Electric Vehicle Technologies Workshop
Session EV-05
Electric Vehicle Charging

Presented by
Rich Scholer
April 22, 2014
About the Lecturer...

• Rich Scholer is a graduate of Purdue University – BS Mechanical Electrical, then Lawrence Tech and Wayne State Universities – BS & MS Electrical Engineering

• Manager at Fiat Chrysler Automobiles responsible for Vehicle to Grid interface

• Extensive vehicle systems design experience

• Chair the SAE Plug-In Electric Vehicle (PEV) communications standards

• Participated in NIST & SGIP Roadmaps for Electric Transportation and initial DEWGs & PAPs
Vehicle Charging Outline

• Electronic, communications, standards, policy, and market infrastructure required to support EV’s

• Marketplace – companies, charging infrastructure – SAE Standards, PEV and EVSE variations, ...

• V2G concept, power services that could be supplied by EV’s, implications to the grid and to vehicle owners; deployment path

• R&D and commercialization challenges for EV charging infrastructure
Electronic, communications, standards, policy, and market infrastructure required to support EV’s

- National Institute of Standards Technology (NIST) conducted workshops in 2009 with stakeholders for Smart Grid
  - Established a Roadmap and identified gaps
  - Created the Smart Grid Interoperability Panel (SGIP) along with Priority Action Plans (PAP), Domain Expert Working Groups (DEWGS) and committees to address further actions and resolutions.

http://members.sgip.org/apps/group_public/
NIST Smart Grid Network
Customer Interface
Smart grid com system (expanded NIST model)
PEV portion - within the Home Area Network (HAN) section.
SEP 2.0 HAN - PEV and EVSE included

Other items in the Home Area Network

Home Area Network (HAN)
MARKETPLACE – COMPANIES, CHARGING INFRASTRUCTURE

Vehicle Variations

SAE Standards
Vehicle Variations

Typical Vehicle Rechargeable Energy Storage System (RESS) Capacity size variations:

- **HEV**: Full Hybrid (does not plug-in) 1.5 kWh
- **PHEV**: Plug-In Hybrid (plug in plus hybrid engine) 8 kWh
- **BEV**: Battery Electric (only plugs in) 25 kWh, 50 kWh, 95 kWh

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Electric Vehicle Supply Equipment (EVSE) Connection architectures:

- **AC Level 1**: Cordset (120V) 1.5 or 2 kWh (15 or 20A outlet)
- **AC Level 2**: Premise unit (240V) – up to 19.2 kW (80A)
- **AC Level 3**: Premise unit greater than 19.2 kW
- **DC Level 1, 2 & 3**: Premise unit that includes the charger
- **DC (Mode 1, 2, 3, 4)**: Case A, B & C
  - ISO/IEC
  - AC 1φ and 3φ (> 20 kW & 3φ)
J1772™ Charging Types

- **AC L1**: 120V AC, single phase, 1.4 or 1.9kW
- **AC L2**: 240V AC, single phase, most are 7.2, 7.7, but up to 19.2kW
- **AC L3**: TBD AC, can be supplied by single or 3φ,

- **DC L1**: 200 – 500V DC, ≤ 20 kW (30-32A @ home), ≤ 40 kW max (80A @ business)
- **DC L2**: 200 – 500V DC, most are 50-60 kW, ≤ 100kW max (100A)
- **DC L3**: 200 – 500V DC, ≤ 200kW (400A)
AC Level 2 EVSEs

Most are connected to a 40 A CBR to deliver 30 or 32A (240V) or 7kW. 
PHEV would charge in about 1 ½ hours if it has an on-board 6.6 kW charger, BEV is the same if charged every day.
DC Level 2 EVSEs
most are 50-60 kW (100-175A)
PHEV would charge in 5-10 minutes, BEV is expected to take more energy (more distance) and may take 20 minutes.
DC L1 & L2 EVSE

DC L1 is capable of 80A (30 kW) or 5-6 minutes for most daily commutes
Smaller units are expected in homes and most businesses.

World’s 1st DC L1 & DC L2 50 kW EVSE
SAE PEV Communication

Major Documents and Functions

1. J2836™ - Use Cases (establishes requirements)
   - TIR and harmonized with ISO/IEC 15118-1
2. J2847 – Messages, diagrams, etc. (derived from the use case requirements)
   - RP and harmonized with ISO/IEC 15118-2
3. J2931 – Communication Requirements & Protocol
   - TIR and harmonized with ISO/IEC 15118-3
4. J2953 – Interoperability
   - RP and harmonized with ISO/IEC 15118-4 (PHY/MAC) & -5 (upper layers)
Document Interaction

Use Cases
- Smart Charging (U1 – U5)
- DC Charging
- PEV as Distributed Energy Resource (DER) (U6 & U7)
- Diagnostics
- Customer to PEV and HAN/NAN (U8 & U9)
- Wireless Power Flow

Applications & Signals
- J2836/1™
- J2836/2™
- J2836/3™
- J2836/4™
- J2836/5™
- J2836/6™
- J2847/1
- J2847/2
- J2847/3
- J2847/4
- J2847/5
- J2847/6

