



STRIDE Collaborative: Virtual Annual Partners Meeting State of Charge: The Latest on Battery Technology

SEPTEMBER 15, 2020 – OCTOBER 1, 2020



Reuse and Recycling of EV Batteries

Hanjiro Ambrose, PhD

Union of
**Concerned
Scientists**

UC DAVIS
UNIVERSITY OF CALIFORNIA

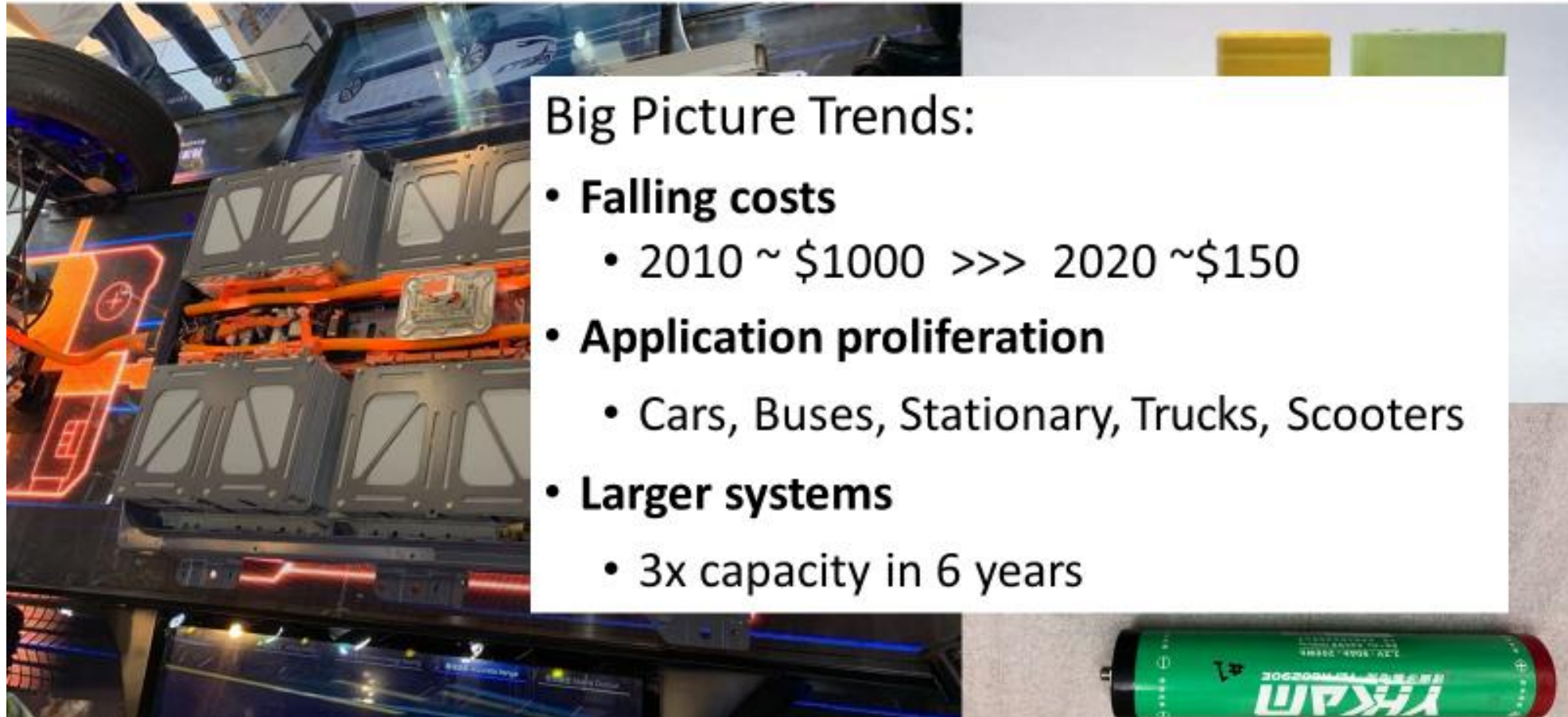
August 18, 2020

Short-term vs Long-term Constraints

- **Potential for >>1 billion 40 kWh batteries given current mineral reserves and LIB electrode technologies¹**
- **Lithium and cobalt are the closest lithospheric constraints (depending on technology development!)**
- **Currently, there is a global ramp-up in production of battery materials**
- **But, mineral reserves are geographically concentrated which could create supply risks**

¹Wadia, C., Albertus, P., & Srinivasan, V.(2011). Resource constraints on the battery energy storage potential for grid and transportation applications. *Journal of Power Sources*, 196, 1593-1598. doi:10.1016/j.jpowsour.2010.08.056

