



EV Charging Stations



Prepared by Tom Lawton, TESCO
The Eastern Specialty Company

*For Southeastern Distribution Apparatus School
Module 200
Tuesday, November 9, 2021, 3-4 p.m.*

EVSE

Electric Vehicle Service Equipment What is it all about?



INTRODUCTION

- Types of EVSE's
- Market growth
- Regulatory environment
- Type approval & testing

AC EVSE STANDARDS

- **J1772 AC Level 2**

- Home and Commercial Installation
- 240 Volts at up to 80 Amps (**30A** most common)
 - ♦ Home 30A, Commercial 30A, 50A, 75A
- Maximum Power Delivery (19.2 kW)
 - ♦ Mostly vehicle limited to 7.2kW
- Typical time to charge
 - ♦ Pluggable Hybrid (0.5 – 1.5 hours, 0% to 90%)
 - ♦ EV 80 Mile Range (1.5 – 4 hours, 20% to 90%)
 - ♦ EV200 Mile Range (3.2 – 10 hours, 20% to 90%)
- 21 miles per hour of charge @ 30A
- If you drive <160mi/day you can recharge overnight.

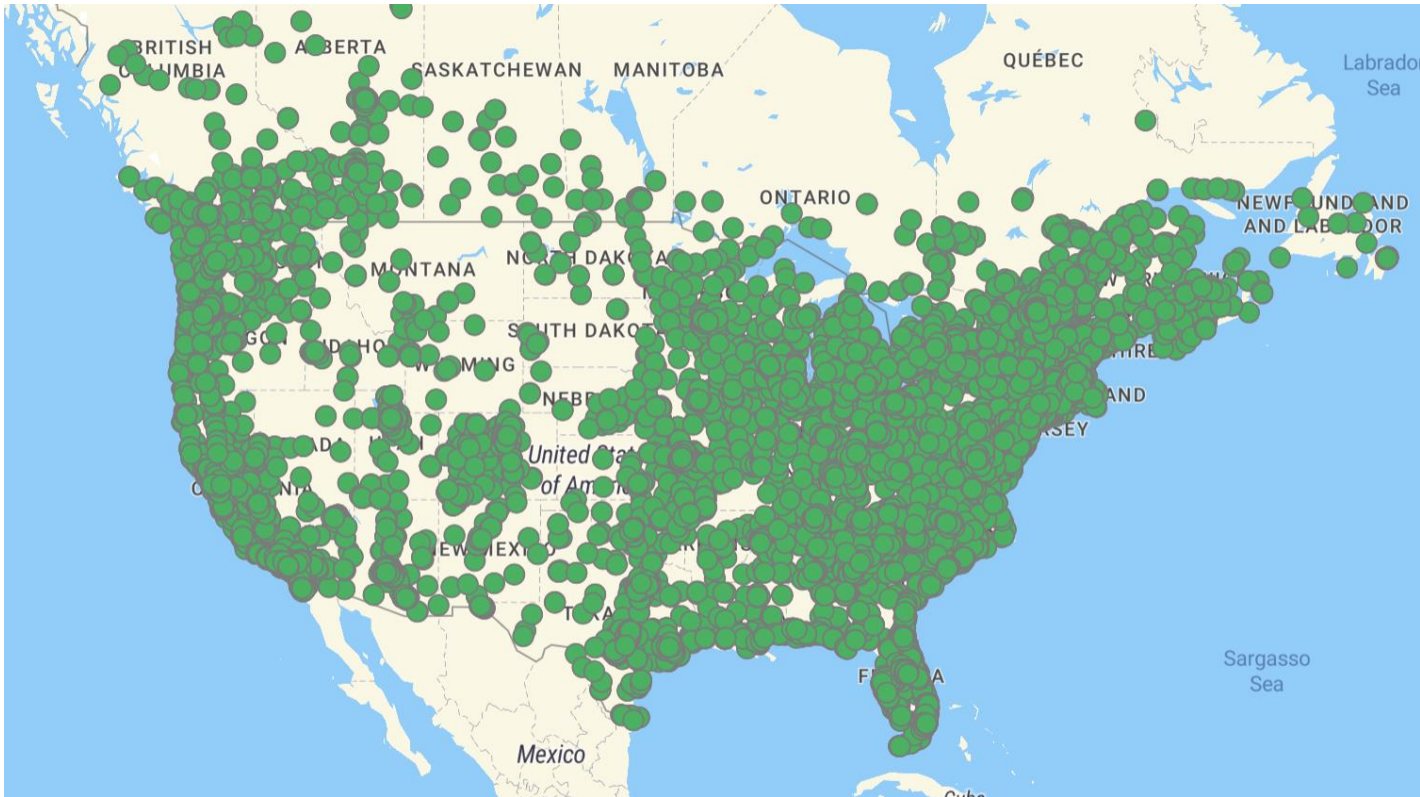


AC EVSE STANDARDS

- **J1772 AC Level 2**
 - Over 85% of commercial EVSEs are AC Level 2
 - All current EV/PEV in US can use this type though some (Tesla) need adapters
 - Stations cost \$5K to \$8K per port including installation



J1772 AC Level 2 Public Stations



2019

Sites:
19,216

2020

Sites:
30,145

4/2021

Sites:
43,132

Number of sites, not ports. A site typically has many ports.

