The Impact of the Introduction of Electric Vehicles in 2010 and Beyond

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WGA Transportation Fuels Council
2010 Spring Workshop
Outline

• What’s coming in the near term?
• Grid impacts
  – Overall energy impact
  – Overall power impact
  – Distribution system impact
  – Environmental impact
• Infrastructure readiness
• Non-road electric vehicles
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Common Terminology

- Plug-in Hybrid Electric Vehicle (PHEV) – a hybrid vehicle with a larger battery pack that is capable of using stored electricity instead of gasoline
- Extended Range Electric Vehicle (E-REV) – a vehicle that is capable of driving around on electricity alone, but has an engine to extend range
- Electric Vehicle (EV) – a vehicle that drives on electricity alone
- Plug-in Electric Vehicle (PEV) – any vehicle which uses electricity as a fuel
First to market in US…..recent news

Initial factory-built Chevrolet Volts roll off the production line
- Extended Range Electric Vehicle
- 40-mile range. ~8kWh useable capacity
- Regular production from Nov 2010
- Charging
  - 8-9 hours at 120V, 12A
  - 3 hours at 240V, 15A

Nissan Leaf Pricing
- $32,780 excluding $7,500 federal tax credit and some state credits such as $5000 in CA
- Electric Vehicle
- Expected first model 50000 units
- Smyrna TN facility ramp-up ~150000 by 2012
- 100-mile range, ~24kWh useable capacity
- Charging
  - 20 hours at 120V, 12A
  - 8 hours at 240V, 15A
  - $2200 home charging infrastructure
Plug-in electric vehicle commercialization timeline

- BYD F3DM (China)
- i-MiEV (Japan)
- Chevy Volt EREV
- Transit Connect EV
- BYD (U.S.)
- Nissan Leaf
- Tesla Roadster
- Mini E
- BYD (U.S.)
- PHEV
- i-MiEV (U.S.)
- Focus EV
- Production PHEV
- Expected Launch PHEV, EV
- Toyota
- More OEMs
- More Models
- Unconfirmed Plans For EV, PHEV

- 2009
- 2010
- 2011
- 2012
- 2013
- 2014
Between 1999 and 2004, there were three hybrids introduced to the U.S. market (Prius, Insight, Civic Hybrid)
Gas price impact of PEV purchase intent

- **Gasoline $/Gallon**
  - 2.50
  - 3.00
  - 3.50
  - 4.00
  - 4.50
  - 5.00

- **% Acquisition Interest**
  - 0%
  - 20%
  - 40%
  - 60%

- **Vehicle Types**
  - **Today**
  - **Conventional Vehicle**
  - **Plug-in Hybrid Electric Vehicle**
  - **Electric Vehicle**
  - **Hybrid Vehicle**
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Overall energy impact is relatively low

Adequate energy supply to meet any realistic penetration

Annual Residential Electricity Consumption

Opportunity to Alleviate Issues Related to Nighttime Over Generation

US Average
Chevy Volt
The load is growing even without vehicles

Capacity expansion 19 to 72 GW by 2050 nationwide (1.2 – 4.6%)
Overall power demand is relatively low
Peak power impact can be locally significant

Average Peak Summer Demand Per Household (KW)

<table>
<thead>
<tr>
<th>Feeders</th>
<th>Average Peak Summer Demand Per Household (KW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PEV (240V@32A)</td>
<td>7.7</td>
</tr>
<tr>
<td>PEV (240V@15A)</td>
<td>3.6</td>
</tr>
<tr>
<td>PEV (120V@12A)</td>
<td>1.4</td>
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<tr>
<td>San Francisco, CA</td>
<td>3.0</td>
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<tr>
<td>Hartford, CT</td>
<td>4.3</td>
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<tr>
<td>Dulles, VA</td>
<td>4.6</td>
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<tr>
<td>South Bend, IN</td>
<td>6.0</td>
</tr>
<tr>
<td>Springdale, AR</td>
<td>7.7</td>
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</tbody>
</table>

