EVTC
Electric Vehicle Transportation Center

EV Technology and Standards

Doug Kettles, Research Analyst
Electric Vehicle Transportation Center

2015 EV Summit

Cocoa, Florida

October 21, 2015

EV Technology

The Qualifiers:

- Technically accurate but broadly generalized
- The focus is on EV technology
  - Why? Many variants operate as pure EVs
- Nissan Leaf is used for explanation
  - Why? It's the most common EV on the road
- The technology is advancing…quickly!

EV Technology

- Operates almost identically to a conventional auto…or does it?
  - Drives similarly, it's quiet!
  - Where do I fill up?
  - What's Eco Mode?
  - What's the temperature outside?

EV Technology

- Mechanically much simpler…or is it?
  - Basic EV has no radiator or transmission
  - Hybrids significantly more complex
  - Chevy Volt in a class by itself
  - Tesla also in a class by itself

EV Technology Benefits

- Significant environmental and health benefits
  - Huge reductions in GHG, particulate matter, noise and heat generation
  - Batteries can have a second life and are classified as non-hazardous waste
  - Benefits magnified in the urban environment

EV Technology Benefits

- Cost ~ $1.00/ gallon to fuel

Vehicle Comparison

Battery Electric (*BEV*)

Nissan Leaf

Grid charged batteries range ~110 miles, no gas powered engine, batteries and electric motor only

Plug-In Hybrid Electric Vehicle (*PHEV*)

Ford C-Max Energi

Grid charged batteries range ~20 miles, gas powered engine works alone or in tandem with electric motor

Extended Range Electric Vehicle (*EREV*)

Chevy Volt

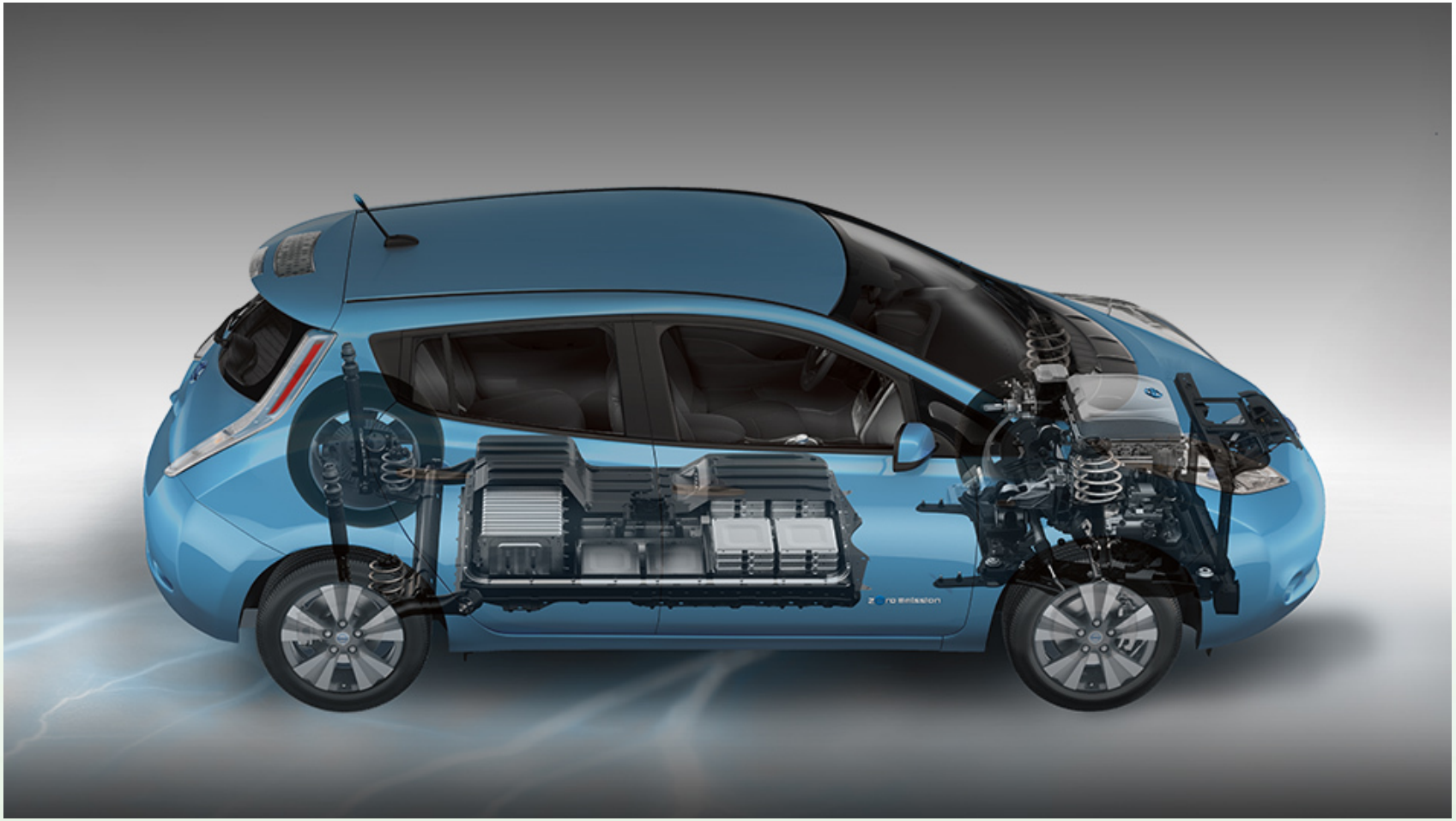
Grid charged batteries range of ~53 miles, small gas powered generator charges batteries to extend range

