Electric Vehicle Chargers: An Exploding Energy Market

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The Eastern Specialty Company

For EEI Spring Meeting
Metering Session
Tuesday, April 2, 2019

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

- **AC Standards are well established and stable**
- **J1772 AC Level 1**
  - Primarily for home installation
  - 120 Volts at up to 16 Amps (1.92 kW)
  - Typical time to charge
    - Pluggable Hybrid (3 – 5 hours, 0% to 90%)
    - EV 80 Mile Range (8 – 20 hours, 20% to 90%)
    - EV200 Mile Range (15 – 40 hours, 20% to 90%)
  - 5.6 miles per hour of charge
  - If you drive <40mi/day you can recharge overnight.

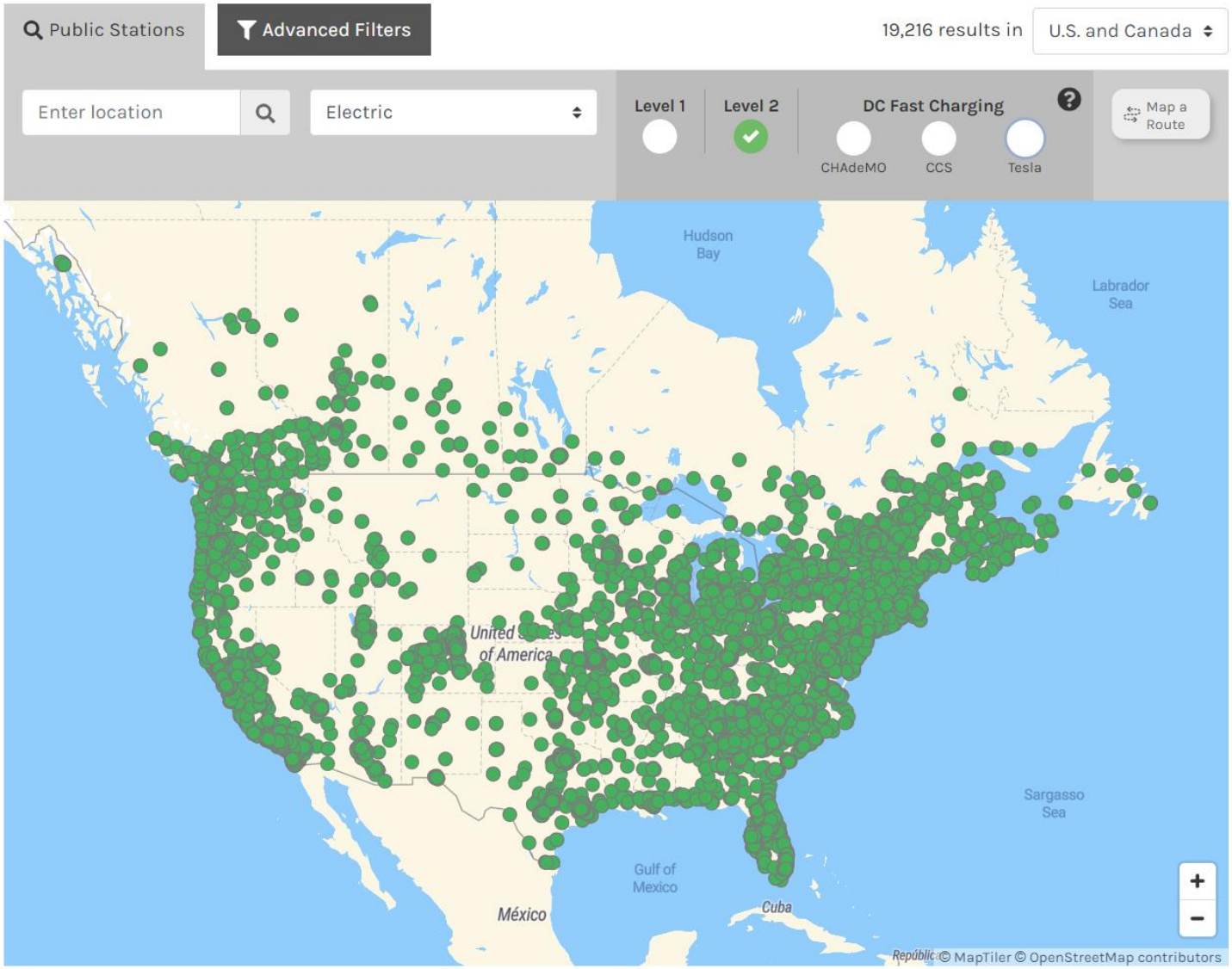
AC EVSE STANDARDS

- **J1772 AC Level 2**
  - Home and Commercial Installation
  - 240 Volts at up to 80 Amps (30A and 50A most common)
    - Home 30A, Commercial 30A, 50A, 75A
  - Maximum Power Delivery (19.2 kW)
  - 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 need adapters
  - Stations cost $400 to $8,000

