# EV CHARGING: OEM STRATEGIC APPROACH

OEM Commercialization

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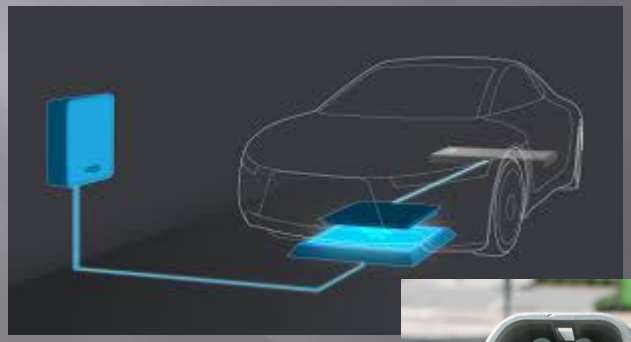

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# 2012 Projections

- UC – Berkeley Projected that by 2020 EV sales would be 50% of all Vehicle sales.
- President Barack Obama made EV sales a priority, 1M cumulative by 2015:
  - Funded Tax Incentives
  - Funded DOE/DOT Research and Dev't.
  - Subsidized Advanced Battery Dev't and Production.
- OEMs announced > 100 Plug-in Vehicles by 2020.

# 2012 Outlook

- UC – Ber[illegible] Projected that by 2020 EV sales wou[illegible]hicle sales.
- Presi[illegible] a prior[illegible]
  - Fu[illegible]
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  - Sub[illegible]duction.
- OEM[illegible] announced > [illegible]s by 2020.

2016 Reuters: "Electric Vehicle Sales Fall Far Short of Obama Goal"
- 115,000 Plug-in Sales
- 3.9% of Total Vehicle Sales

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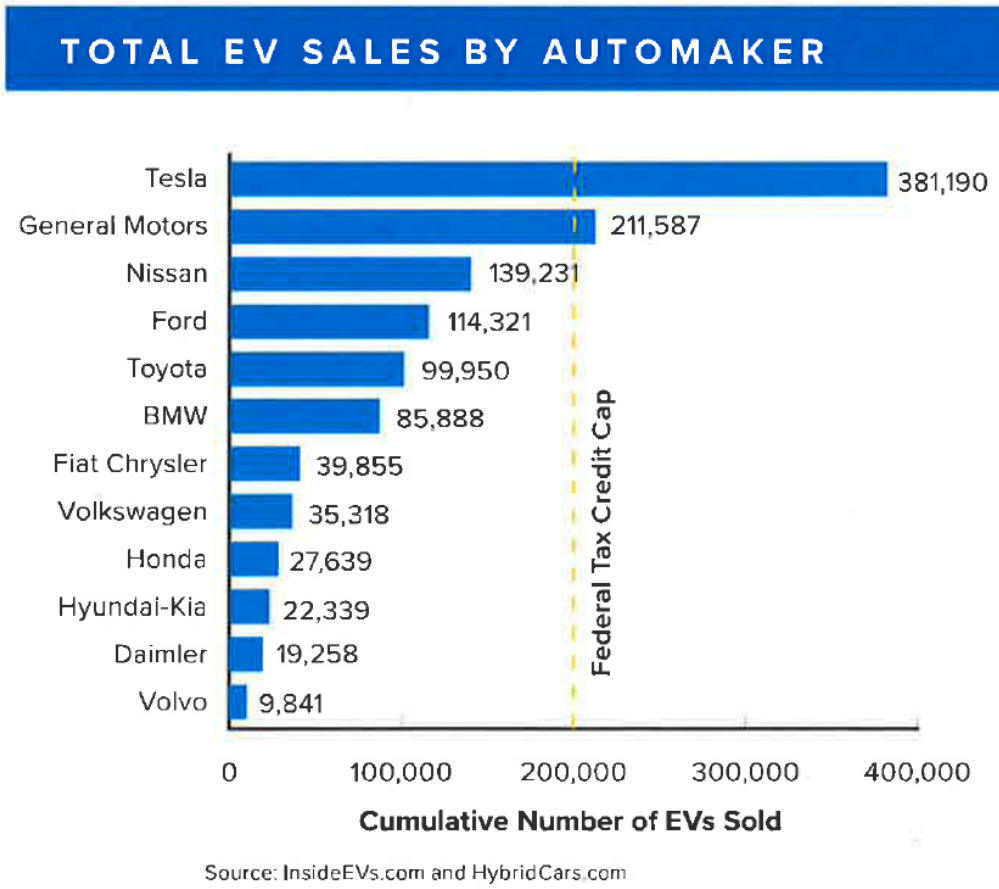
2020 Edison Electric Institute (EEI):
- 2019 EV Sales Top 1M for the First Time
- 8% of Total Market Sales

