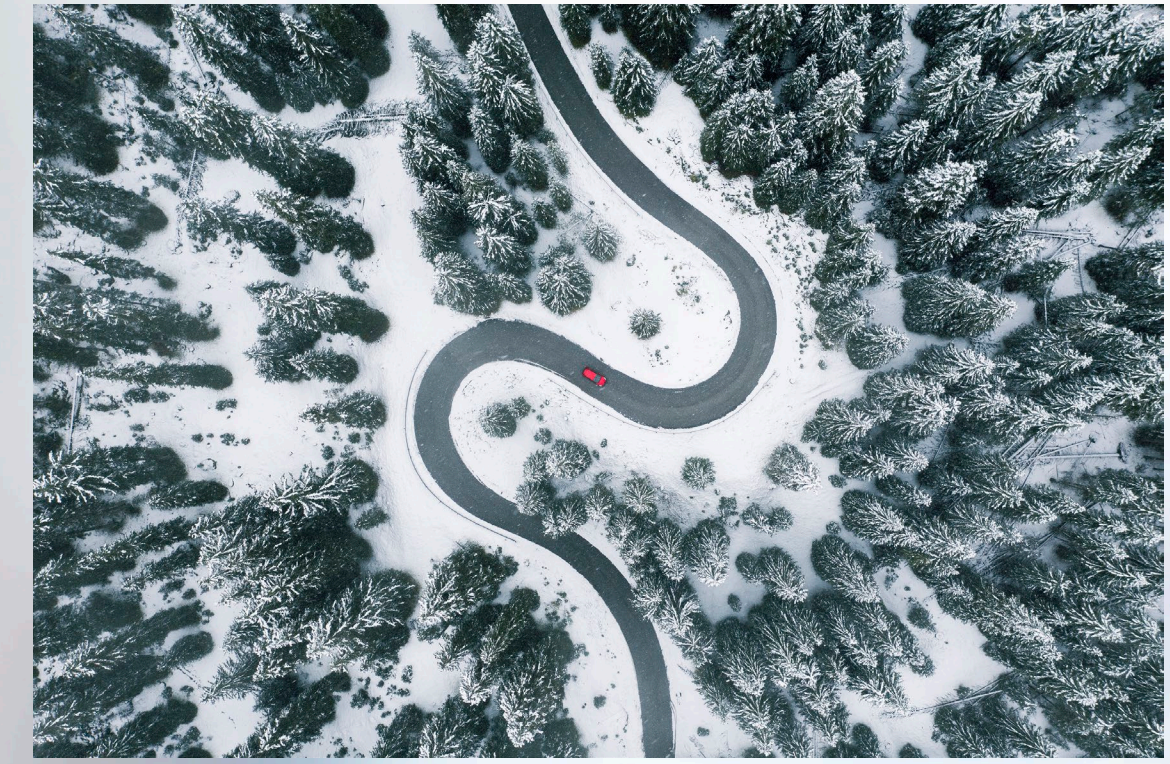
BEVs – Best Practices to Extend Range



- Driver habits
- Opportunity charging
- Route planning

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BEVs – Determining Charger Needs

- The fastest/most powerful chargers are not always the right chargers
- Factors to consider:
  - Daily range
  - Availability of depot charging
  - Availability of opportunity charging
  - Vehicle down time
- Resources/services available to help

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BEVs – Charging options

- Public charging
  - Opportunity charging
    - Loading/unloading
    - Downtime
    - Can sometimes be combined with route planning to maximize efficiency
- Private charging
  - Owning/installing infrastructure
  - CaaS options - Lease vs own
  - Working with utilities early
  - Developing accurate timeline

BEVs - Common Myths

Myth

- BEVs can't yet meet the range demands for most commercial vehicle uses
- There aren't enough commercial BEVs on the market

Fact

- Most trucks and vans operate less than 100 miles per day
- Over 135 different models of vans, trucks, and buses are currently available

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Applying Charging Strategies

- Determine optimal vehicle battery size
  - Range
  - Weight
  - Cost
- Determine optimal charger speed
  - Route distance
    - Distance to opportunity chargers
  - Battery capacity
  - Planned downtime
  - Cost

ZEV TruckStop - Partners

- California Energy Commission (CEC)
- Local Utilities
- GO-BIZ
- CALSTART
- California Air Districts
- NESCAUM

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