Thoughts on Electric Vehicles and the Grid

EV Roadmap 7: Vehicles to Grid

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Ecofys

> Founded in 1984.
> Knowledge leader in renewable energy, energy efficiency and climate change.
> Around 200 professionals, 6 offices in 5 countries.
  - Netherlands, Germany, UK, China, US
> Over 500 clients served across 50 countries.
> The Nobel Peace Prize 2007, awarded to Al Gore and the IPCC, was supported by 10 Ecofys experts who contributed to the IPCC reports.

**Ecofys Mission: Sustainable energy for everyone!**
Transformational Breakthrough

- Wind and solar technologies, together with rapid improvements in energy efficiency make the transformation to low-fossil energy possible.
Electrifying Transportation Key

Global overall energy use in the Transport sector, by energy carrier type.
Variable Energy Resource Stressors

Perceived Flexibility Needs

1. Rapid increases and decreases in generation levels.
   - Timescales of minutes to hours.
2. High levels of output.
3. Low levels of output.

Load net renewable generation for Germany over renewable energy penetration levels.

Source: Flexibility Options in Electricity Systems, Ecofys, 2014
Flexibility Sources

- Supply Side
  - Generators
- Demand Side
  - Flexible loads
- Energy Storage
- Network Operational Improvements
Energy Storage

Comparison of Energy Storage Resources

Logarithmic Scale!

<table>
<thead>
<tr>
<th>Storage Capability (GWh)</th>
<th>Regional Resources</th>
<th>National Resources</th>
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</thead>
<tbody>
<tr>
<td>Grand Coulee/FDR Lake</td>
<td>North West Electric Heaters (@6 kWh)</td>
<td>National Nat Gas Storage (@50% conversion eff to e)</td>
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<tr>
<td>1.0E+07</td>
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<tr>
<th>Large Pump Storage Project (1GW @ 6hr)</th>
<th>150 Million Electric Vehicles (@30kWh)</th>
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<td>1.0E+00</td>
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Electric Vehicles and the Grid

• Charging a 20 kW battery in one hour with a demand charge of $10/kW-month could cost $200 per month, before paying for the energy!
  • Charging can be net cost, or net benefit – needs to be coordinated.

• Does not seem to be on utility planners’ radar yet.
  • Expected penetration levels relatively modest over next ten years.

• Price-responsive demand may be problematic.
  • Adds uncertainty to power system operators looking for more certainty.
  • Be careful not to add up-side risk to end use customers.
Electrically Fueled Vehicles

- Renewable electricity fueled vehicles not limited to electric battery vehicles.
  - Daimler’s hydrogen fuel-cell vehicle.
    - Can imagine refueling stations converting electricity to hydrogen and vice versa.
  - Audi’s renewable electricity derived methane powered cars.
    - Constructed 6 MW production facility in Germany, operational last year.
    - Potentially leverages huge capacity of the natural gas storage system and existing natural gas power plant infrastructure.
- Grid storage contribution could far exceed the penetration of electrically fueled vehicles themselves.

Daimler B Class hydrogen fuel cell vehicle.

Audi A3 g-tron compressed natural gas vehicle.
Summary

- Coordination needed to ensure vehicle charging is a benefit to the grid and that flexibility is used to reduce charging costs.
- Although storage in electric vehicle batteries is somewhat limited, it is significant and may be leveraged by “community” charging stations.
- Care needed in pursuing price-responsive demand to ensure benefits to the grid and the end user.

Audi 6 MW methane production facility
Thank You!