SAE Ground Vehicle Standards
SmartGrid

08 November 2010

New era of mobility

Vehicle is now connected to the electrical grid

Vehicle is now part of the smart grid environment

Why Electric Vehicles?

- Reduced environmental impact
- Displace half of US oil imports
- Reduce CO_2 by 20%
- Reduce urban air pollutants 40%-90%
- Idle capacity of the power grid could supply 70% of energy needs of today’s cars and light trucks
- Batteries in EVs could provide power during peak demand

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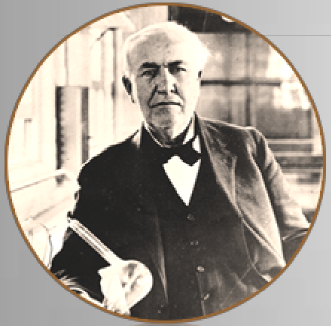
A look at today's Grid

- Today's electricity system is 99.97 percent reliable
  - still allows for power outages and interruptions
  - Cost = $150 billion each year



Since 1982, growth in peak demand for electricity driven by:
- population growth
- bigger houses
- bigger TVs
- more air conditioners
- more computers
- – has exceeded transmission growth by almost 25% every year

- **Economy has grown digital**
  - 1980s - electrical load from sensitive electronic equipment was limited
  - 1990s, chip share grew to roughly 10%.
  - Today, load from chip technologies has risen to 40%
  - By 2015 the load is expected to increase to more than 60% by 2015.

"The Smart Grid: "An Introduction" U.S. Dept. Of Energy

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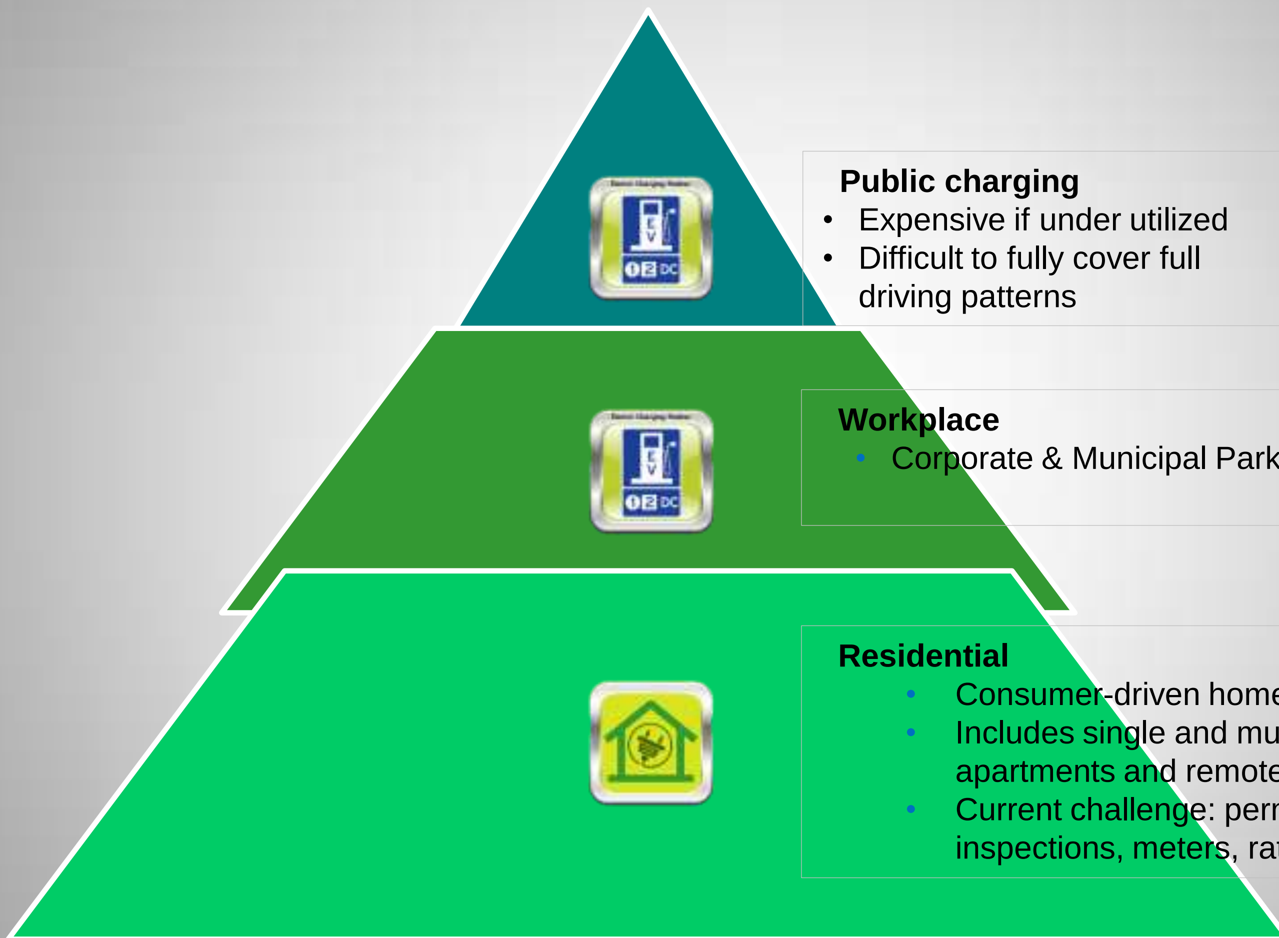
Charging Infrastructure



Public charging
- Expensive if under utilized
- Difficult to fully cover full driving patterns

Workplace
- Corporate & Municipal Parking

Residential
- Consumer-driven home installation process
- Includes single and multiple family homes, apartments and remote charge locations
- Current challenge: permits, electricians, inspections, meters, rates

Need market pull to determine public infrastructure build-out – PHEVs are key to help initiate market pull for public infrastructure

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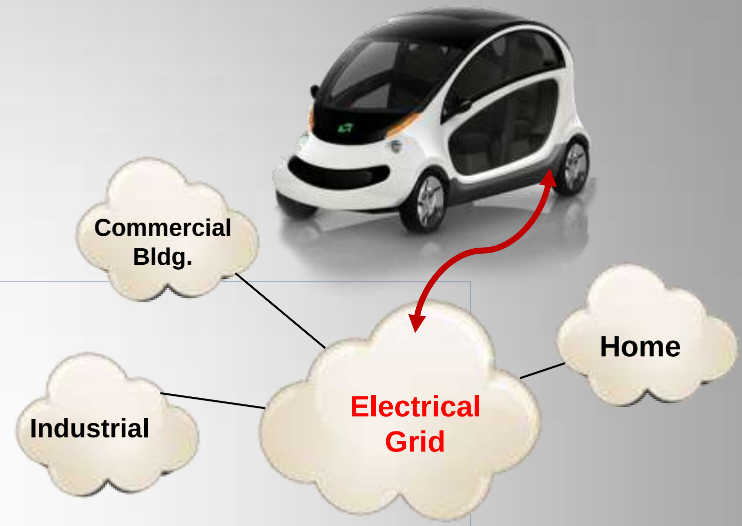
What’s at stake



- Reliability
- National Economy
- Efficiency
- Security
- Environment/Climate Change
- Global Competitiveness

Key pillars for success

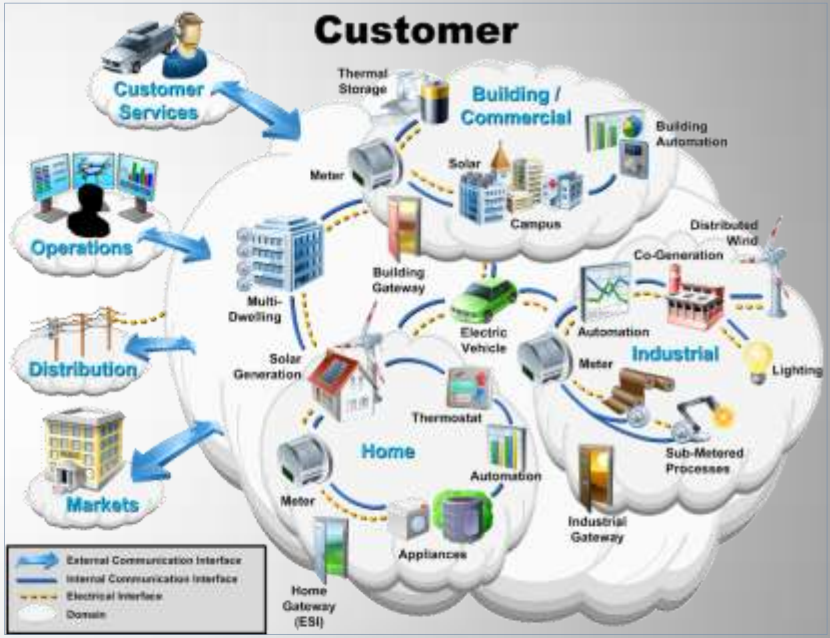
- Committed long-term policy environment by industry and government
- Infrastructure: recharging infrastructure for electrically chargeable vehicles
- Customer acceptance and market demand
- Reliable, durable, affordable, vehicles for a variety of customer needs
- Standardization: Common interfaces (e.g. vehicle - infrastructure)

