Grid Architecture & V2G

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V2G Overview

Grid Operator

Wholesale Markets

Bids / Charging Data

Dispatch / $$

Aggregator

Internet

(Wholesale Market Participant)

Internet

Driver Usage Profile & Preferences

Wireless Provider

GPS

2-way power flows
ISO/RTO Council

• PEV Study Underway to assess impact on ....
  – Market products
  – Reliability operations
  – Information technology and interoperability standards
IRC PEV Penetration by ISO

1 million PEVs deployed in U.S. between 2015 and 2019

Other ISOs under 50,000
- ERCOT
- NY ISO
- SPP
Timing & Stages of V2G Capabilities?

- **Stage 1** – Simple charging control *(1-5 years)*
  - Off peak charging
  - No V2G capability

- **Stage 2** – Smart charging based on pricing signals *(3-10 years)*
  - Demand response (DR) – variable charging
  - Participation in ISO ancillary services market as DR
  - No V2G capability
Timing & Stages of V2G Capabilities?
(continued)

• **Stage 3** – V2G Participation in Ancillary Services Market *(5-12 years)*

• **Stage 4** – V2G Participation in Energy Market *(10-20 years)*

• **Timing** of above dependent on...
  – PEV volumes
  – Battery technology and warranties
Smart Charging with V2G Capabilities

Synergy with Wind Generation

Load (MW)

PEV Discharging

PEV Charging

Hours of Day

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24

0 20 40 60 80 100 120 140

Midwest ISO
Energizing the Heartland
Potential ISO Market Participation

- **Regulation**
  - Automatic Generation Control (frequency)
  - Response within 5 min.
  - Market limited to approximately 1% peak load

- **Contingency Reserve**
  - Reserves to cover loss of transmission or generation facilities
  - Response within 10 min.
  - Market typically limited to size of largest online facility

- **Energy**
  - Scheduled in day-ahead market
  - Unlimited market potential
Necessary Changes to Grid Structure to Support V2G?

• Policy
  – Net metering retail rates
  – Time of use/hourly retail rates

• Business model
  – Aggregator role

• Operations
  – Smart Charging infrastructure

• Grid Infrastructure
  – Distribution feeders
Challenges for V2G?

- **Smart charging infrastructure**
- **Battery charging cycles**
- **Distribution grid**
  - Transformer loads (capacity)
  - Two-way power flows (reliability, quality)
- **Aggregator capabilities**
  - Communications to vehicle
  - Charging/discharging management
- **Interoperability**
  - Communications standards incorporating security
Sample PEV Activities
Midwest ISO Region

- **DTE Energy / GM / Univ. of Michigan**
  PEV 2009 conference in Detroit
- **IUPUI (IN Univ. Purdue Univ.) & IPL**
  Plug-in-Electric Vehicle Study
- **Madison Gas & Electric**
  Vehicle charging network demonstration project
- **Michigan PSC**
  Pilot to integrate PEVs into the grid
Electric Car History

- Detroit Electric
- Range 65-100 miles
- 100 years old