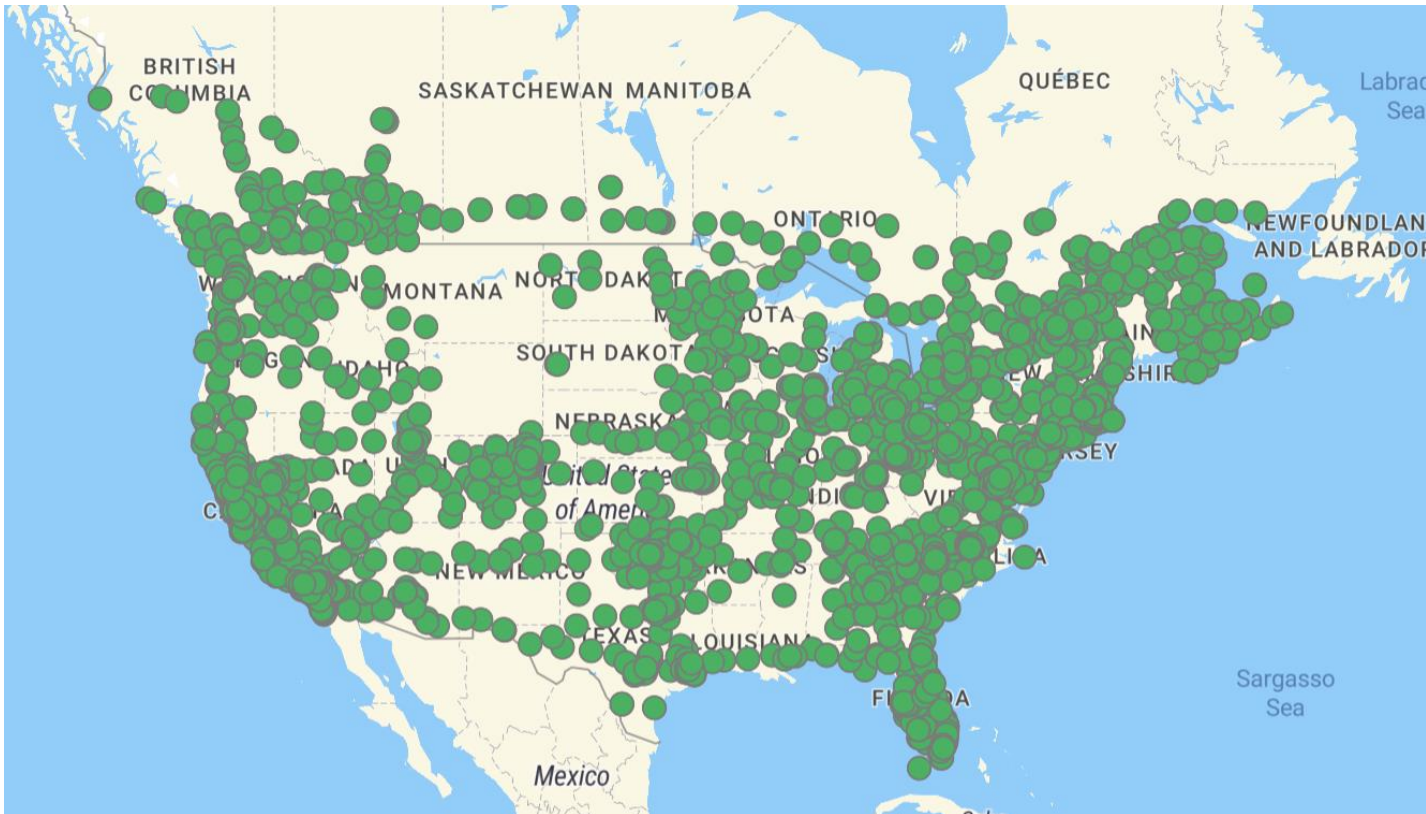
DC EVSE STANDARDS

- **Standards evolving rapidly**
 - Combined Charging System
 - ♦ CCS1 SAE J1772 North America
 - ♦ CCS2 Europe
 - CHadeMO (Only Nissan and Mitsubishi)
 - Tesla V1
 - Tesla V2/V3 (New in 2019)
 - Chaoji (China, Japan, India – successor to CHadeMO and GB/T)
 - >100kW is considered “high end” (400V Systems)
 - First US **350kW** units installed Dec 10, 2018 (800V)

DC EVSE STANDARDS

- **Deployment is growing rapidly in US**
 - Biden proposes adding **400K** stations by 2025
- **But slowly compared to Europe, China and Japan**
- **Total PUBLIC chargers installed**
 - AC Level 1 1180
 - AC Level 2 43,132 locations
 - DC Rapid 6,028 locations
 - ♦ Tesla 1,126 locations
 - ♦ CHadeMO 4,390 locations
 - ♦ J1772 4,333 locations

J1772 DC Public Stations



Number of sites, not ports. A site typically has many ports.