SAE International

US Roadmap to Smart Grid

- *September 24, 2009 –*

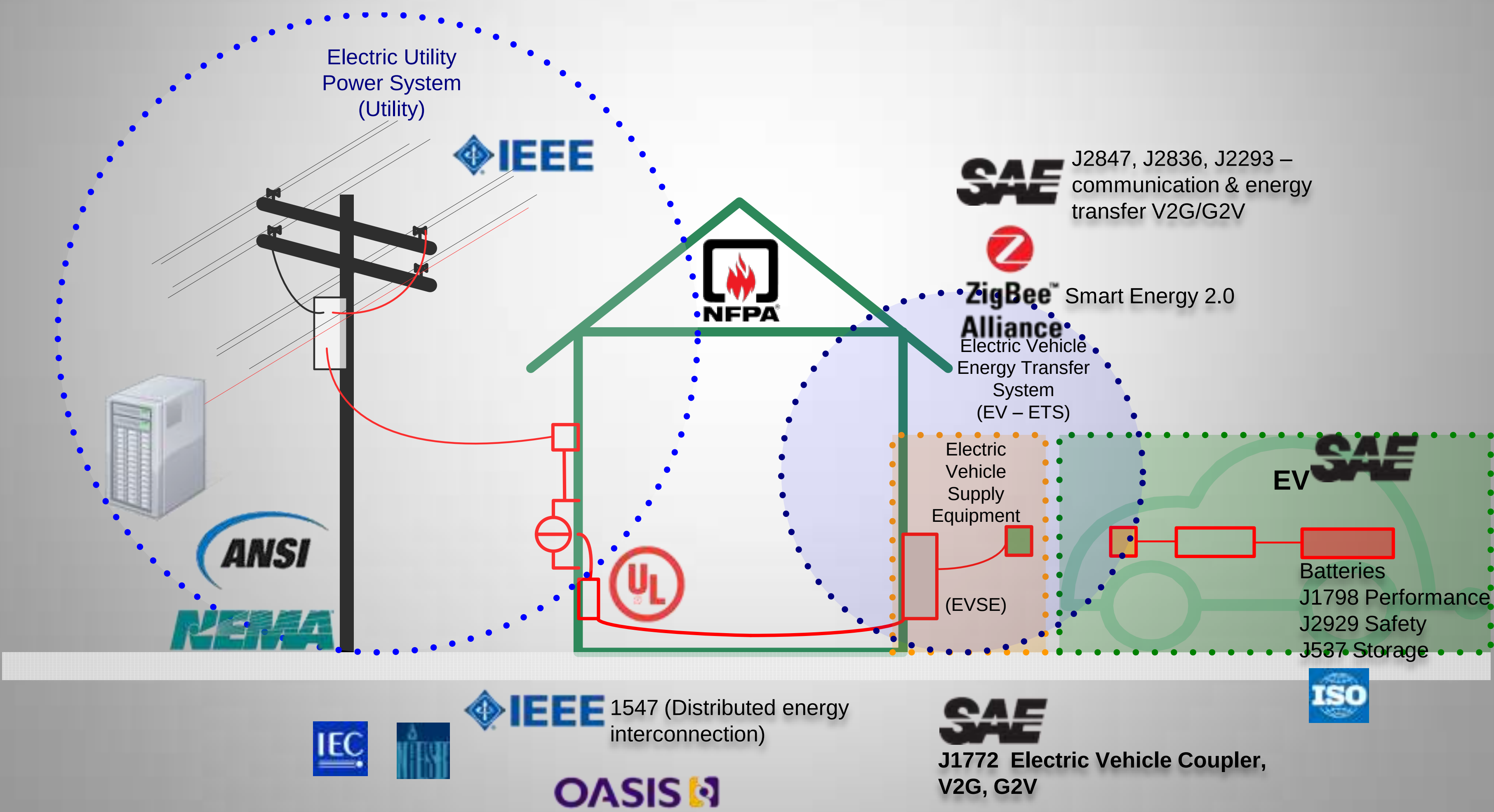
  US Commerce Secretary Gary Locke unveils an accelerated plan for developing standards to transform the U.S. power distribution system into a secure, more efficient and environmentally friendly Smart Grid
- 80 initial standards will support interoperability of all the various pieces of the system—ranging from large utility companies down to individual homes and electronic devices.
- Set of 14 “priority action plans” addresses the most important gaps in the initial standard set.
- SAE International identified as a leading standards organization identified in the Phase 1 NIST Framework and Roadmap for Smart Grid Interoperability Standards paragraph 5.13 for *"Interoperability Standards to Support Plug-In Electric Vehicles."*



•SAE – V2G communication, physical plug
•Zigbee – Home communications
•ANSI – Metering
•IEEE – Electric vehicle infrastructure
•NEMA/UL – Building and product

http://www.nist.gov/public_affairs/releases/smartgrid_interoperability_final.pdf

Simply connecting?



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SAE Ground Vehicle Standards Program

660
standards in-progress

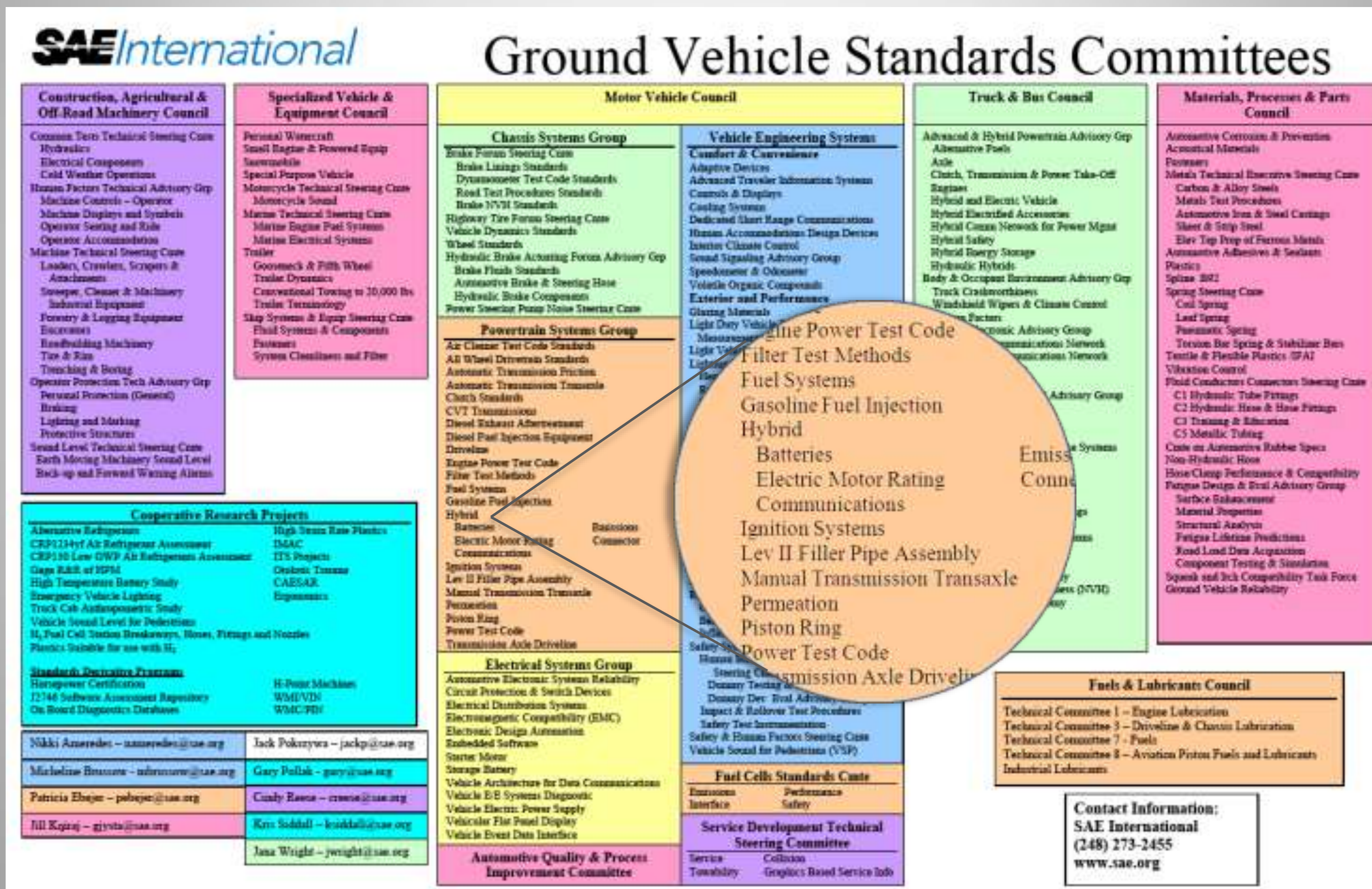
580 standards committees

8,100
committees members

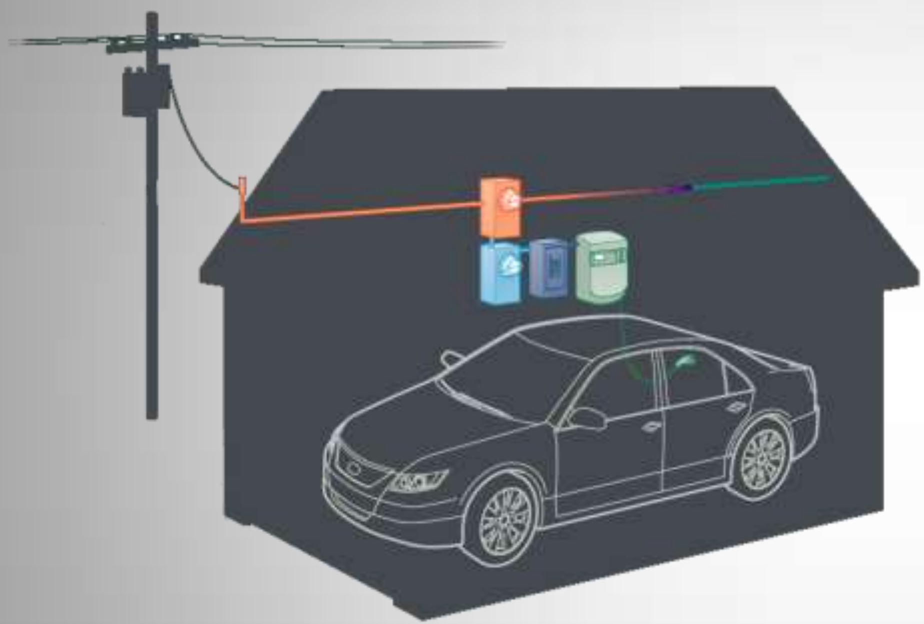
2,080
existing standards

6 Industry Councils

How SAE Standards help



Communication with grid – SAE standards



EV or PHEV require multitude of standards:
- Physical connectors
- Interfaces
- Power levels
- Battery standards
- Energy exchange protocols
- V2G communication protocols (between vehicles and the grid)

Interoperability standards are needed to ensure software and hardware components from different vendors will work together seamlessly

Graphics: "Electrification Roadmap" – Electrification Coalition

SAE International

V2G – Critical SAE Standards

SAE J	Title	Scope	Status
SAE J2847/1	Communication between Plug-in Vehicles and the Utility Grid	J2847/1 identifies the communication medium and criteria for the Plug-In Electric Vehicle (PEV) to connect to the utility for Level 1 & 2 AC energy transfer.	Published June, 2010
SAE J2847/2	Communication between Plug-in Vehicles and off-board DC Chargers	Identifies additional messages for DC energy transfer to the PEV. The specification supports DC energy transfer via Forward Power Flow (FPF) from grid-to-vehicle.	WIP
SAE J2847/3	Communication between Plug-in Vehicles and the Utility Grid for Reverse Power Flow	Identifies additional messages for DC energy transfer to the PEV. The specification supports DC energy transfer via DC Reverse Power Flow (RPF) from vehicle-to-grid.	WIP
SAE J2847/4	Diagnostic Communication for Plug-in Vehicles	Establishes the communication requirements for diagnostics between plug-in electric vehicles and the EV Supply Equipment (EVSE) for charge or discharge sessions.	WIP
SAE J2847/5	Communication between Plug-in Vehicles and their customers	Establishes communication requirements between (*all vehicles*) Plug-in Vehicles and the internet	WIP