J1772 AC Level 2 Public Stations



Heads:
58,077

Sites:
19,216

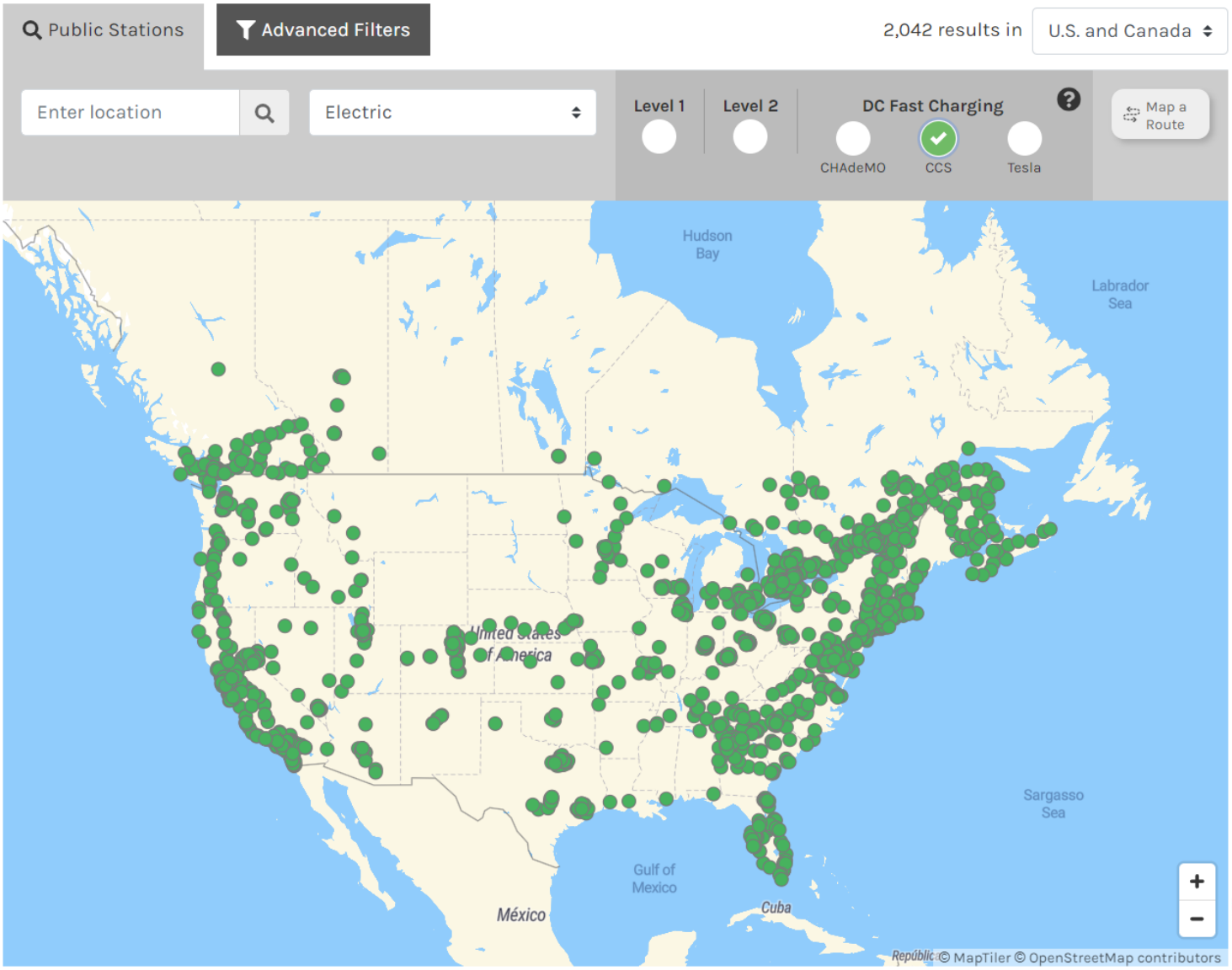
DC EVSE STANDARDS

- **Standards evolving rapidly**
  - Combined Charging System
    - CCS1 SAE J1772 North America
    - CCS2 Europe
  - CHadeMO
  - Tesla V1
  - Tesla V2 (New in 2019)
  - CHadeMO – BG/T (China-Japan-India) (New)
  - Now 100kW is considered “high end”
  - First US **350kW** units installed Dec 10, 2018

DC EVSE STANDARDS

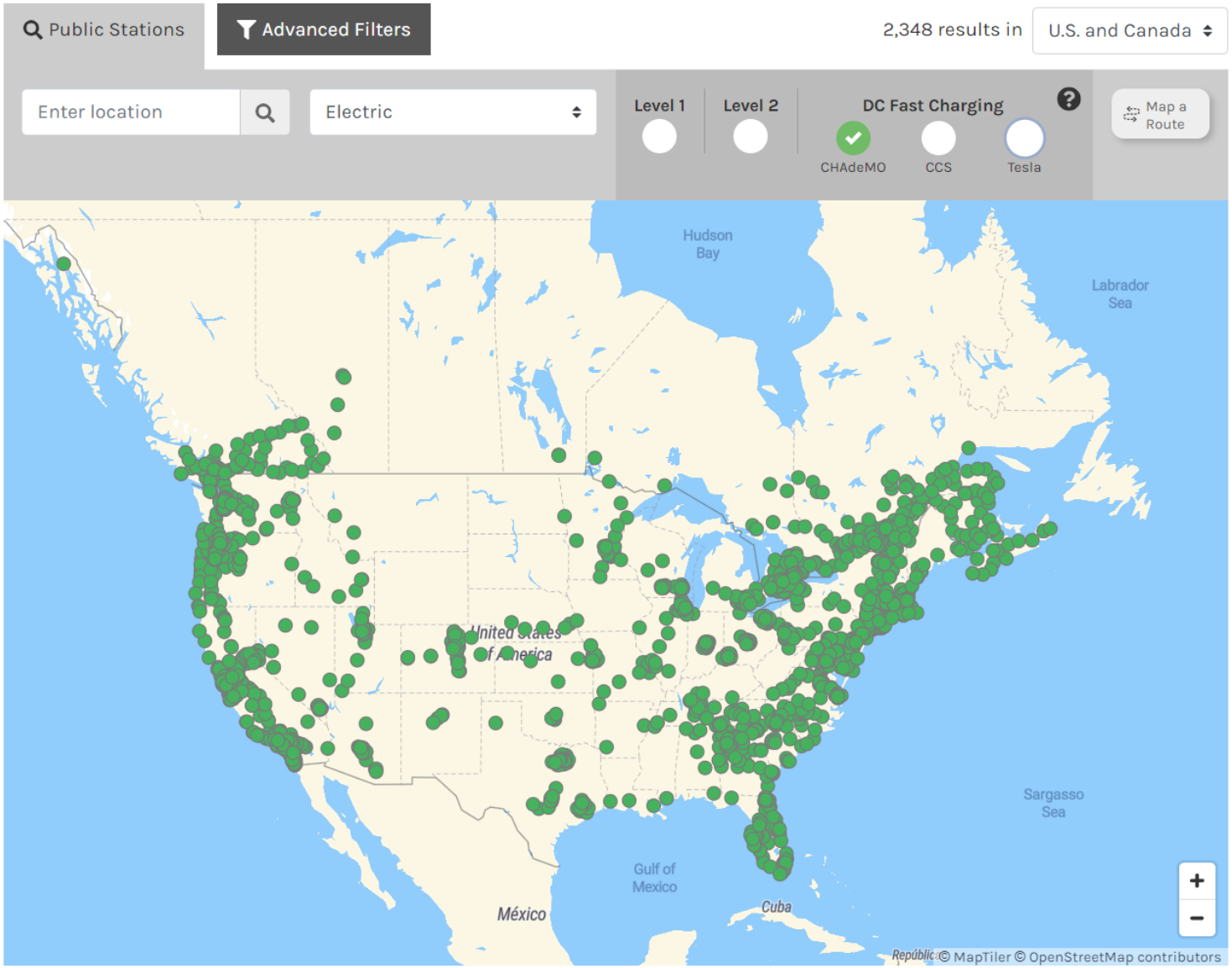
- **Deployment is growing rapidly in US**
- **But slowly compared to Europe, China and Japan**
- Total PUBLIC chargers installed **(70,212/25,246)**
  - AC Level 1 — 1180
  - AC Level 2 — 58,077 heads /19,216 locations
  - DC Rapid — 10,955
    - Tesla — 5,871 heads / 644 locations
    - CHadeMO — 2,348 locations
    - J1772 — 2,042 locations