2019

Sites:
2,042

2020

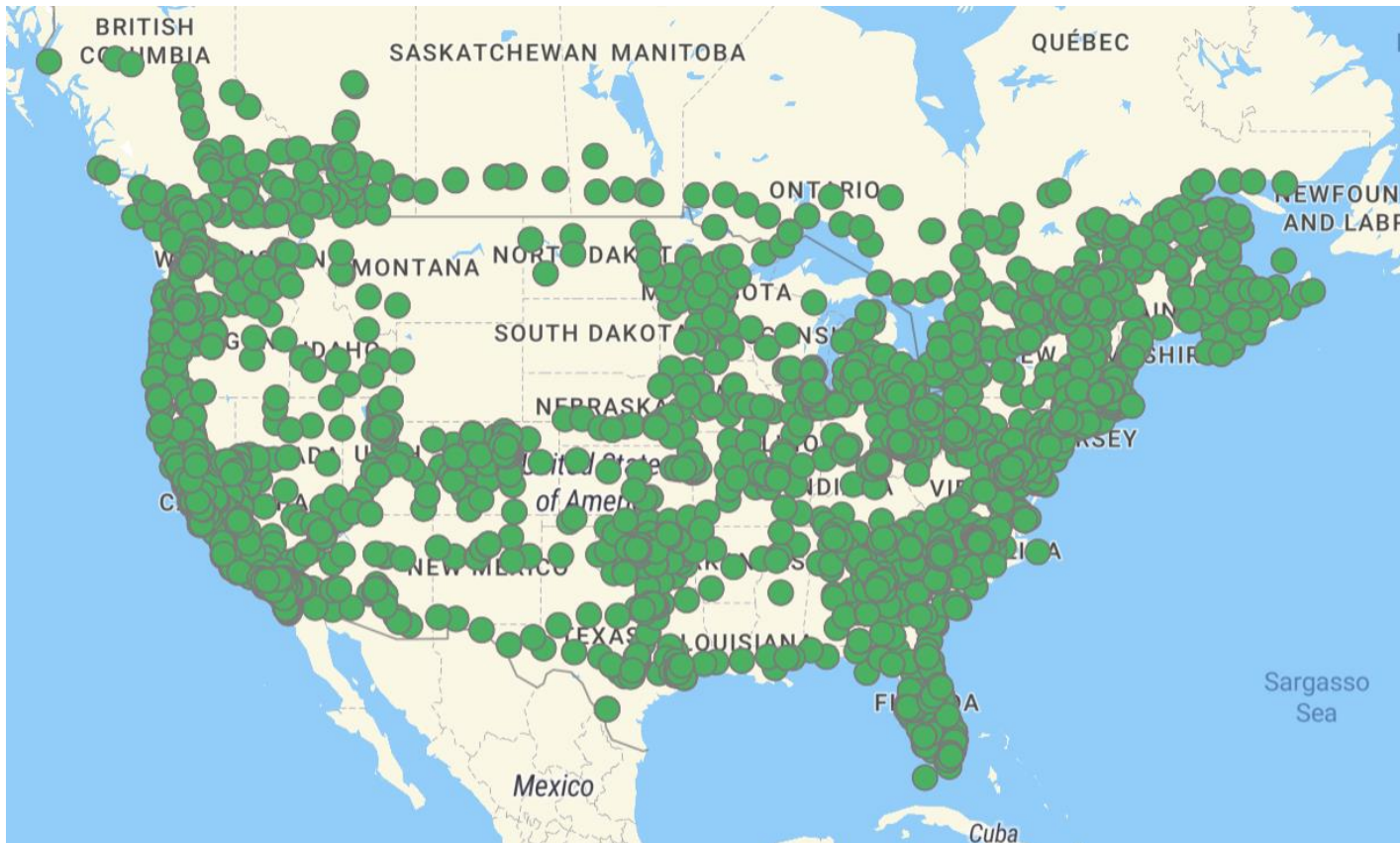
Sites:
3,489

4/2021

Sites:
4,333



CHademo DC Public Stations



2019

Sites:
2,348

2020

Sites:
3,640

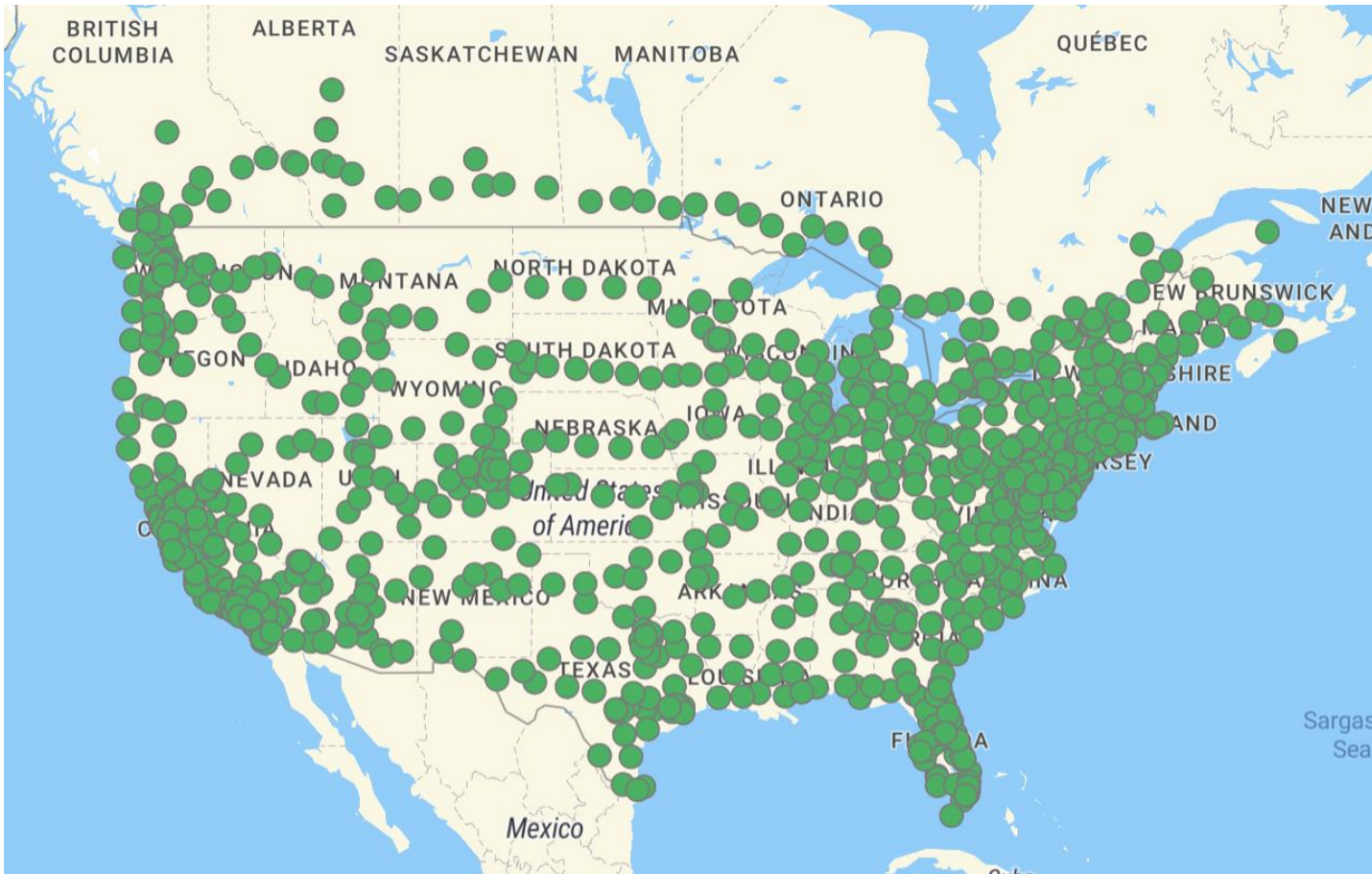
4/2021

Sites:
4,390

Number of sites, not ports. A site typically has many ports.



Tesla DC Public Stations



2019
Sites:
644

2020
Sites:
1,039

4/2020
Sites:
1,126

Number of sites, not ports. A site typically has many ports.

DC EVSE STANDARDS

- **Market Direction**
 - DC Generation 1 (less than 150kW)
 - ♦ Nominal 400-500 VDC
 - ♦ Up to 300 A max
 - ♦ All current EV's except one
 - DC Generation 2 (up to 400 kW)
 - ♦ Nominal 800 VDC (1000VDC max)
 - ♦ Up to 350A typ, 500 A max
 - ♦ Multiple vehicles announced for 2022
 - ♦ Expected to be the norm by 2025



THE EVSE MARKET

- Charge Times (hours)

Battery kWhr	AC Level 1 & 2			DC Fast Charge			
	1.92	7.2	19.2	50	120	200	400
10	3.65	0.97	0.36	0.14	0.06	0.04	0.02
20	7.29	1.94	0.73	0.28	0.12	0.07	0.04
40	14.58	3.89	1.46	0.56	0.23	0.14	0.07
60	21.88	5.83	2.19	0.84	0.35	0.21	0.11
80	29.17	7.78	2.92	1.12	0.47	0.28	0.14
90	32.81	8.75	3.28	1.26	0.53	0.32	0.16
100	36.46	9.72	3.65	1.40	0.58	0.35	0.18
110	40.10	10.69	4.01	1.54	0.64	0.39	0.19
120	43.75	11.67	4.38	1.68	0.70	0.42	0.21
Estimate based on 20% to 90% charge							
PHEV	EV80	EV100+			Happy Spot		



THE EVSE MARKET

- Fill the Tank Costs

COST TO FILLUP						
Price per kWhr	Energy (kWhr)					
	10	20	40	80	100	120
0.10	1.00	2.00	4.00	8.00	10.00	12.00
0.15	1.50	3.00	6.00	12.00	15.00	18.00
0.20	2.00	4.00	8.00	16.00	20.00	24.00
0.30	3.00	6.00	12.00	24.00	30.00	36.00
0.40	4.00	8.00	16.00	32.00	40.00	48.00
0.50	5.00	10.00	20.00	40.00	50.00	60.00
Charge at Home			Commercial Charging Station			

Evgo \$0.31/kWh subscriber price (~\$0.10/mile)

Compare to gas at \$3.00/gal in a 30mi/gal vehicle



The EV Market

Manufacturers have announced over 100 EV models to be introduced by 2024.



