Electric Vehicles and the Power Grid

American Association of State Highway and Transportation Officials

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PJM Interconnection
PJM’s Responsibilities

- Ensures the reliability of the high-voltage electric power system
- Coordinates and directs the operation of the region’s transmission grid
- Administers a competitive wholesale electricity market
- Plans regional transmission expansion improvements to maintain grid reliability and relieve congestion.
Operators of for Energy Markets…

Air Traffic Controllers for the Transmission Grid…

Match Generation to Load

SIMULTANEOUSLY!

RELIABLY!
PJM as Part of the Eastern Interconnection

KEY STATISTICS
- PJM member companies: 650+
- Millions of people served: 51
- Peak load in megawatts: 144,644
- MWs of generating capacity: 164,905
- Miles of transmission lines: 56,250
- GWh of annual energy: 729,000
- Generation sources: 1,310
- Square miles of territory: 164,260
- Area served: 13 states + DC
- Internal/external tie lines: 250

- 26% of generation in Eastern Interconnection
- 23% of load in Eastern Interconnection
- 19% of transmission assets in Eastern Interconnection

19% of U.S. GDP produced in PJM
The Smart Grid is realized by merging data from these areas of automation to achieve a total end-to-end systems view by integrating information technology and operational technology.
Smarter Grid Network – Smart Home

- Smart Appliance Energy Management
- Smart Charger (PHEV) Storage

- Ancillary Services Signals
- Price Signals
- Generation Mix
- Reliability Control
- Load Curtailment
Integrate SMART Grid with PHEVs

- Enable greater penetration of PHEVs through coordination with state SMART Grid and retail tariff innovation initiatives
- Develop infrastructure to support non-traditional demand based regulation resources
- Develop operational tools and forecasting techniques to enable PHEV deployment

- Develop Vehicle to grid / Plug-in hybrid electric vehicles (PHEVs) protocol
- Participate in Mid-Atlantic Grid Interactive Cars Consortium (MAGICC) – electric companies, research institutes, and vehicle manufacturers
- Test storage batteries in regulation markets
Assumptions
- 1,000,000 PEV Vehicles by 2015
- ~18% of U. S. Population is within the PJM territory
- ~ 180,000 PEV Vehicles in the PJM Territory
- ~ 33** Miles traveled per vehicle per day
- ~ Average vehicle fuel usage: 22** mpg
- ~ No tax compensation

Daily cost per PEV Vehicle
Gasoline: 33 miles/day * $3.00 /gal // 22 miles/gal = $4.50
Electric: 33 miles/day * $.07 / kWh // 4 miles/kWh = $0.60

Annual cost/savings
Cost:
Gasoline: 365 days * $4.50 /day = $1650
Electric: 365 days * $0.60 /day = $220
Savings:
~ $1400 annually per vehicle
180,000 vehicles (within PJM) = ~ $250,000,000 annual

** U.S. Bureau of Transportation Statistics
PJM Load and Wind Resources – August 26, 2009

PJM Load
August 26, 2009

Load MW

0 20,000 40,000 60,000 80,000 100,000 120,000

12:00 AM 2:00 AM 4:00 AM 6:00 AM 8:00 AM 10:00 AM 12:00 PM 2:00 PM 4:00 PM 6:00 PM 8:00 PM 10:00 PM 12:00 AM

PJM Load, MW
PJM Load and Wind Resources – August 26, 2009

PJM Load and Wind Contribution
August 26, 2009

- Load MW
- Wind MW

PJM Load, MW
PJM Total Wind, MW

Chicago LMP
August 26, 2009

Locational marginal Price $/MWh
Wind Generation in PJM - Operational and Proposed

Cumulative Nameplate MW

- Cumulative [graph]

40,888 MW

* In planning 1/15/2010
Vehicle Charging Impact on PJM

Load (MW x 1000)

Charging Energy
- 180,000 PEV Vehicles * 33 miles // 4 miles/kWh = ~ 1500 MWh
- ~ 500 additional MW over 3 valley hours

Capacity for 25+ million PEVs
Fast Regulation: Speed Matters...

A fossil power plant following a regulation command signal

Energy Storage (batteries / flywheels) accurately following a regulation command signal
Vehicles
• ~18% of U. S. Population is within the PJM territory
• 180,000 PEV Vehicles in the PJM Territory

V2G Equipped PEVs within PJM
• Assume 10% of Vehicles have V2G capability
• Bi-Directional Power (with inverter) – 15 kW
• 18,000 vehicles * 15 kW = 270 Mw

Availability for Participating in Regulation
• Plugged In 12 hours each day (6 pm–6 am)
  365 days * 12 hours = 4380 hours/year

Payment for participation in the PJM Regulation Market
• PJM average historic price paid for regulation = $35/MWh
• PJM Regulation price during valley load periods = $28/MWh
• Per Vehicle: 4380 hrs * $28 * .015 MW = $1800 annually
• PJM Overall: 4380 hrs * 270 MW * $28 = ~$33,000,000 annually
MAGICC – PJM’s PHEV Demonstration Project

- Smart Meter allows car to roam
- Mid-Atlantic Grid Interactive Car Consortium (MAGICC)
- Over one year experience
AES Grid-Scale Energy Storage System

Operational Details

- Altairnano, Inc – Lithium Ion nano titanate battery
- Power: 1 MW for 15 minutes
- Usable Charge Range: 5% - 99%
- Energy: 300 kWh
- Efficiency: 90% round trip
“Cash Back” for Storage

- Frequency Regulation Signal

- \( 0.018 \text{ MW} \rightarrow 1 \text{ MW} \)
- \( \approx \$850/\text{day} \)
- \( 1.018 \text{ MW} \rightarrow 1 \text{ MW} \)
- \( \approx \$10/\text{day} (20 \text{ Hrs.}) \)
• Modeling of PHEVs and interactions with the grid
• PHEV Energy Management
• PHEV-Grid Connectivity Issues
• PHEV Fleet Studies
1. Reduce Oil Imports/Energy Independence

2. Reduced Cost of Fuel and Cash Back

3. Reinvent Auto Industry

4. Recharge Off Peak/Higher Use of Power Industry Assets