DOD Perspectives on Vehicle-to-Grid (V2G)

17 October 2012

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What is V2G?

- Electric vehicle battery power can use bi-directional flow to act as an energy resource when the vehicle is parked and plugged in.

Vehicle to Grid (V2G) Ancillary Services
- Peak Power Shaving Capability
- Frequency Regulation Services
- Spinning/Non-Spinning Reserve Services

Other Energy Uses
- Energy Storage and Localized Backup Power
- Integrated within Installation Energy Security Plan
- Micro-grid integration
V2G Ancillary Services

- **Power (MW)**

- **Time of Day**

- **Spinning Reserves**: Extra generation available to serve load in case of unplanned event. Good match for V2G.

- **Aggregate Daily Load Curve**

- **Peak Power Shaving**: Generation at times of high power demand. May be used for V2G.

- **Frequency Regulation**: Used to regulate frequency and voltage of the grid by matching instantaneous generation supply to load demand. Best match for V2G.
Where is frequency regulation valuable?
Value of Frequency Regulation

CY 2011 Monthly Frequency Regulation Revenues

Monthly Revenues

Bi-Directional Power Capacity (kw)

CAISO (Southern)
ERCOT
PJM
Case Study: EV Fleet Sedan in Southern California

- Assumptions:
  - Lease Price: $290/month
  - 15kw bi-directional capability
  - Participation in Frequency Regulation Market only
  - 12,000 miles driven per year
  - Typical operation from 9am to 5pm
  - 2011 remuneration values for California ISO, in Southern California
V2G Case Study (cont’d)

- How much was 15kw of bi-directional capacity worth in 2011?
  - Southern California (south of Path 26) remuneration for 2011 was approximately $168/kw for storage available 24/7
    - Assumes resource is simultaneously participating in both up- and down-regulation markets
  - Total value of approximately $2,520 for the year or $210/month
    - Markets are highly variable by both time of day and time of year
    - Markets are open 24/7 for 365 (or 366) days per year

- Bottom line: Frequency Regulation alone can reduce the monthly lease price of a PEV sedan by about 72%.
  - Frequency regulation revenues are expected to rise as natural gas prices increase and per the implementation of FERC Order 755
V2G Case Study (cont’d)

- Assuming vehicles are “used” during normal business hours (8am-5pm, M-F), approximately 73% of frequency regulation value is retained.
  - Financial value does not change in non-business hours

- What does this mean for leasing a V2G-capable sedan?

<table>
<thead>
<tr>
<th>ICE Sedan</th>
<th>V2G Sedan</th>
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<tbody>
<tr>
<td>GSA lease price: $174/month</td>
<td>Base lease price: $290/month</td>
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<tr>
<td>Operating cost ($.145/mile): $145/month</td>
<td>Operating cost ($.06/mile): $60/month</td>
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<tr>
<td>Net Cost: $319/month</td>
<td>V2G value: $150/mo</td>
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<td>Net Cost: $200/month</td>
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**Net Savings for V2G: $119/month**
Other V2G Financial Considerations

- Infrastructure costs are significantly higher for V2G systems than conventional charging systems
  - Costs scale roughly proportional with power capacity (i.e. a 15kw system costs about twice as much as a 7.5kw system per station)
  - V2G requires that there is one charging station per PEV

- Frequency regulation is a highly variable market
  - A collapse in revenues is unlikely but possible

- Value of frequency regulation is stable in most markets when “normal business hours” are omitted

- Market saturation is possible but would require tens of thousands of V2G vehicles in a given RTO/ISO region

- Additional work is underway to identify new V2G activities that can draw financial value
Broader Implications of V2G

- A few hundred V2G vehicles on DOD bases can reduce costs and enhance mission capabilities
- What would happen if 100,000 V2G vehicles were placed in California?
  - At 15kw per vehicle, that’s 1.5GW of bi-direction power
  - Current ancillary service markets would be saturated
  - Financial value would have to be drawn from other demand response activities
    - At that point, we would hope that PEV prices are closer to ICE vehicles anyway.
  - Ancillary service market structures could be built around statistical models for driving patterns
- Electrical and transportation infrastructure would be effectively merged
Conclusion

- There is a pathway for fleets to procure PEV’s at total cost of ownership parity (or better) with conventional vehicles
- V2G is an essential element to satisfy financial constraints on DOD’s fleet electrification efforts
- Additional operational and tactical benefits occur with the implementation of V2G technologies
- Implementation of a V2G fleet will require a fundamental change in the manner in which fleet vehicles are organized and operated
- DOD is committed to exploring avenues that will bring V2G technologies to bear
DISCUSSION