J1772 DC Public Stations



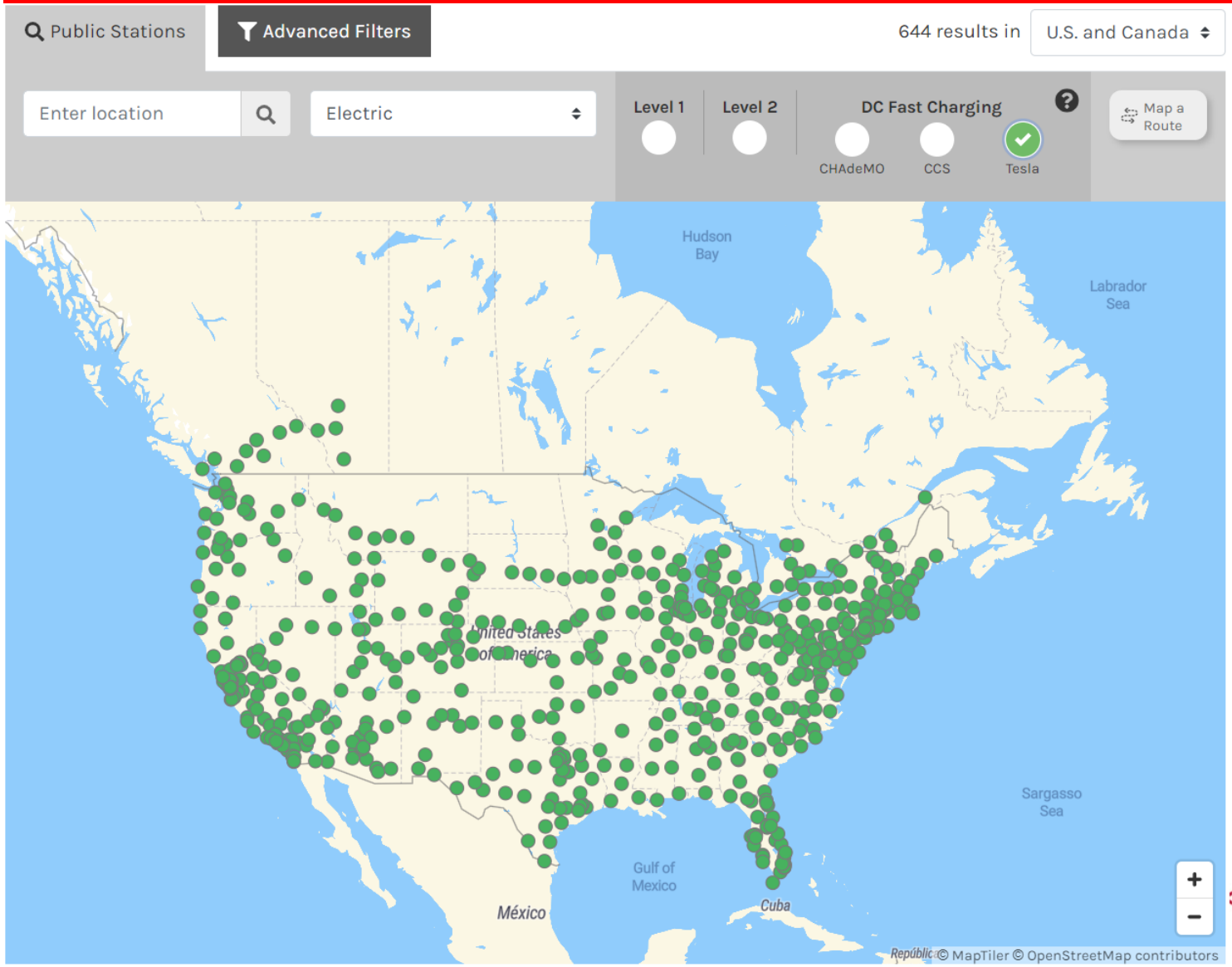
Sites:
2,042

CHadeMO DC Public Stations



Sites:
2,348

Tesla DC Public Stations



DC EVSE STANDARDS

- **Market Direction**
  - Higher current, higher voltage
    - Typical J1772 or CHadeMO 50kW or 100kW
    - Tesla SuperCharger 90kW or 120kW
  - Tesla just announced V2 SuperCharger
    - 145kW charge rate
  - First ABB 350kW chargers installed Dec 2018 as part of VW backed network
  - ChargePoint has announced a 500kW DC system

