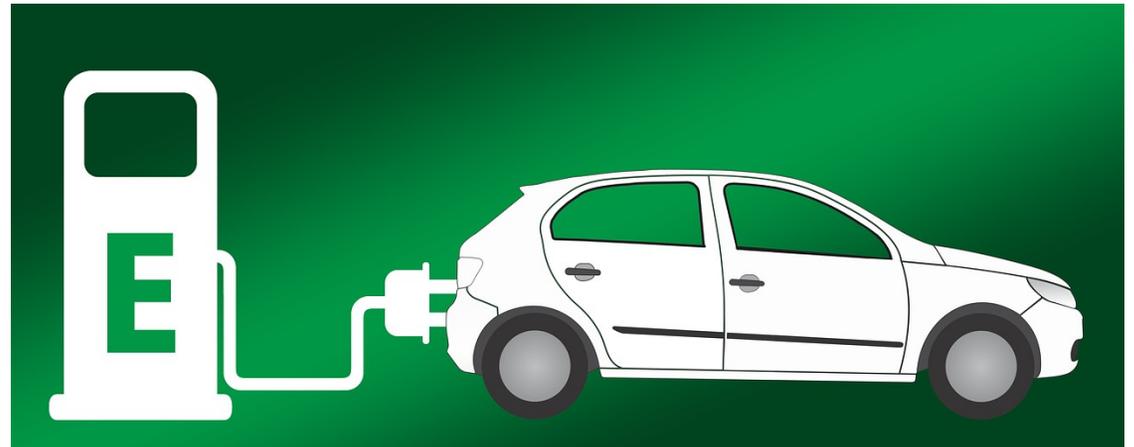




SOUTHEASTERN COLORADO (SECREs)

- Non-profit organization staffed by volunteers
- Mission: To educate the public and promote the use of clean, healthy and low cost renewable energy, and energy efficiency.
- More information, join, or donate:
 - cres-energy.org
- CRES lecture videos: cres-energy.org/video.html

The Basics of Electric Vehicles



Southeast Colorado Renewable Energy Society
2022 Lecture Series
June 25, 2022



Overview

- Types of electric vehicles
- How do they work?
- How do you charge?
- Available makes and models
- Cost
- Myth busting