SAE International

V2G – Critical SAE Standards

SAE J	Title	Scope	Status
SAE J2836/1	Use Cases for Communication Between Plug-in Vehicles and the Utility Grid	Identifies the equipment (system elements) and interactions to support grid-optimized AC or DC energy transfer for plug-in vehicles, as described in SAE J2847/1. Key system elements include the vehicle's rechargeable energy storage system (RESS), power conversion equipment (charger and/or inverter), utility meter, etc.	Published April, 2010
SAE J2836/2	Use Cases for Communication between Plug-in Vehicles and the Supply Equipment (EVSE)	J2836/2 establishes use cases for communication between plug-in electric vehicles and the off-board charger, for energy transfer and other applications. J2836/2 use cases must be supported by SAE J2847/2.	WIP
SAE J2836/3	Use Cases for Communication between Plug-in Vehicles and the Utility Grid for Reverse Power Flow	Establishes use cases for communication between plug-in electric vehicles and public electric power grid, a home branch circuit or a isolated micro grid, for reverse energy transfer and other applications.	WIP
SAE J2836/4	Use Cases for Diagnostic Communication for Plug-in Vehicles	Provides information required for diagnostics and J2847/4 will include the detail messages to provide accurate information to the customer and/or service personnel to identify the source of the issue and assist in resolution	WIP
SAE J2836/5	Use Cases for Communication between Plug-in Vehicles and their customers.	Describes how the customer will be able to interact with the PEV as it charges/discharges. Identifies information and control for each session, including status, updates and potential changes	WIP

SAE International

V2G – Critical SAE Standards

SAE J	Title	Scope	Status
SAE J2931	Electric Vehicle Supply Equipment (EVSE) Communication Model	This SAE Recommended Practice J2931establishes the digital communication requirements for the Electric Vehicle Supply Equipment (EVSE) as it interfaces with a Home Area Network (HAN), Energy Management System (EMS) or the Utility grid systems. This Recommended Practice provides a knowledge base addressing the communication medium functional performance and characteristics, and interoperability to other EVSEs, Plug-In Vehicles (PEVs) and is intended to complement J1772™ but address the digital communication requirements associated with smart grid interoperability.	WIP
SAE J2931/2	Inband Signaling Communication for Plug-in Electric Vehicles	This SAE Recommended Practice J2931/2 establishes the requirements for physical layer communications using Inband Signaling between Plug-In Vehicles (PEV) and the EVSE. This also enables the onward communications via an EVSE bridging device to the utility smart meter or Home Area Network (HAN). This is known as Frequency Shift Keying (FSK) and is similar to Power Line Carrier (PLC) but utilizes the J1772" Control Pilot circuit.	WIP
SAE J2953 **NEW!**	Plug-In Electric Vehicle (PEV) Interoperability with Electric Vehicle Supply Equipment (EVSE)	Plug-In Vehicle (PEV) and EVSE digital communication is required to insure the customer is able to roam and connector any PEV to any EVSE for these additional features. This market will continue to expand and change, and the customers need to connect and charge any PEV with any EVSE using their preferred communication medium and still interface with the local utility.	WIP

SAE International

V2G – Critical SAE Standards

SAE J	Title	Scope	Status
SAE J2293/1	Energy Transfer System for Electric Vehicles--Part 1: Functional Requirements and System Architectures	This document describes the total EV-ETS (Energy Transfer System) and allocates requirements to the EV or EVSE for the various system architectures. It requires an SAE J1850-compliant network for communicating data and control information between an EV and EVSE.	Published July, 2008
SAE J2293/2	Energy Transfer System for Electric Vehicles--Part 2: Functional Requirements and System Architectures	This document describes the SAE J1850-compliant communication network between the EV and EVSE for this application (ETS Network). It treats the network as a system with the EV and EVSE from Part 1 as external elements using the network.	Published July, 2008
SAE JJ2758	Determination of the Maximum Available Power from a Rechargeable Energy Storage System on a Hybrid Electric Vehicle	This document describes a test procedure for rating peak power of the Rechargeable Energy Storage System (RESS) used in a combustion engine Hybrid Electric Vehicle (HEV).	Published April, 2007
SAE J2344	Guidelines for Electric Vehicle Safety	Technical guidelines relating to safety for Electric Vehicles (EVs) during normal operation and charging that should be considered when designing electric vehicles for use on public roadways. This document covers electric vehicles having a gross vehicle weight rating of 4536 kg (10 000 lb) or less that are designed for use on public roads.	Published March, 2010

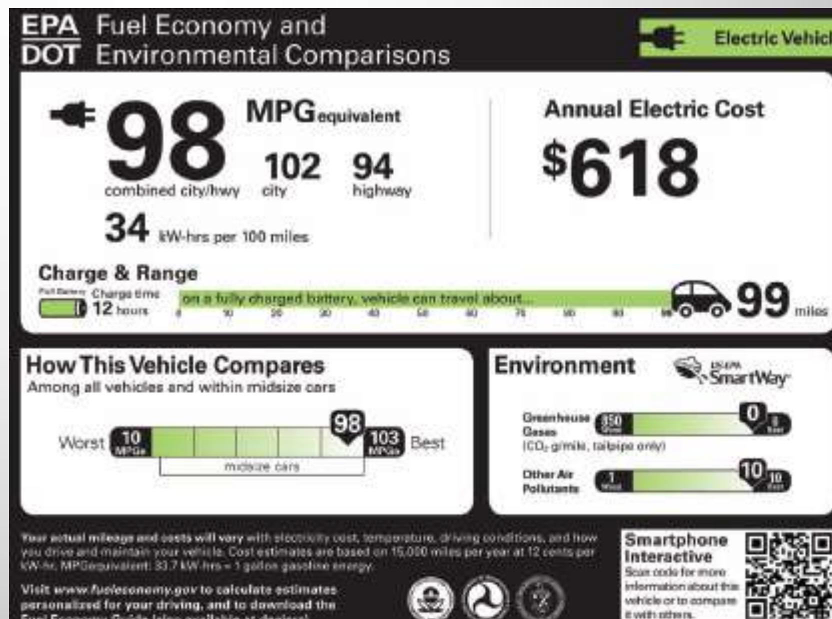
SAE International

V2G – Critical SAE Standards

SAE J	Title	Scope	Status
SAE J1711 **NEW!**	Recommended Practice for Measuring the Exhaust Emissions and Fuel Economy of Hybrid-Electric Vehicles	Sets recommended practices for measuring the Exhaust Emissions and Fuel Economy of Hybrid-Electric Vehicles, Including Plug-in Hybrid Vehicles. It provides foundation to assist government regulatory agencies in developing emissions and fuel economy certification and compliance tests for HEVs.	Published June, 2010
SAE J2841	Definition of the Utility Factor for Plug-In Hybrid Electric Vehicles Using NHTS Data *NHTS: National Household Travel Survey Data*	The total fuel and energy consumption rates of a Plug-In Hybrid Electric Vehicle (PHEV) vary depending upon the distance driven. Total distance between charge events determines how much of the driving is performed in each of the two fundamental modes. An equation describing the portion of driving in each mode is defined.	WIP

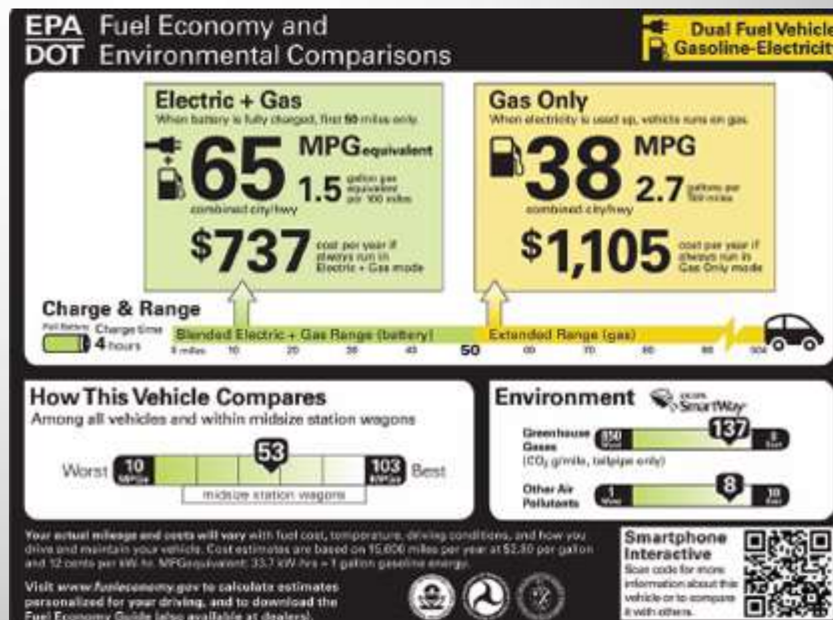
Proposed EPA fuel economy labels

EV



Proposed EPA fuel economy labels

PHEV



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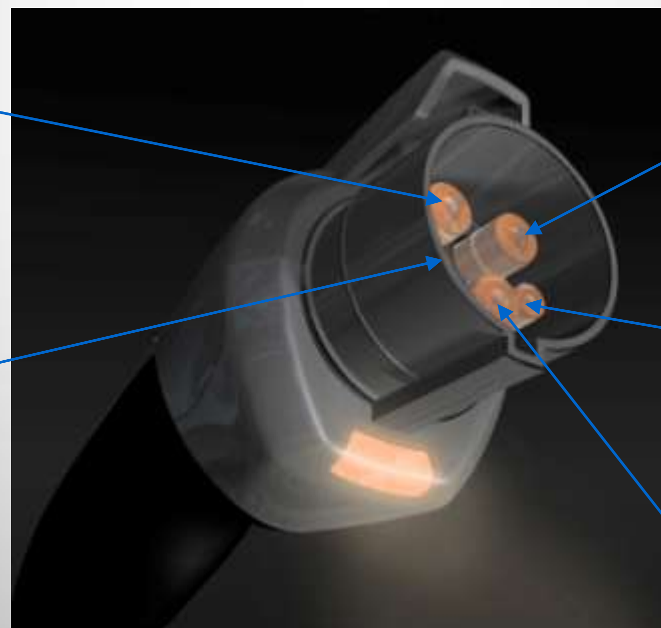
Vehicle 2 Grid SAE Connector