Hybrid (*HV*)

Toyota Prius

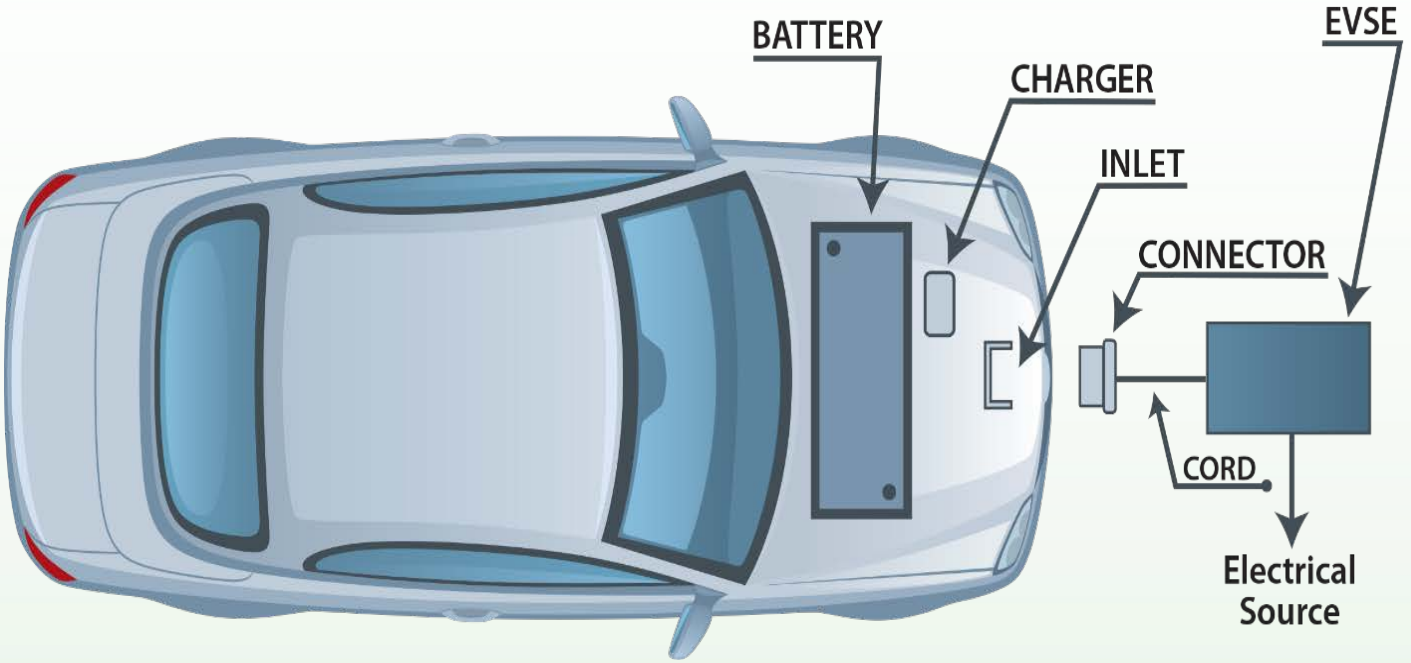
No grid charged battery range, gas powered engine charges batteries and works alone or in tandem with electric motor

