

VEHICLE TECHNOLOGIES PROGRAM

U.S. DEPARTMENT OF
ENERGY | Energy Efficiency &
Renewable Energy



PEV Connectivity Standards ... *Global Perspective*

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Support SDOs refine and validate connectivity standards between key elements of the charging infrastructure

1) Utility/Grid Operator

- Distributes power to community grid
- Integrates vehicles in smart grid (load balancing, automated demand response, etc.)

2) Home Energy Management/Home Area Network (HAN)

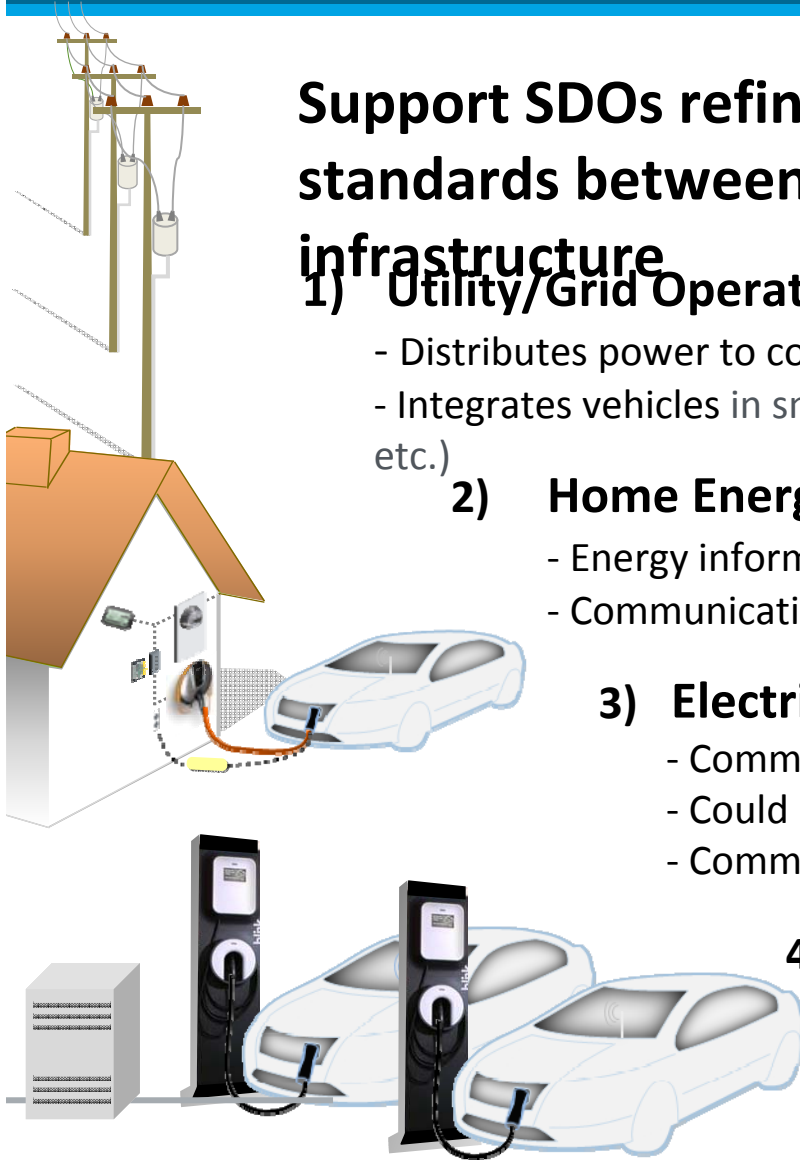
- Energy information portal; gateway for demand reduction settings
- Communication between smart meter and EVSE/vehicle/consumer

3) Electric Vehicle Supply Equipment (EVSE)

- Communicates with vehicle/battery and provides recharge power
- Could include revenue-grade energy meter
- Communicates with HAN and consumer

4) Plug-In Electric/Hybrid Vehicle (PEV)