Protocol Requirements
- J2931/1
- J2931/4
- J2931/5
- J2931/6
- J2953/1 Interoperability, J2953/2 Test Procedures

Protocol
- PLC (BB OFDM)
- Internet
- IEEE 802.11ac or 802.11n or 802.11p

J2931/7 Security
Typical home loads and service

- Local distribution and transformers sized for average loads, not peak demands
- Sized for existing loads, not PEVs

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Overloads - 140% for brief periods of time, 3-4 hours

2007 heat-storm data, at 1 am the average home load was still 5.5 kw
Now add random PEV loads (either Battery Electric Vehicle or Plug-in Hybrid Electric Vehicle)

- Case 1a
  - Arrives at 4pm
  - Home for the evening

- Case 2d
  - Arrives at 6pm
  - Wants immediate charge to leave @ 7pm

- Take the single home and multiply this times 5 + add BEVs (what happens)?
Why we need Smart Charging

- Price & DRLC are Utility tools used now to minimize peak loads
- This shows the effect on Home load along with PEV connected period.

![Graph showing price and DRLC over time]

- TCIN
- Connected time
- DRLC
- Home Load
- Time
Charge now - when connected at home

- Increases Home load from 2 kW to almost 10 kW.
Now add FlowReservation to Price & DRLC

Delays and/or reduction in Home load peak may be controlled below any Demand Charge limit.
Program Summary

• Price programs are meant to delay energy usage for non-urgent devices
• Demand Response Load Control is meant to delay or curtail usage during high load periods.
  – This request an acknowledgement during use
• Neither of these provide any advanced notice on power level, energy or time period.
• Residential customers are now experiencing Demand Charges
• FlowReservation is needed for energy management (private and public sites)
Method of communication
(SEP1.x or SEP2 or both)

On-board Charger

Controller

PEV Module

PEV

Controller

EVSE Module

EVSE

Ethernet, Serial, or CAN

SEP2 Wi-Fi

SEP2 PowerLine Carrier (PLC) on J1772™ Control Pilot

SEV2 Wi-Fi

SEP1.x

Smart Meter w/ ZigBee 1.x

SEP1.x ZigBee

ALG

Wi-Fi

Gateway

SEP2

SEP2 Application Server
V2G CONCEPT, POWER SERVICES THAT COULD BE SUPPLIED BY EV’S, IMPLICATIONS TO THE GRID AND TO VEHICLE OWNERS; DEPLOYMENT PATH
Vehicle to Grid (V2G) and Vehicle to Load (V2L)

Both can be accomplished using either on-board or off-board equipment.

- V2G is a current source, supplementing a grid.
- V2L is a voltage source, supplying power to a load.
  - Sub-sets include Vehicle to Home (V2H) and Vehicle to Vehicle (V2V)
Now add V2G to the Distributed Energy Resource (DER) function set

Also called Reverse Power Flow (RPF)
R&D AND COMMERCIALIZATION CHALLENGES FOR EV CHARGING INFRASTRUCTURE
Items that still need resolution

• Metering
  – Whole house, sub-meter, on-board vehicle

• V2G
  – Utilities are not required to participate
    • Permission required to connect
    • Requires additions to EVSE (digital com, new signals, etc.)
  – Interoperability and Safety standards are still being developed
    • Not UL for the PEV but part of SAE

• ...
V2G issues – onboard or offboard

Energy Storage System (DER)
- Inverter*
- Battery

Premises Network

Inverter*

Plug-in Electric Vehicle (DER)
- Inverter*
- Battery

EVSE (AC L2)

PLC & J2847/3

DC EVSE Inverter*

PLC & J2847/2

EVSE and PEV (DER)
- Inverter*
- PEV Battery

*NOTE: Inverter means bidirectional or four quadrant converter

ESI

Meter

AC

This (and solar PV) is where the DER community is focused

- J2847/3 Completed
- PEV access to V_{REF}
- Utility Approval to interconnect

- Need requirements for DC RPF & DER modes for update of J2847/2
Recap

• When are the standards going to be done?

Never!

e.g. J1772 (architecture, EVSE and connector) was complete 20 years ago and we are still working on V6 that reopened 8 years ago.
• NIST - National Institute of Standards Technology
• SGIP - Smart Grid Interoperability Panel
• PAP - Priority Action Plans
• DEWGS - Domain Expert Working Groups

• EVSE – Electric Vehicle Supply Equipment
• PEV – Plug-in Electric Vehicle
• BEV – Battery Electric Vehicle
• PHEV – Plug-in Hybrid Electric Vehicle

• C&I – Commercial and Industry
• DRLC – Demand Response Load Control
• EMS – Energy Management System
• HAN – Home Area Network
• SEP1.x – Smart Energy Profile 1.x
• SEP2 – Smart Energy Profile 2.0
• TCIN – Time Charge Is Needed
• V2L – Vehicle to Load
  – Includes Vehicle to Vehicle (V2V) & Vehicle to Home (V2H)
• V2G – Vehicle to Grid