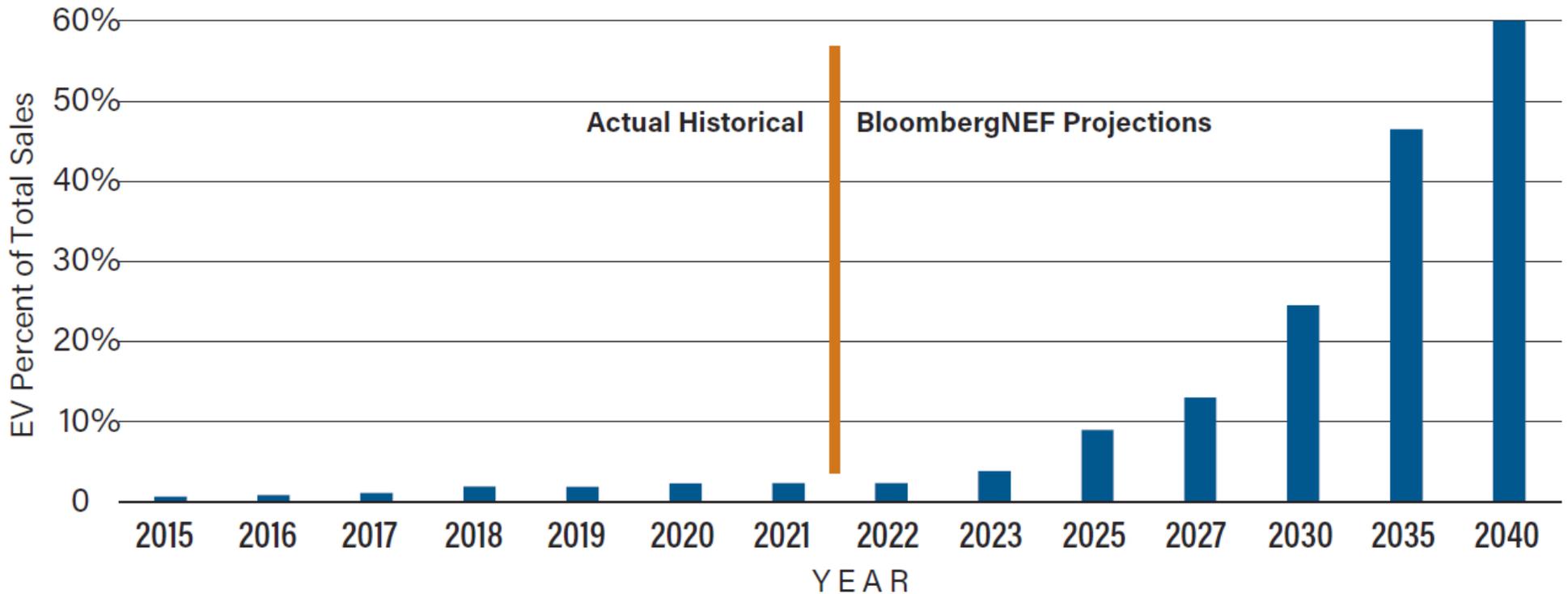
Definitions

- **BEV:** Battery Electric Vehicle. Electric-only with energy stored in batteries
- **PHEV:** Plug-in Hybrid Electric Vehicle. Internal combustion engine (ICE) combined with electric drive train. Typically 20 to 40 miles of battery-only range. Can externally recharge battery.