Lithium Ion Batteries



Big Picture Trends:

- **Falling costs**
 - 2010 ~ \$1000 >>> 2020 ~\$150
- **Application proliferation**
 - Cars, Buses, Stationary, Trucks, Scooters
- **Larger systems**
 - 3x capacity in 6 years

Critical Energy Minerals

- Current EV Batteries rely on a short list of key materials
- 7 of 35 elements on US Department of Critical Minerals List

Battery Critical Energy Materials	Lithium	Graphite	Aluminum	Manganese	Cobalt	Nickel	Copper
	Li	C	Al	Mn	Co	Ni	Cu
	3	6	13	25	27	28	29



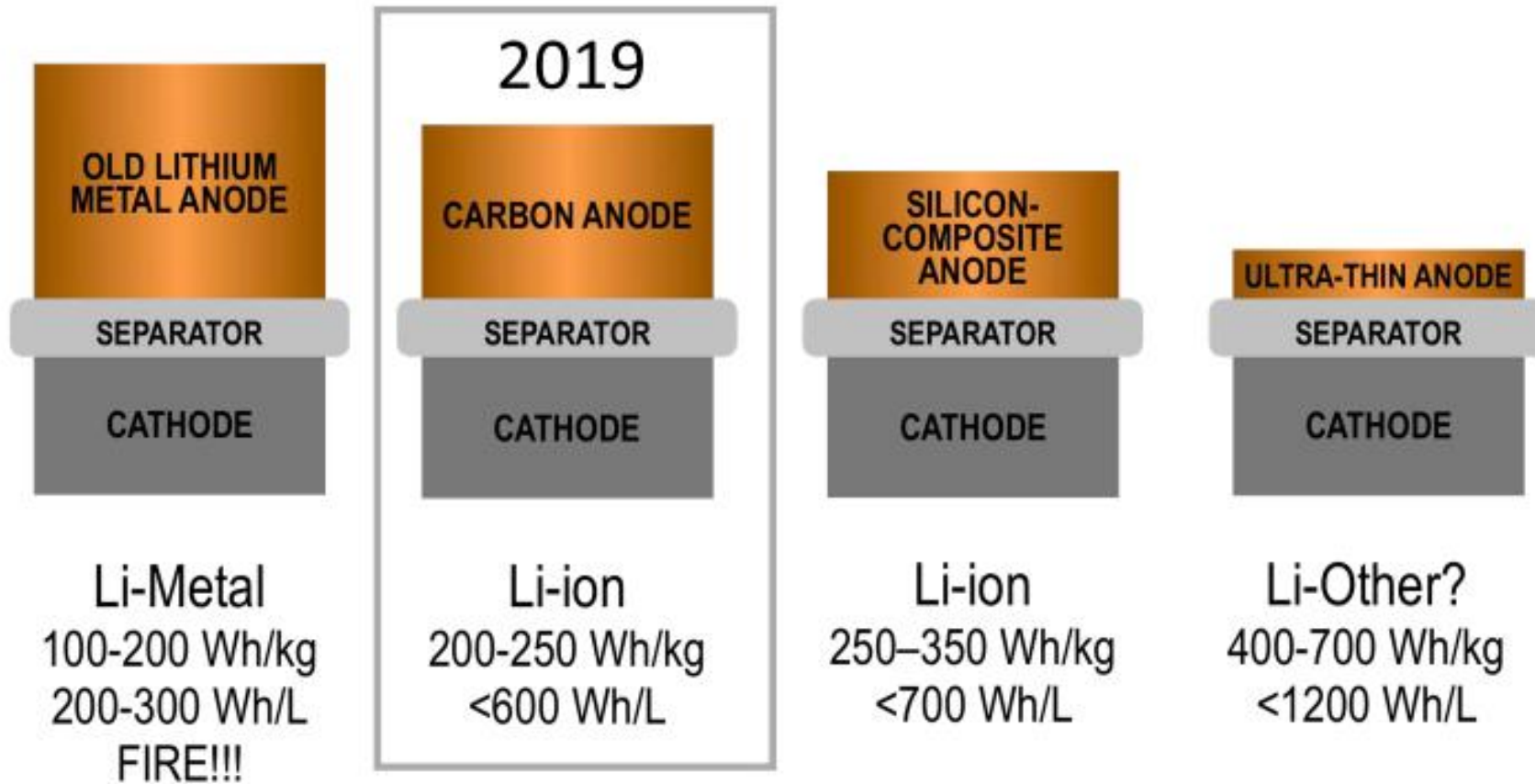
Rare Earth Elements	Scandium	Yttrium	Lanthanum	Cerium	Praseodymium	Niobium	Samarium	Europium	Europium	Terbium	Dysprosium	Ytterbium	Lutetium
	Sc	Y	La	Ce	Pr	Nd	Sm	Eu	Eu	Tb	Dy	Yb	Lu
	21	39	57	58	59	60	62	63	64	65	66	70	71