Nissan Leaf

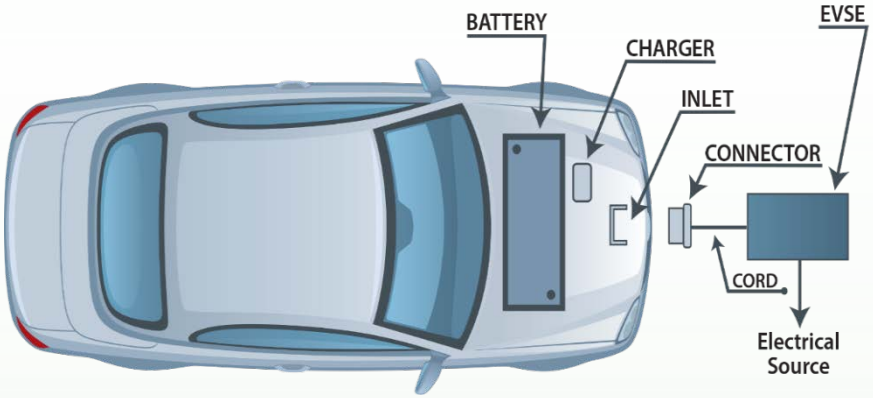


mynissanleaf.co.uk

EV Charging Components



EV Charging Components, EVSE



Electric Vehicle Service Equipment (EVSE)

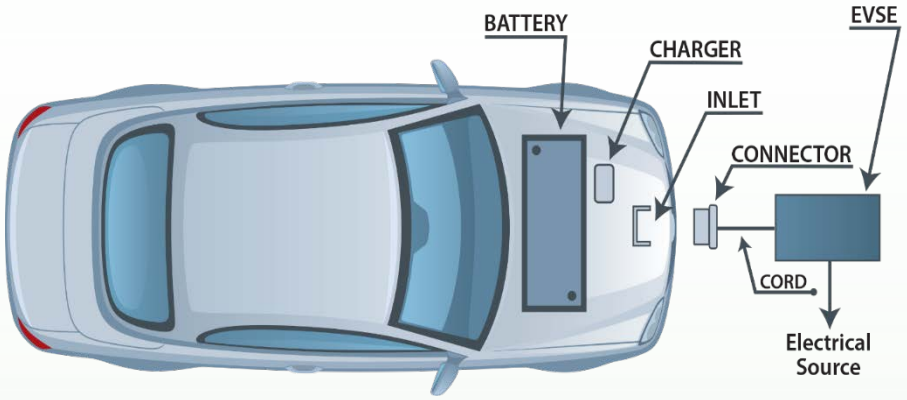
- Connected to an electric power source
- Provides AC or DC power
- EVSE communicates with EV to regulate power
- Power output is important

Level 1 Charging Cord
Source: RoperId

Level 2 Charging Station
Source: ClipperCreek

DC Fast Charging (DCFC)
Source: Evcaro

EV Battery Systems



Traction Battery Systems

- Traction are usually Lithium-ion, like laptops
- AKA, Rechargeable Energy Storage Systems (RESS)
- Traction batteries power electric drive motors
- Conventional 12-volt battery for aux systems
- Nickel-Metal Hydride has been used in hybrids

Photo: Nissan

EV Battery Systems

Traction Battery Sizes and Mileage Range

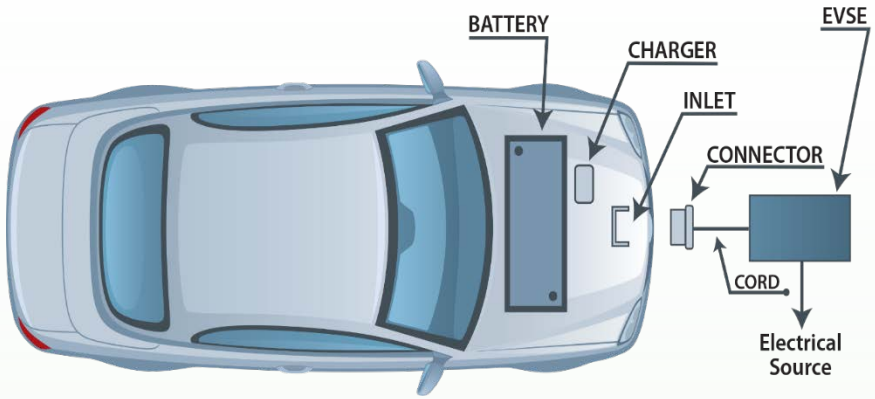
Larger battery = more range…and weight = less range