- Connected to home/grid through standard connector
- Communicates with HAN/consumer/aggregator/grid



<p>Safety</p>	<p>J2344 – Electric, HEV & PEV Safety J1766 – Crash Integrity Testing J2578 – FCV Safety</p>	<p>} ISO 6469 – EV Safety ISO 23273 – FCV Safety</p>
<p>Connector/inlet & EVSE</p>	<p>J1772™ – PEV Conductive Charge Coupler J2954 – PEV Wireless Charge</p>	<p>IEC 62196 – Industrial plugs and socket-outlets IEC 61980-1 – Inductive charging safety coupler supply equipment</p>
<p>Communications</p>	<p>J2836™ – General Information (use cases) .../1 – interface with utilities .../2 – off-board charger communications .../3 – reverse energy flow .../4 – diagnostics .../5 – customer/HAN .../6 – wireless charging/discharging J2847™ – Detailed Information (messages) (same sub-categories as J2836) J2931 – Protocol (requirements) J2953 – Interoperability</p>	<p>similar to ISO/IEC 15118-1 – Vehicle to grid communication interface (Part 1: General information and use-case definition) similar to ISO/IEC 15118-2 – Technical protocol description and Open Systems Interconnections (OSI) layer requirements similar to ISO/IEC 15118-3 – Wired physical and data link layer requirements</p>

Focus on Charge Couplers (US)

	Charge Method <i>Typical charge rates</i>	Nominal Voltage/ Branch Circuit Rating	Charge Coupler (aka plug and receptacle)
 <p>Residential AC L1, AC L2</p>	<p>AC Level 1 RESIDENTIAL 5 mi/hour @ 1.7 kW</p>	<p>120v/20A (15A continuous)</p>	 <p>SAE J1772™</p>
	<p>AC Level 2 RESIDENTIAL 10 mi/hour @ 3.4 kW COMMERCIAL 20 mi/hour @ 7.2 kW</p>	<p>240v/20A (15A continuous) 240v/40A (30A continuous)</p>	 <p>SAE J1772™</p>
 <p>Non-residential AC L2, DC L2</p>	<p>DC Level 2 (Fast Charging) COMMERCIAL 165 mi/hour @ 50 kW</p>	<p>Standards in process 480v AC, 3Ø (supply to EVSE)</p>	 <p>Proposed SAE J1772™ Hybrid</p>

Global Differences and Similarities



	US	EU	CHINA	JAPAN
AC Charging 	Single-Phase (1Ø) SAE J1772™	IEC 62196-2 Type 1 	Type 2 	SAE J1772™ *
	Single- or Three-Phase (1Ø or 3Ø) 		IEC 62196-2 Type 2 IEC 62196-2 Type 3 	China charge couplers (not standard yet) have unique control signals and overall physical shape
DC Charging 	SAE J1772™ 'Hybrid' 	IEC 62196-2 Type 2 'Hybrid' 	Mode 3 	JEVS G105-1993 (ChAdeMO)

SAE and IEC AC standards have common control signals

SAE and IEC working toward harmonization of DC 'Hybrid' charge couplers

* SAE J1772™ AC connector has also been adopted by Korea and Australia

- **Joint development or implementation of tools to verify (or refine) connectivity standards**
 - Test fixtures to evaluate communication and interoperability between key nodes in the vehicle charging infrastructure
- **Joint field evaluation of universal communication and metering technology**
 - As a means to identify and address ‘in-use’ issues associated with proposed (multiple) communications methods and requirements for sub-metering

