Business and Policy for Plug-In Vehicle Grid Uses

NIST/DOD PCS Workshop
June 13, 2011
Outline

• Frequency regulation and spinning reserves provides significant revenues for existing storage projects
• Current rules allow non-generating resources (even loads and charge-only EVs) to provide frequency regulation
• Bidirectional applications face technical constraints
• Variable charging may provide a sufficient business case
Frequency Regulation Revenues from Storage

Existing commercial deployments show promising performance
Ancillary Services from Non-Generators

Most markets exhibit few policy barriers

- FERC Order 890 (2007):
  - “Ancillary services by load resources should be permitted where appropriate on a comparable basis to services provided by generation resources.”

- PJM Demand Response Programs
  - Curtailment Service Providers can aggregate loads
  - Eligible to bid into Energy, Capacity, Day-Ahead Scheduling Reserves, Synchronized Reserve and Regulation

- CAISO Regulation Energy Management (2/2011)
  - Specific implementation allowing storage to sell frequency regulation
  - Provides an energy set point to manage state of charge
  - Could be used to charge an EV battery while providing regulation
Frequency Regulation from Generators


Generator Real Time Dispatch

- Regulation Capacity
- Scheduled Generation

12:00:00 AM  1:00:00 AM  2:00:00 AM  3:00:00 AM

Time

40 MW Set Point

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Frequency Regulation from Storage

Revenue = Freq. Reg. Capacity

Storage Real Time Dispatch

Quantity (MW)

Time

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Frequency Regulation from Loads


Load Real Time Dispatch

-5 MW Set Point

Example:
- 20 kWh PHEV battery
- 4 hr. charge, offpeak
- 5 kW/hr energy
  - $0.05/kWh*5kW*4hr=$1.00
- 10 kW/hr freq. regulation
  - $0.03/kWh*10kW*4hr=$1.20
- Net payment of $0.20
No bidirectional connection required!
Cycle Life Test Results, A123 Systems ANR-26650
+1C/-1C, 23°C, 100% DOD

Each cycle depletes usable driving range

To date, A123 is not aware of any production vehicle incorporating bidirectional capabilities.
Cycle Life Test Results, A123 Systems ANR-26650
+1C/-1C, 23°C, 100% DOD

Variable charging provides ancillary market revenues without consuming cycles

Potential end-of-life revenue from remaining battery capacity

Drive

Grid
### Business Case Comparison

**Minimal incremental benefit from bi-directional flows**

<table>
<thead>
<tr>
<th></th>
<th>Frequency Regulation</th>
<th>Renewables Ramp Management</th>
<th>Spinning Reserve</th>
<th>Energy/Peak Shaving</th>
<th>Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Steady State Charging</strong></td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Partial (with dynamic pricing)</td>
<td>Partial</td>
</tr>
<tr>
<td><strong>Variable Rate Charging</strong></td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Partial (no arbitrage)</td>
<td>Partial</td>
</tr>
<tr>
<td><strong>Bidirectional Flows</strong></td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes (but faster battery life reduction)</td>
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</tr>
</tbody>
</table>

*Highest-valued applications for today’s standalone energy storage projects*

*Likely sweet spot for near-term electric vehicles*
A123 Selected Grid Deployments Worldwide

Over 40MW in service today
Conclusion

Full V2G may not be necessary

- Ancillary services (AS) provide sufficient revenue to spur commercial standalone storage projects
  - Frequency regulation (example of actual revenues)
  - Spinning reserves
  - Renewable ramp management
- Charge-only operation maximizes useful driving range
- EVs with variable charging can access AS markets with existing policy and market rules (EV acts like DR)
- Variable-rate charging likely to optimize vehicle performance and cost
Thanks!

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Hourly Regulation Prices

Highest value during morning and afternoon ramps

PJM Average Regulation Price by Hour (2011 Q1)
Hourly Regulation Prices

Highest value during morning and afternoon ramps

NYISO Average Regulation Price by Hour (2011 Q1)