PEV Charging Standards Status Including AC, DC and Wireless Technologies

Theodore Bohn
Argonne National Laboratory

This work supported by DOE Vehicle Technology Program, Lee Slezak sponsor
100 Year Old Ad: Value of Electric Transportation

6kW DC Offboard Charging- 1910
Also called ‘Wattstation’

8000 Chargers in use, 1910

~ Avg man can’t afford to maintain a horse, EV OK

Steinmetz Says:

“I believe that the Electric will be the car of the future on account of its simplicity of operation and reliability. It is rare that it gets out of order. When it does so it is an accident—not as with the gasoline car, an incident. The man of moderate means cannot afford a horse and buggy because of the attention required. He will be able to afford an Electric Vehicle to take him to business because it requires no attention—if equipped with an Edison Battery. It often has to stand idle for several days and this is not good for a lead battery. I have tried to invent a lead battery that would not spoil, but gave it up.”

From a 1914 Speech: "Some Enterprise Remarks of the Edison Electric at a Recent Meeting of Engineers."
Standardized architectural concepts, data models and protocols are essential to achieve interoperability, reliability, security and ‘evolvability’

- NIST
ANL SAE Standards Committees Support

Compatiblity/Interoperability
- SAE J2931 (Communication, telematics, security)
- SAE J2953 (EVSE-PEV compatibility)

Power Ratings
- SAE J2907 (Motor and power electronics)
- SAE J2908 (Propulsion system)

Support ranges from supplying reference materials to chairing committees, supplying hardware/test fixtures and testing.
PEV Related Charging Standards

Avoiding Alphabet Soup (chart below paraphrased): Use cases, Requirements, Protocols- Utility/AC, DC Charging, 2-way flow, Diagnostics, Customer functions, Wireless Charging. All of the above covered with Interoperability and cyber security.
### High Level Charging Standards Description

<table>
<thead>
<tr>
<th>Standard</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAE J1772(v5), IEC61851</td>
<td>AC and DC coupler</td>
</tr>
<tr>
<td>SAE J2847-J2931</td>
<td>DC messaging/communication/protocols</td>
</tr>
<tr>
<td>SAE J2953 (ISO 15118-pt5)</td>
<td>PEV-EVSE Interoperability</td>
</tr>
<tr>
<td>SAE J2894/2</td>
<td>Charging equip. power quality/test proc.</td>
</tr>
<tr>
<td>SAE J2954</td>
<td>Wireless charging</td>
</tr>
<tr>
<td>IEEE P2030.1</td>
<td>Guide Electric Sourced Trans. Infrastructure</td>
</tr>
<tr>
<td>ANSI EVSP</td>
<td>EV Standards Panel- summary of standards</td>
</tr>
<tr>
<td>NIST HB44/HB130</td>
<td>National Working Group on Electric Fueling and Submetering Standards</td>
</tr>
<tr>
<td>ANSI C12</td>
<td>New section fed by submetering reqs.</td>
</tr>
</tbody>
</table>
Interoperability of Three Similar But Different DC Charging Methods - Adapters When Possible

Chademo and J1772 Level 2 DC Combo

Consumer choices; Level 1 DC combo
40kW/43 mm, <$100

SuperCharger to J1772 Adapter
Boundary Between Charging (Power) Levels is Blurred