- Nissan Leaf, 30 kWh (~110 mile range*)
- Ford C-Max, 7.6 kWh (~20 mile range)
- Chevy Volt, 18.4 kWh (~53 mile range*)
- Toyota Prius, 1.3 kWh (works tandem with ICE)
- Tesla, 85 kWh (~265 mile range)

2016 model*

Photo: Nissan

EV Onboard Charger



Onboard Charger

- Communicates with EVSE during charging
- Converts EVSE AC to DC to charge batteries
- Bypassed with DCFC, direct DC to the batteries
- Regulates power during Level 1, 2 charging
- Typically 3.3 kW or 6.6 kW per hour

EV Inlet

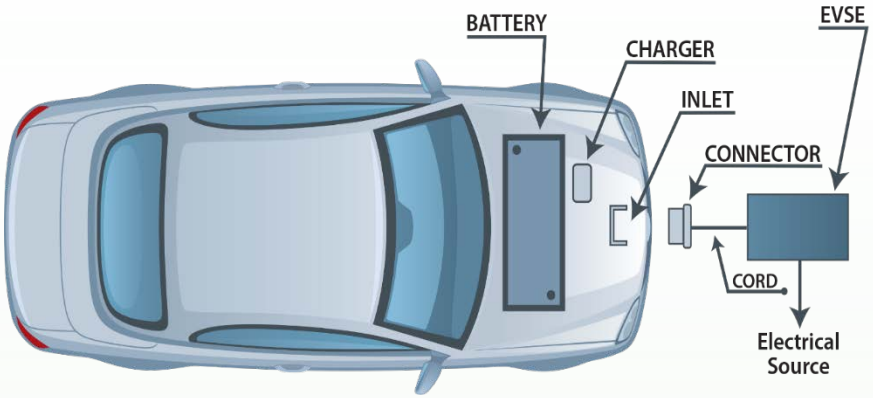
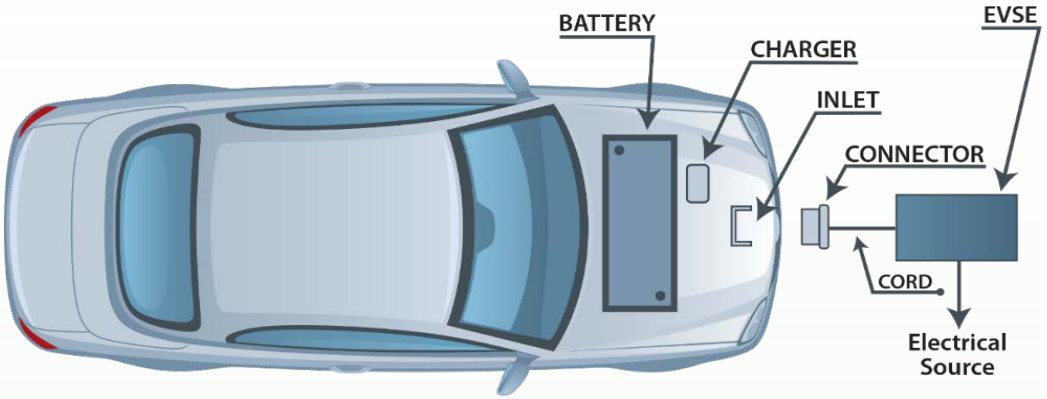


Photo: Wardsauto.com

Inlet

- Connects EV to EVSE
- Interface between EVSE and onboard charger
- Can be SAE J1772 or CHAdeMO, or both

EVSE (Charger) Connector



- Connects EVSE to EV
- 1772 and CHAdeMO meet all safety standards
- Very similar in operation
- Choice based on a variety of technical needs
- Can be used for both Level 2 and DCFC
- There are other international standards (IEC)

EVSE Connectors

CHAdeMO

- Developed by Japanese auto manufacturers
- Standard for Nissan, Mitsubishi and others
- CHAdeMO is most widely deployed

SAE J1772 Combo T2

- Develop by SAE International
- Standard, for Chevy, Ford, BMW and others
- 100 kW rating versus 62.5 for CHAdeMO