SAE J	Title	Scope	Status
SAE J1772™ **NEW!**	SAE Electric Vehicle Conductive Charge Coupler	General requirements for the electric vehicle conductive charge system and coupler for use in North America. Define a common electric vehicle conductive charging system architecture including operational requirements and the functional and dimensional requirements for the vehicle inlet and mating connector.	Published January, 2010

The ac Line 1 power pin of the coupler connects the vehicle inlet for 120- to 240-V ac single-phase nominal supply voltage with maximum current

The coupler's proximity detection pin (just barely viewable in this illustration) prevents the car from being intentionally
moved while connected



The ac Line 2 or neutral pin of the coupler is the return for the vehicle inlet for 120-to 240-V ac single-phase nominal supply voltage with maximum current (continuous) of up to 80 A and a branch circuit breaker rating (minimum) per NEC 625

The coupler's control pilot pin connects to the vehicle inlet's control pilot to verify such things as vehicle connection, readiness of equipment to supply and of vehicle to accept energy, indoor ventilation, equipment current capacity, and equipment grounding continuity

The coupler's ground pin connects the current-supply equipment with the chassis ground on the vehicle inlet

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SAE Charging Configurations and Ratings Terminology

AC level 1 (SAE J1772™)	PEV includes on-board charger	***DC Level 1**	EVSE includes an off-board charger
	120V, 1.4 kW @ 12 amp 120V, 1.9 kW @ 16 amp		200-450 V DC, up to 20 kW (80 A)
	Est. charge time:		Est. charge time (20 kW off-board charger):
	PHEV: 7hrs (SOC* - 0% to full)		PHEV: 22 min. (SOC* - 0% to 80%)
	BEV: 17hrs (SOC – 20% to full)		BEV: 1.2 hrs. (SOC – 20% to 100%)
AC level 2 (SAE J1772™)	PEV includes on-board charger (see below for different types)	***DC Level 2**	EVSE includes an off-board charger
	240 V, up to 19.2 kW (80 A)		200-450 V DC, up to 80 kW (200 A)
	Est. charge time for 3.3 kW on-board charger		Est. charge time (45 kW off-board charger):
	PEV: 3 hrs (SOC* - 0% to full)		PHEV: 10 min. (SOC* - 0% to 80%)
	BEV: 7 hrs (SOC – 20% to full)		BEV: 20 min. (SOC – 20% to 80%)
	Est. charge time for 7 kW on-board charger		
	PEV: 1.5 hrs (SOC* - 0% to full)	***DC Level 3 (TBD)**	EVSE includes an off-board charger
	BEV: 3.5 hrs (SOC – 20% to full)		200-600V DC (proposed) up to 200 kW (400 A)
	Est. charge time for 20 kW on-board charger		Est. charge time (45 kW off-board charger):
	PEV: 22 min. (SOC* - 0% to full)		BEV (only): <10 min. (SOC* - 0% to 80%)
	BEV: 1.2 hrs (SOC – 20% to full)		
***AC Level 3** (TBD)	> 20 kW, single phase and 3 phase		

*Not finalized
Voltages are nominal configuration voltages, not coupler ratings
Rated Power is at nominal configuration operating voltage and coupler rated current
Ideal charge times assume 90% efficient chargers, 150W to 12V loads and no balancing of Traction Battery Pack

Notes:
1) BEV (25 kWh usable pack size) charging always starts at 20% SOC, faster than a 1C rate (total capacity charged in one hour) will also stop at 80% SOC instead of 100%
2) PHEV can start from 0% SOC since the hybrid mode is available.

ver. 080110

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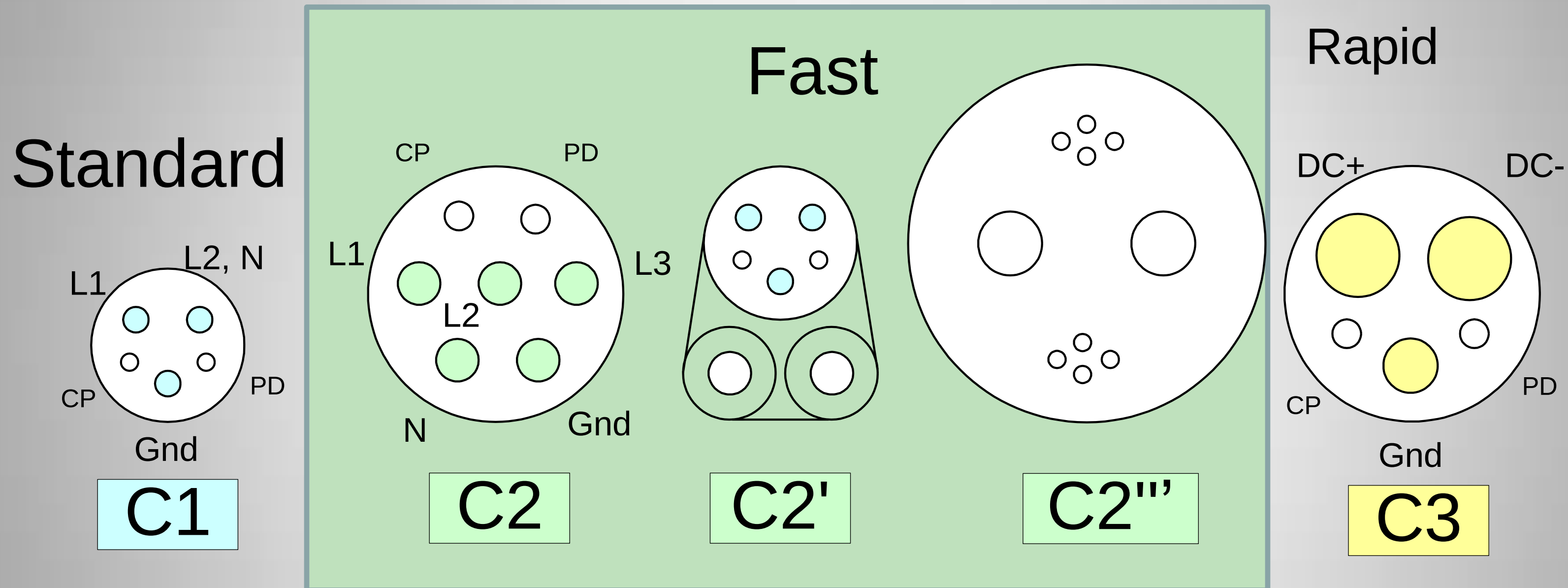
Which: AC or DC – that is a question?



33mm (1.3 inches)

51mm Mennekes (2.0 inches)

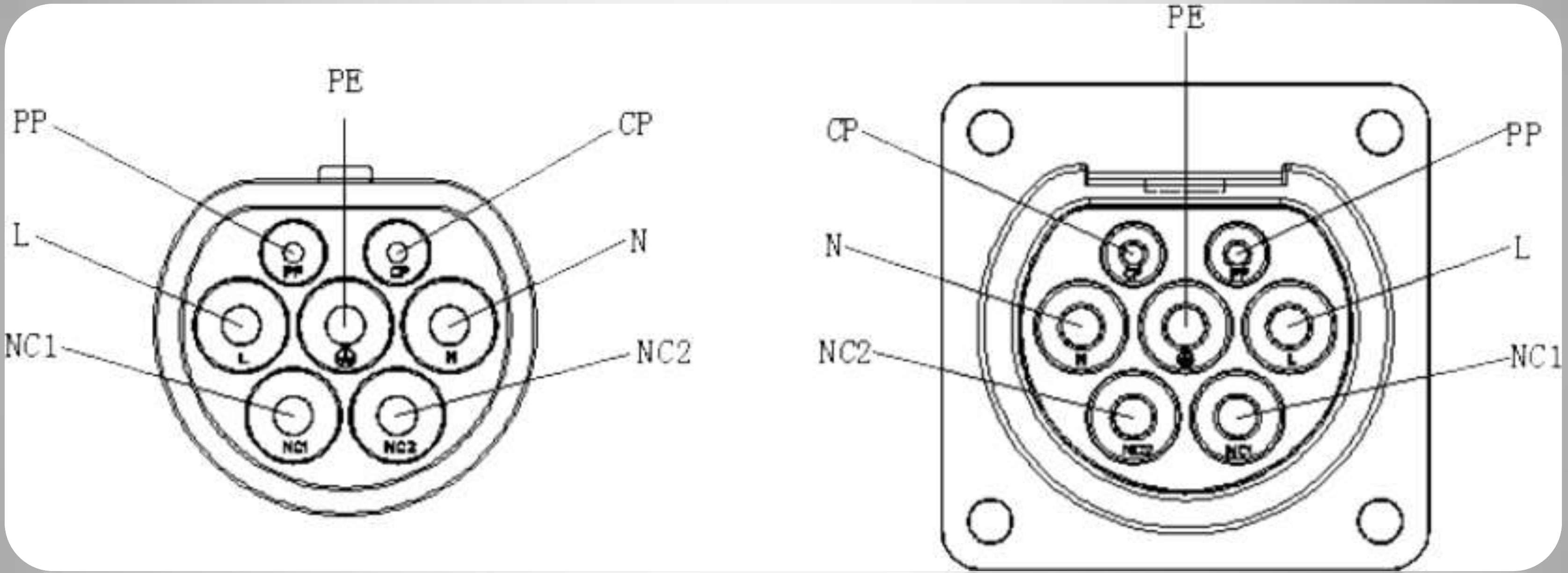
50mm Combo (2.00 inches)

70mm Tepco (2.75 inches)

58mm AV (2.3 inches)

- Fast connector is still being debated.
  - SAE is proposing C2' as it accepts the Std plus Fast connectors from the EVSE
  - ISO/IEC has included the Std plus C2 (Mennekes) and an Italian proposal for small EVs.