- **HEV:** Hybrid Electric Vehicle. Internal combustion engine combined with electric drive train. Batteries only recharged by ICE
- **HFCV:** Hydrogen Fuel Cell Vehicle. Compressed hydrogen run through a fuel cell to generate electricity and power an electric drive train.



Growth of Electric Vehicle Adoption

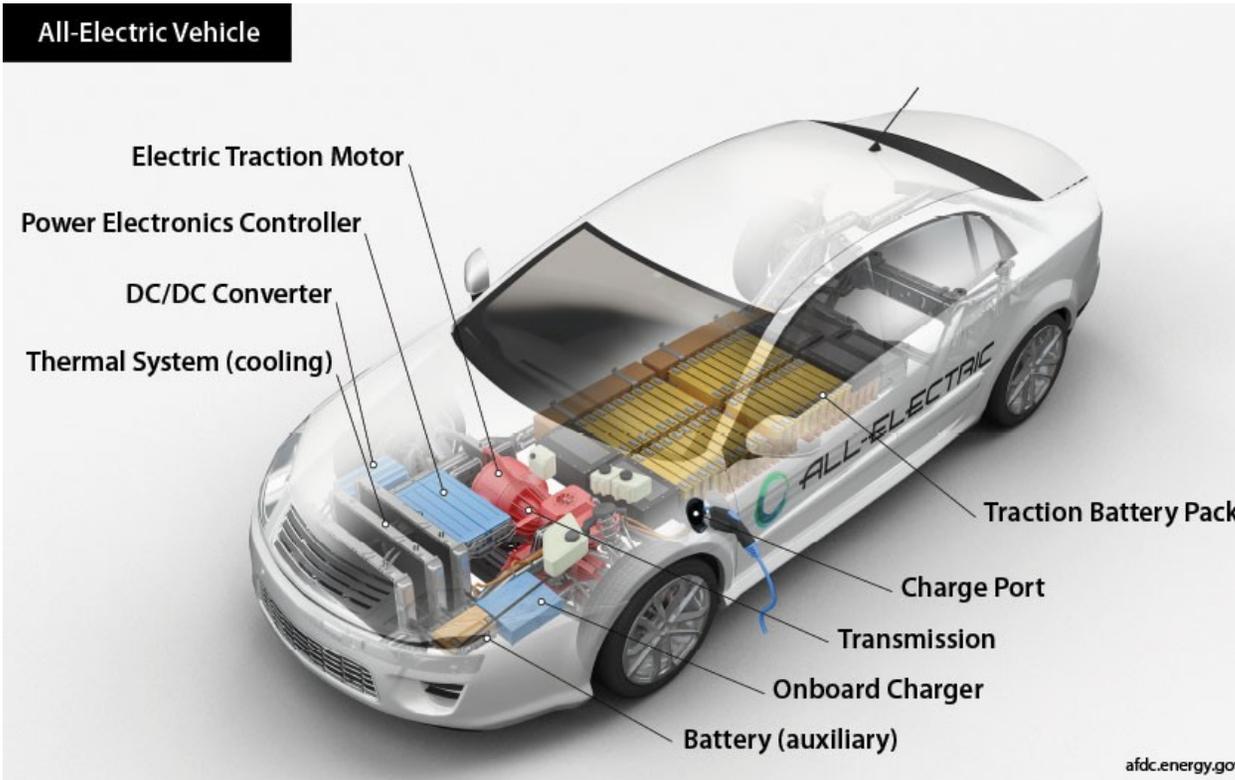
Figure 1: EV as a Percentage of All U.S. Light-Duty Auto Sales



