Standardized architectural concepts, data models and protocols are essential to achieve interoperability, reliability, security and ‘evolvability’

- NIST
Detroit was the first American city to use electric taxi cabs, in 1914.

Detroit’s first electric taxi accumulated >46,000 miles first two years of operation.
Unique Charging Needed for Each Vehicle Type

– Plug in Hybrid Electric Vehicle (PHEV)
  • Very limited electric range – small battery 5-10 kWhr
  • Charge power 1-3 kW

– Extended Range Electric Vehicle (EREV)
  • Increased electric range – medium battery 10-20 kWhr
  • Charge power up to 6 kW

– Battery Electric Vehicle (BEV)
  • All electric range – large battery >20 kWhr
  • Charge power > 6 kW
Relative Annual PEV Energy Usage
{≈2500kWhr/year or $275/year; ≈$23/month}

**Annual Energy Usage – Electrical Appliances**

<table>
<thead>
<tr>
<th>Appliance</th>
<th>Energy Usage (kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Home Heating System</td>
<td>3,524</td>
</tr>
<tr>
<td>Central Air Conditioning</td>
<td>2,796</td>
</tr>
<tr>
<td>Refrigerator/Freezer</td>
<td>2,610</td>
</tr>
<tr>
<td>Water Heater</td>
<td>2,552</td>
</tr>
<tr>
<td><strong>VOLT</strong></td>
<td><strong>2,520</strong></td>
</tr>
<tr>
<td>Clothes Dryer</td>
<td>1,079</td>
</tr>
<tr>
<td>Lighting</td>
<td>940</td>
</tr>
</tbody>
</table>

1. Computer & monitor operating ALL day

1. CHEVY for annual energy usage
Historical Perspective on EV Charging Equipment 1900 to Today … and Tomorrow

1913- 150A/48vdc coupler (30,000 EVs in 1913)

1990’s J1772 Conductive SAE J1773 Inductive

2010 SAE J1772 Level 2 240vac/<80A (32A typ.)

2011 SAE J2954 Wireless Charging
DC Fast Charging Couplers: JARI-ChAdEMO→SAE J1772-Hybrid

Nissan Leaf uses two connectors (DC-JARI and AC-J1772)

<table>
<thead>
<tr>
<th>Level</th>
<th>Volts</th>
<th>Amps</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC-1</td>
<td>120</td>
<td>20</td>
</tr>
<tr>
<td>AC-2</td>
<td>240</td>
<td>&lt;80</td>
</tr>
<tr>
<td>DC-1</td>
<td>&lt;450</td>
<td>&lt;80</td>
</tr>
<tr>
<td>DC-2</td>
<td>&lt;450</td>
<td>&lt;200</td>
</tr>
<tr>
<td>DC-3</td>
<td>&lt;600</td>
<td>&lt;400</td>
</tr>
</tbody>
</table>

CAN Pins avoided via J2931 PLC over Pilot

SAE/ISO AC+DC Combo J1772

Look mom, no lever! Due to fewer Comm. Pins

The J1772 coupler standard is being revised to address dc fast charging (enabled by the two pins at bottom) in addition to ac charging, the...
DC Fast Charging and Utility Programs
Communication is the Key (Enabled by New Standards)

DC EVSE
- DC Power Supply
  - SECC
  - HGP Adapter

PEV
- BMS
- EVCC

Communication Layers:
- CAN Bus
- SPI
- BB OFDM
- CAN

Messages/Control
Object/Transfer Layers
CAN Bus
DC Charging Stations

- Currently only Nissan Leaf and Mitsubishi iMIEV have DC charging inlets (50kW)- (previously ~$900 option, now std.)
- SAE/IEC combination DC-AC charging standards are coming in 2012- vehicles 2014?

\[ 50kW = \frac{50}{3} = 12.6 \text{kWhr} \rightarrow \$1.26 \text{ of electricity at } \$0.10/\text{kWhr}; \]
\[ \text{Including service fee } \$20/12.6 \text{kWhr} = \$1.59/\text{kWhr} \]

Blink, Coulomb-Acker Wade, Nissan, Epyon- Holland, Aerovironment

All of the above use the JEVS105-1993 (JARI) DC coupler

Others include Eaton, Efacec, Delta Products, Fuji Electronics, DBT, etc
SAE J2953-PEV-EVSE Compatibility
EVSE-PEV-EUMD-Utility Test Fixture/Tools

Many Combinations of EVs, EVSE and Utility Region Installations

Occasional use cable  EVSE  DC off board charger

? Interoperability ?
Charge location & power levels

Power Level Summary

- **AC L1 (1.4 kW)**
  - Street parking, parking garages, businesses
- **AC L2 (7 kW)**
  - Parking lots, parking garages, businesses
- **DC L1 (35-45 kW)**
- **DC L2 (50-100 kW)**
- **DC L3 (150 kW)**
  - Gas station model, between cities
- **DC L1 (10-20 kW)**
- **DC L2 (7 kW)**
  - 7 kW – most installations
  - 20 kW – allowed by J1772™
- **DC L1 (10-20 kW)**

Source: R. Scholer VPPC, 2011- Smart Grid Charging and V2G
Where Does the EUMD/Sub-meter Reside? (Depends on your segment of the EV industry)

The UEMD measures just the branch circuit power flow to the EV, but may be located in different segments of that branch.

1) **Utilities** tend to favor locating it in an outdoor, technician accessible area, such as **next to the main meter**; possibly as a fused sub-panel with dedicated run to EVSE.

2) **Home Owners** may want it next to their service panel or in garage **near the EVSE**.

3) **EVSE manufacturers** want to build it into the EVSE, or in a socket **in the EVSE**.

4) **Auto manufacturers** may want the EUMD **on-board the vehicle** to simplify access to EUMD consumption information and eliminating association problems.