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

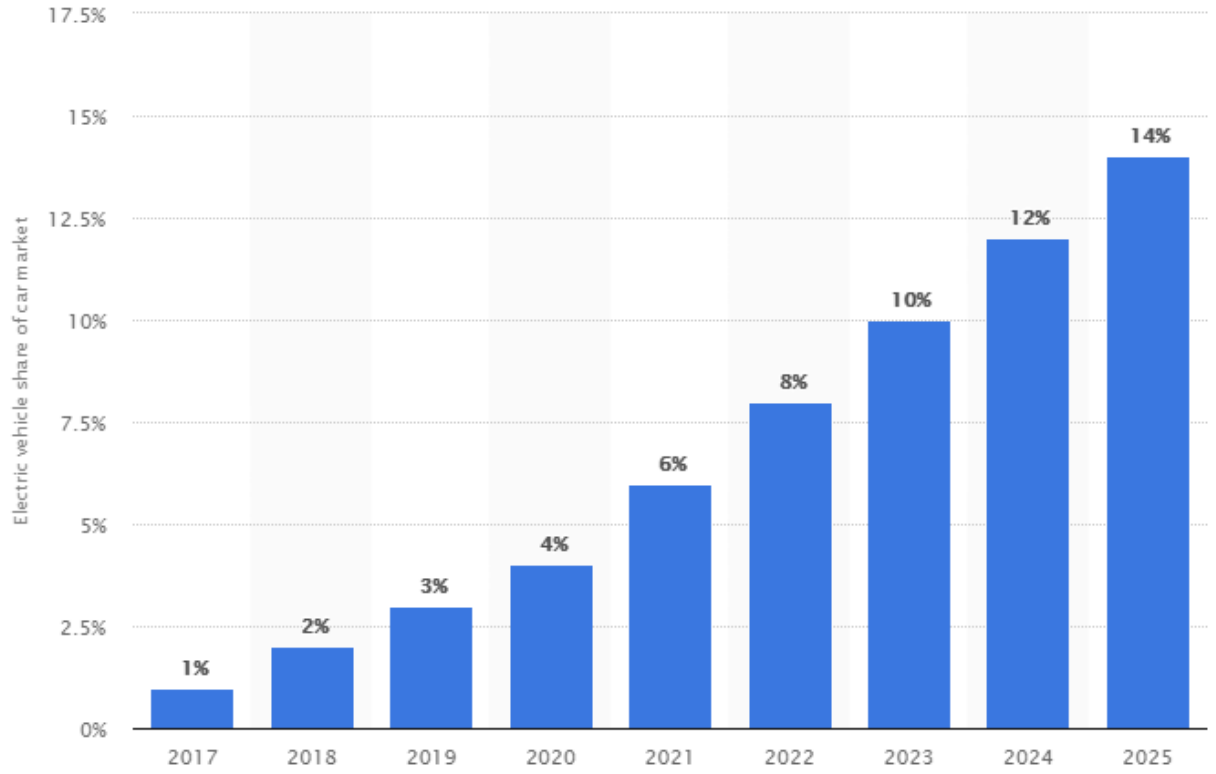
- Fill the Tank Costs

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			

The EV Market

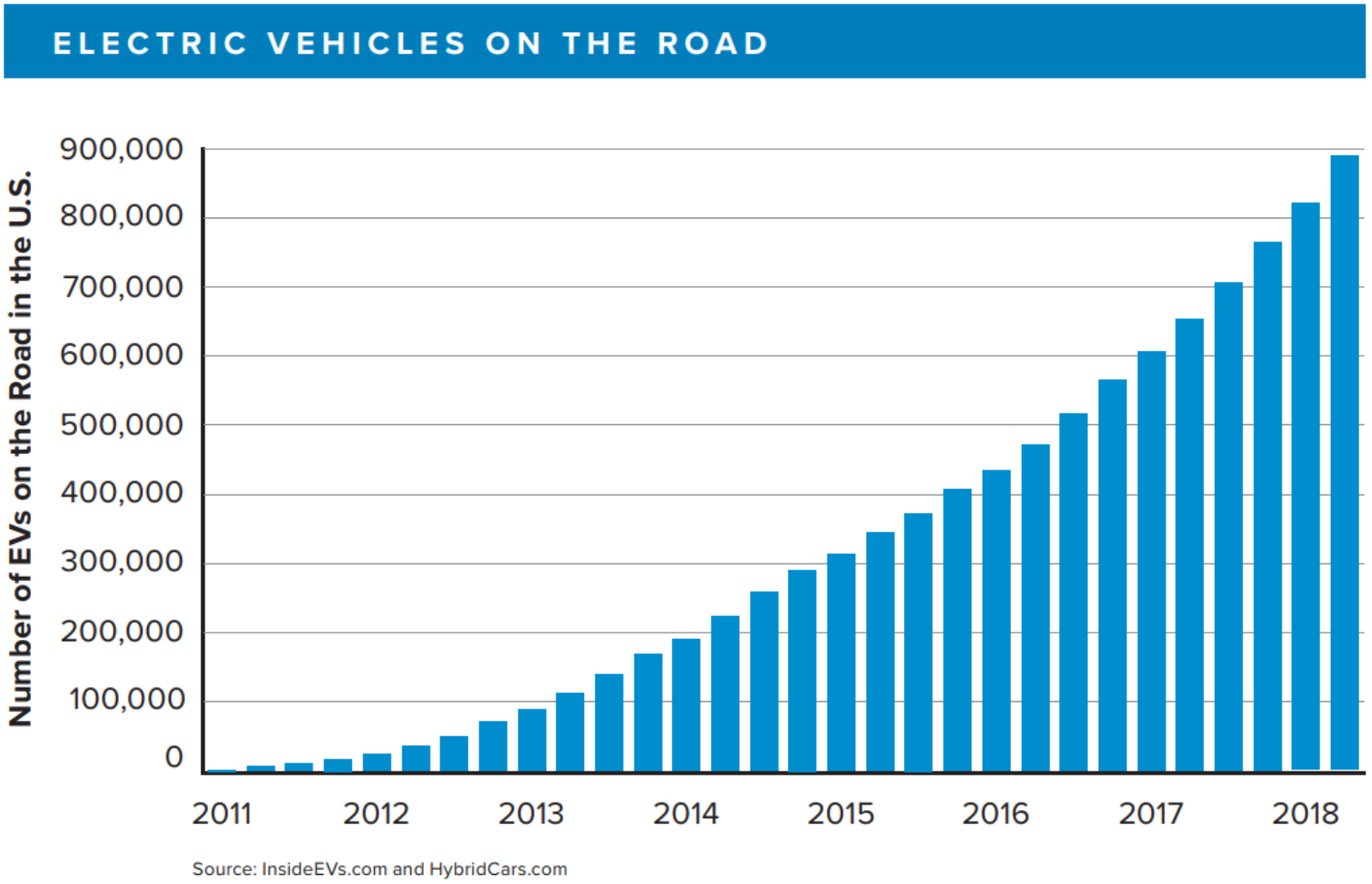
- **2015 - 11 PHEV and 14 EVs**
- **ONE HAS 200+ MILE RANGE, most < 100**
  - **ALL have AC Level 1 and 2 Capability**
    - maximum Charging Rate is 7.2 kW, many only 1.92kW
  - **Three Offer DC Rapid Charge**
- **2018/19 – 43 PHEV and 44 EVs**
  - **EVs have >100 mile range**
  - **All EVs have DC Rapid Charge**

The EV Market



EV sales grew 89% in 2018 but future unclear.