The EV Market



GM to go all-electric by 2035, phase out gas and diesel engines

The Start Button to an All-Electric Future has Been Pushed

Introducing the revolutionary Ultium Platform. Engineered for range, power and flexibility to charge fast, run long and fit every type of vehicle. An innovation that's powering General Motors' plan to offer 30 new EVs globally by 2025. Which means the day will soon come when everybody can drive an EV. Welcome to Generation E. Join us and together we'll emit optimism.

30 by 2025



The EV Market



Ford to go all electric in Europe by 2030

Ford announced during its fourth-quarter earnings report that it will invest \$22 billion in electric vehicles and \$7 billion in autonomous vehicles through 2025.

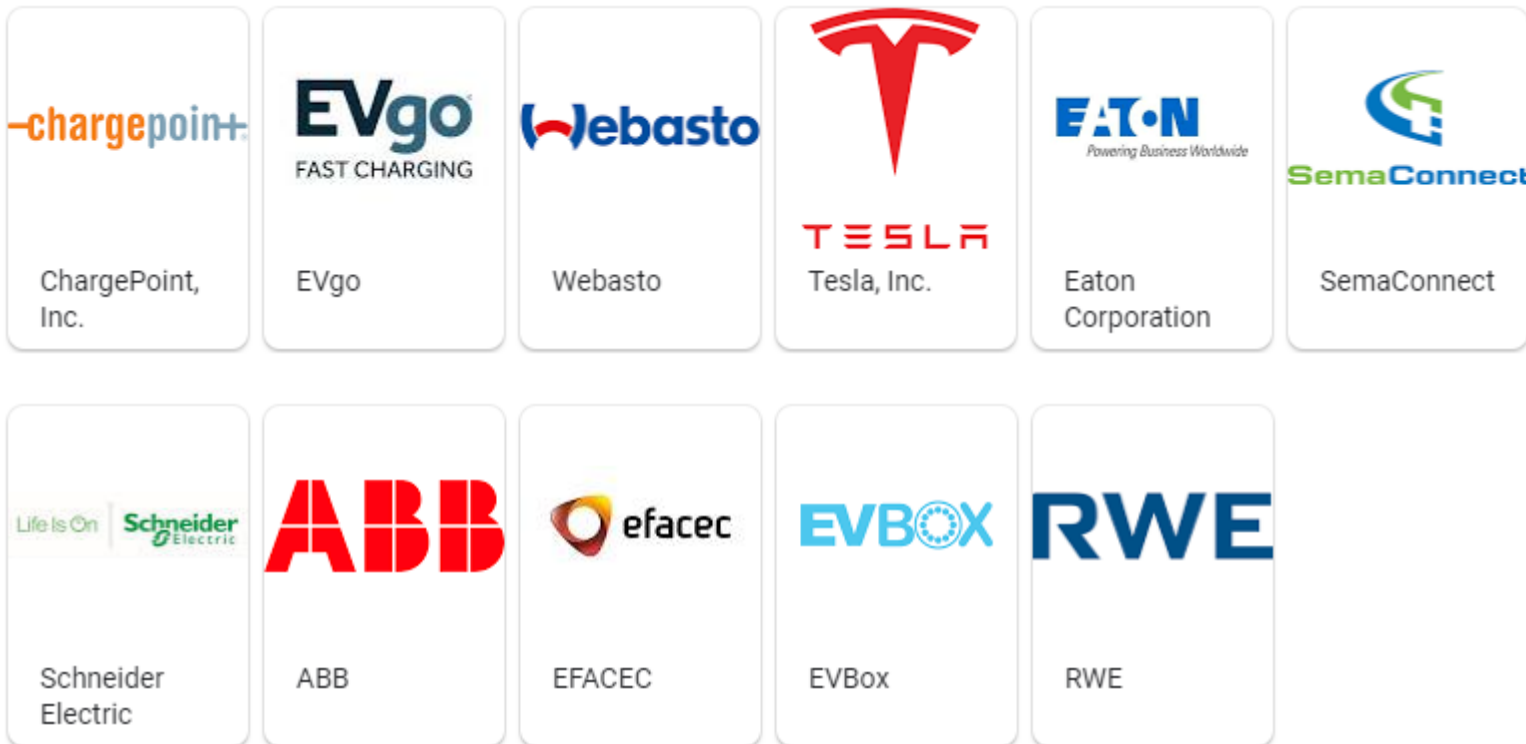


The EV Market

- **Hyundai Unveils EV Platform, Will Have 23 Global Electric Vehicles by 2025**
- **Toyota Details Six New EV Models Launching for 2020–2025**
- **BMW raises target for EV sales, plans new electric-focused platform**