Platinum Group and Precious Metals	Ruthenium	Rhodium	Palladium	Silver	Osmium	Iridium	Platinum	Gold
	Ru	Rh	Pd	Ag	Os	Ir	Pt	Au
	44	45	46	47	76	77	78	79



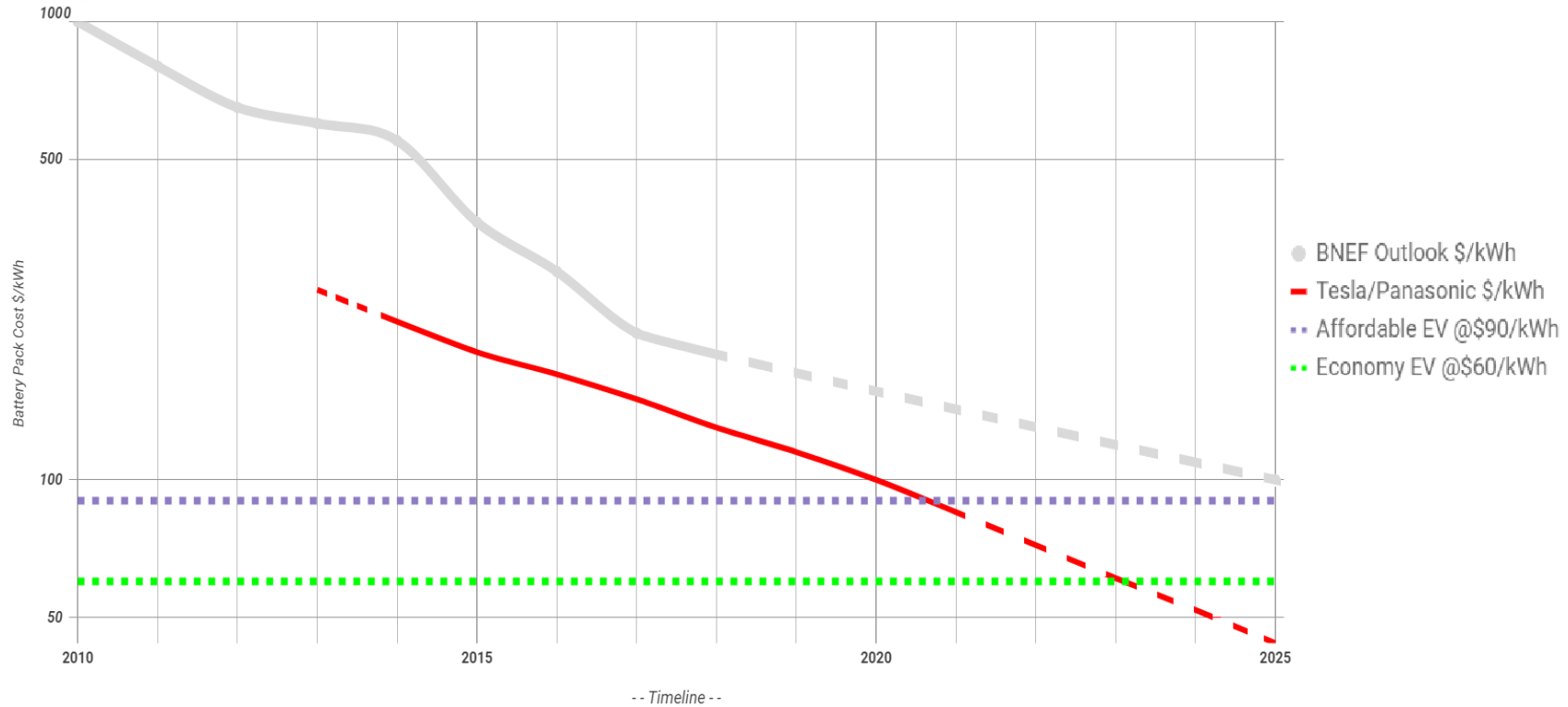
