Impact of Plug-in Hybrids on the Electrical System in the Northwest
a preliminary assessment

We have two modes:
"Complacency and Panic"

James Schlesinger
Credits


Background

- About 230 million passenger and light trucks on the roads today.

- Vehicles per 1000 people
  - In the US about 800
  - Compared to Western Europe/Canada-600
  - Or China – 20

- MPG ~ in low 20s
## Changes in Transportation

<table>
<thead>
<tr>
<th></th>
<th>1970</th>
<th>2005</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Vehicles (millions)</td>
<td>110</td>
<td>235</td>
</tr>
<tr>
<td>Miles traveled (Trillion)</td>
<td>1.1</td>
<td>2.9</td>
</tr>
<tr>
<td>Miles per vehicle</td>
<td>10,303</td>
<td>12,482</td>
</tr>
</tbody>
</table>

### Adjusted Fuel Economy by Model Year

(Annual Data)

![Adjusted Fuel Economy Chart](chart.png)
Trends in Cost of Transport

Figure 10. Annual indices of Real Disposable Income, Vehicle-Miles Traveled, Consumer Price Index (CPI-U), and Real Average Retail Gasoline Price, 1975-2004; 1985=100

Source: Energy Information Administration, Annual Energy Review 2004; Bureau of Economic Analysis.
Note: * = recession year.

Figure 5. Average Commuting distances, 1969-2001

Average length of trip to work (miles)

Source: Federal Highway Administration, National Household Transportation Survey.
Travel Time to Work

<table>
<thead>
<tr>
<th>Percent</th>
<th>Less than 30 minutes</th>
<th>Between 30 Minutes to an 1 hour</th>
<th>Over an hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>70%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>60%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0%</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Description of different options

- **Current options**
  - Gasoline system
  - Turbo Diesel
  - hybrid

- **Future options**
  - Gasoline
  - Turbo Diesel
  - Hybrid
  - plug-in hybrid
  - Battery electric
  - Fuel Cell

Audi Turbo Diesel
GM Volt
Hyundai’s Fuel Cell
Tesla’s Battery electric car
Barriers to new alternative fueled vehicles

- Demand
  - High first cost for vehicle
  - Fuel storage/limited range
  - Reliability and durability
  - Lack of refueling infrastructure
  - Market entry barriers (high entry cost)
  - High discount factors and risk aversion

Barriers to new alternative fueled vehicles

- Supply side constraints
  - Lead times for new product line
  - High Capital investment requirements
  - Limitations of critical supply components
  - Global market response / increase in price of components/ backlog
Simple model

- Forecast of passenger and light trucks – Global Insight
- Market share fraction ~ 3% to start 26% in 10 years
- Miles traveled per day ~33 held constant
- Energy requirement ~ 0.26-0.46 watts/mile (0.3 midsize)
- Energy efficiency improvement -5% per year
- Battery size 10 KWh
- Battery type Lithium-Ion
- T&D and conversion efficiency losses ~20%
- Recharge at 110 v 15 amp in 8 hours
- Recharge at 220 v 30 amp in under 2 hours
- Assumed 95% recharge off peak, 5% during peak hours
- Current average MPG for gasoline vehicles 20.2
- CO2 emissions for gasoline ~ 1 lb/mile
Cumulative New Plug-in Hybrid Vehicles

Typical US Commute Distance

We assumed 33 miles round trip for our modeling work.
Modeling Storage Opportunities

- Assumed that 25 MW of storage can be placed in the Plug-in vehicles.
- Charge period
- Discharge Period
- Assumed efficiency

Implications of Hybrids

- 2020 MID C prices (annual mean)
  - Base case - $71.42/MWh
  - With Plug-ins - $72.07/MWh
  - With Plug-in and V2G - $65.27/MWh
  - Discharge period price $70.30
  - Recharge period price $54.60

- Power Plant CO2 Emissions (WECC wide)
  - Base case - 475 million tons
  - With Plug-ins - 476 million tons
  - With Plug-in and V2G - 444 million tons
Preliminary results from Aurora

- Increased Load
- CO2 reduction
- Increase in off peak prices

Incorporating Plug-in Hybrids

- Plug-in hybrid characteristics will be incorporated into Energy2020 model
- Penetration rates can be exogenously set or endogenously determined.
- V2G will be incorporated into Aurora model.