Sources: CFC Issue Brief Nov 2021; Bloomberg, *Plugging In: The EV Transition Gains Speed*, 2021

How Do BEVs Work

All-Electric Vehicle



Source: National Renewable Energy Lab

- High voltage (“traction battery”) used by drive motor(s)
- 12 volt battery controls onboard computers and electronics. Recharged by DC/DC converter.
- Drive motors used as generators for regenerative braking to charge battery
- Charge port accepts either:
 - High voltage, direct current (DC) power into the traction battery, or
 - Alternating current (AC) into the onboard charger, converting AC to DC for traction battery

Eliminated:

- Spark plugs
- Exhaust and catalytic converter
- Oil
- High temp coolant

EV Charging

Level 1 (Home)

- 120 volt AC, 12 amp (1.8 kW)
- Household outlet
- Uses onboard charger
- Adds 2-5 miles range/hour



Level 2 (Home/Public)

- 240 Volt AC, 30-72 amp (7.2-17.3 kW)
- Uses onboard charger
- Clothes dryer socket or EVSE*
- Adds 10-55 miles range/hour



Level 3 (Public)

- “DC Fast Charger”
- 50-350 kW
- Bypasses onboard charger
- Adds up to 900 miles range/hour at peak



*EVSE: Electric Vehicle Supply Equipment. “Charging Station”