EVSE MANUFACTURERS

- Major charging system manufacturers

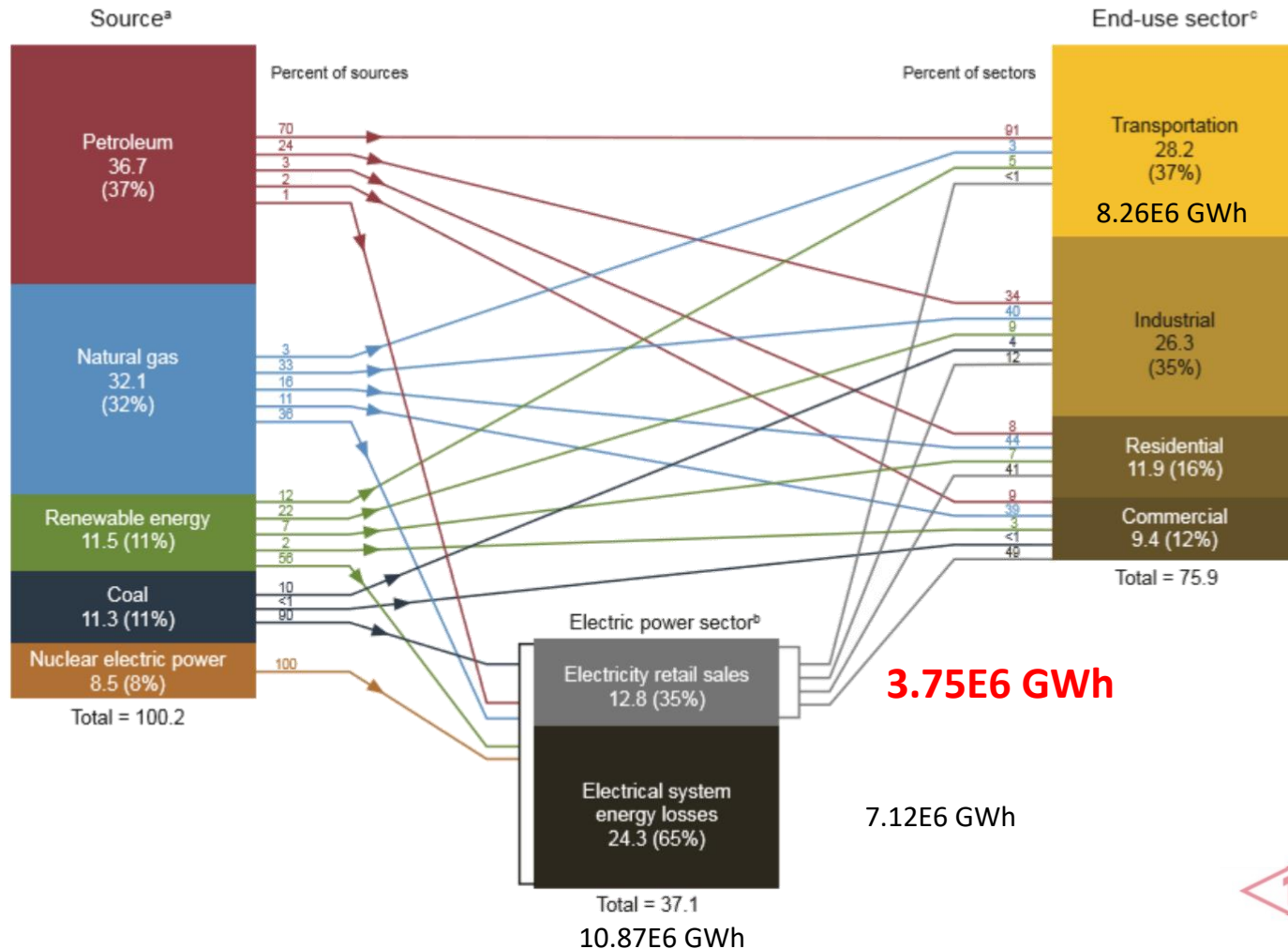


CHARGING NETWORKS

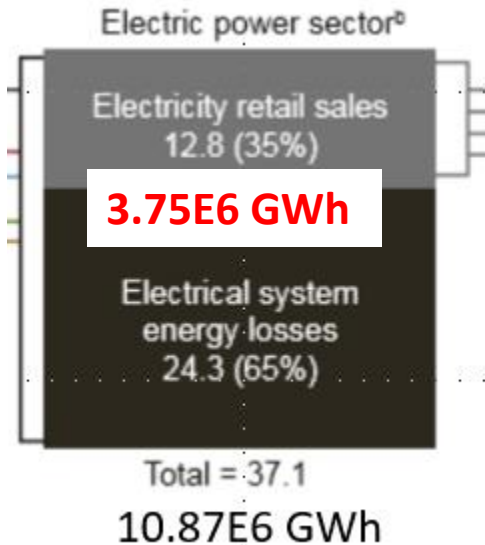
- **Major charging system networks**
 - **Blink**
 - **Chargepoint**
 - **Electrify America**
 - **EvGo**
 - **Tesla**
 - **Volta**

US TOTAL ENERGY CONSUMPTION

U.S. energy consumption by source and sector, 2019
(Quadrillion Btu)



US ELECTRIC ENERGY CONSUMPTION



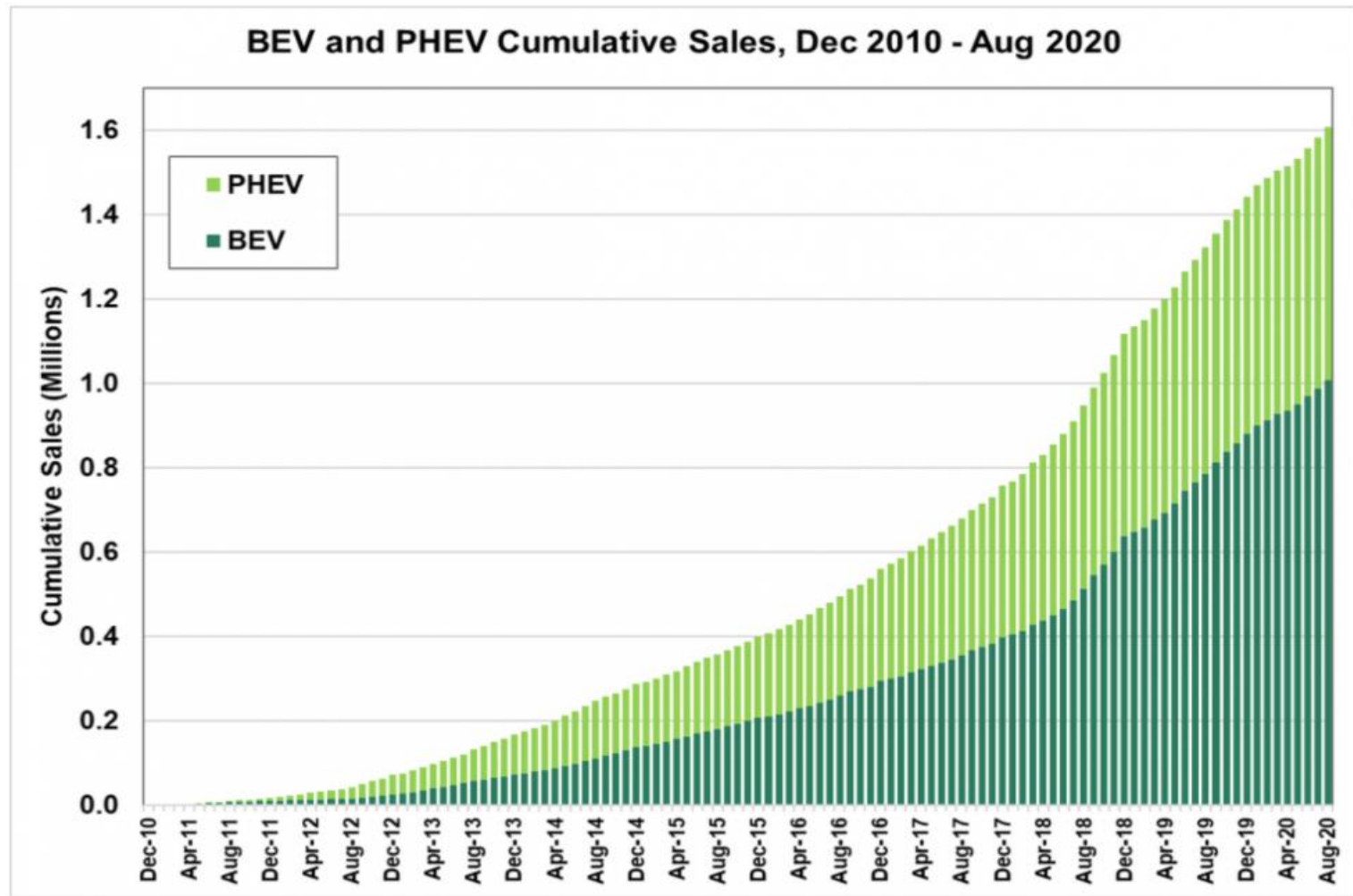
Americans drove 3.23 trillion miles in 2019. If this was all done in electric vehicles getting 3 mi/kWh, then we would need 1.1E6 GWh of energy just to charge cars.