<table>
<thead>
<tr>
<th>Charging Level</th>
<th>Setting</th>
<th>Supply Power</th>
<th>Representative Example</th>
<th>Where Charging Occurs</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC Level 1</td>
<td>Residential/Parking Lot 5 mi/hour @ 1.7 kW</td>
<td>120vac/20A (16A continuous)</td>
<td><img src="https://via.placeholder.com/150" alt="Image" /></td>
<td>Residential</td>
</tr>
<tr>
<td>AC Level 2 (minimum)</td>
<td>Residential/Commercial 10 mi/hour @ 3.4 kW</td>
<td>208/240vac/20A (16A continuous)</td>
<td><img src="https://via.placeholder.com/150" alt="Image" /></td>
<td>2/3 of charging</td>
</tr>
<tr>
<td>AC Level 2 (maximum)</td>
<td>Commercial (up to) 60 mi/hour @ 19.2 kW</td>
<td>208/240vac/100A (80A continuous)</td>
<td><img src="https://via.placeholder.com/150" alt="Image" /></td>
<td>Commercial</td>
</tr>
<tr>
<td>DC Level 1</td>
<td>Commercial up to 500v @ 80Adc (up to) 120 mi/hour @ 40 kW</td>
<td>208vac/480vac 3-phase (input current proportional to output power; ~20A-200A AC)</td>
<td><img src="https://via.placeholder.com/150" alt="Image" /></td>
<td>1/3 of charging</td>
</tr>
<tr>
<td>DC Level 2</td>
<td>Commercial up to 500v @ 200Adc (up to) 300 mi/hour @ 100 kW</td>
<td>208vac/480vac 3-phase (input current proportional to output power; ~20A-400A AC)</td>
<td><img src="https://via.placeholder.com/150" alt="Image" /></td>
<td></td>
</tr>
</tbody>
</table>
Battery Safety Concerns Today- SAE J3009, J2990, etc

Perception is Reality;
Current media focus on Dreamliner battery, hobbyist ‘issues’
Transformative Value of Workplace Charging on PEV Deployment; Charging Levels - cost/benefit to users

http://www.workplacecharging.com/
Wireless Charging Standards- SAE J2954 Tasks
Task groups; Alignment, interop, performance, Bus, EMC/safety, frequency, communication- TIR in Dec ‘13
SAE Standards support- J2931; AC/DC charging Comm. 
HPGP EV-SE Communication Controller, AMI, SEP2.0

TQM28 (iMX28) processor (1” x 1.5”) ($75) 
JetLun RD7000 (QCA7000) (1” x 1.5”) ($30) 
I/O carrier- Deutsch box- 133mm x 120mm

**Figure 1.** Baseline System Architecture of Interest for System-Cost-Optimized Smart EVSE. Home gateway solution provides bi-directional communication with both utility and smart EVSE; consumer can configure EV charging preferences at the EVSE based on information exchange through the gateway.
Phase 1, 2, 3 DC Charging Communication Interop
EVCC-SECC and DC Charger Connected to ‘Real’ Loads

**Phase 1:**
ABC-170 as load/battery
CAN communication

**Phase 2:**
Telecom 5kWhr ESS
CAN communication

**Phase 3:**
Production PEV,
Level 1, Level 2 DC Couplers
EVCC to vehicle CAN

IEC/SAE Combo Charger Vendors
IES, Eaton, BTCP, Aker-Wade,
Efacec, Siemens and ABB.
EVSEs- J2953 Interoperability/Benchmarking

~40 EVSEs, mounted on skid- testing assets
Some deployed in the field.
Testing Tools- EVE-100, Labview V.I.s

Labview based test rack; AC, DC loads and sources; J1772 signal pass through monitoring/fault injection
Objectives of Project:
This project establishes requirements, specification, test procedures and conformance processes to ensure the interoperability of PEV’s and PHEV’s and Electric Vehicle Supply Equipment (EVSE) for multiple suppliers.
• Interoperability (AC Level 1 & 2 and DC Level 1 & 2)
• Reliability
• Charger efficiency
• Vehicle to grid communication
• Bi-directional power flow
US-EU-(China) EV-Smart Grid Interoperability Center

Agreement signing at the annual Transatlantic Economic Council meeting in Washington, D.C. 2011

- **Charging systems**: Studying and validating EVSE technologies (AC, DC, and wireless) to ensure any EV can plug into any EVSE safely and reliably.

- **Communications technologies**: Developing and verifying software, embedded systems, and cyber security protocols that connect EVs and EVSE with the utility/grid operator to provide information to support billing and load management.

- **Networks**: Examining infrastructure-related systems to help ensure a robust and reliable vehicle-to-grid network – from emerging smart grid technologies to microgrids.