Transportation Electrification
Role of the Electric Sector

November 13th, 2009

Mark Duvall
Director, Electric Transportation
and Energy Storage
Overview

• Current status of auto industry
• Grid Impacts of Plug-In Vehicles
• Environmental Benefits of Electric Transportation
• Smart Charging
• Charging Infrastructure
• Utility Roles
Plug-In Vehicles Enter Market in Late 2010
What is the Near-Term Achievable Market Penetration?

Market penetration grows as vehicle production numbers increase, new models are introduced, and economies of scale drive down prices.

Source: Southern California Edison

<table>
<thead>
<tr>
<th></th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>BEV</td>
<td>500</td>
<td>5,800</td>
<td>31,850</td>
<td>73,967</td>
<td>97,500</td>
<td>126,550</td>
<td>181,800</td>
<td>517,967</td>
</tr>
<tr>
<td>PHEV</td>
<td>150</td>
<td>250</td>
<td>25,000</td>
<td>167,100</td>
<td>196,700</td>
<td>238,000</td>
<td>316,000</td>
<td>943,200</td>
</tr>
</tbody>
</table>

Market Penetration post-2015 difficult to estimate
Environmental Benefits of Plug-In Vehicles

Key Challenges

• Electricity is a low-carbon fuel
  – Potential 400-500 mton reduction
  – 3-4 million barrels/day petroleum reduction

• Ownership of CO₂ reductions

• Quantify societal value

• Competing perceptions – similar to energy efficiency studies

Annual Reduction in GHG Emissions due to PHEV Adoption
Source – 2007 EPRI-NRDC Study
Grid Impacts of Plug-In Vehicles

• Not all vehicles are ‘created equal’
• Generation and transmission impacts likely minimal
  – Full light-duty fleet electrification at 7-8% of demand
  – Aggregate fleet charging demands are modest
    • Most drivers at 40 miles per day or less
• Distribution
  – Charging load first impact smaller residential transformers and other fully utilized equipment
  – Optimal system requires managing time and level of charging
Power demand for uncontrolled charging

- Vehicle mix is 30% E-REVs, 50% blended PHEVs, 20% EVs
- Average charge power is about 700W per vehicle
Analyzing Distribution Impacts of PEVs

Residential transformers are the first assets significantly impacted

- **Flexibility in Model Development**
  - High-fidelity distribution feeder models
  - Spatial and temporal variation of circuit loads and PHEV Loads
  - Dynamic simulation of full electrical model serving PHEV

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Asset overloading can increase quickly

- With medium rate charging, it takes less than one PHEV per household to significantly increase overloading.
Smart Charging – Integration of Plug-In Vehicles with the Smart Grid
Plug-In Vehicle Grid Integration

Open communication standards

Standard Interface

AMI Path

Non-AMI Path

Smart Charging Back End
Energy Management, Customer ID, Billing
Standards Necessary for All Infrastructure Strategies

- Common Level 1 (120V) and Level 2 (240V) connector
- Communication standard governing vehicle-to-grid messages and information
- Standards for high rate charging, electrical installations, and others
Distribution System Analysis
Smart Charging is a Key Technology to Reduce Impacts

July 27th 2007 24 hr: Total Loading for the Feeder Under Study

- **Base Load Scenario**
- **PHEV Case 1:** (240V, 12A) Charging @6pm Penetration=10%
- **PHEV Case 2:** (240V, 12A) Charging @9pm Penetration=10%

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Distribution System Analysis
Smart Charging is a Key Technology to Reduce Impacts

July 27th 2007 24 hr: Total Loading for the Feeder Under Study

- Base Load Scenario
- PHEV Case 3: (240V, 12A) Diversified Charging @9pm-1am Penetration=10%

Off-peak loading
To Electrify Transportation, You Must Get Electricity to the Vehicles

Build Today’s Infrastructure Today

Focus on Residential

• Seamless installations for homeowners
• Permits, electricians, inspections
• Rates and customer programs

Workplace

Public Charging – as needed

• Retail, private, public spaces
• Open access

Know what drivers need

Know where cars are parked
Deliver Electricity, Charging Infrastructure to the Vehicle’s Location