# January 2020 Status

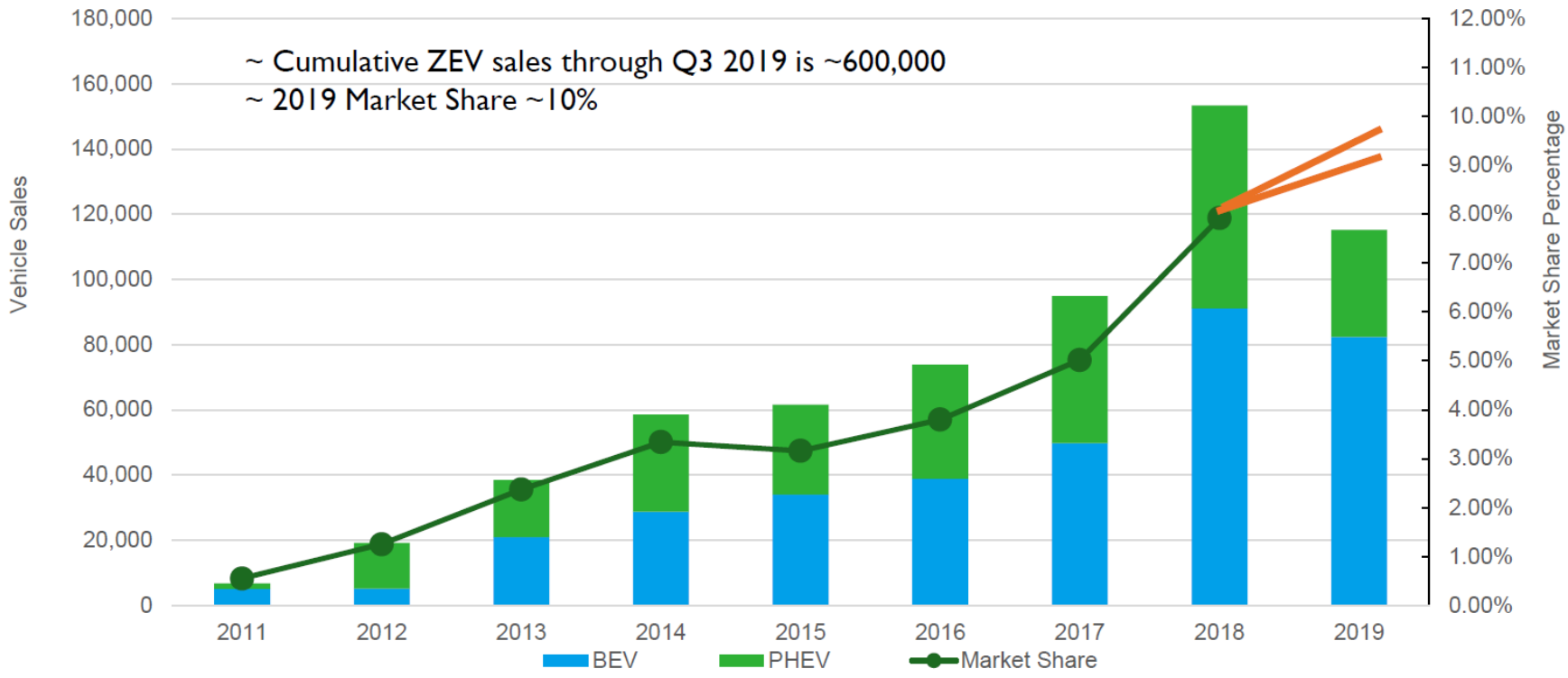



## KEY FACTS

- General Motors EV sales have surpassed the 200,000 cap for the federal tax credit. The credit will begin to phase out in April 2019.
- Tesla, GM, and Nissan account for 62% of the 1.18 million EVs sold.