China Charge Coupler - AC



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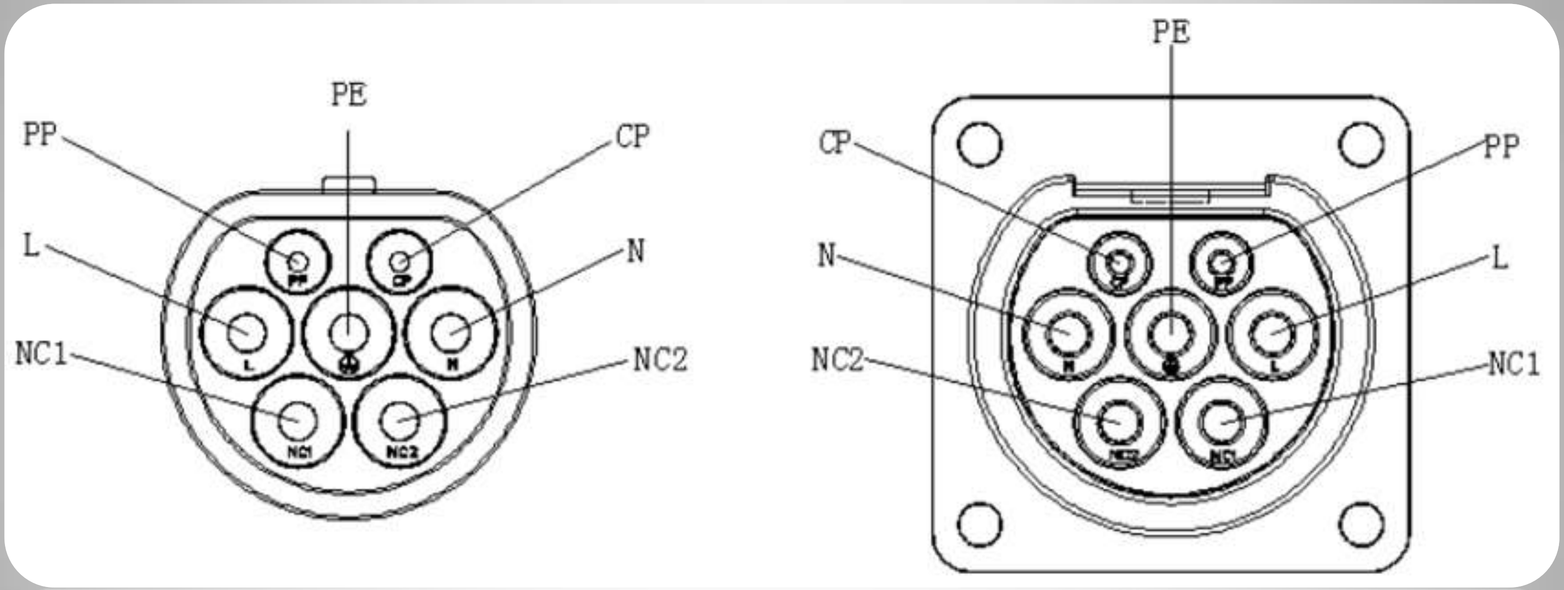
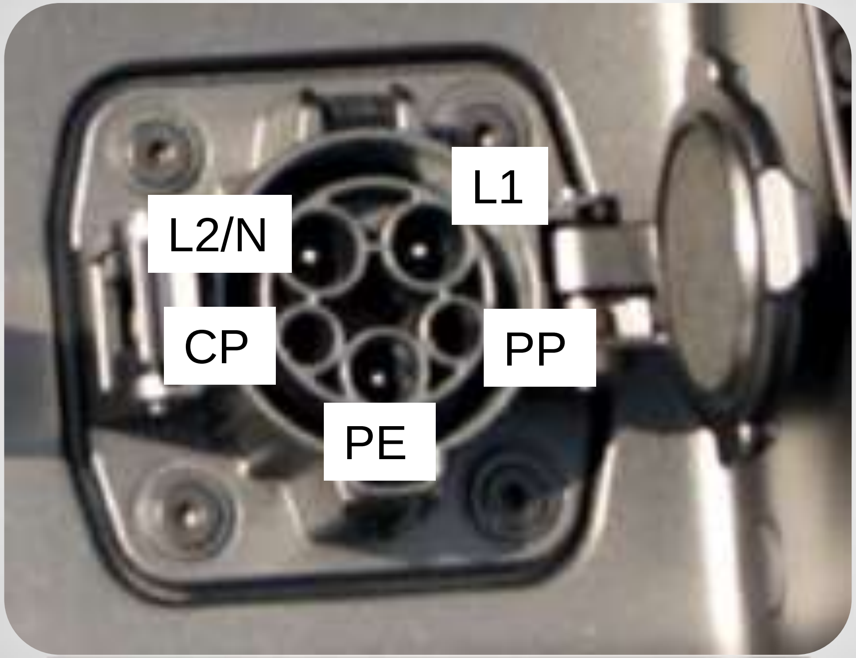
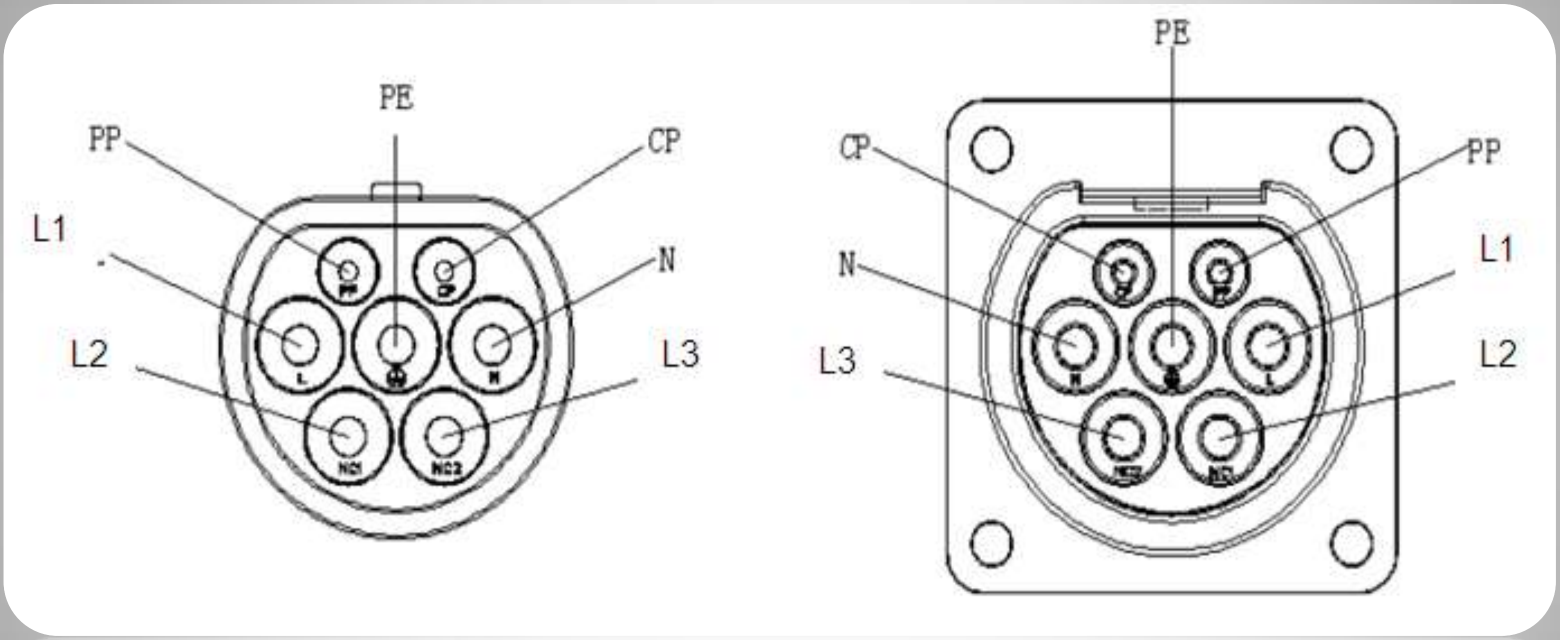
China Charge Coupler - DC



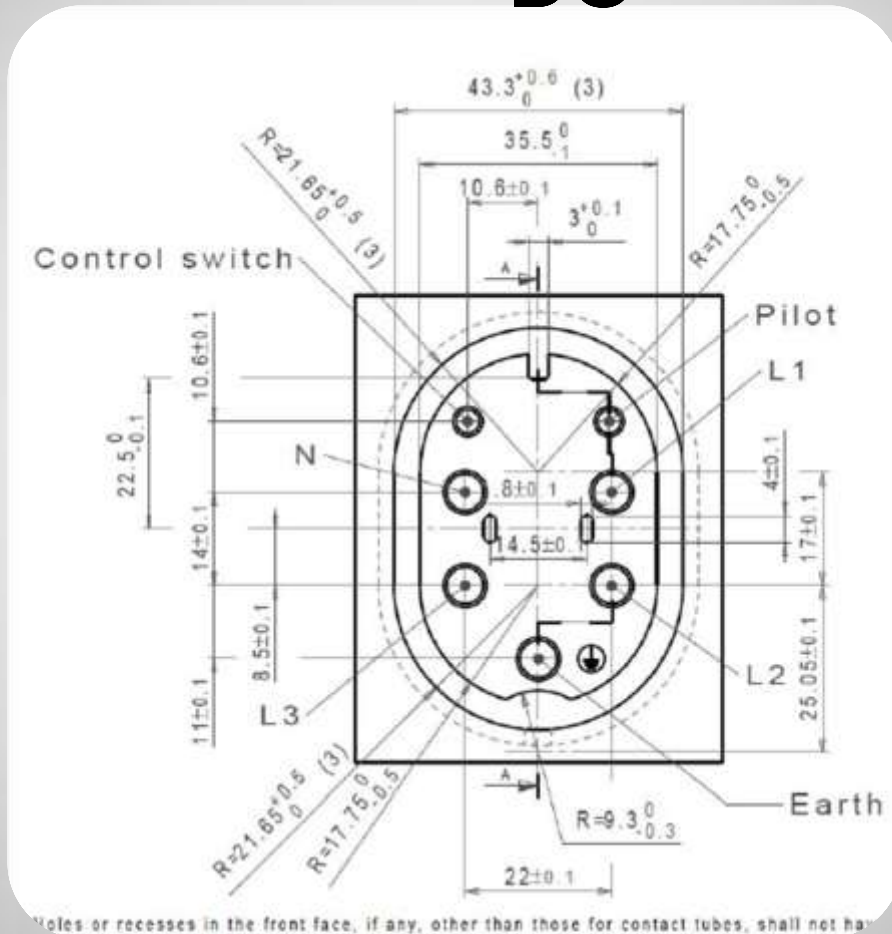
Current state
EU Type 1 (SAE J1772) Charge Coupler - **AC**



Current state
EU Type 2 Charge Coupler – **AC**



Current state:
EU Type 3 Charge Coupler – **DC**



Current state: German proposal

Car manufacturers support integrated standard for a modular connector system for electric vehicle charging

INGOLSTADT, Germany, Sep 16, 2010 - Car manufacturers Audi, BMW, Daimler, Porsche and Volkswagen commonly support a modular connector system for electric vehicle charging. A globally integrated standard is to ensure that customers always have direct and easy access to the energy grid, independent of vehicle brand and supplier of electric energy. The company development directors have decided to conceptualize a modular connector system made from two parts: The core of the connector system has been submitted for standardization under the designation IEC 62196-2 Type 2 for single- up to three-phase charging with alternating current (AC). An extension for direct current (DC) is currently being developed.