Battery Design Continues to Evolve



Battery Costs Continue to Drop

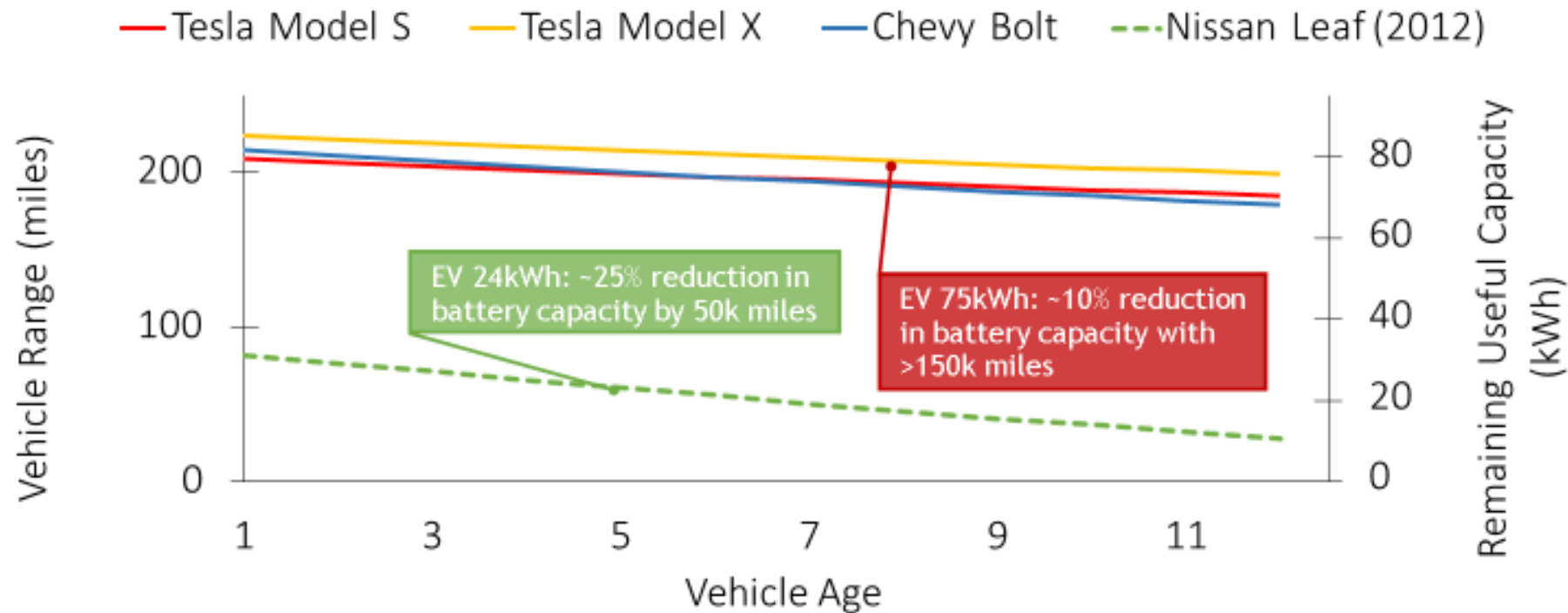
Trend Data for Battery Pack \$/kWh - Tesla vs. Market Average (BNEF research)