The EV Market



EV sales grew 89% in 2018 but future unclear.

The EV Market

Policies in place today will make China and Europe the biggest adopters, in the IEA's view. In China, credits and subsidies will help EVs grow to account for more than a quarter of the car market by 2030. Meanwhile, tightening emissions standards and high fuel taxes in Europe will boost the vehicles to 23 percent of the market.

As for the United States, the IEA sees electric vehicle deployment growing at two speeds. While it sees "rapid market penetration" in places like California and other states with zero emissions plans, relatively low taxes on fuels and the Trump administration's intentions to scale back vehicle emissions standards could hold back growth.

Tom DiChristopher | @tdichristopher

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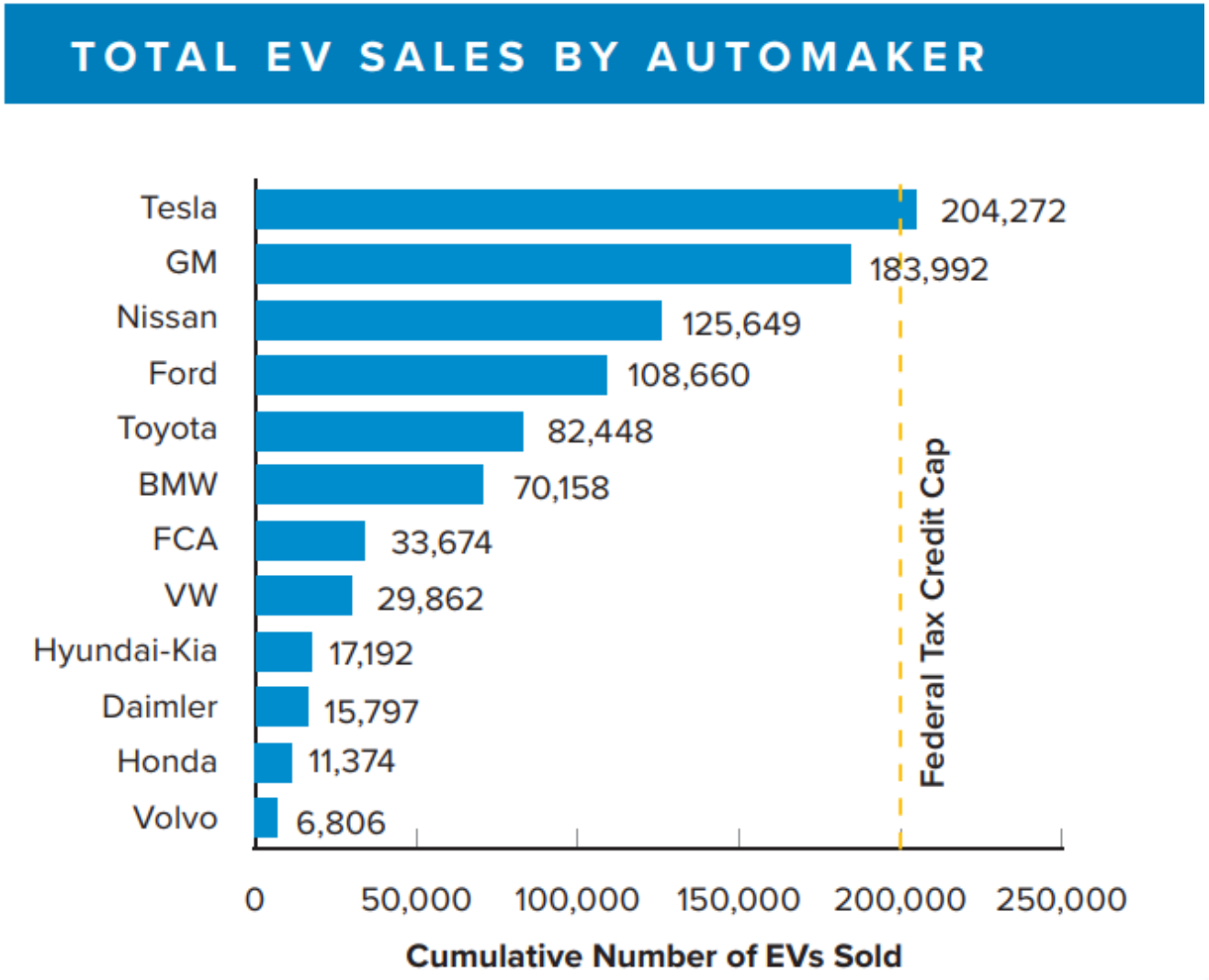
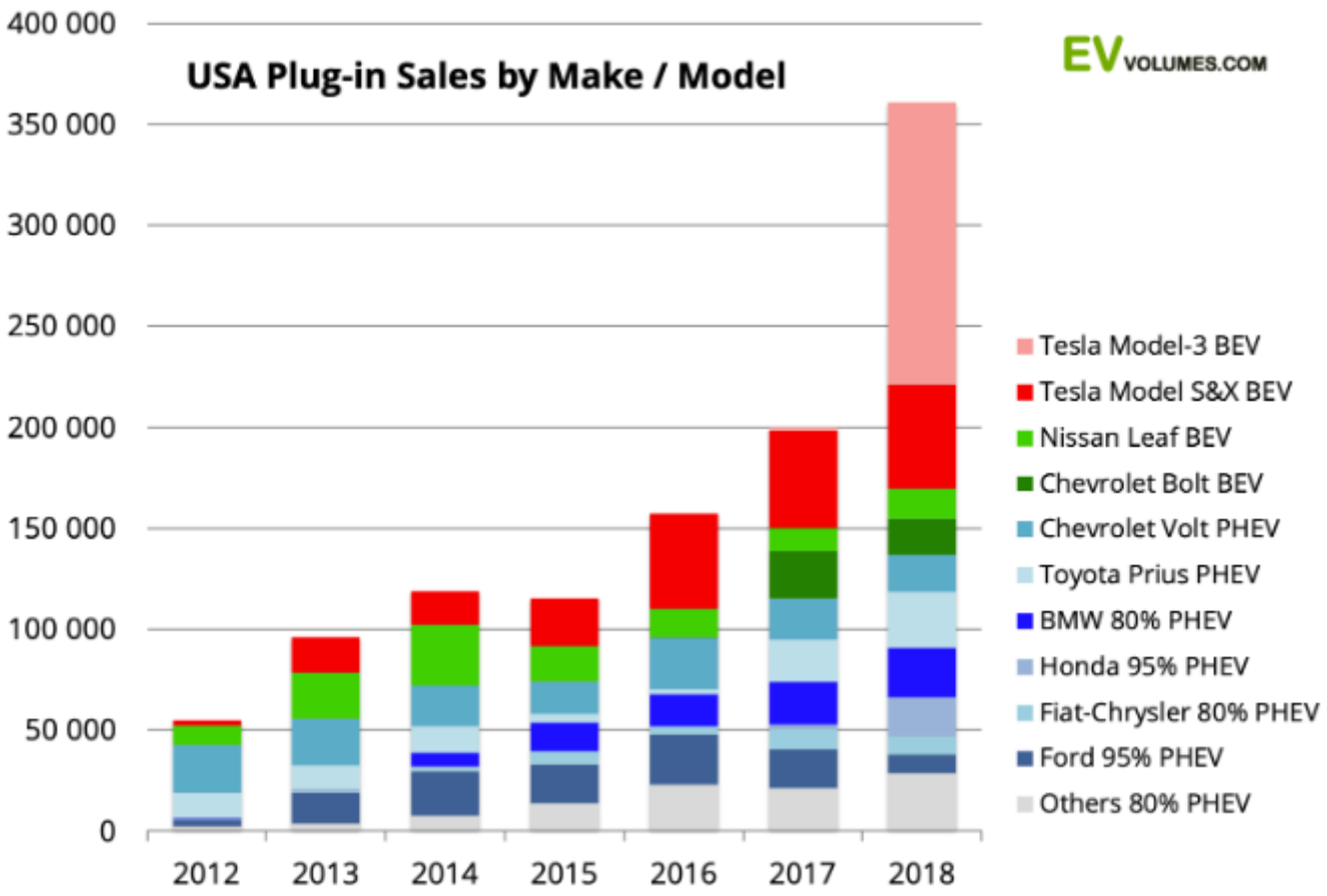
CNBC