Photo: WordPress

EV Motors

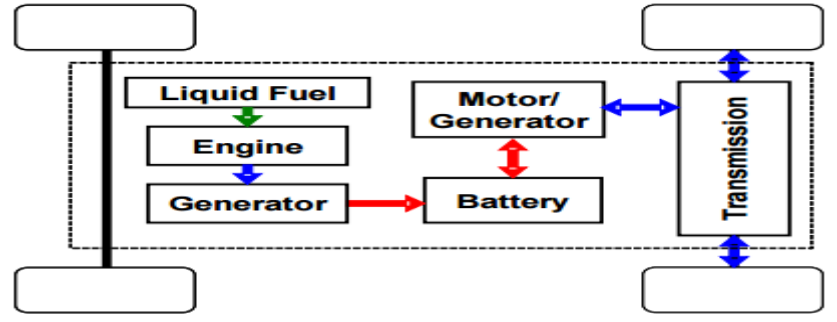
- Variations between vehicles is significant
- Considerations for efficiency, performance, size
- Leaf uses Permanent Magnet AC (107 hp)
- Tesla uses AC induction (360 hp)

Permanent Magnet AC

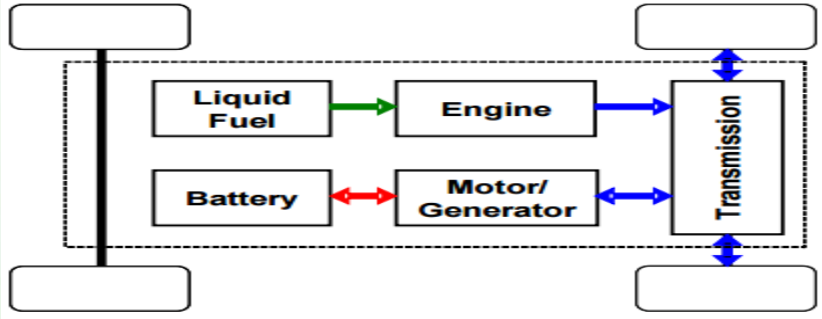
Tesla AC Induction

EV Drivetrains

- **Series** Hybrid Electric Vehicle
  - Two power sources
  - Single path to power the wheels



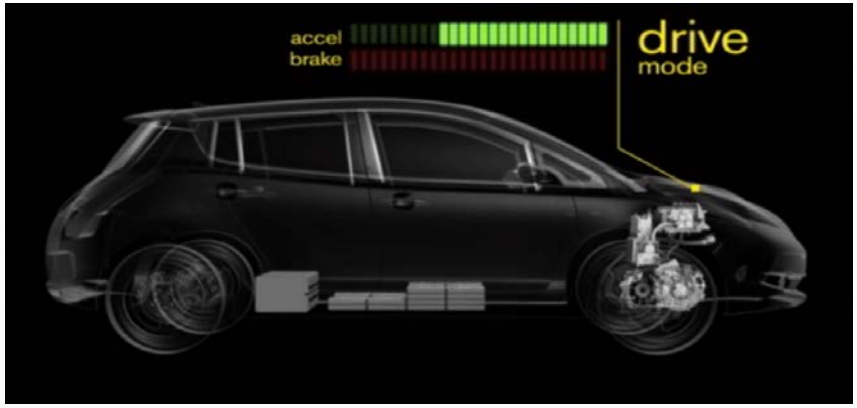
- **Parallel** Hybrid Electric Vehicle
  - Two power sources
  - Two parallel paths to power the wheels



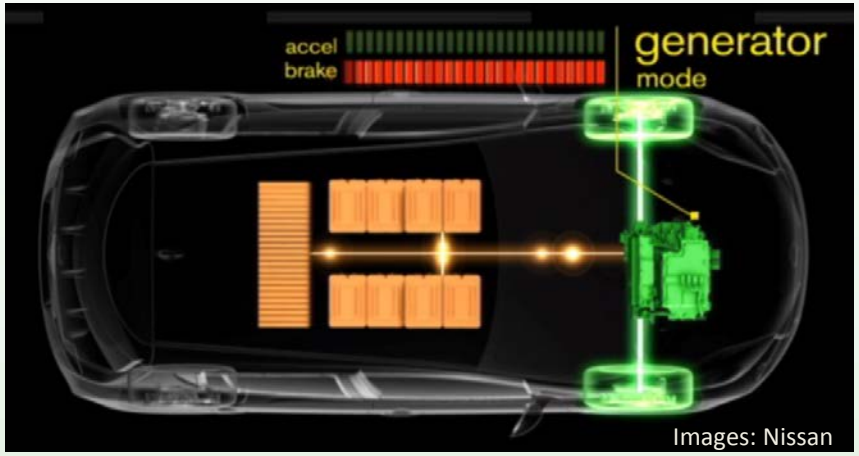
Drawings: MIT

EV Regenerative Braking

- **Drive Mode**
  - Electric motor operating normally
  - Consuming battery power