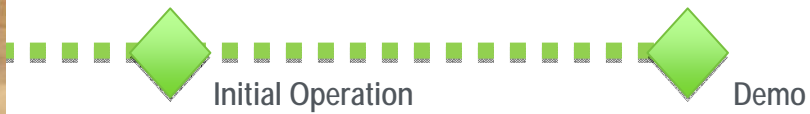
Tools for Standards Verification



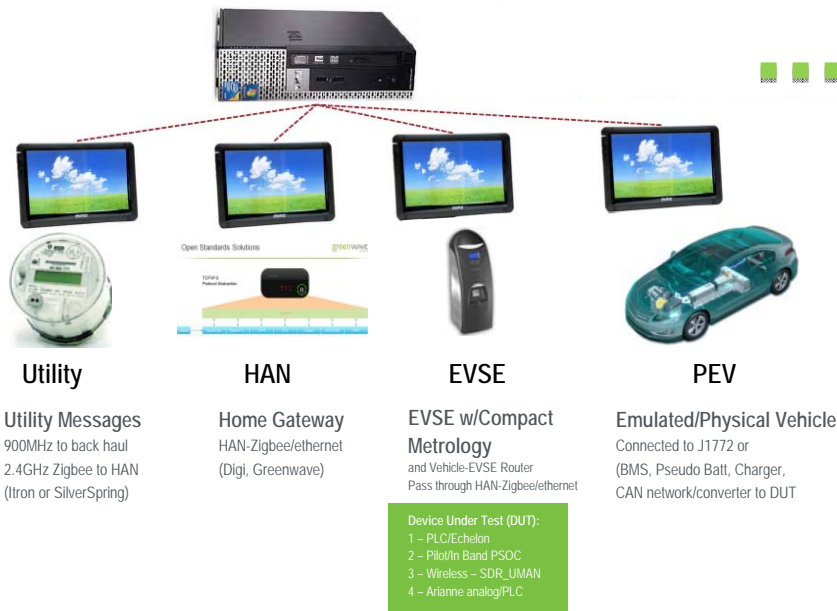
EVSE-EUMD-HAN Connectivity (SAE J2836/2847)



Connectors/connectivity- Zigbee, USB, serial, power, status
Allows user to emulate Grid messages/power flow, etc.