{Cost Axis is Log Scale, dashed lines are estimated data}

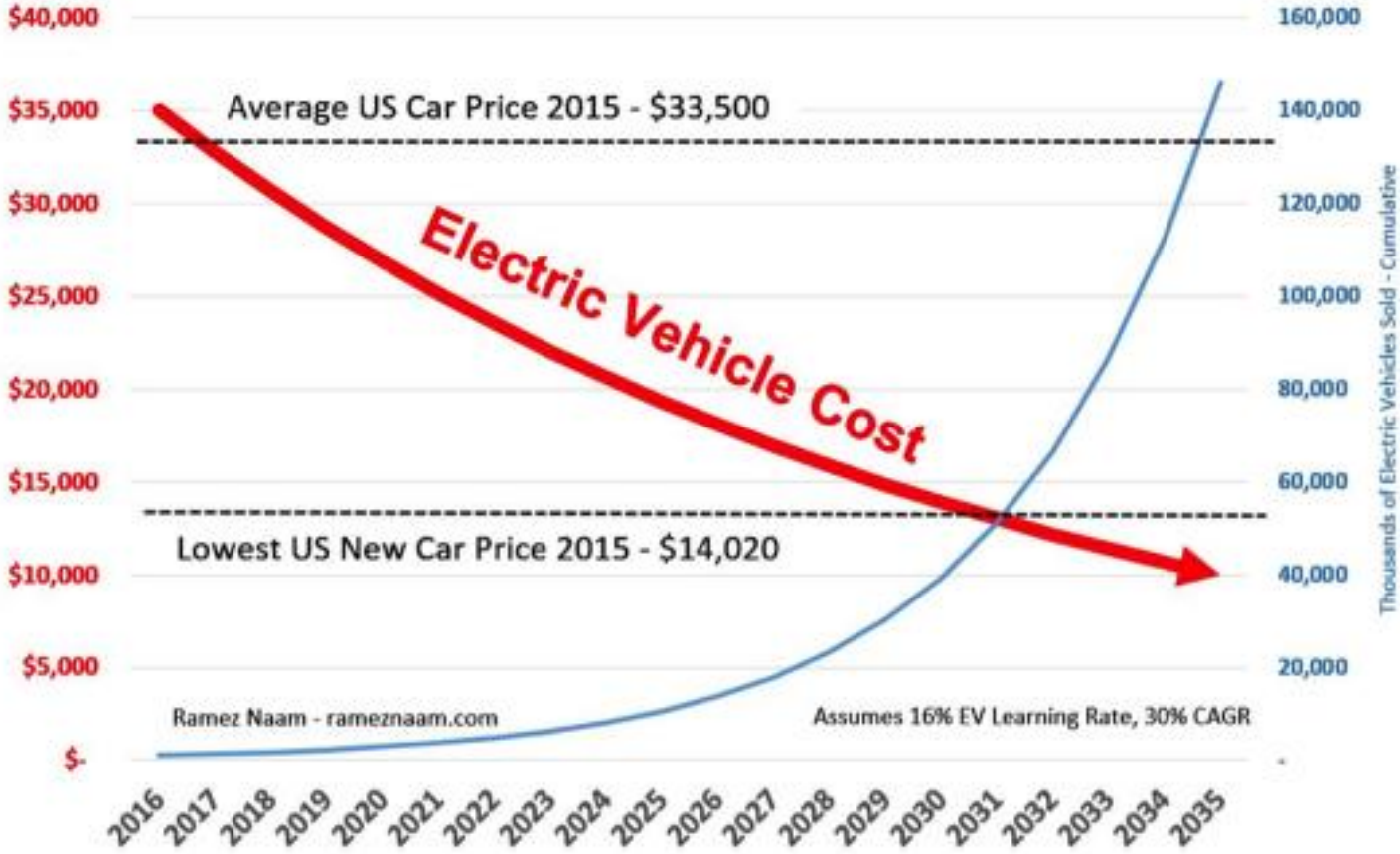


Battery Capacity and Lifetime

Increasing battery sizes + improved lifetimes = more 2nd life potential

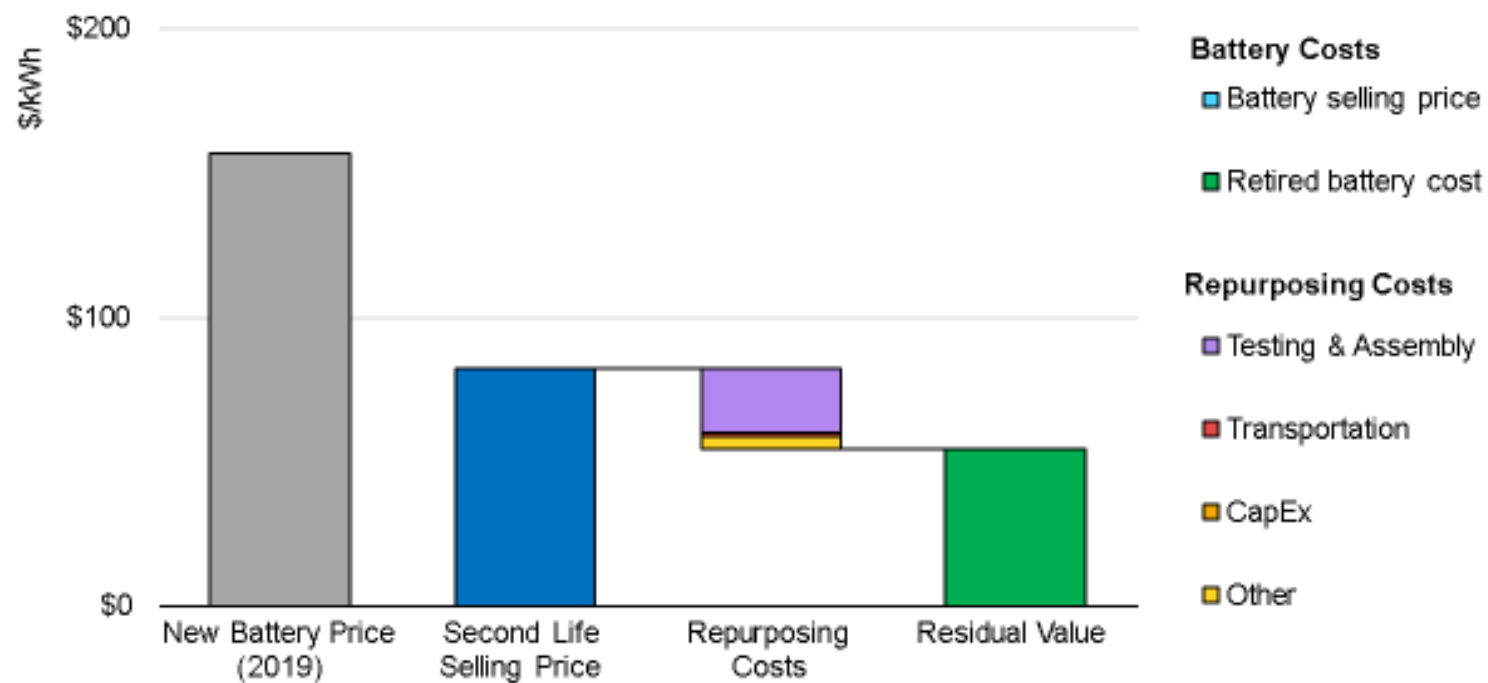


Cost of 200-mile range EV