The EV Market

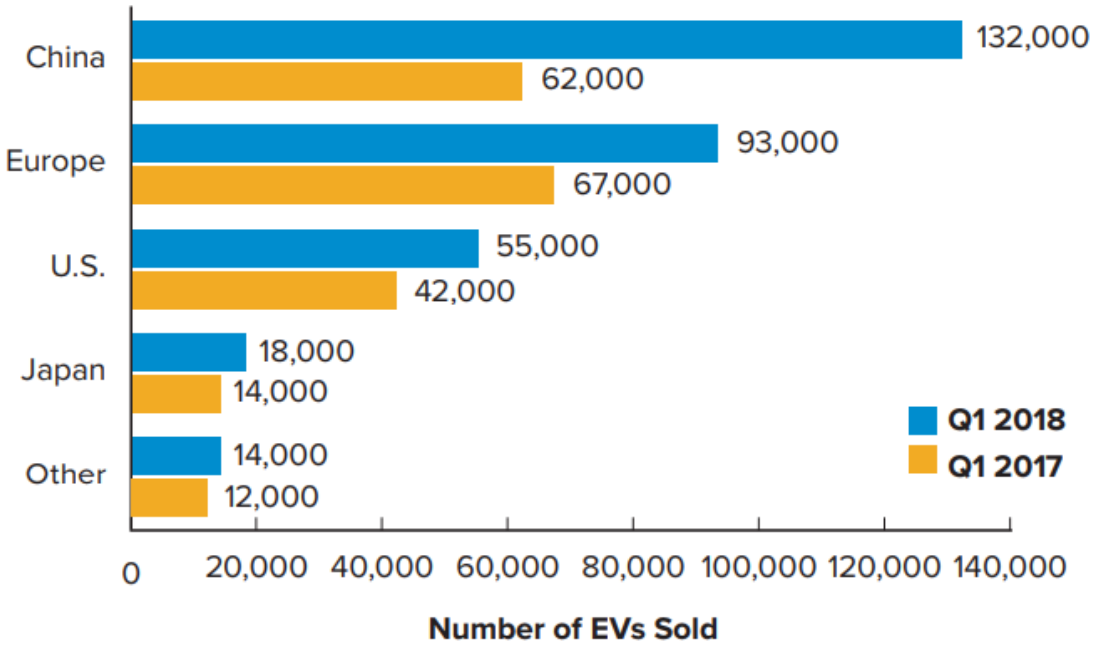


The EV Market



The EV Market

GLOBAL EV SALES Q1 2018 VS. Q1 2017



Source: EV-Volumes.com

KEY FACTS

- Global EV sales totalled about 312,000 in Q1 2018, an increase of 58% compared to Q1 2017.
- U.S. EV sales made up about 18% of global EV sales in Q1 2018.
- U.S. EV sales in Q1 2018 grew by about 32% over Q1 2017, lagging behind growth in Europe of 39% and growth in China of 113%.

REGULATORY BACKGROUND

- **New Provisional National Standard Approved in July 2015 Effective Jan 1, 2016**
  - HB44 Section 1.10 General Code
    - Several changes relevant to EVSE
  - HB44 Section 3.4 – Electric Vehicle Fueling Systems – Tentative Code
  - HB44 Section 5.5 – Timing Devices
    - Several changes relevant to EVSE

REGULATORY BACKGROUND

- **Additional New Standards**
- NIST Handbook 130 Examination Procedure for Retail Electric Vehicle Fueling Systems
    - Procedure approved and published
- NTEP PB14 Working Group
    - Checklist approved and published

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 Equipmentused 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 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
    - An 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

Implementation Status

- Federal Codes are still provisional
- California will go fully compliant for AC EVSE systems January 1, 2020
- California will go fully compliant for DC EVSE systems January 1, 2021
- NTEP should start approving AC EVSE's by late summer 2019.

CA - CHANGES

- **EVSE Value of Smallest Unit.** – The value of the smallest unit of indicated delivery by an EVSE, and recorded delivery, if the EVSE is equipped to record, shall be 0.0005 MJ or 0.0001 kWh.
- **Minimum Measured Quantity.** –
- Measuring systems shall have a minimum measured quantity not exceeding 2.5 MJ or 0.5 kWh.
  - Specified by Manufacturer, encouraged to be much lower

HB44 - REQUIREMENTS

- **Temperature Range for System Components.**
  – EVSEs shall be accurate and correct over the temperature range of – 40 °C to + 85 °C (– 40 °F to 185 °F). If the system or any measuring system components are not capable of meeting these requirements, the temperature range over which the system is capable shall be stated on the NTEP CC, marked on the EVSE, and installations shall be limited to the narrower temperature limits.