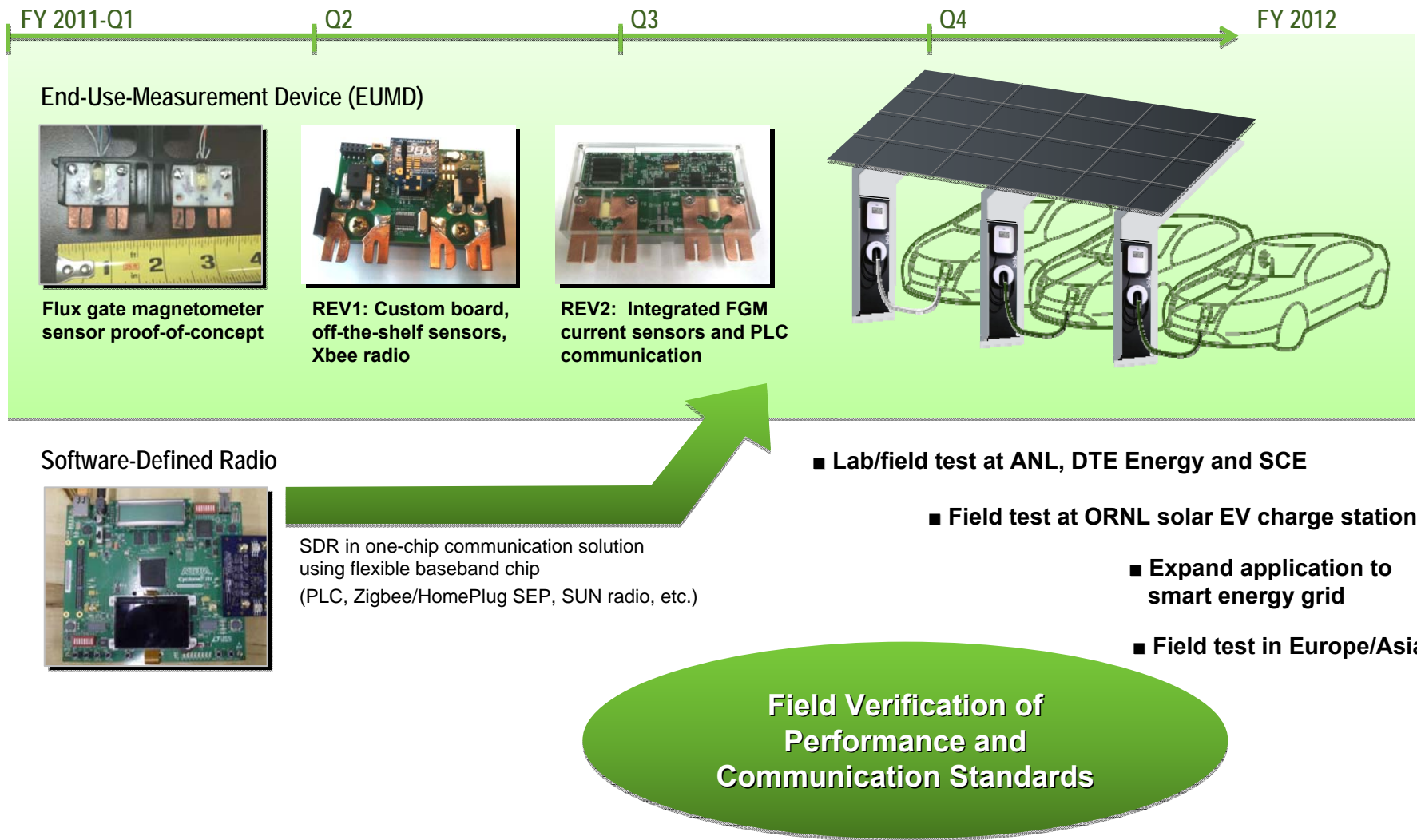


Vehicle-Grid Interoperability (SAE J2953)



Test Fixtures to Verify Compliance with SAE J2953 – Interoperability Between Key Elements of Vehicle Charging Infrastructure

EUMD with Universal Communication



- **Work with SDOs to establish requirements for test fixtures to refine/verify connectivity standards**
 - SAE J2836/2847 and ISO/IEC 15118-1/2/3 communication standards
 - Verification of SAE J2953 interoperability standards
- **Evaluation of enabling technologies**
 - Quantify requirements of (universal) communications architecture for vehicles and smart energy grid; expand SDR demo to multiple vehicles and nodes
 - Quantify requirements of EUMD for vehicles and smart energy grid; demonstrate/emulate connectivity of vehicles and smart grid (including renewable sources and grid storage)

Background

Status of SAE Standards

Safety	J2344 – Electric, HEV & Plug-in Vehicle Safety J1766 – Crash Integrity Testing J2578 – FCV Safety	
Connector/inlet & EVSE	J1772™ – PEV Conductive Charge Coupler J2954 – PEV Wireless Charge	PUBLISHED; AC charging complete, DC ‘fast’ charging in process In process, launched Dec. 2010
Communications	J2836™ – General information (use cases) .../1 – interface with utilities .../2 – off-board charger communications .../3 – reverse energy flow .../4 – diagnostics .../5 – customer/HAN .../6 – wireless charging/discharging J2847™ – Detailed information (messages) .../1 – interface with utilities .../2 – off-board charger communications .../3 – reverse energy flow .../4, 5, 6 (same as J2836) J2931 – Protocol (requirements) .../1 – General requirements ... /2 – In-Band signaling (control pilot) .../3 – Narrow-Band OFDM PLC-pilot/mains .../4 – Broad-Band OFDM PLC-pilot/mains .../5 – RFID J2953 – Interoperability .../1 – General requirements .../2 – Testing & Certification	PUBLISHED, in Step 2* In process (Step 1*) ready for Step 2* ; Next: Hybrid Committee ballot In process (Step 1*) Kick-off in March 2011 Kick-off in March 2011 Kick-off in March 2011 PUBLISHED, in Step 2* In process (Step 1*) ready for Step 2* ; Next : Hybrid Committee ballot Not started Kick-off in March 2011 Step 1* Step 1* Step 1* Step 1* Not started Step 1* Not started