Second-life Batteries and Residual Value

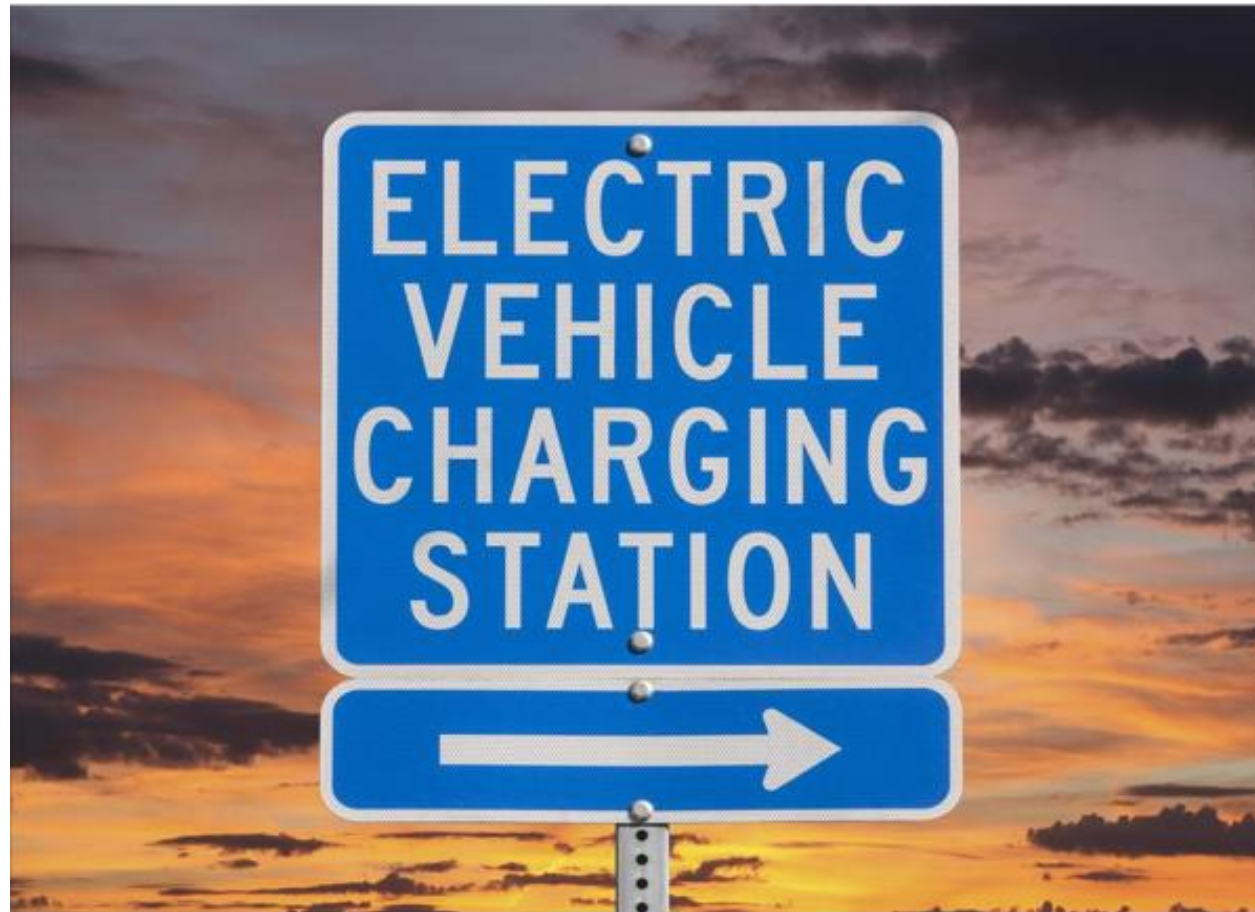
Second-life could help to lower the costs of EVs



Generated using the NREL Battery Second-Use Repurposing Cost Calculator (<https://www.nrel.gov/transportation/b2u-calculator.html>), assumes 1 GWh/year volume, 60kWh pack.