HB44 – TESTING REQUIREMENTS

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.

WHH – How long to run test not specified.

N.2. Starting Load Test. – A system starting load test **may be** conducted by applying rated voltage and 0.5-ampere load.

WHH – Is there any level of accuracy required?

HB44 – TESTING REQUIREMENTS

N.3. Minimum Test Draft (Size). – Full and light load tests shall require test of the EVSE System for a delivery of the minimum measured quantity as declared by the manufacturer.

HB44 – TESTING REQUIREMENTS

Accuracy Testing – AC Systems

(1) Accuracy test of the EVSE system at a load of not less than 85 % of the maximum deliverable current (MDA) as determined from the pilot signal for a total energy delivered of at least twice the minimum measured quantity (MMQ). If the MDA would result in maximum deliverable power of greater than 7.2 kW, then the test may be performed at 7.2 kW.

(2) Accuracy test of the EVSE system at a load of not greater than 10 % of the maximum deliverable current (MDA) as determined from the pilot signal for a total energy delivered of at least the minimum measured quantity (MMQ).

HB44 – TESTING REQUIREMENTS

Accuracy Testing – DC Systems

(1) Accuracy test of the EVSE system at a load of not less than 85 % of the maximum deliverable current (MDA) as determined from the pilot signal for a total energy delivered of at least twice the minimum measured quantity (MMQ).

WHH – The following was omitted from the final version of the standard.

If the MDA would result in maximum deliverable power of greater than 7.2 kW, then the test may be performed at 7.2 kW.

HB44 – TESTING REQUIREMENTS

Accuracy Testing – DC Systems

(2) Accuracy test of the EVSE system at a load of not greater than 10 % of the maximum deliverable current (MDA) as determined from the pilot signal for a total energy delivered of at least the minimum measured quantity (MMQ).

Note: For DC systems it is anticipated that an electric vehicle may be used as the test load. Under that circumstance testing at the load presented by the vehicle shall be sufficient.

HB44 – TESTING REQUIREMENTS

Repeatability Testing – DC Systems

Tests for repeatability should include a minimum of three consecutive tests at the same load, similar time period, etc., and be conducted under conditions where variations in factors are reduced to minimize the effect on the results obtained.

HB44 – TESTING TOLERANCES

GENERAL

- The tolerances apply equally to errors of underregistration and errors of overregistration.
- The tolerances apply to all deliveries measured at any load within the rated measuring range of the EVSE.
- Where instrument transformers or other components are used, the provisions of this section shall apply to all system components.

HB44 – TESTING TOLERANCES

TEST TOLERANCES

- The tolerances for EVSE load tests are Acceptance Tolerance: 1.0 % and Maintenance Tolerance: 2.0 %.
- **Repeatability.** – When multiple load tests are conducted at the same load condition, the range of the load test results shall not exceed 25 % of the absolute value of the maintenance tolerance and the results of each test shall be within the applicable tolerance.

HB44 – TESTING TOLERANCES

TEST TOLERANCES

- **No Load Test.** – An EVSE measuring system shall not register when no load is applied.
- **Starting Load.** – An EVSE measuring system shall register starting load test at a 0.5 ampere (A) load.

HB44 – TESTING TOLERANCES

TYPE EVALUATION

- For type evaluation examinations, the acceptance tolerance values shall apply under the following conditions:
  - at any temperature, voltage, load, and power factor within the operating range of the EVSE, and
  - regardless of the influence factors in effect at the time of the conduct of the examination, and
  - for all quantities greater than the minimum measured quantity.

EPO 30 – FIELD TEST

- **Process in EARLY stage of development**
  1. Verify EVSE labeling meets requirements
  2. Record all site information
  3. Power on test equipment with load connected
  4. Start test process on test equipment
  5. Connect EVSE to test equipment
  6. Determine maximum deliverable current (MDA) from CP signal
  7. Set load to <=10% of MDA and perform the light load test

EPO 30 – FIELD TEST

- **Process in EARLY stage of development**
  8. Perform the light load test
     (a) This requires doing a charging cycle and at the conclusion of energy delivery comparing the total energy and price registered on the EVSE with that measured by the test equipment.
  9. Record the test results
     (a) Repeat 8 & 9 multiple times for reproducibility test
  10. Set load to >85% of MDA and perform the full load test
     (a) This requires doing a charging cycle and at the conclusion of energy delivery comparing the total energy and price registered on the EVSE with that measured by the test equipment.
  11. Record the test results
     (a) Repeat 10 & 11 multiple times for reproducibility test

EPO 30 – FIELD TEST

- **Process in EARLY stage of development**

12. Verify that after the final test that the display on the EVSE remains visible for at least 15 seconds
13. No Load Test (optional)
    (a) Test system must initiate a valid charging sequence without placing a load on the EVSE. No energy should be registered.
    (b) Not yet defined what “No” means or for how long the test should be performed

EPO 30 – FIELD TEST

- **Process in EARLY stage of development**

14. Starting Load Test (optional)

(a) Test system must initiate a valid charging sequence with a load of 0.5 amps.

(b) Energy must be registered, not clear at this point what the accuracy requirement is, if any if 0.5 amps is less than 10% of MDA.

EPO 30 – FIELD TEST

- **Process in EARLY stage of development**

15. Time Test (tbd)
16. RFI/EMI Test (tbd)
17. Zero-Setback Test
    a) On equipment activated with a single remote controller, activate one EVFS and check all others operated by the same controller to make certain they will not operate without activating the individual EVFS starting mechanism.