30% of total US capacity just to charge Cars!!!

Average household uses 10.6 MWh/yr.
Charging their cars would take 8.8 MWh/yr.

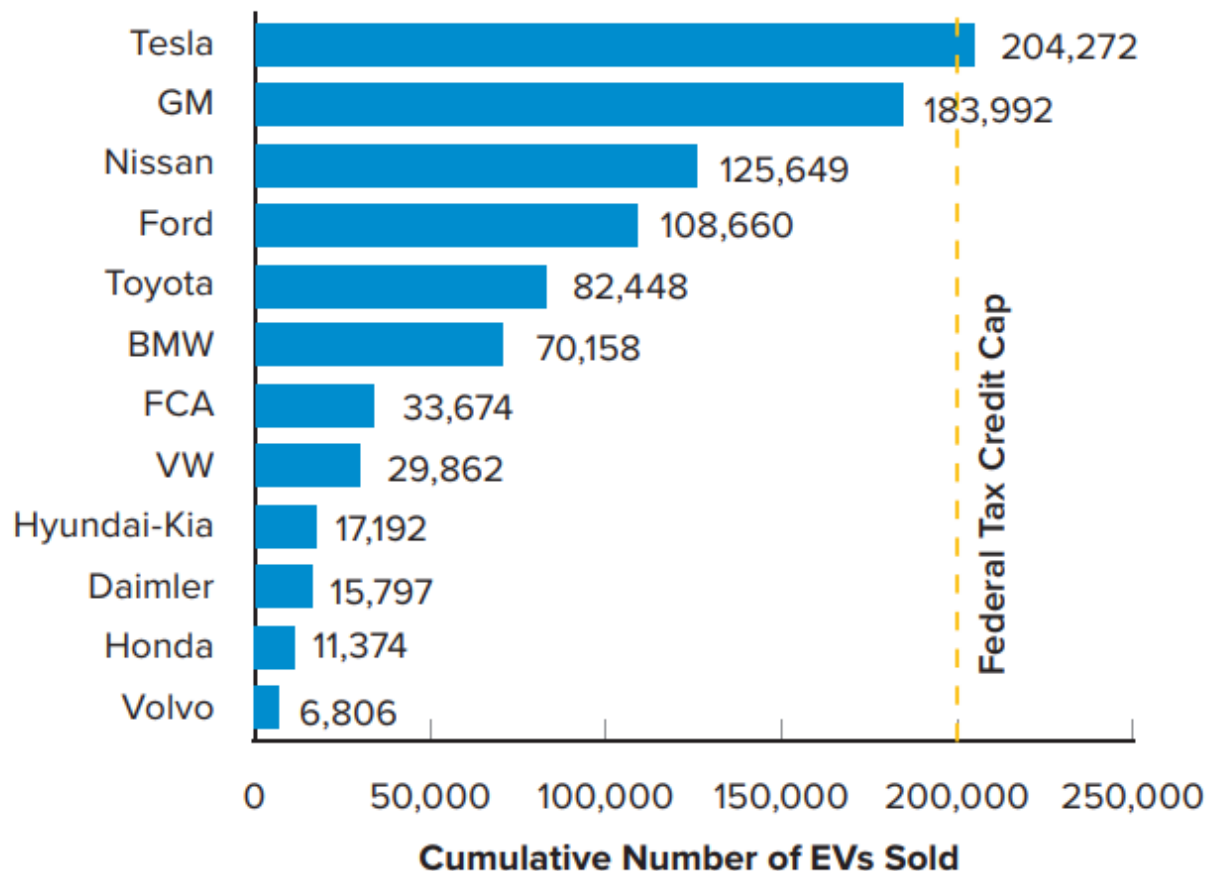


The US EV Market



The US EV Market

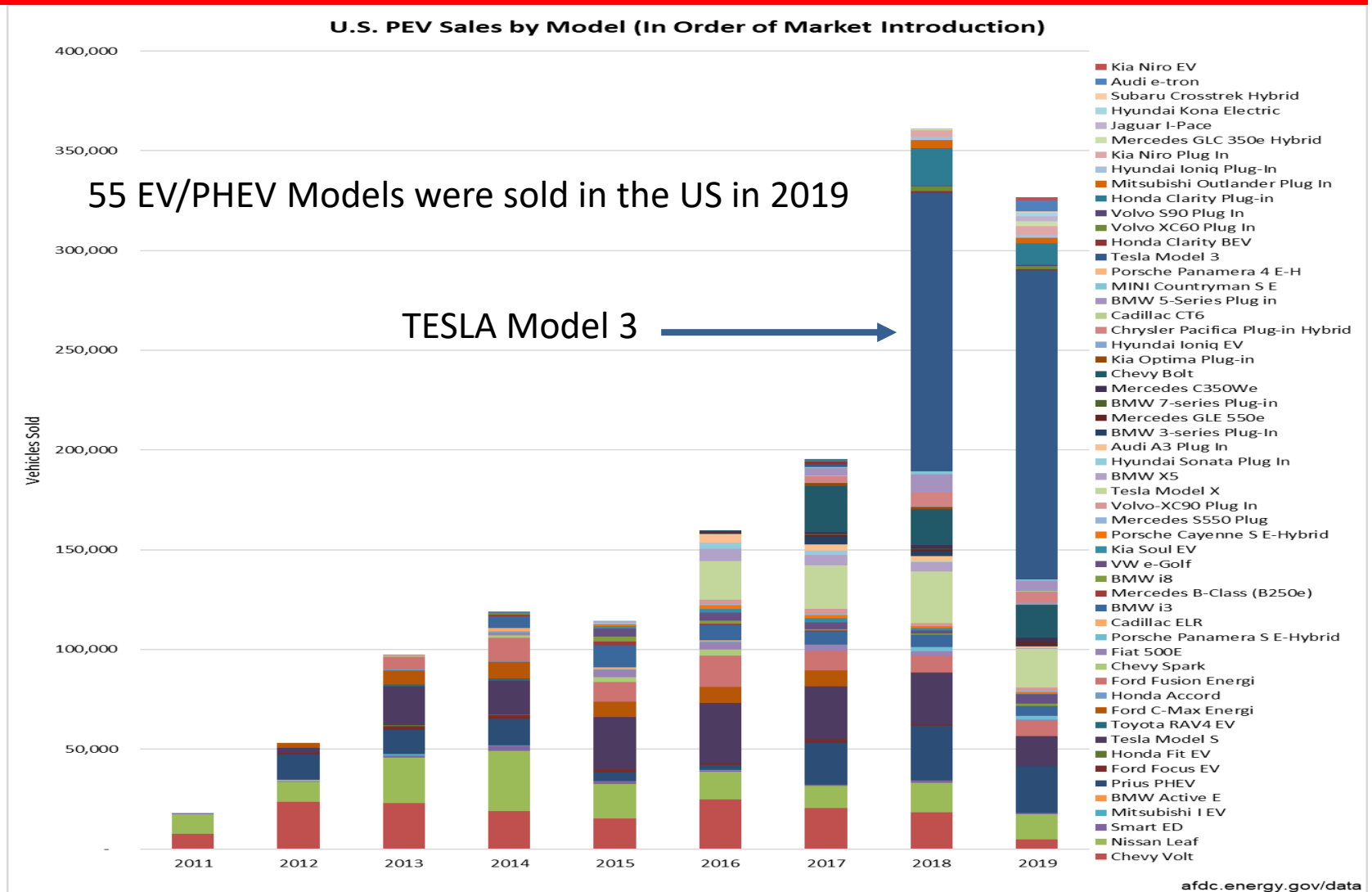
TOTAL EV SALES BY AUTOMAKER



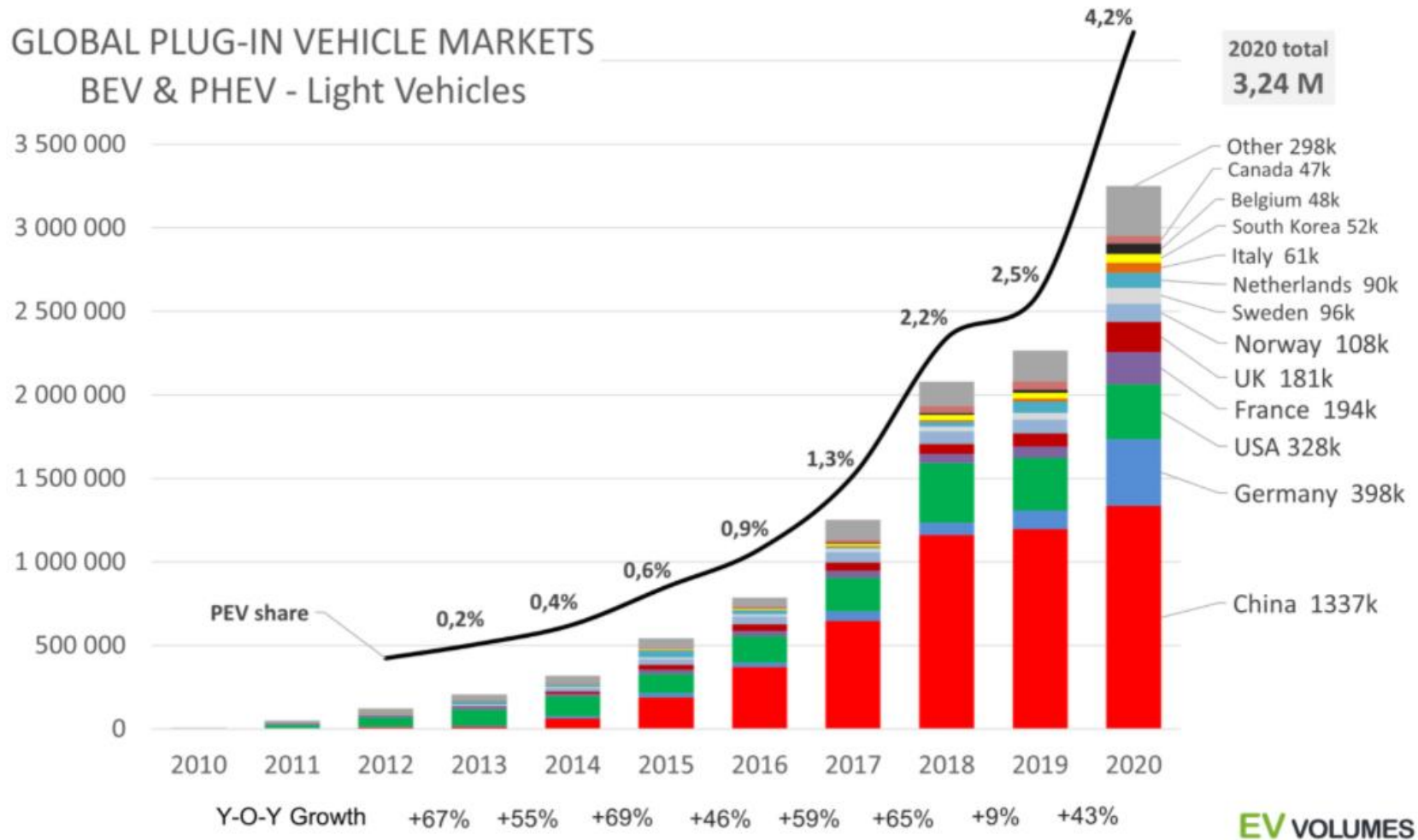
Source: InsideEVs.com and HybridCars.com



The EV Market



The World EV Market



REGULATORY BACKGROUND

- Sales of electricity as a vehicle fuel are regulated by the Department of Commerce
- Like all sales of all things based on quantity sold, EVSE sales are regulated by NIST Handbooks 130 and 44.
- HB130 establishes that all sales of electricity as a vehicle fuel must be based on the quantity delivered.
- HB44 sets performance requirements for devices (Electric Vehicle Service Equipment) used to dispense electricity for sale.