* ‘Step__’ refers to the process in the communications technical committees (R. Scholer, chair) [expected times are typical]:

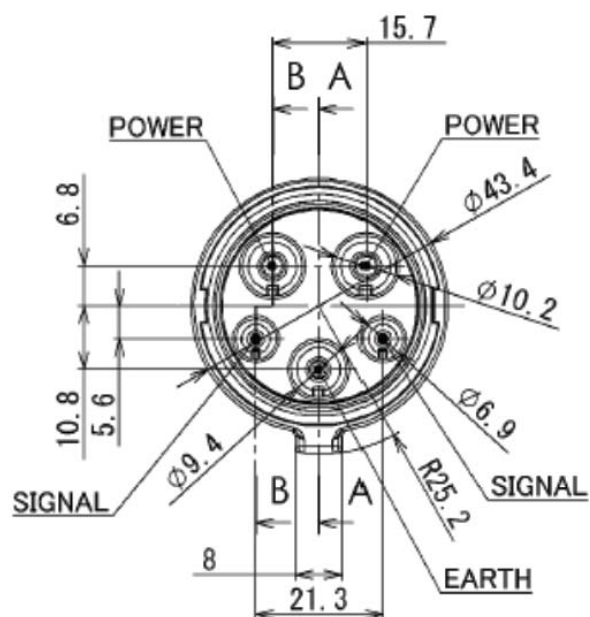
Step 1: “What we think we want” in documents published for comment (allows referencing) [expected time is 1 to 1½ years]

Step 2: Implement “what we think works” (simulate, model, pilot) to verify, correct/add, re-ballot with updates [additional 1-1½ years]

Step 3: Final ballot to clean up; include new items and delete unnecessary items [6 months to 1 year]