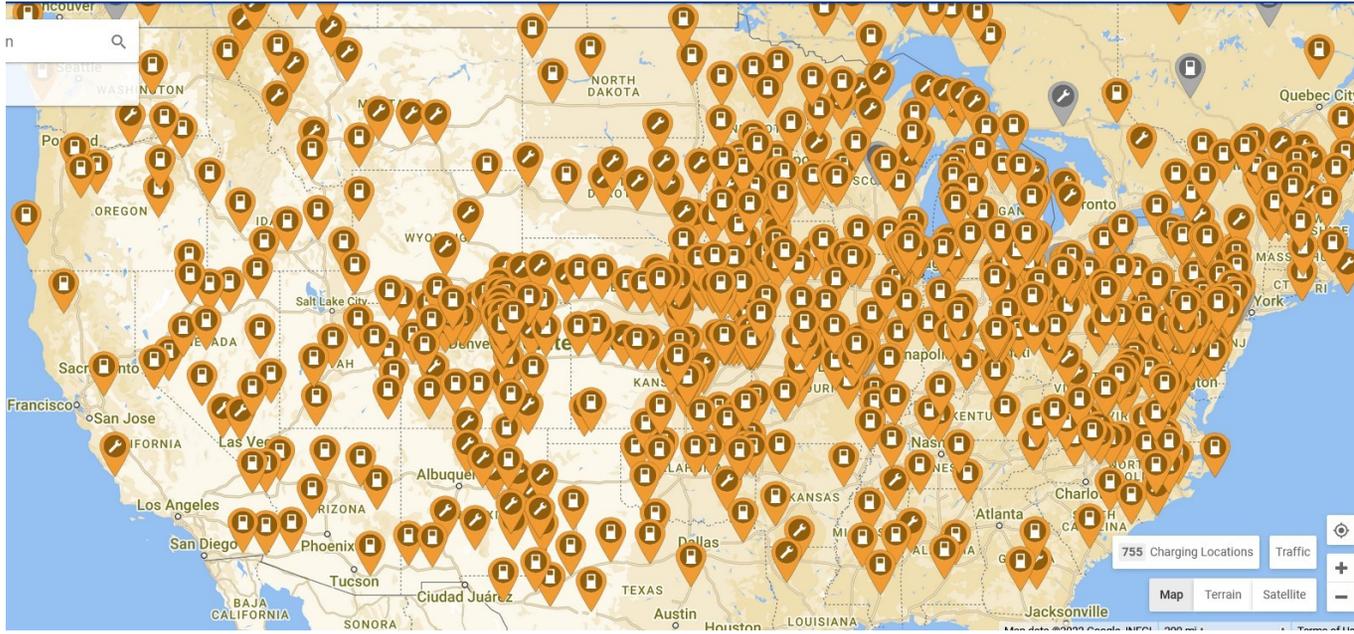


DC Fast Charging Standards (VHS vs. Betamax!)

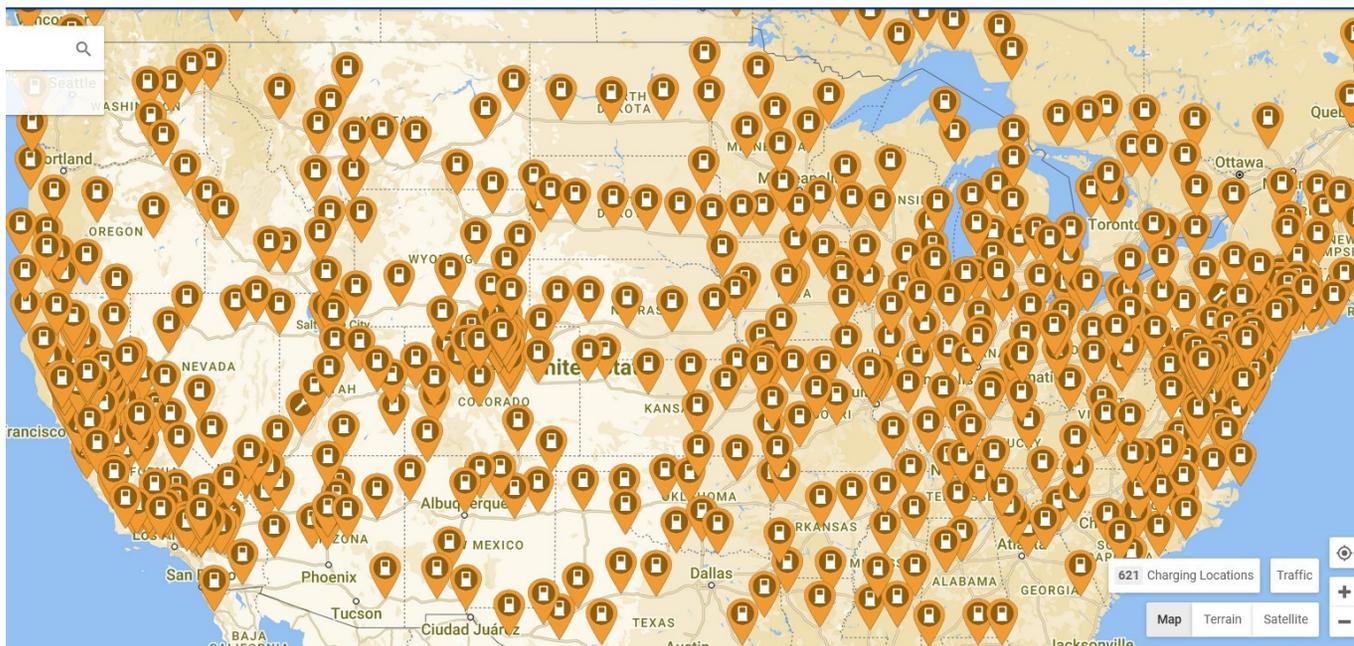
- Tesla Supercharger (250 kW max)
 - Proprietary to Tesla vehicles
 - Tesla opening stations with Tesla-to-CCS adapters in U.S. and Europe
- Combined Charging Standard (CCS) (150 or 350 kW)
 - CCS1: North America, Korea
 - CCS2: Europe
 - All non-Tesla vehicles except Nissan Leaf and Mitsubishi iMiEV
- CHAdeMO: Japan and (soon) China (63, 400, or (pending) 900 kW)
 - In U.S., Nissan Leaf and Mitsubishi iMiEV only
- GB/T: China only