# California Market

## PEV Market California 2019

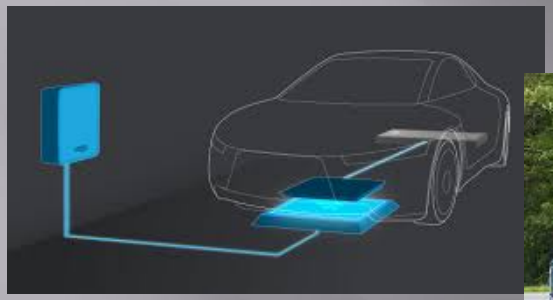



Source: UC-Davis Gil Tal

# Path to Commercialization

- Need for Interoperability. Importance of Harmonized Standards.
- WPT is a Tough Sell. 10% of vehicle cost. (5% is general target.)
- Tesla (largest producer) has indicated WPT is not needed in N.A. market. No plans to develop.
- Dynamic Charging is unlikely to be deployed any time soon. (infrastructure cost, extreme maintenance expense, battery cost reductions defeat value calculations, political pressure (benefit to rich early adopters.))

# SAE J2954 Interoperability



All OEMs consider Interoperability to be Critically Important to This Technology! (Home, Workplace, Public)

- Defined Frequency, Communication protocol and Master Coil set to confirm product interoperability.
- Product shown to function at minimum efficiency levels, with the Master Reference, are confirmed to be J2954 Compliant.
- Future-compatibility planned. Allowing for innovation while preserving existing commercial product compliance.
- Standard publication expected ~May 2020.
- Harmonization established with ISO 19363 and IEC 61980 (2/18 ~ 2/27)

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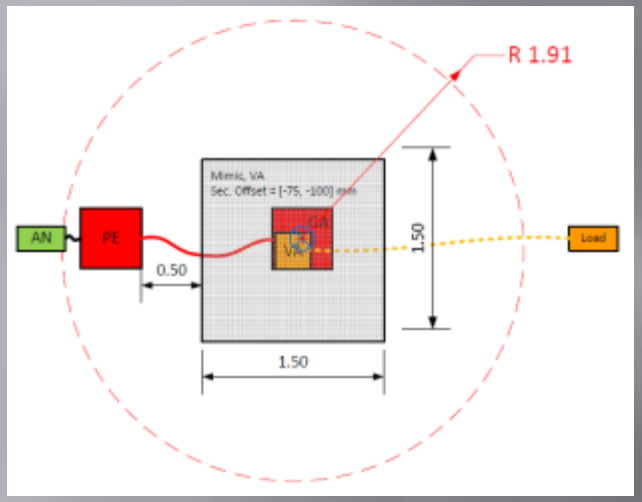
# Minimum Interoperability Requirements

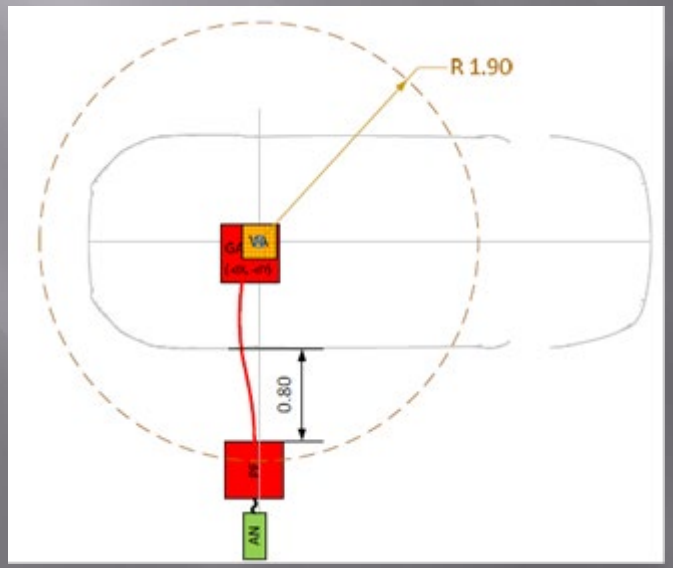
- Communication (SAE J2847/6, ISO/IEC 15118-7)
- Comply with EMC/EMI Requirements (Incl. FCC Part 18)
- Comply with Human Exposure Limits (ICNRP2010) and Medical Device Exposure Limits 15uT.
- Achieve Power Transfer Performance Targets
  - Single Frequency (85kHz)
  - Minimum Efficiency 85% aligned, 80% offset.
  - Defined Alignment (X,Y,Z)
  - Within Packaging Constraints of OEMs.
  - Standardized location in parking spot/vehicle.