HB44 APPLICABILITY

- **A.1. General.** – This code applies to devices, accessories, and systems used for the measurement of electricity dispensed in vehicle fuel applications wherein a quantity determination or statement of measure is used wholly or partially as a basis for sale or upon which a charge for service is based.

HB44 APPLICABILITY

- **Exceptions-This code does not apply to:**
 - The use of any measure or measuring device owned, maintained, and used by a public utility or municipality only in connection with measuring electricity subject to the authority having jurisdiction such as the Public Utilities Commission.
 - Electric Vehicle Supply Equipment used solely for dispensing electrical energy in connection with operations in which the amount dispensed does not affect customer charges or compensation.
 - The wholesale delivery of electricity.

HB44 APPLICABILITY

- **Use Cases – NOT COVERED**
 - A store provides a free EVSE in its parking lot
 - A paid parking lot provides EVSEs for which there is no charge based on the amount of energy delivered
 - Tesla provides free charging services for some owners
 - An organization charges a monthly fee for unlimited use of its network of EVSEs.

HB44 APPLICABILITY

- **Use Cases –COVERED**
 - ANY transaction which is based on the amount of energy delivered
 - Examples
 - ♦ A network of charge stations charges a monthly fee to belong AND a fee based on the amount of energy used
 - ♦ A EVSE charges for the amount of energy delivered
 - ♦ A parking lot charges for parking and EVSEs located in it also charge for the amount of energy delivered if used

HB44 REQUIREMENTS

- Type Approval
 - All EVSE used in commercial transactions (subject to HB44) must pass type approval by an NTEP testing laboratory.
 - ♦ NTEP is National Type Evaluation Program which is created by NIST and run by the National Conference of Weights and Measures.
 - ♦ For EVSE, the NTEP lab is the CTEP lab of the California Department of Weights and Measures
 - ♦ EVSE type approvals for AC EVSE are being done now.
 - ♦ Three devices have been approved.

HB44 REQUIREMENTS

- **Metrological Requirements of HB44**
 - **S.3.1. Metrological Components.** – An EVSE measuring system shall be designed and constructed so that metrological components are adequately protected from environmental conditions likely to be detrimental to accuracy.
 - **S.3.5. Temperature Range for System Components.** – EVSEs shall be accurate and correct over the temperature range of -40°C to $+85^{\circ}\text{C}$ (-40°F to 185°F).
 - **S.8. Minimum Measured Quantity (MMQ).** – The minimum measured quantity shall satisfy the conditions of use of the measuring system as follows:
 - ♦ (a) Measuring systems shall have a minimum measured quantity not exceeding 2.5 MJ or 0.5 kWh.

HB44 REQUIREMENTS

- Accuracy Tests

- **N.1. No Load Test.** – A no load test may be conducted on an EVSE measuring system by applying rated voltage to the system under test and no load applied.
- **N.2. Starting Load Test.** – A system starting load test maybe conducted by applying rated voltage and 0.5-ampere load.
- **N.5.2. Accuracy Testing.** – The testing methodology compares the total energy delivered in a transaction and the total cost charged as displayed/reported by the EVSE with that measured by the measurement standard.
 - ♦ **Light Load Test.** - $\leq 15\%$ of maximum available charge current
 - ♦ **Full Load Test.** - $\geq 85\%$ of maximum available charge current

HB44 REQUIREMENTS

- Commissioning
 - All EVSE used in commercial transactions (subject to HB44) must have their performance verified after installation and before any sale can occur.
 - EVSE performance must be reverified on a periodic basis as long as they are in service.
 - EVSE are treated as fuel dispensers just like a gas pump. They are inspected and “sealed” by state/county Department of Weights and Measures personnel.

FIRST GENERATION TEST SOLUTIONS

PL200 200 AC Level 1 & 2 to 64 Amps

PL400 AC Level 1 & 2 to 64 Amps, DC Level 2 to 32 Amps



Second Generation EVSE Site Testers




Second Generation EVSE Tester

- **Universal Testing Capabilities**
 - **AC Single Phase (CCS1, CCS2, GB/T, Tesla)**
 - **AC 3-Phase (CCS2, GB/T)**
 - **DC to 200A at 1000V (Higher when connectors are available)**
 - ♦ CCS1 (J1772 DUO)
 - ♦ CCS2
 - ♦ CHadeMO
 - ♦ GB/T
 - ♦ Tesla
 - **Use programmable load to 17kW or EV for higher DC loads**


Industry Needs

- **Automated Operation**

- Create Test sequences that completely automate process
- Testing is then a simple one click process
- Why?

**ACCURACY TEST**

1



100%

5:20 PM
04/29/2021

TYPE	ITERATIONS	LOAD	TIME WHICHEVER COMES FIRST	ENERGY (kwh)
<input checked="" type="checkbox"/> NL	<input type="text" value="1"/>	<input type="text" value="0.0"/> A	<input type="text" value="0:10:00"/>	<input type="text" value="0.500"/>
<input checked="" type="checkbox"/> SL	<input type="text" value="1"/>	<input type="text" value="0.5"/> A	<input type="text" value="0:10:00"/>	<input type="text" value="0.500"/>
<input checked="" type="checkbox"/> ADV	<input type="text" value="1"/>	<input type="text" value="10"/> %	<input type="text" value="0:10:00"/>	<input type="text" value="0.200"/>
<input checked="" type="checkbox"/> ADV	<input type="text" value="1"/>	<input type="text" value="25"/> %	<input type="text" value="0:10:00"/>	<input type="text" value="0.300"/>
<input checked="" type="checkbox"/> ADV	<input type="text" value="1"/>	<input type="text" value="50"/> %	<input type="text" value="0:10:00"/>	<input type="text" value="0.500"/>

☐ GFCI TEST☐ DIODE TEST

START



Certification and Traceability

- **None of this means anything if we can not certify and provide traceability for these tests.**
- **Two general approaches – New York approach and California Approach**
- **Traceability through a National Lab to an International Standard**
 - **This requires a DC “Standard”**
 - **Fortunately DC Power = VA**
 - ♦ **Need a certifiable voltage source and a certified current source and the ability to measure down to the appropriate levels for both Volts and Amps, then have a National Lab do the same test on the lab equipment**
- **ANSI has also spent a great deal of time creating a new Standard to cover DC Metering – ANSI C12.32 ready for re-balloting this year. This will be the DC version of C12.1 for AC metering.**

Questions and Discussion



Tom Lawton

President

tom.lawton@tescometering.com

TESCO – The Eastern Specialty Company

Bristol, PA

215-228-0500

This presentation can also be found under Meter Conferences and Schools on the TESCO website: www.tescometering.com

ISO 9001:2015 Certified Quality Company
ISO 17025:2017 Accredited Laboratory