DC Fast Charging Availability: Numerous and Growing Rapidly



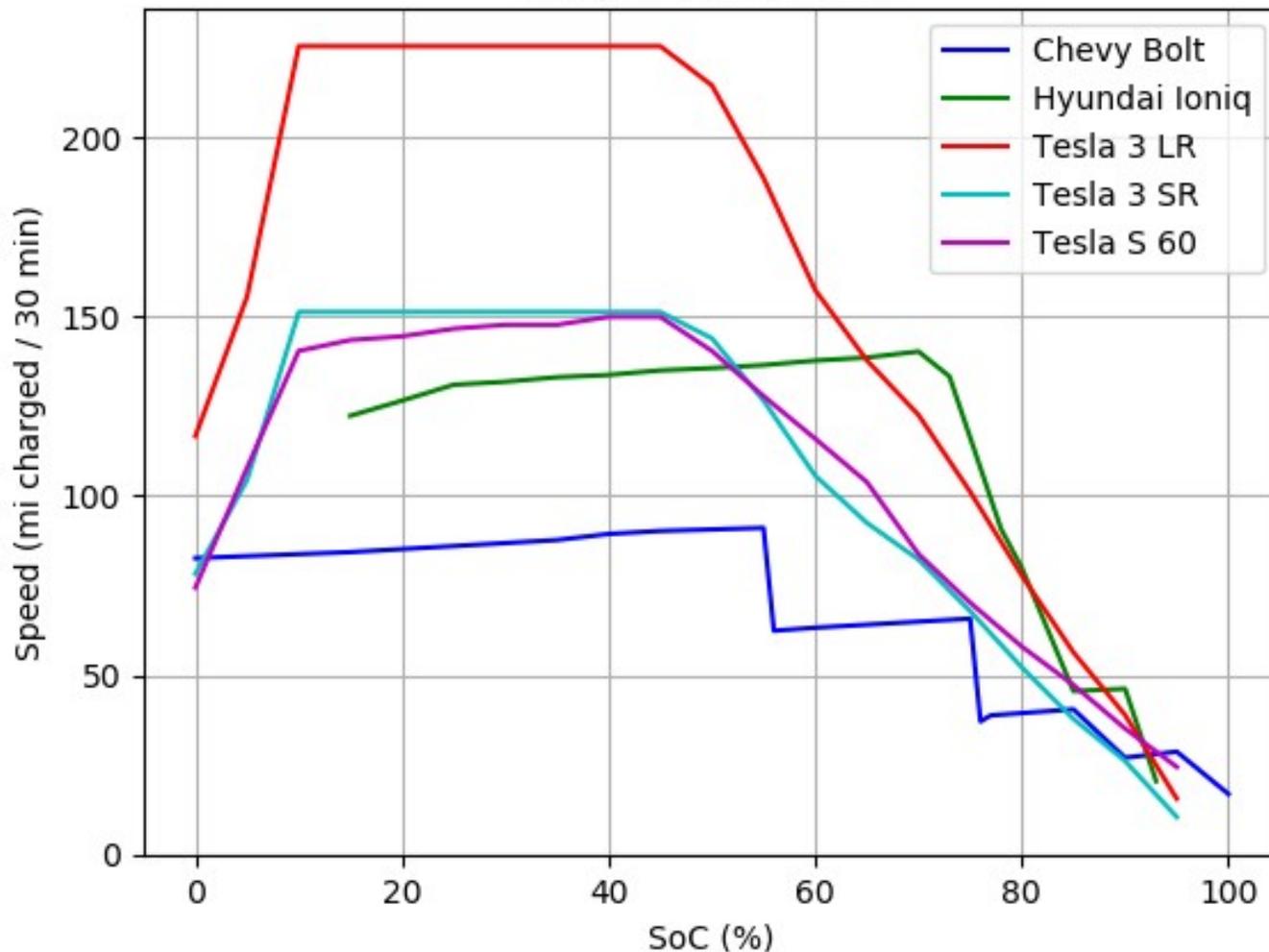
CCS1 Fast Chargers



Tesla Superchargers

DC Charging is Not Linear

Charge Speed vs SoC



As state-of-charge increases, charging speed tapers off.



Available BEVs in U.S.

(Name/MPGe) [Note: Wh/mile= 33705/MPGe]

Sedans

- BMW i4 / 108
- Chevy Bolt / 120
- Lucid Air / 131
- Mercedes EQS / 97
- Mini Cooper SE / 110
- Nissan Leaf / 111
- Polestar 2 / 107
- Porsche Taycan / 79
- Tesla Model S / 120
- Tesla Model 3 / **132**
- *Mercedes EQE (Fall 22)*

SUV/Crossovers

- Audi E-Tron / 82
- BMW iX / 86
- Chevy Bolt EUV / 115
- Ford Mustang Mach-E / 101
- Hyundai IONIQ 5 / 114
- Hyundai Kona Electric / 120
- Jaguar I-Pace / 76
- Kia EV6 / 117
- Kia Niro EV / 112
- Mazda MX 30 / 92
- Rivian R1S / 69
- Tesla Model X / 102
- Tesla Model Y / 122
- Volvo C40 Recharge / 87
- VW ID.4 / 99
- *Cadillac Lyriq (Summer 22)*
- *Mercedes EQB (Summer 22)*
- *Nissan Ariya (Fall 22)*
- *Toyota bZ4X (Summer 22)*
- *Genesis GV60 (Fall 22)*
- *Polestar 3 (Fall 22)*

Pickups

- Ford F-150 Lightning / 70
- GMC Hummer EV / **47**
- Rivian R1T / 70



Electric Vehicle Efficiency

- Comparing “fuels”
 - 1 gallon of gas = 114,000 BTUs = 33.41 kilowatt-hours (kWh) of energy
 - At \$3.00/gal, 1 kWh of gas energy costs 9 cents
 - 1 kWh of home electricity costs 11 cents
- But, unit fuel costs do not tell the whole story



Efficiency is the Difference

- Internal Combustion Vehicle: 12% to 30% efficient
 - Losses: engine heat and friction (68%-72%), drive train. (3% - 5%), pumps and parasitic losses (0% to 2%)
- BEV: 60% to 73% efficient before regenerative braking; 77% to 90%+ with regen
 - Losses: drive system (18%), battery charging (10%), accessories (3%), auxiliary systems (0-4%)