SAE J1772™ - 19.2kW Single Phase

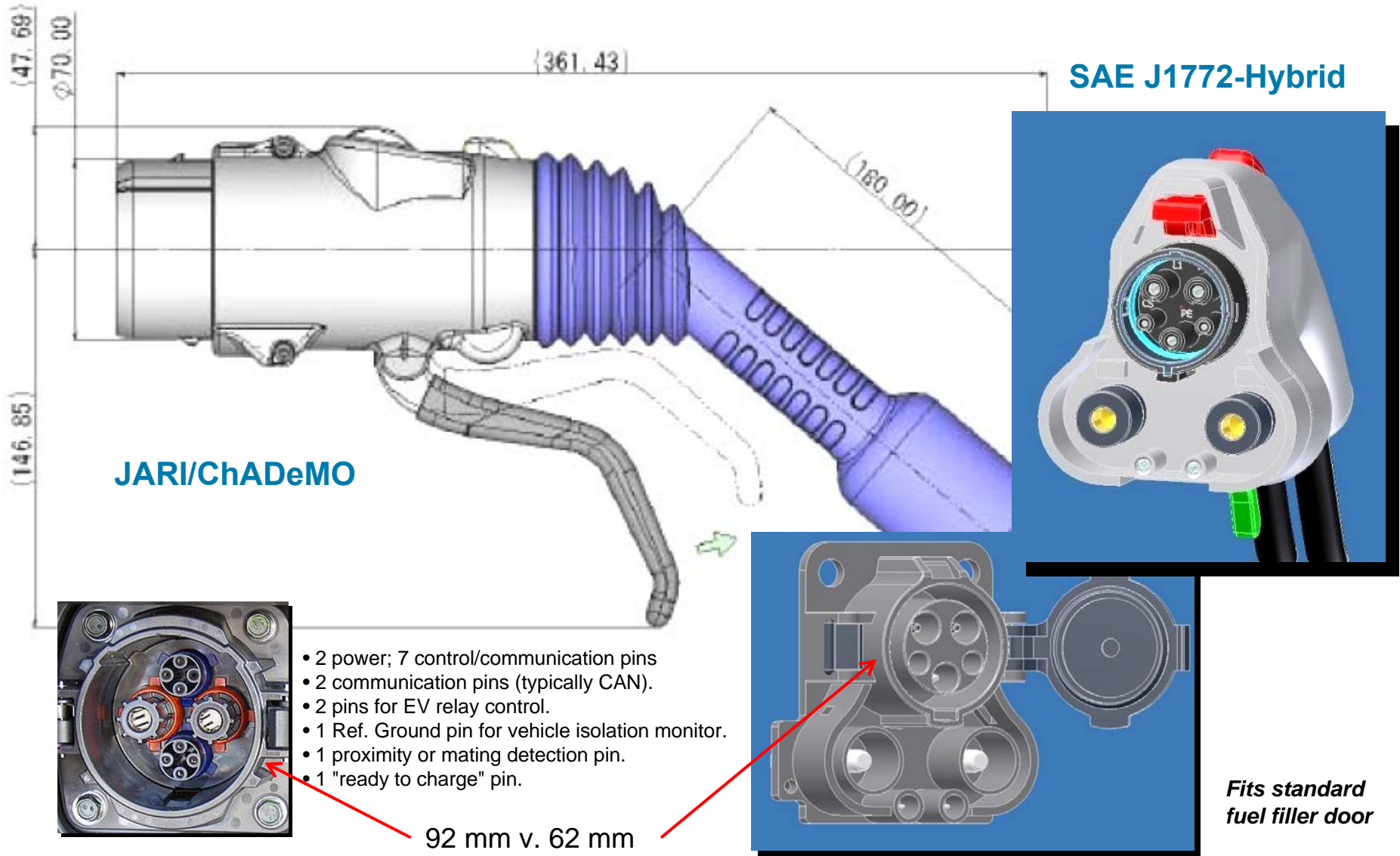
Contact #	Connector Function	Vehicle Inlet Function	Description
1	AC Power (L1)	Charger 1	Power for AC Level 1 and 2
2	AC Power (L2,N)	Charger 2	Power for AC Level 1 and 2
3	Equipment ground	Chassis ground	Connect EVSE equipment grounding conductor to EV/PHEV chassis ground during charging
4	Control pilot	Control pilot	Primary control conductor (operation described in Section 5)
5	Proximity Detection	Proximity Detection	Allows vehicle to detect presence of charge connector