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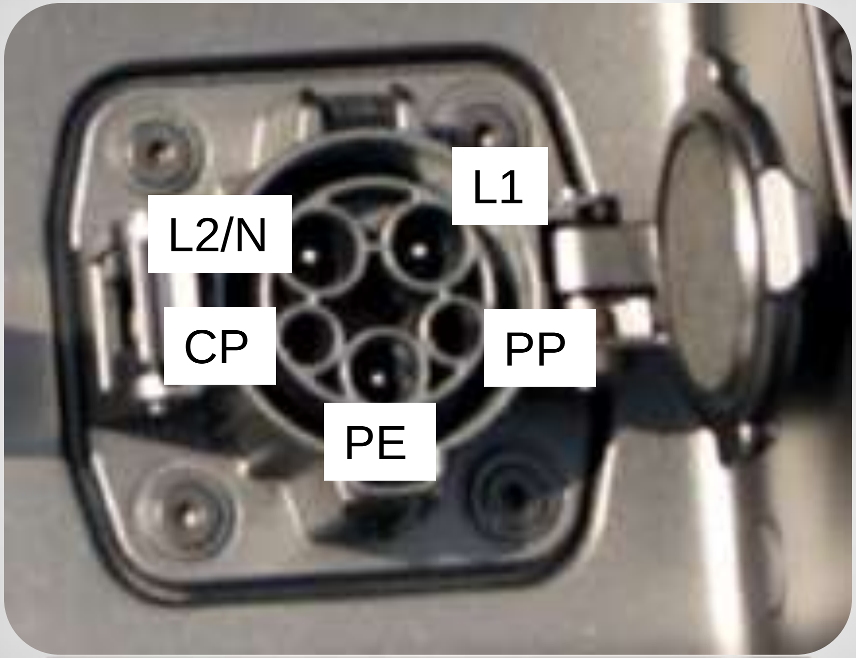
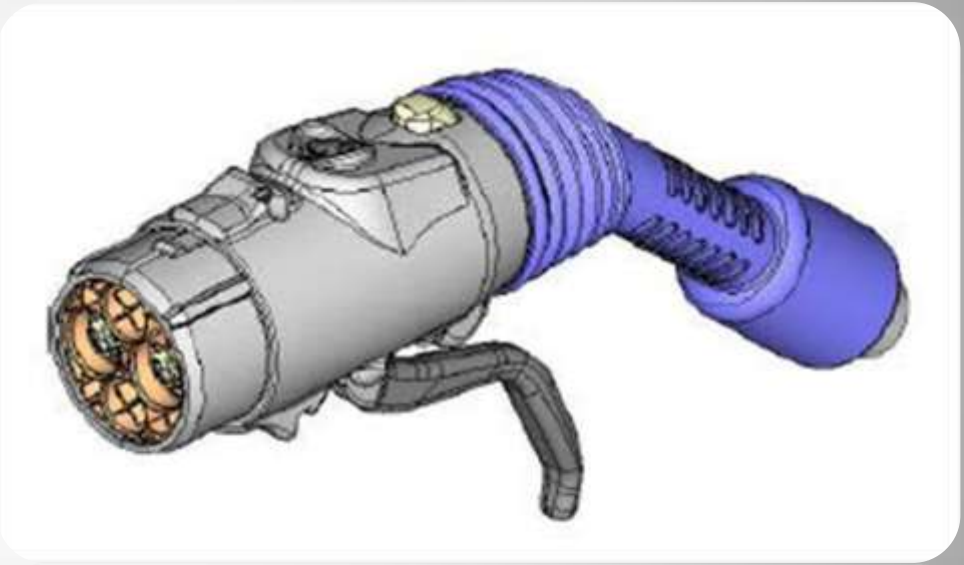
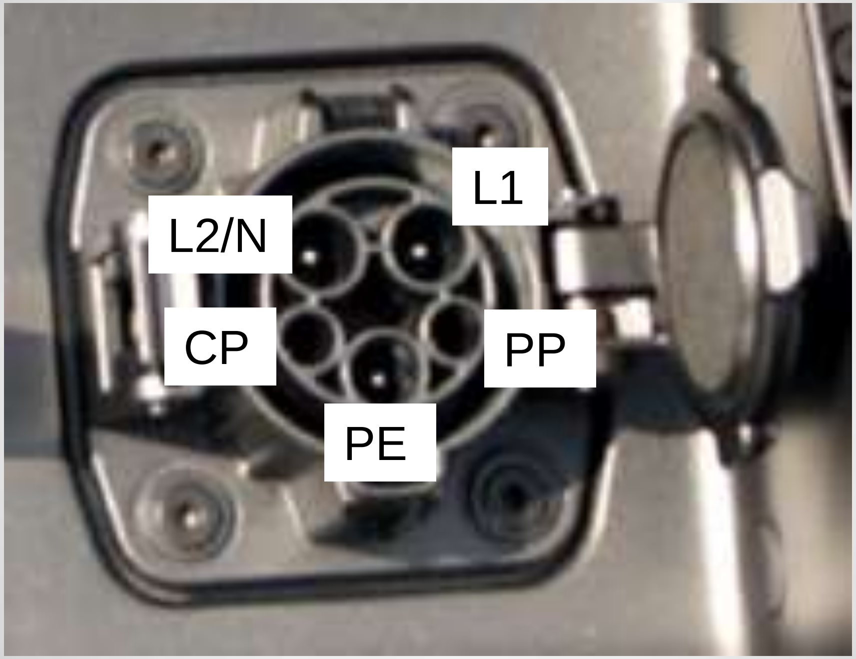
Japan (SAE J1772) Charge Coupler- AC



Japan Charge Coupler - DC



US (SAE J1772) Charge Coupler - AC



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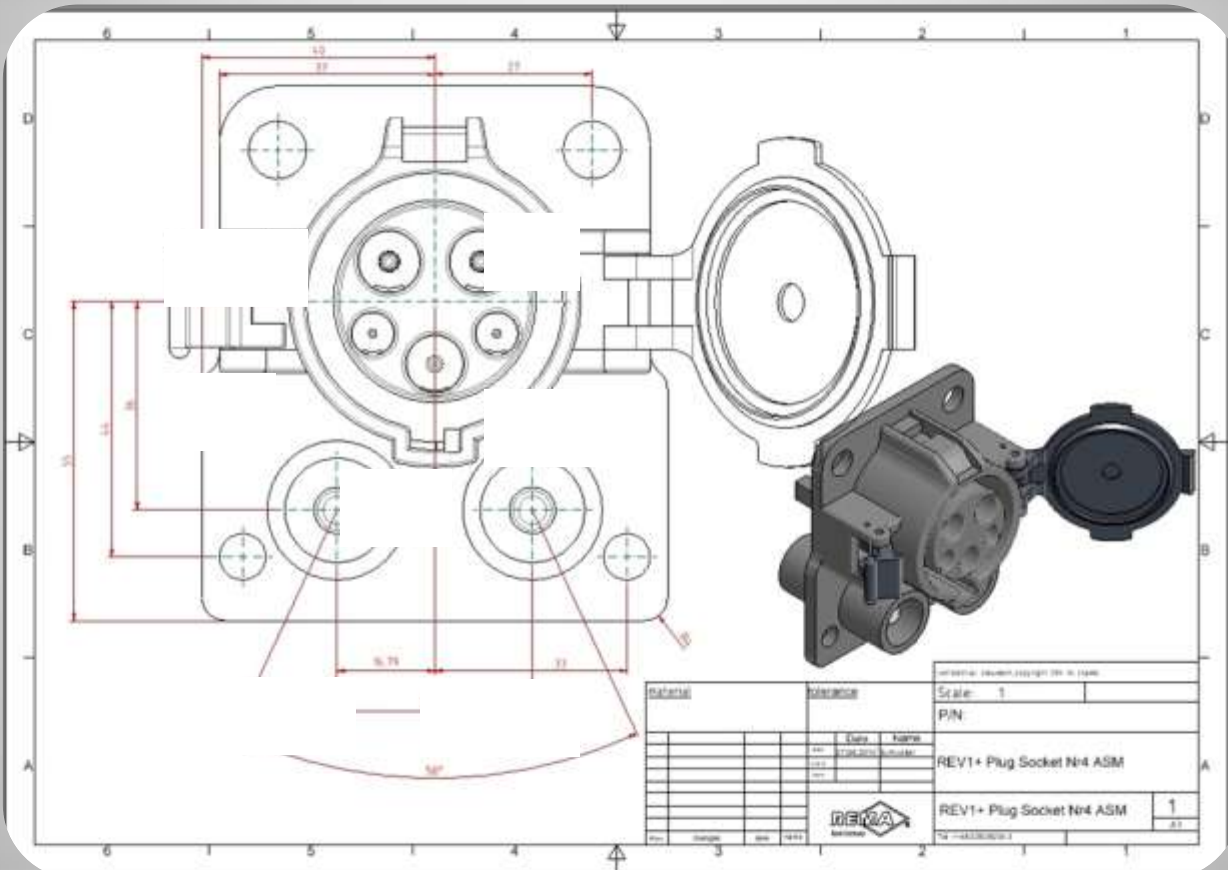
US “Hybrid” Charge Coupler – AC/DC (under study)