# The Trouble with High Power WPT (L3, L4)

- FCC Industry Waiver For Part 18 Non-Compliance.
- OEM WPT Advisory Board submitted FCC Petition for threshold and test procedure relief.
  - Limit of 64.4dBuA/m protects L3 with circular topology.
  - Support filings from Qualcomm, Daimler and ProDrive requesting higher limit of 82dBuA/m.
  - Objection filing from Amateur Radio Operators Guild
  - FCC hearing expected in 2020.
- OEM and Aftermarket Systems that Fail EMF Reference Levels Risk Production Injunction

# ANSI 63.30




Agreed test procedure:

- Fixed EUT Ring 1.9m radius
- Centered VA/GA Assy.
- Measure at 10m from boundary
- Extrapolate to FCC 300m

Repeatable, Consistent
Standard, single measurement.
Downside – underestimates emissions (limit matter)
Paves the way for FCC limit rule.

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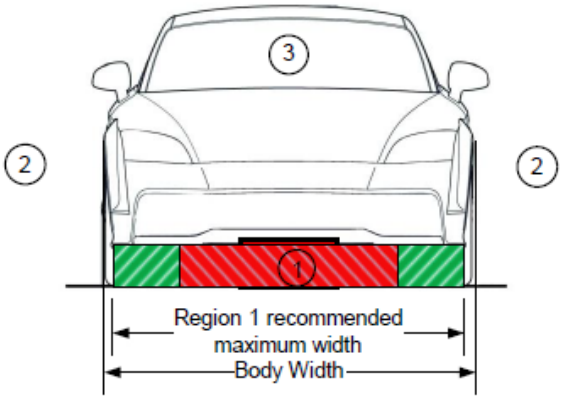
# Human Exposure and Medical Device Compliance




| SAE J2954 Region | ISO 14117-2012 IMD Requirement | ICNIRP 2010 Human Exposure Requirement |
|---|---|---|
| 3 | AAMI Zone 2 (**15 µT** @ 85 kHz) | Reference Level (**27µT**) or Basic Restrictions |
| 2 | AAMI Zone 2 (**15 µT** @ 85 kHz) | Reference Level (**27µT**) or Basic Restrictions |
| 1 | none | Three options are given:<br>i) Active or passive access control<br>ii) Detection and shutdown<br>iii) Meet region 2a Human Exposure Requirement |

Note: RMS values are given for comparison to AAMI and ICNIRP levels.
Multiple by 1.414 to obtain TIR J2954 specification of peak values.
No issue in Region 1 if the shutdown system or access control is functioning.

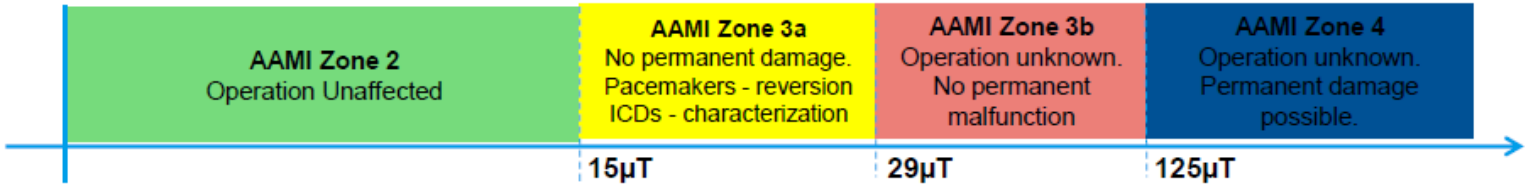
*Region 1 Discussion*

**Example of Region 1 Human Exposure Requirement Compliance with spatially varying approach:**

Part of Region 1 where exposure is prevented by options (i) or (ii)

Part of Region 1 where options (i) or (ii) may not cover, but option (iii) is applied (e.g. Basic Restrictions)

**Performance requirement for pacemakers & ICDs at 80-90kHz according to ISO 14117-2012***




* According to AAMI, EMF exposure levels higher than Zone 2 values should be infrequent and transient, lasting a matter of seconds.

# Topics Under Development/Resolution

1. Communication Protocol for interoperable control. ISO 15118-20 FDIS available for harmonization ~2/2020.
2. ANSI C63.30 Publication ~5/2020.
3. Petition Action for FCC EMC threshold (Level 3 and higher) or Industry waiver.
4. SAE J2954 Standard to include flush-mounted spec. and Dynamic Charge Requirements.