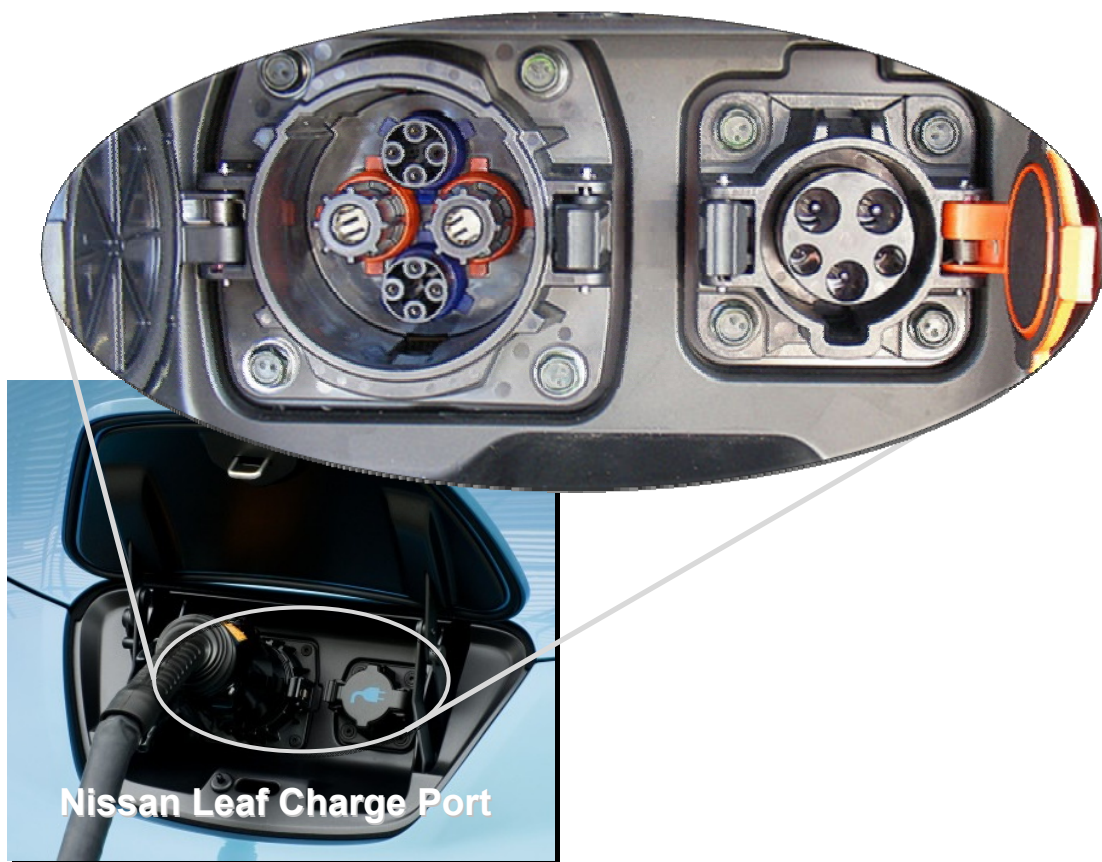
J1772-Focus on Compact, robust- 43mm diameter, 240v/80A

DC Fast Charge Couplers

Proposed SAE J1772-Hybrid v. JARI/ChAdeMO



ECOtality DC Fast Charge Station



Nissan Leaf Charge Port

AC input: 3-phase, 208v@200A to 575v@74A
DC output: 60 kW max, 200 A, 200-500v
JARI/ChAdeMO charge coupler

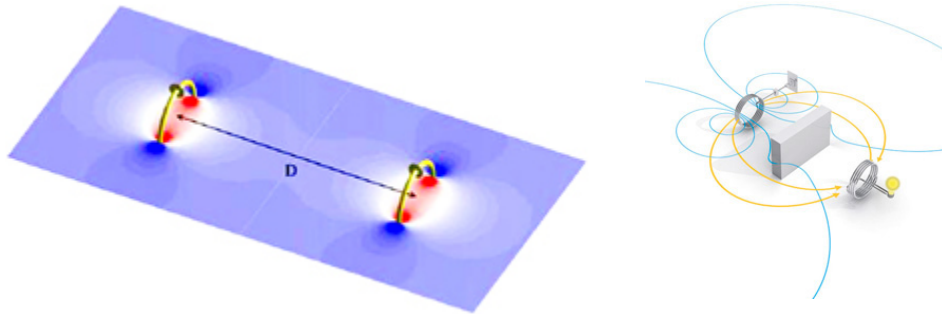
Wireless Charging in the Future?

SAE J2954 Standard Activity

Objective

- Customer convenience
- Smart Grid programmability
- Enhanced global harmonization potential

Inductive charging: Electromagnetic field used to transfer energy between two objects in close proximity. A charging station sends energy through inductive coupling to an electrical device, which stores the energy in the batteries.



Magnetic Resonance: Based on coupling when two objects exchange energy oscillating magnetic fields. Occurs when natural frequency each object is approx. the same. Two idealized resonant magnetic coils, shown in yellow. The blue and red color bands illustrate their magnetic fields. The coupling of their respective magnetic fields is indicated by the connection of the colorbands.