Fleet Distribution during week

- Home
- Work
- Commercial
- Other
- School & Church
- Driving

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Deliver Electricity, Charging Infrastructure to the Vehicle’s Location

Fleet distribution during the week:
- Home: 66%
- Work: 14%
- Commercial: 6%
- Other: 8%
- School & Church: 5%
- Driving: 1%
Opportunity Charging Increases Electrification
Impact Depends on Vehicle Range

Utility factors
(1.44 kW)

- Red: Home, work and commercial
- Green: Home
- Blue: Relative improvement

PHEV Range (miles)
Plug-In Vehicles as Distributed Energy Resources

- **Definitions**
  - V2G – bidirectional transient power & ancillary services
  - V2H – premise peak shaving and DR
  - Smart charging – load shaping, DR, etc.

- **Whether or not true V2G is realized, vehicles will eventually be aggregated for grid services**
  - 3rd party DR
  - Grid regulation, even if one-way
  - 3rd party smart charging
  - Renewables integration
### PHEV Purchase Interest
Hybrid and Non-Hybrid Owners

**PHEV Purchase Interest**
Base: Among Those Who Currently Own A Standard Vehicle

<table>
<thead>
<tr>
<th></th>
<th>General Market/Non-Hybrid (n=583)</th>
<th>Hybrid Owner (n=290)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Top 2 Box</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Definitely will purchase or lease</td>
<td>28%</td>
<td>53%^A</td>
</tr>
<tr>
<td>Probably will purchase or lease</td>
<td>19%</td>
<td>33%^A</td>
</tr>
<tr>
<td><strong>Might or might not purchase or lease</strong></td>
<td>42%</td>
<td>35%</td>
</tr>
<tr>
<td><strong>Probably will not purchase or lease</strong></td>
<td>20%^B</td>
<td>9%</td>
</tr>
<tr>
<td>Definitely will not purchase or lease</td>
<td>10%^B</td>
<td>3%</td>
</tr>
<tr>
<td><strong>Bottom 2 Box</strong></td>
<td></td>
<td>12%</td>
</tr>
</tbody>
</table>

**NOTE:** Capital letters represent statistical differences at a 95% confidence level.

Q. 15 How likely are you to purchase or lease this vehicle as a plug-in hybrid electric vehicle the next 5 years?
# Customer Expectations of Their Utility

**Expectations Of The Utility**
Base: General Market (n=602)

## How The Electric Company Can Help Keep Consumers Informed

<table>
<thead>
<tr>
<th>Service</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provide info on charging options</td>
<td>67%</td>
</tr>
<tr>
<td>Provide info on availability of plug-in hybrid electric vehicles in your area</td>
<td>64%</td>
</tr>
<tr>
<td>Make available the experience of those who purchased/leased the vehicle early on</td>
<td>46%</td>
</tr>
<tr>
<td>Offer info about the environmental benefits of these types of vehicles</td>
<td>41%</td>
</tr>
<tr>
<td>Other</td>
<td>3%</td>
</tr>
</tbody>
</table>

## Consumers' Desired Services From The Electric Company

<table>
<thead>
<tr>
<th>Service</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Publish a list of public charging hot spots and charging prices</td>
<td>67%</td>
</tr>
<tr>
<td>Develop a public charging infrastructure</td>
<td>58%</td>
</tr>
<tr>
<td>Ensure that if you buy, you have ready charging access at home</td>
<td>57%</td>
</tr>
<tr>
<td>Install ‘Smart Metering’</td>
<td>52%</td>
</tr>
<tr>
<td>Other</td>
<td>1%</td>
</tr>
</tbody>
</table>

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Q. 40a How can your electric utility company best help you stay informed about plug-in hybrid electric vehicles?
Q. 40b If you were planning on purchasing or leasing a plug-in hybrid electric vehicle, which of the following services would you want from your electric company?
## Preferred Charging Locations