OUR TEST SOLUTIONS

T200 AC Level 1 & 2 to 64Amps

T400
AC Level 1 & 2 to 64 Amps
DC Level 2 to 75 Amps

OUR TEST SOLUTIONS

PL200 200 AC Level 1 & 2 to 64 Amps

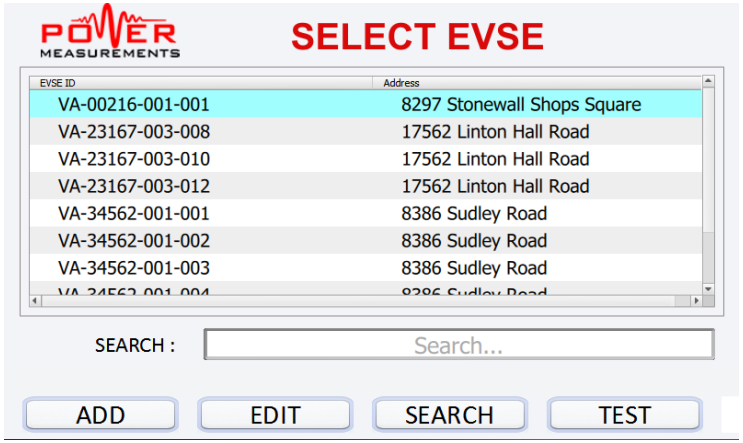
PL400 AC Level 1 & 2 to 64 Amps, DC Level 2 to 32 Amps

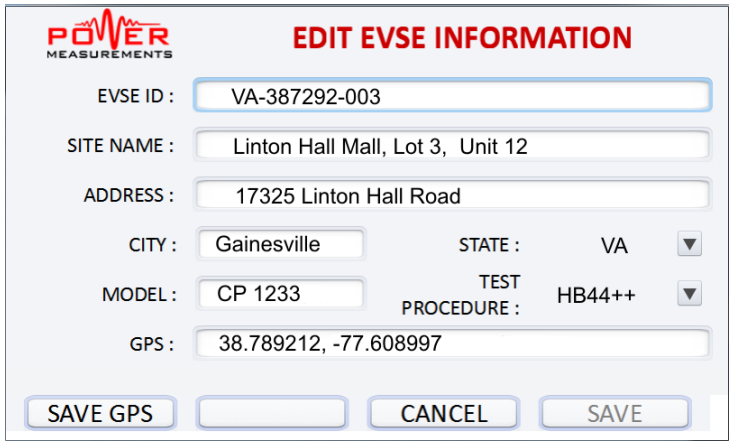
OUR TEST SOLUTIONS

- **T200/T400 EVSE TESTERS**
  - **Fully Self Contained**
    - **AC or AC/DC Models**
    - **Rugged Pelican Case**
    - **Run from internal battery, AUX AC or L1-L2 of EVSE**
    - **High Res Color display**
    - **Ethernet, USB, Serial**
    - **Built in GPS**

OUR TEST SOLUTIONS

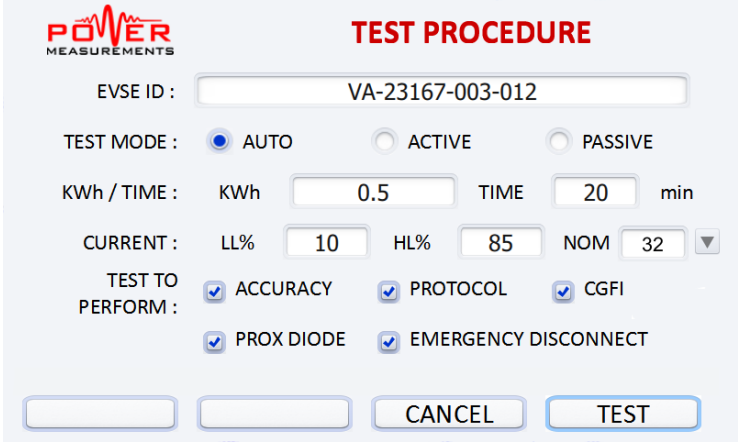
- **T200/400 EVSE TESTERS**
  - **Database driven**
    - **Select a site and test**
    - **Download all of your site data from your PC**
    - **Locate site by GPS , ID or any other field**





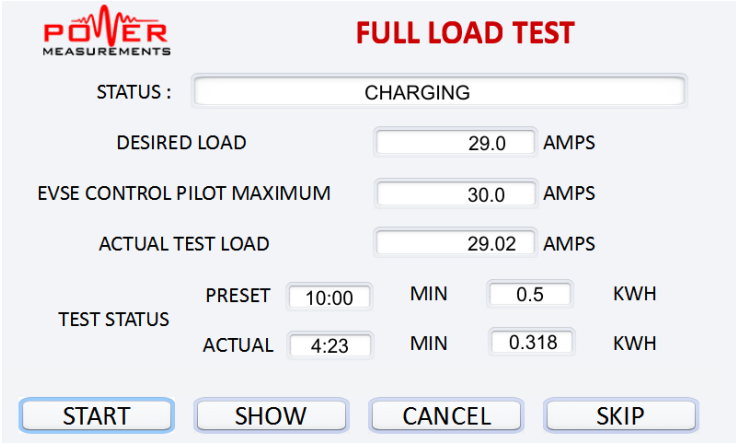
OUR TEST SOLUTIONS

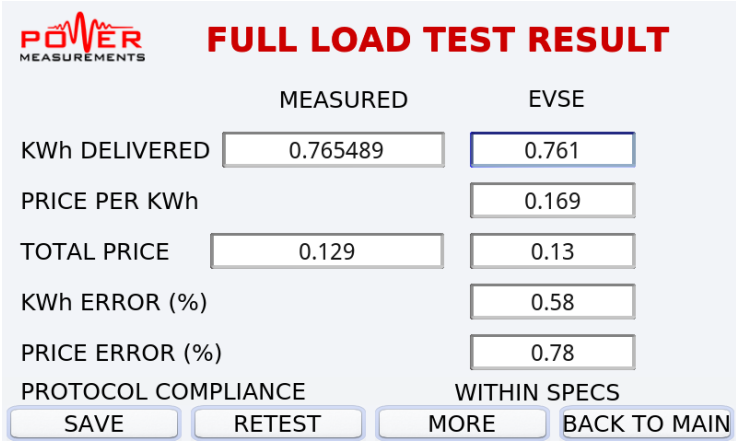
- **T200/400 EVSE TESTERS**
  - **Automated Operation**
    - **Create Test sequences which completely automate process**
    - **Testing is then a simple one click process**



OUR SOLUTION

- **T200/400 EVSE TESTERS**
  - **Simple Results**
    - **Process and Status During Testing**
    - **Easy entry of EVSE Displayed Results**





BREAKING NEWS

- **NTEP/CTEP will conduct first dry run type approval testing this month**
- **California issues final regulations**

QUESTIONS & DISCUSSION

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