- **Generator Mode**
  - Electric motor operates in reverse to provide “engine braking”
  - Converts the electric motor into a generator to recharge batteries



Images: Nissan

EV Related Standards

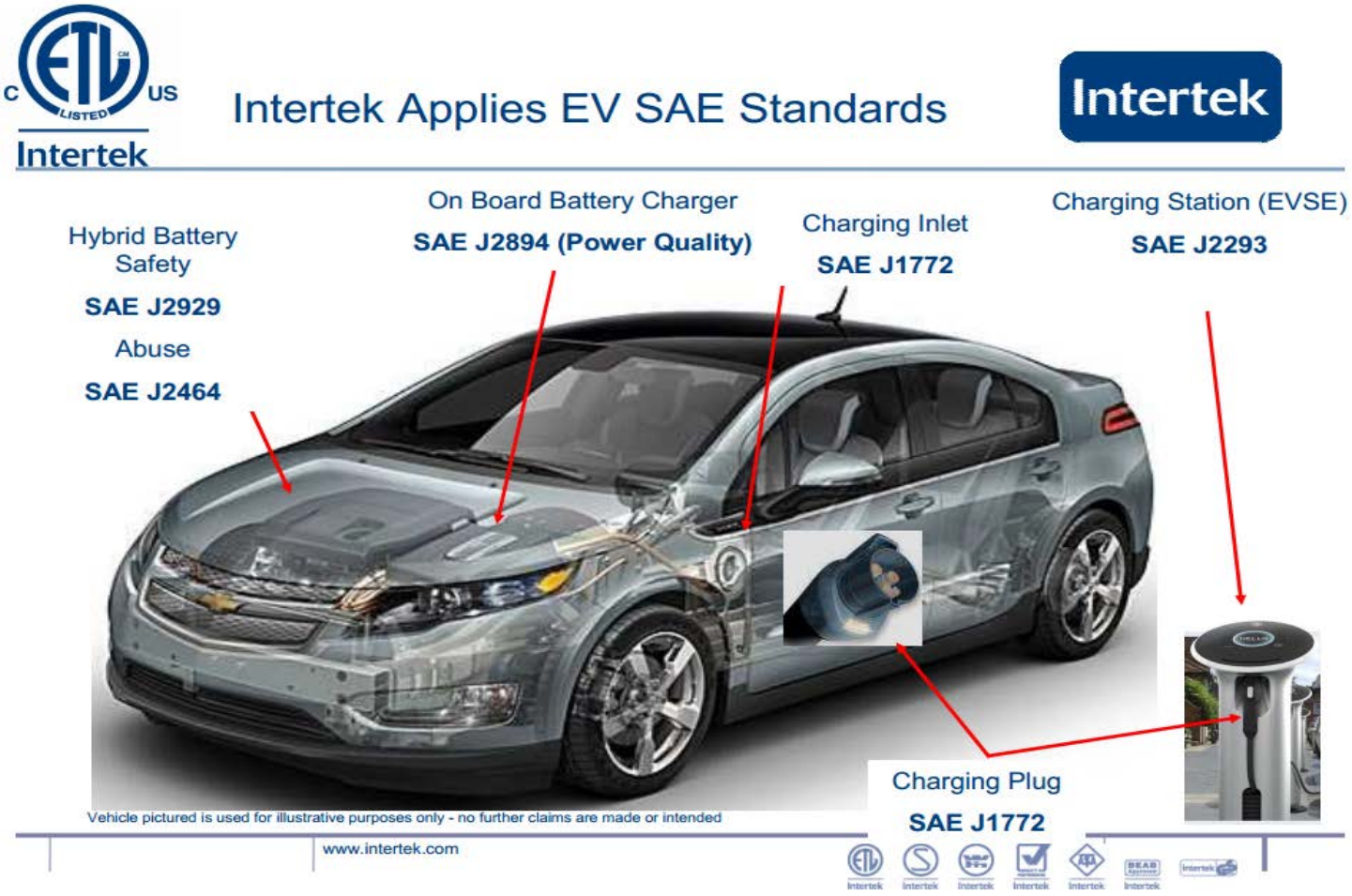
Robert Galyen, SAE International

EV Related Standards

Vehicle Design and Systems

- American National Standards Institute (ANSI) coordinates EV standards development by:
    - Society of Automotive Engineers (SAE), National Highway Traffic Safety Administration (NHTSA) and others
    - ANSI November 2014 Progress Report, “The Standardization Roadmap for Electric Vehicles”

SAE EV Standards



EV Related Standards

National Electrical Code (NEC)

- NEC Article 625, wiring and equipment external to the EV connecting it to a supply of electricity. (AKA, the charger…AKA, EVSE)