Base: Among Those Who Mentioned A Preferred Station

### Top 2 Preferred Charging Locations

<table>
<thead>
<tr>
<th></th>
<th>General Market/Non-Hybrid (n=472)</th>
<th>Hybrid Owner (n=265)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>At home</strong></td>
<td>94%</td>
<td>95%</td>
</tr>
<tr>
<td><strong>At your place of work</strong></td>
<td>45%</td>
<td>61%&lt;sup&gt;A&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>Gas stations</strong></td>
<td>25%&lt;sup&gt;B&lt;/sup&gt;</td>
<td>15%</td>
</tr>
<tr>
<td><strong>Shopping centers/malls</strong></td>
<td>23%</td>
<td>19%</td>
</tr>
<tr>
<td><strong>Colleges or universities</strong></td>
<td>4%</td>
<td>2%</td>
</tr>
<tr>
<td><strong>Friend/family's home</strong></td>
<td>3%</td>
<td>0%</td>
</tr>
<tr>
<td><strong>Government offices/buildings</strong></td>
<td>2%</td>
<td>3%</td>
</tr>
<tr>
<td><strong>Train stations</strong></td>
<td>2%</td>
<td>0%</td>
</tr>
<tr>
<td><strong>Coffee shops</strong></td>
<td>1%</td>
<td>3%&lt;sup&gt;A&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>Other</strong></td>
<td>1%</td>
<td>0%</td>
</tr>
</tbody>
</table>

NOTE: Capital letters represent statistical differences at a 95% confidence level.

Q. 19 If you owned a plug-in hybrid electric vehicle, which locations do you think you would use the most to charge the vehicle?
Q. 21 How much time do you expect it to take to fully recharge a plug-in hybrid electric vehicle, assuming that the battery was low?

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### Planned Use of Public Charge Stations

**Planned Usage Of Public Charging Stations**
Base: Total Respondents

#### Charging Stations Most Likely To Use

<table>
<thead>
<tr>
<th></th>
<th>General Market/Non-Hybrid (n=587)</th>
<th>Hybrid Owner (n=292)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(A)</td>
<td>(B)</td>
</tr>
<tr>
<td>A retail store</td>
<td>22%</td>
<td>20%</td>
</tr>
<tr>
<td>A typical gas station</td>
<td>21%B</td>
<td>13%</td>
</tr>
<tr>
<td>A charging station that offered free Wi-Fi</td>
<td>16%</td>
<td>18%</td>
</tr>
<tr>
<td>A club store</td>
<td>11%</td>
<td>16%</td>
</tr>
<tr>
<td>A city-owned station</td>
<td>10%</td>
<td>12%</td>
</tr>
<tr>
<td>A government-owned station</td>
<td>6%</td>
<td>4%</td>
</tr>
<tr>
<td>An electric utility company</td>
<td>6%</td>
<td>6%</td>
</tr>
<tr>
<td>A college or university</td>
<td>4%</td>
<td>3%</td>
</tr>
<tr>
<td>A coffee shop</td>
<td>4%</td>
<td>6%</td>
</tr>
<tr>
<td>Some other company</td>
<td>1%</td>
<td>2%</td>
</tr>
</tbody>
</table>

**NOTE:** Capital letters represent statistical differences at a 95% confidence level.

Q. 27  Assuming that each station were to offer recharging at the same price, which of the following types of stations would you use the most?
240-Volt Accessibility

240 Volt Accessibility Near Parking Location
Base: General Market

Available 3-Prong Outlet within 25 Feet of Parking Location
(n=602)

- Yes: 65%
- No: 24%
- Not Sure: 11%

Current Parking Situation
Base: Among Those Who Have Access To 3-Prong Outlet Within 25 Feet Of Parking Location And Are The Primary Driver of A Standard Vehicle (n=360)

- Enclosed space (e.g., carport, garage): 45%
- Driveway of residence: 36%
- Street parking (consistent or various places): 11%
- Outdoor parking lot (assigned or not assigned spot): 8%

NOTE: Capital letters represent statistical differences at a 95% confidence level.

Q.22 In a typical week, which of the following best describes where you park your primary vehicle the most?

Q.23 Do you currently have a conventional 3-prong electrical outlet within 25 feet of where you park your primary vehicle at your residence?
Together...Shaping the Future of Electricity

Image from NASA Visible Earth
Potential Utility Roles

• Seamless customer experience
  – Outreach and education
    • Consumers and fleet
  – Facilitate residential, commercial infrastructure
  – Support public infrastructure

• Minimize Grid Impacts
  – Smart grid integration – smart charging
  – Distribution planning
  – Customer programs