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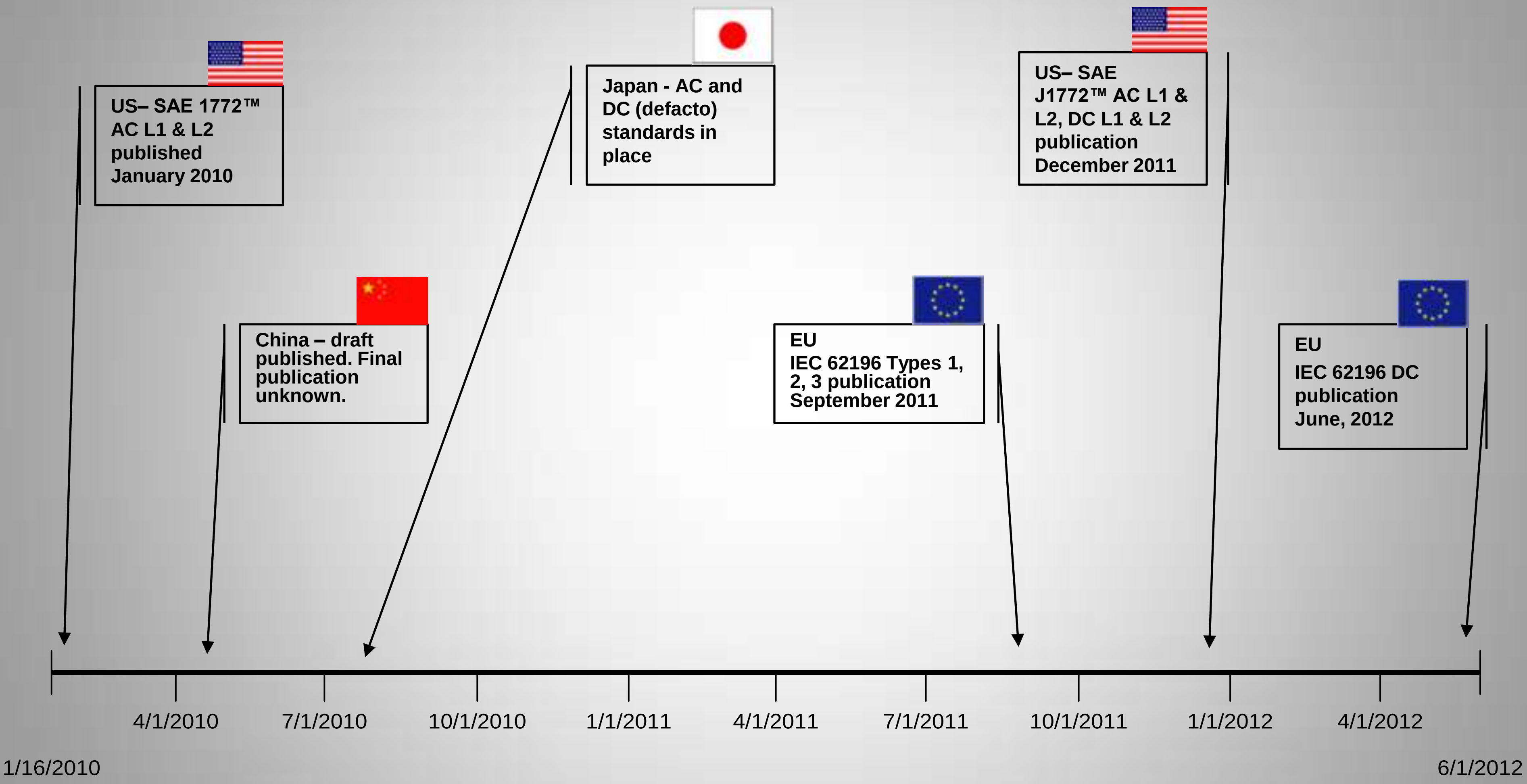
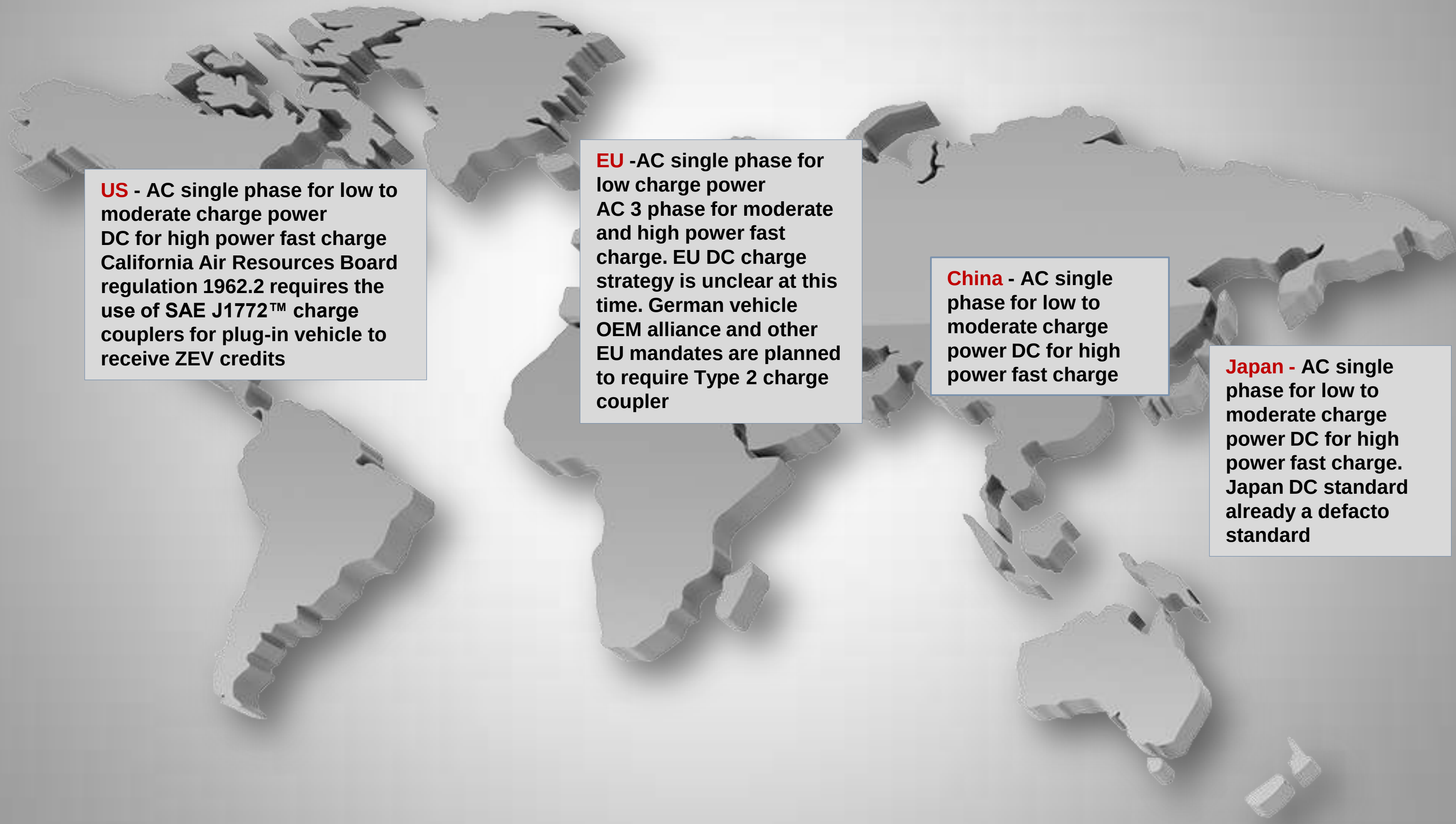
(Charger) Standards Timing



Regional charge strategies and Harmonization potential



US - AC single phase for low to moderate charge power
DC for high power fast charge
California Air Resources Board regulation 1962.2 requires the use of SAE J1772™ charge couplers for plug-in vehicle to receive ZEV credits

EU -AC single phase for low charge power
AC 3 phase for moderate and high power fast charge. EU DC charge strategy is unclear at this time. German vehicle OEM alliance and other EU mandates are planned to require Type 2 charge coupler

China - AC single phase for low to moderate charge power DC for high power fast charge

Japan - AC single phase for low to moderate charge power DC for high power fast charge. Japan DC standard already a defacto standard

SAE International

Harmonization – current status

- Helps to expedite the global acceptance of electrified vehicles
  - Helps vehicle OEMs to develop common global components
  - Common global infrastructure. Customer charging experience the same globally, similar to fueling a vehicle with gasoline
- Regions with similar charge strategies have the most potential to harmonize
- AC charge strategy of China, Japan and US are very similar

Harmonization – what if we don’t?

- Vehicle OEMs need to package different charge receptacles and have different vehicle controls
- Number of vehicle sheet metal openings for are different for different regions
- Infrastructure cannot be shared
- Costs are higher (vehicle and infrastructure) with no benefit to customers

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Harmonization – current challenges

- US desire for single charge receptacle combining AC and DC charging not consistent with China and Japan strategies
- Japan de-facto standard already in place
- Proposed communications and control of DC charger are unique between China, Japan and US

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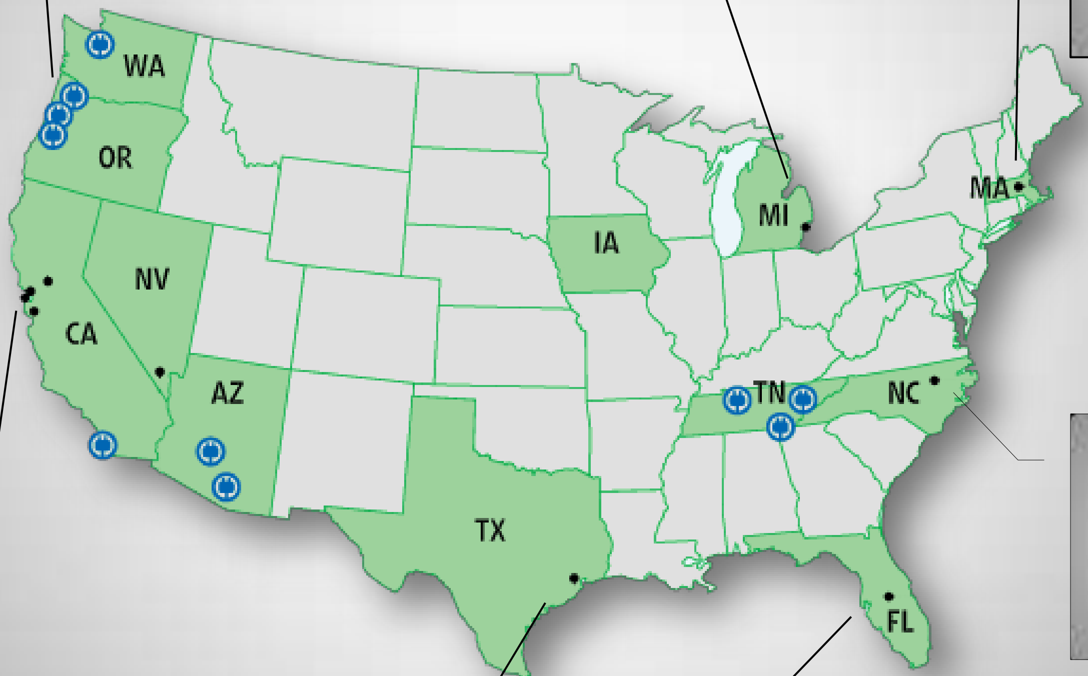
Implementation – current projects

11,000 charging stations deployed in 5 states: WA, OR, CA, AZ, TN

Coulomb Technologies testing 6 charging stations in Ann Arbor and Detroit

State of Massachusetts developing plans for home, workplace and public charging



San Francisco, San Jose, Oakland – partnership with Better Place to install charging stations throughout the city

Reliant Energy and Nissan partnering with City of Houston to install charging stations

City of Orlando, Nissan and Orlando Utilities Commission promotional project

Municipality of Raleigh, Nissan and Progress Energy creating local infrastructure for charging EVs – Project “Get Ready”

It's coming…

Electric vehicle charging station next to a Shell station, Lake Oswego, Oregon

546 charging points planned in Madrid, Barcelona and Seville using existing phone booths

Paris launches online map of EV charging stations

The city of San Francisco is installing three EV charging stations across the street from city hall
as part of a two-year pilot project to promote electric vehicle use.