Peak demand can impact distribution infrastructure
EPRI is studying the distribution system impacts

- Detailed electrical model of selected feeders that includes each customer
- Assessment of different PEV charging type and penetration mode
- Hourly analysis using 8760 hours load profile to assess localized hotspots
Sample study results – likelihood of overload

Unlikely impacted assets at even 20% penetration

Assets at risk at a 2% penetration

Assets “closest to the load” are the most likely to be impacted first.
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Greenhouse gas emissions reductions

- Electricity grid evolves over time
- Nationwide fleet takes time to renew itself or “turn over”
- A potential 400-500 million metric ton annual reduction in GHG emissions (the US currently emits 6 billion metric tons annually)

Annual reduction in greenhouse gas emissions from PHEV adoption
Criteria emissions are decreased by introducing PHEVs

Power Plant Emissions
• Emissions under caps (SO₂, NOx, Hg) are essentially unchanged
• Primary PM emissions increase (defined by a performance standard)

Vehicle Emissions
• NOx, VOC, SO₂, PM all decrease
• Significant NOx, VOC reductions at vehicle tailpipe
• Reduction in refinery and related emissions

<table>
<thead>
<tr>
<th>Emissions (tons)</th>
<th>SOx</th>
<th>NOx</th>
<th>VOC</th>
<th>PM</th>
</tr>
</thead>
<tbody>
<tr>
<td>On-Road Vehicle</td>
<td>-7,716</td>
<td>-236,292</td>
<td>-234,342</td>
<td>-9,255</td>
</tr>
<tr>
<td>Refinery and Other Stationary</td>
<td>-23,549</td>
<td>-20,076</td>
<td>-17,804</td>
<td>-3,282</td>
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<tr>
<td>Distributed Upstream</td>
<td>0</td>
<td>-1,293</td>
<td>-103,323</td>
<td>-101</td>
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<td>Power Plant</td>
<td>-16,284</td>
<td>58,916</td>
<td>0</td>
<td>49,434</td>
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<tr>
<td>Total</td>
<td>-47,549</td>
<td>-198,745</td>
<td>-355,469</td>
<td>36,796</td>
</tr>
</tbody>
</table>

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PHEVs reduce formation of secondary PM$_{2.5}$

- PM$_{2.5}$ includes both direct emissions and secondary PM formed in the atmosphere.
- PHEVs reduce motor vehicle emissions of VOC and NOx.
- VOCs emissions from power plants are not significant.
- Total annual SO$_2$ and NOx from power plants capped by federal law.
- The net result of PHEVs is a notable decrease in the formation of secondary PM$_{2.5}$.
Daily PM$_{2.5}$ Design Value Exposure Changes
Electricity as a low carbon fuel in California
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Codes and standards status

• ‘Normal’ charge connector standard is done
• Communication standards are about 18 months away
• Connector standards for fast charging are also about 18 months away
  – Fast charging is very beneficial for electric vehicles, less so for plug-in hybrids
Although average power is manageable, it happens at the wrong time.
Smart Charging can prevent negative impacts

Shifts the charge load to nighttime, but spreads it out relatively evenly over 6 hours

Only shifting the time without evening out the profile can make the situation worse
Deliver electricity and charging infrastructure to the vehicle’s location

Fleet distribution during the week

- Home: 66%
- Work: 14%
- Commercial: 8%
- Other: 5%
- School & Church: 6%
- Driving: 1%
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
    - Viable business models?
  - Know what drivers need
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Non-road electric transportation

• There are a large number of opportunities for electrification of non-road vehicles
• Many of the opportunities are economic now
• There can be many side benefits such as improved indoor air quality

Photo credit: Georgia Ports Authority
Estimated reductions in electric drive transportation for California

Data: TIAX estimates these achievable reductions in greenhouse gas and criteria emissions from electric drive transportation.
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