<https://blog.ucsusa.org/hanjiro-ambrose/the-second-life-of-used-ev-batteries>

Charging – Standards and Issues



Electric Vehicle Charging

The infographic illustrates three levels of electric vehicle charging. Level 1 uses 110V and provides approximately 4 miles of range per hour, utilizing a J1772 plug. Level 2 uses 208V and provides approximately 24 miles of range per hour, also using a J1772 plug. Level 3 uses 480V and allows for a full charge in 5 to 60 minutes, supporting both Combo (CCS) and CHAdeMO plug types. The background features a red car being charged by a person at a charging station, with a city skyline in the distance. The Georgia Power logo is located in the bottom right corner.

Level	Voltage	Range/Charge Time	Plug Type
Level 1	110V	~4 miles per hour	J1772 plug
Level 2	208V	~24 miles per hour	J1772 plug
Level 3	480V	Fully charge in 5-60min	Combo (CCS) plug, CHAdeMO plug

Georgia Power

EVSE Categories

Level 1: 120 V AC @15 amps

Current home charging standard (full charge 8-16 hours)

Generally Included

Level 2: 208/240 V AC @ 20 to 100 amps

Current home, workplace and public charging standard (full charge 4-8 hours)

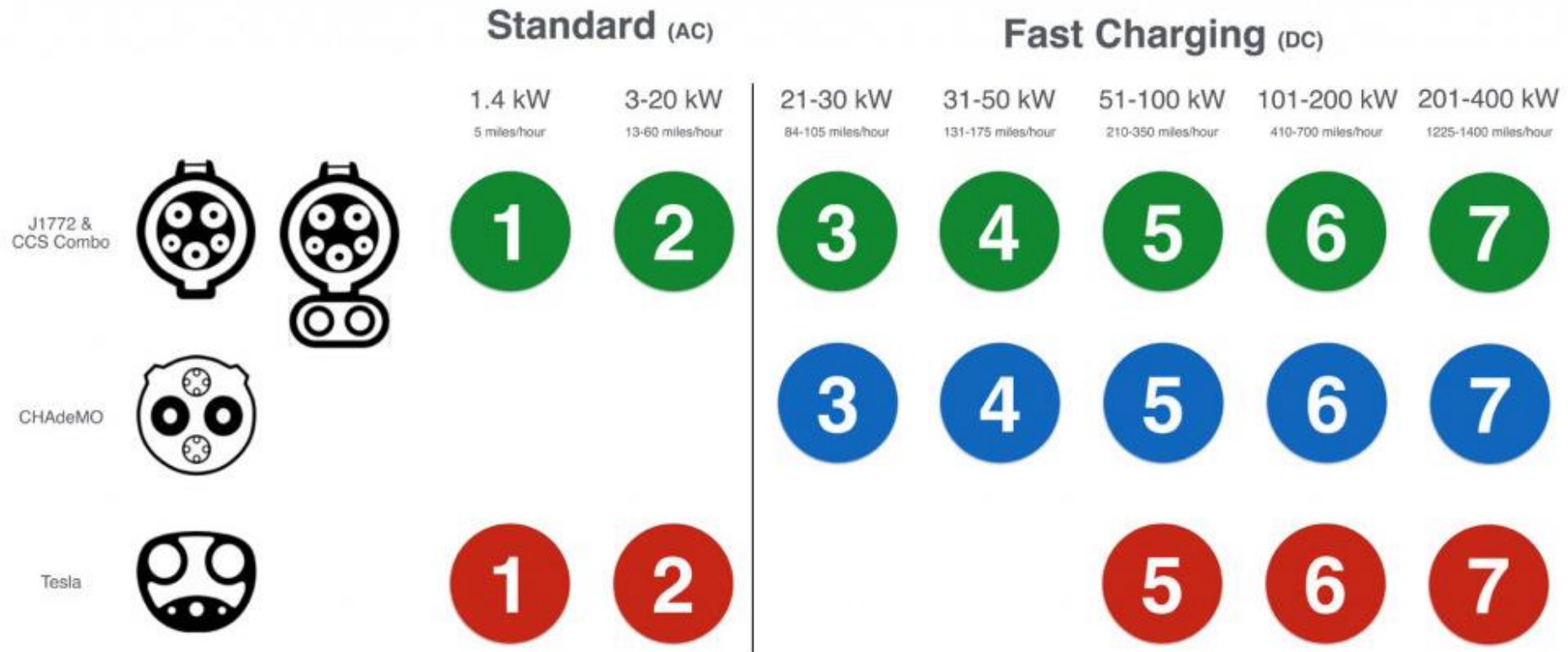
Price \$500 to \$8,000

Level 3: 480 V DC @ 50 to 450 kW

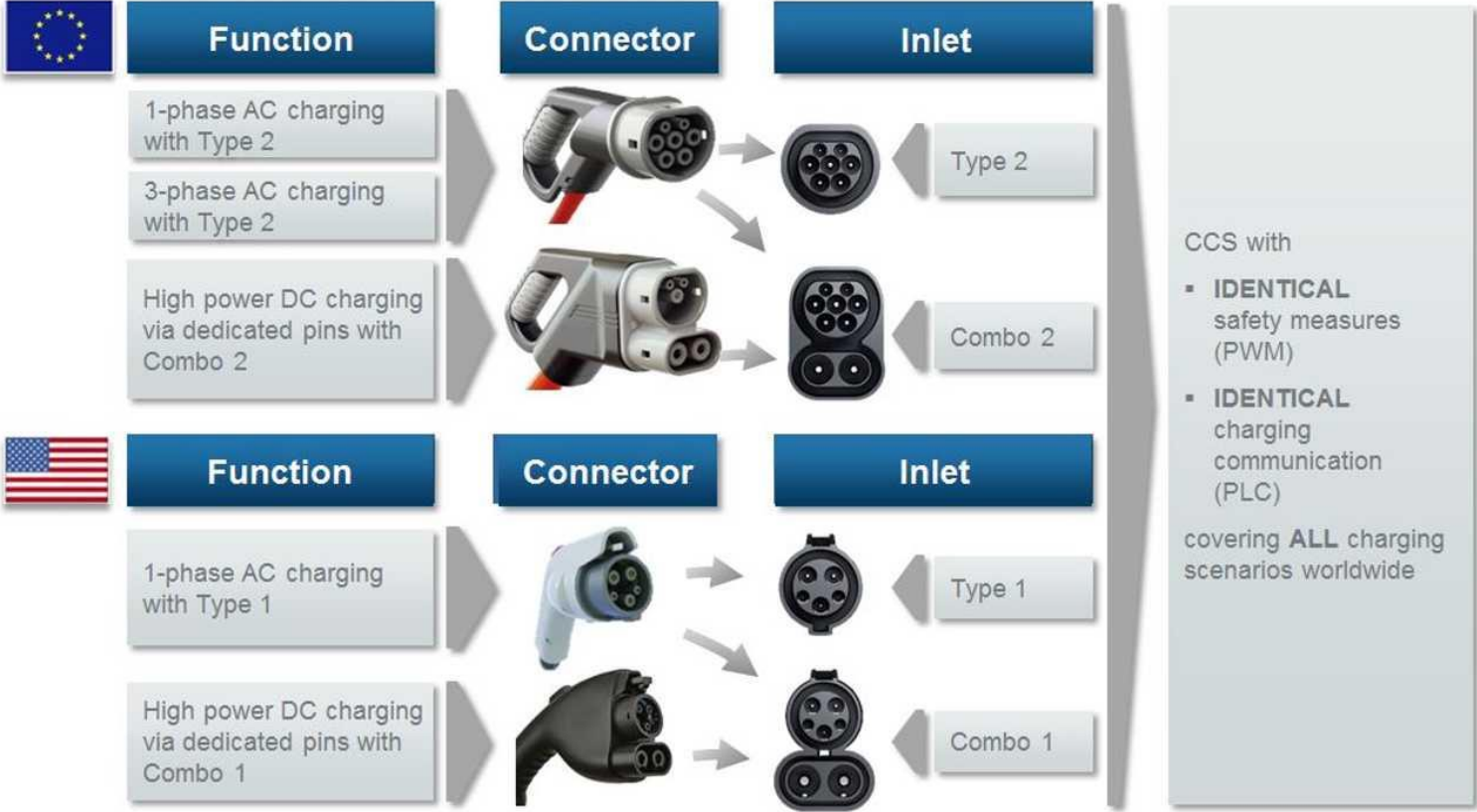
Public quick charge station (80% charge in <30 minutes)

Price +\$30,000

Confusing Charging Standards



CCS Worldwide Standard



ClipperCreek, Inc.

Charging Products and Solutions

Presented By: Don Francis – SE Regional Representative

(C) 404-906-0656

(E) don@clippercreek.net



CLIPPERCREEK,INC