BEV vs ICE “Fuel” Costs

Cost Per Mile

	\$3/gal Gas	\$4/gal Gas	\$5/gal Gas	\$0.11/kWh Elec (Home)	\$0.28/kWh Elec (Tesla Super Charger)	\$0.43/kWh Elec (Electrify America)
25 MPG ICE	\$0.12	\$0.16	\$0.20			
40 MPG ICE	\$0.08	\$0.10	\$0.13			
70 MPGe BEV (482 Wh/mile)				\$0.05	\$0.13	\$0.21
130 MPGe BEV (259 Wh/mile)				\$0.03	\$0.07	\$0.11

Rivian R1T, Ford F-150 Lightning: 70 MPGe
 Tesla Model 3: 130 MPGe



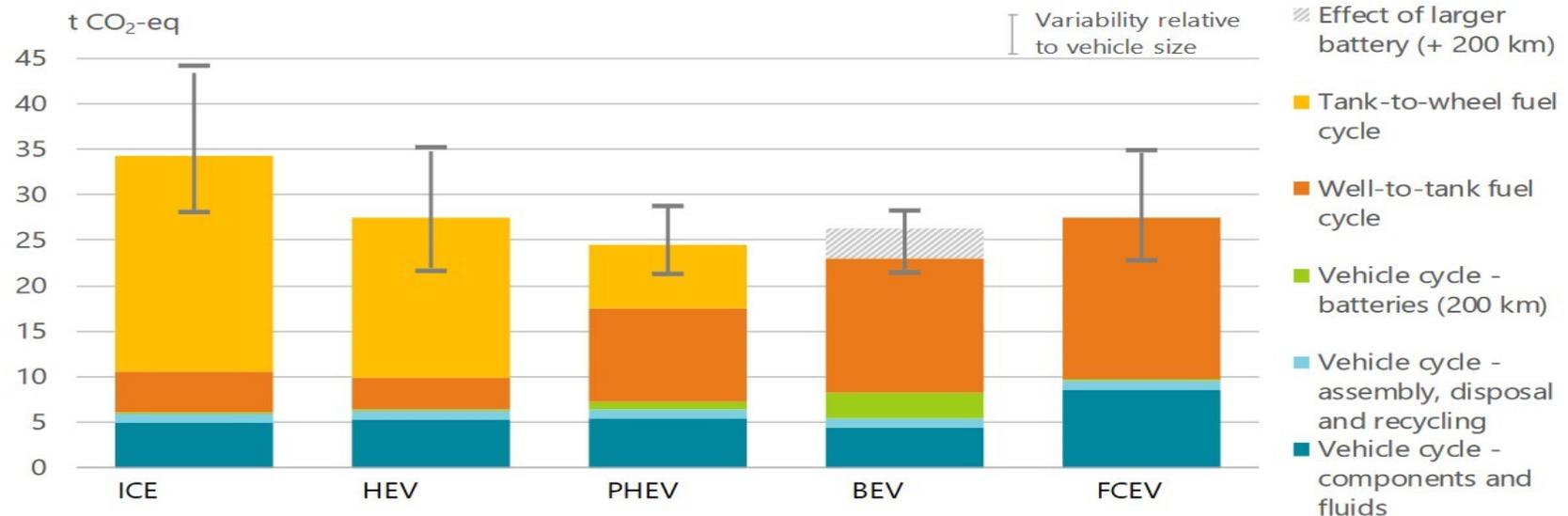
Incentives

- Time-of-Use rate structure may decrease your bill-
Check utility
- Rebates and Credits:
 - \$7500 federal tax credit (does not apply to Tesla or GM EVs)
 - \$2500 (\$2000 starting 2023) Colorado tax credit
 - Xcel: \$5500 rebate in lieu of CO tax credit; \$500 home wiring rebate for Level 2 EVSE
 - Mountain View Electric: Level 2 EVSE- 50% of equipment and installation costs up to \$500
 - Colorado Springs Utilities: no residential rebates for vehicle or EVSE