- Article 625 requires NRTL certification of the EVSE

Level 1 Charging Cord
Source: RoperId

Level 2 Charging Station
Source: ClipperCreek

DC Fast Charging (DCFC)
Source: Evcaro

EV Related Standards

- The Occupational Health and Safety Administration (OSHA) and Nationally Recognized Testing Laboratories (NRTL)
    - OHSA requires NRTL certification for many products, electronic equipment is the largest category
    - Underwriters Laboratories (UL) and Intertek Testing Services (ITSNA)
- International Organization for Standardization (ISO)
- International Electrotechnical Commission (IEC)

Level 1 Charging Cord
Source: RoperId

Level 2 Charging Station
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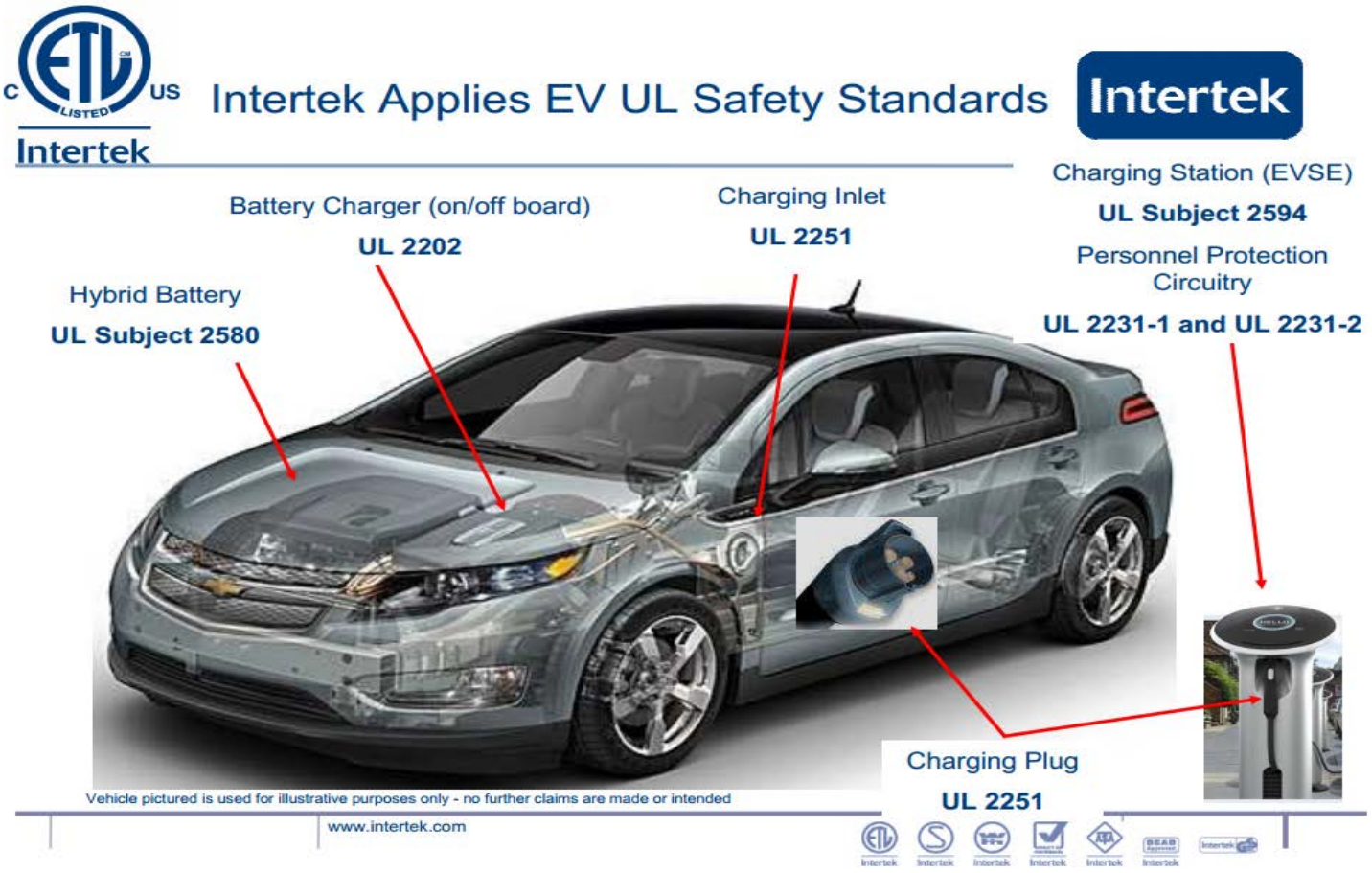
UL EV Standards