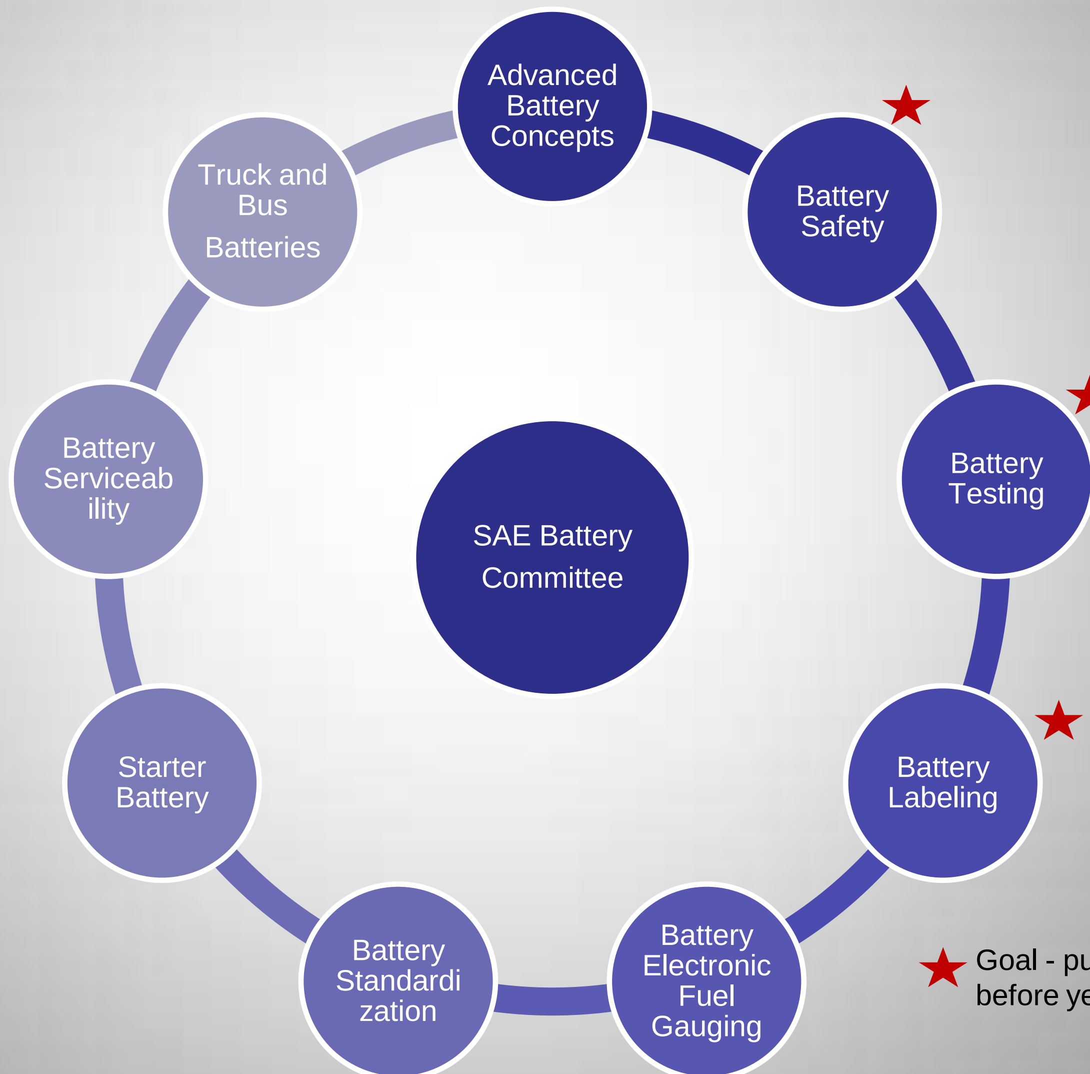
Vehicle Battery Standards Committee

Scope

"One solution in reducing carbon footprint is via the electrification of the transportation sector. It is this emphasis of electrification that is driving the need for higher energy and power density batteries for storing energy whether for traction drive or handling auxiliary loads. With these higher energy and power storage devices comes new technology challenges which must be addressed. These new challenges, along with maintaining the past and present battery technology standards, is the essence of this newly formed Battery Standards Committee."

Vehicle Battery Standards Committee

Started – November 2009
Current Membership - 70+
Representatives from all major OEM's, Suppliers, Government and Academia



Task Force groups have an aggressive meeting agenda with each meeting twice per month.

★ Goal - published documents before year end 2010.

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Batteries – Critical SAE Standards

SAE J	Title	Scope	Status
SAE J1798	Recommended Practice for Performance Rating of Electric Vehicle Battery Modules (Revision)	Common test and verification methods to determine Electric Vehicle battery module performance. The document creates the necessary performance standards to determine (a) what the basic performance of EV battery modules is; and (b) whether battery modules meet minimum performance specification established by vehicle manufacturers or other purchasers.	WIP
SAE J537	Storage Batteries (Revision)	This SAE Standard serves as a guide for testing procedures of automotive 12 V storage batteries and as a publication providing information on container holddown configuration and terminal geometry.	WIP
SAE J2936	Vehicle Battery Labeling Guidelines (New)	This document provides labeling guidelines for any energy storage device labeling (such as: including cell, battery and pack level products) used in mobility applications. Every attempt is made to cover information useful during the entire life spectrum of the product.	WIP
SAE J2929	Electric and Hybrid Vehicle Propulsion Battery System Safety Standard (New)	Minimum set of acceptable safety performance criteria for a battery system to be considered for use in a vehicle propulsion application as an energy storage system galvanically connected to a high voltage power train.	WIP
SAE J2758	Determination of the Maximum Available Power from a Rechargeable Energy Storage System on a Hybrid Electric Vehicle	This document describes a test procedure for rating peak power of the Rechargeable Energy Storage System (RESS) used in a combustion engine Hybrid Electric Vehicle (HEV).	WIP
SAE J2946	Battery Electronic Fuel Gauging Recommended Practices	Sets definition, collection, storage and transfer of quantitative information within the battery control system. Applies to any battery, regardless of cell chemistry, cell construction, pack configuration, or control strategy.	WIP

Batteries – Critical SAE Standards

SAE J	Title	Scope	Status
SAE J2380	Vibration Testing of Electric Vehicle Batteries	Describes the vibration durability testing of a single battery (test unit) consisting of either an electric vehicle battery module or an electric vehicle battery pack. For statistical purposes, multiple samples would normally be subjected to such testing	Published March, 2009
SAE J2464	Electric Vehicle Battery Abuse Testing	A guide toward standard practice and is subject to change to keep pace with experience and technical advances. It describes a body of tests which may be used as needed for abuse testing of electric or hybrid electric vehicle batteries to determine the response of such batteries to conditions or events which are beyond their normal operating range.	Published Nov., 2009
SAE J1797	Recommended Practice for Packaging of Electric Vehicle Battery Modules	Provides for common battery designs through the description of dimensions, termination, retention, venting system, and other features required in an electric vehicle application. The document does not provide for performance standards. Performance is addressed by SAE J1798. This document does provide for guidelines in proper packaging of battery modules to meet performance criteria detailed in J1766.	Published June 2008
SAE J1798	Recommended Practice for Performance Rating of Electric Vehicle Battery Modules	Provides for common test and verification methods to determine Electric Vehicle battery module performance. The document creates the necessary performance standards to determine (a) what the basic performance of EV battery modules is; and (b) whether battery modules meet minimum performance specification established by vehicle manufacturers or other purchasers.	Published July, 2008

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Batteries – Critical SAE Standards

SAE J	Title	Scope	Status
SAE J2288	Life Cycle Testing of Electric Vehicle Battery Modules	Defines a standardized test method to determine the expected service life, in cycles, of electric vehicle battery modules. It is based on a set of nominal or baseline operating conditions in order to characterize the expected degradation in electrical performance as a function of life and to identify relevant failure mechanisms where possible	Published June 2008
SAE J2289	Electric-Drive Battery Pack System: Functional Guidelines	Describes common practices for design of battery systems for vehicles that utilize a rechargeable battery to provide or recover all or some traction energy for an electric drive system. It includes product description, physical requirements, electrical requirements, environmental requirements, safety requirements, storage and shipment characteristics, and labeling requirements.	Published July 2008
SAE J551/5	Performance Levels and Methods of Measurement of Magnetic and Electric Field Strength from Electric Vehicles, Broadband, 9 kHz To 30 MHz	The test procedures and performance levels in this SAE Recommended Practice cover the measurement of magnetic and electric field strengths over the frequency range 9 kHz to 30 MHz and conducted emissions over the frequency range of 450 kHz to 30 MHz1.	Published Jan., 2004
SAE J1113	Electromagnetic Compatibility—Component Test Procedure - Part 42 - Conducted Transient Emissions	Defines a component-level test procedure to evaluate automotive electrical and electronic components for Conducted Emissions of transients, and for other electromagnetic disturbances, along battery feed (B+) or switched ignition inputs of a Device Under Test (DUT). Test apparatus specifications outlined in this procedure were developed for components installed in the 12-V passenger cars, light trucks, 12 V heavy-duty trucks, and vehicles with 24 V systems.	Published October, 2006

SAE International

SAE Contact

Jack Pokrzywa
SAE International
755 West Big Beaver, Suite 1600
Troy, MI 48084
USA
Tel. +1(248)273-2460
Fax +1(248)273-2484
Email: jackp@sae.org