EV Myths (Part 1)

- **Myth: EVs are more harmful to the environment than fossil fuel vehicles**
- Fact: Even where electricity comes from high percentage of fossil fuels, EVs have a smaller life cycle impact
- Batteries are recyclable, gas and diesel are not.
- Efficiency of BEVs much higher than ICE vehicles
- The electric grid is getting greener

Comparative life-cycle GHG emissions of a mid-size global average car by powertrain, 2018 (tonnes per vehicle lifetime)



Source: IEA (2019), "Global EV Outlook 2019", IEA, Paris



EV Myths (Part 2)

- **Myth: An EV doesn't have enough range for my daily driving**
- Fact: Most EVs today have far greater range than the average daily use
- The average daily driving is 50 miles (US Dept of Transportation)
- Majority of households drive less than 100 miles per day.
- Typical EV range is 200 to 350 miles
- Note: Just as temperature impacts ICE vehicles, extreme cold temperatures can reduce BEV range by as much as 40%

EV Myths (Part 3)

- **Myth: A BEV is too expensive for most people**
- **Fact: The initial cost is higher, but the total cost of ownership is lower**

- Gas Car: Lower initial cost
- BEV: Lower fuel and maintenance costs. Lower depreciation



Source: Consumer Reports, "Electric Vehicle Ownership Costs: Today's Electric Vehicles Offer Big Savings for Consumers" Chris Harto, October 2020

Figure 4.4. First Owner and Lifetime Savings From EVs vs. ICE That Matches Acceleration⁶¹



EV Myths (Part 4)

- **Myth: Expensive batteries will die quickly and end up in landfills**
- Fact: Modern battery management systems vastly extend life of batteries. Batteries are recyclable
- Tesla claims battery life of 300,000 to 500,000 miles.
- Life Cycle of a Battery Pack: vehicle → replace faulty cells and use for building or utility energy storage → recycle
- Battery recycling is a \$ billion business: Redwood Materials, Li-Cycle Corp., Volkswagen, Renault, ACCUREC, Battery Solutions, SITRASA



EV Myths (Part 5)

- **Claim: Cobalt mining for Li-ion batteries creates human rights abuses.**
- Fact: True statement
- 50% of known Co reserves in Congo
 - Child labor; harsh conditions; unsafe mines
 - Toxic pollution of local communities
- EV battery producers' response
 - Move to LFP chemistry to eliminate Co
 - Heavier reliance on recycled Co
 - Greater scrutiny of Co source



Typical BEV Owner Experience- Local Day to Day

- To preserve battery, charge between 30% and 80%
- Plug in at night every 3 to 4 days, charge for 3 to 5 hours (Level 2). Or, plug in every night in standard Level 1 wall socket.
- **BUT**, charging at home not an option for many apartment or condo residents



Typical BEV Owner Experience- Long Trips

- Always have a “Plan B”- find Level 2 chargers on your route using the PlugShare app
- BUT: combine charging stops with meals or overnight stops
- First time owner- plan on arriving at next charging station with 15% to 20% charge remaining. When more comfortable, drop to 10%
- Add buffer for cold temperatures or strong headwind
- Example: Colorado to Philadelphia, 3.7 hours of charging
- When charging, look ahead 1 to 2 legs for road closures, detours, or charging station outage
- Smoothness, low center of gravity, and minimal noise makes cross-country trips much more relaxing in a BEV



Pros and Cons After 10 Years of BEV Driving

- Pros

- Breathtaking acceleration!
- “Refuel” at home
- Almost zero maintenance
- Cost savings
- Smooth and quiet

- Cons

- Cross-country trips require some advanced planning
- Added time for long trips
- Heavy vehicles- more frequent tire replacement

Questions?