Vehicle Crash Safety Standards

- **National Highway Traffic Safety Administration (NHTSA)**
  - Oversees safety performance standards for motor vehicles and motor vehicle equipment
  - NHTSA is legislatively mandated , manufacturers must comply
  - EVs routinely receive the highest crash safety ratings, Tesla among the best ever
- **EV Accident Recovery**
  - EV traction battery is a sealed system that undergoes rigorous testing
  - Well insulated system with crash and short-circuit auto-shutoff
  - Traction battery systems routinely exceed 350 volts
  - First Responders need special training to understand the technology and safety systems

Additional Standards

- **Americans with Disabilities Act (ADA)**
  - Charging stations must accommodate access
  - Public access and commercial facilities
  - U.S. Americans with Disabilities Act—28 CFR Part 36 (ADA)
  - 2003 International Building Code
  - 2009 ANSI A117.1

- **Signage**
  - Particularly important for EV owners
  - Provides specific information on local regulations and ordinances
  - Federal Highway Administration (FHWA) defines standards
  - FHWA—Manual on Uniform Traffic Control Devices (MUTCD)
  - 2009 ANSI A117.1

Automated and Connected Vehicles

- **Automated Vehicles (AV)**
  - NHTSA definition: "…are those in which at least some aspects of a safety-critical control function (e.g., steering, throttle, or braking) occur without direct driver input."
  - Five levels of automation: ranges are Level 0, No automation ; Level 3, Limited Self-driving; Level 4, Full Self-Driving
- **Connected Vehicles (CV)**
  - Connected vehicle technologies enable safe, interoperable networked wireless communications among vehicles (V2V), the infrastructure (V2I), and travelers' personal communication devices (V2X)
  - Reduce highway crashes; assess the performance of the transportation system; provide accurate information to travelers; reduce unnecessary stops, delays, and emissions
- **Transportation planning**
  - MAP-21 requires state DOTs and regional MPOs to have a multimodal transportation plan with a minimum 20-year time horizon
  - These cars will be here well before 2035 so we better get busy

For Future Reference

- **Electric Vehicle Charging Technologies Analysis and Standards—Doug Kettles**

  http://fsec.ucf.edu/en/publications/pdf/FSEC-CR-1996-15.pdf

- **Electric Vehicle Transportation Center—EVTC**

  http://evtc.fsec.ucf.edu/

- **ANSI, Progress Report, Standardization Roadmap For Electric Vehicles, Version 2.0—ANSI**

  http://publicaa.ansi.org/sites/apdl/evsp/ANSI_EVSP_Progress_Report_Nov_2014.pdf

- **Alternative Fuels Data Center—AFDC**

  http://www.afdc.energy.gov/

- **Clean Cities**

  http://www1.eere.energy.gov/cleancities/

- **A Guide to the Lessons Learned From the Clean Cities Community Electric Vehicle Readiness Projects—Clean Cities**

  http://www.afdc.energy.gov/uploads/publication/guide_ev_projects.pdf

Contact Information

Doug Kettles

Research Analyst

Electric Vehicle Transportation Center

1679 Clearlake Road

Cocoa, FL 32922

321-638-1527

dougkettles@fsec.ucf.edu

www.evsummit.org