Probing the Transition to Electric Drive: PHEVs Risks and Opportunities

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Michael Nicholas
Tom Turrentine

STEPS SYMPOSIUM -- SPRING 2016

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PH&EV Center “Roll-out & ramp-up research” 2013-2016

Annual & semi annual “big” & “contextual” longitudinal data

Studying the ‘Evolution” of the ZEV market; the interaction of policy, technology, energy systems and consumer culture

- Gil Tal & Mike Nicholas
- Ken Kurani
- Tom Turrentine
- Mike Nicholas & Gil Tal
- Lew Fulton
- Gil Tal
- Tom Turrentine

US PEV buyer studies
US car buyers & PEVs
PEV household use patterns
The world PEV market
World PEV sales are doing well, growing faster than HEVs

Data from ev-sales.blogspot.com
NETHERLANDS
Netherlands Quarterly Sales

- BEV
- PHEV

Yearly Sales:
- 2013: Low sales
- 2014: Moderate sales
- 2015: Moderate sales
- 2016: Low sales

Sales Trends:
- 2017: High sales

Note: Sales figures are approximate and may vary.
When PHEVs Backfire

plug-in vehicles 2012

fraction electric

percentage of the vehicles [%]

percentage electric mileage [%]

plug-in Prius type-approval: 50%

Opel Ampera type-approval: 78%

Norbert E. Ligterink EVS27
NORWAY
Norway Sales

PHEV

BEV

Q1 2013
Q2 2013
Q3 2013
Q4 2013
Q1 2014
Q2 2014
Q3 2014
Q4 2014
Q1 2015
Q2 2015
Q3 2015
Q4 2015
Q1 2016

<table>
<thead>
<tr>
<th>Year</th>
<th>Q1</th>
<th>Q2</th>
<th>Q3</th>
<th>Q4</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>89%</td>
<td>96%</td>
<td>95%</td>
<td>98%</td>
</tr>
<tr>
<td>2014</td>
<td>91%</td>
<td>91%</td>
<td>91%</td>
<td>92%</td>
</tr>
<tr>
<td>2015</td>
<td>89%</td>
<td>72%</td>
<td>23%</td>
<td>77%</td>
</tr>
<tr>
<td>2016</td>
<td>11%</td>
<td>28%</td>
<td>25%</td>
<td>40%</td>
</tr>
</tbody>
</table>

Notes:
- Q1-4: First to Fourth Quarter
- 2013-2016: Yearly Sales Period
- PHEV: Plug-in Hybrid Electric Vehicle
- BEV: Battery Electric Vehicle
Lots of new models & lower taxes in Norway for heavier PHEVs

- Weight deduction increased to 15%
- Weight deduction increased to 26%
China, the world’s largest market - over 22 million vehicles per year - has in a short period double the PEV sales volumes of USA.
CHINA
A Tale of Two Cities: Beijing and Shanghai

• Shanghai started to restrict the volume of private vehicles through an auction system.
• 92,947 vehicles per year (2015)
  Winning Probability: 5.07%
• Policy support: BEVs and PHEVs
• 2015 target: 13,000
• 2015 PEVs sold: 44,247 (BEV: 10,845; PHEV: 29,752)

• Beijing restrict the volume through a lottery system.
• 120,000 per year (2015);
  Probability: 0.49%
• Policy support: BEV only
• 2015 target: 30,000
• 2015 PEVs sold: 23,500
Shanghai: PHEVs are the First and Most Cases Only Vehicle in the Household
The Calculation of eVMT by PHEV Qin in Shanghai in 2015 (N=1329)
This method missed the blending of gas and electricity and over-estimated the eVMT. We are asked by Shanghai Int’l Auto City/SHEVDC to help calculate 2015 data of over 25,000 PHEVs.

<table>
<thead>
<tr>
<th>Charging frequency</th>
<th>Number of vehicles</th>
<th>Total number of days on road</th>
<th>Average daily driving mileage (km)</th>
<th>CD stage mileage (km)</th>
<th>Total mileage (km)</th>
<th>Electricity mileage percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Twice/day</td>
<td>389</td>
<td>941</td>
<td>78.35</td>
<td>60254</td>
<td>73727</td>
<td>81.73%</td>
</tr>
<tr>
<td>Once/day</td>
<td>1071</td>
<td>7532</td>
<td>61.78</td>
<td>354979</td>
<td>465354</td>
<td>76.28%</td>
</tr>
<tr>
<td>0.5/day</td>
<td>547</td>
<td>904</td>
<td>87.23</td>
<td>55770</td>
<td>78854</td>
<td>70.73%</td>
</tr>
<tr>
<td>Total</td>
<td>1329</td>
<td>122518</td>
<td>32.88</td>
<td>2431812</td>
<td>4028663</td>
<td>60.36%</td>
</tr>
</tbody>
</table>
USA
US Annual PEV Sales slowed in 2015

Annual PEV Sales in Thousands

- 2011: BEV 56%, PHEV 44%
- 2012: BEV 27%, PHEV 73%
- 2013: BEV 50%, PHEV 50%
- 2014: BEV 50%, PHEV 50% (+26%)
- 2015: BEV 53%, PHEV 47% (-5%)
EVMT PROJECT
How many People just Don’t Plug in?

Percent Using as Hybrid Vehicle vs. Percent Not plugging in

- 0%
- 2%
- 4%
- 6%
- 8%
- 10%
- 12%
- 14%
- 16%

Vehicle Range

- 0
- 10
- 20
- 30
- 40
- 50
EVMT by model

<table>
<thead>
<tr>
<th>Model</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leaf</td>
<td>100</td>
</tr>
<tr>
<td>Volt</td>
<td>76.22222</td>
</tr>
<tr>
<td>C-Max</td>
<td>49.22222</td>
</tr>
<tr>
<td>Fusion</td>
<td>43.88889</td>
</tr>
<tr>
<td>Prius</td>
<td>21.83333</td>
</tr>
</tbody>
</table>
eVMT% by annual miles
Percent eVMT on a Household Basis
DISCUSSION
SUV PHEV sales grew dramatically in 2015
PHEVs are Getting Bigger, Batteries are Not
Conclusions

- PHEVs can ramp up the market by:
  - Electrifying larger vehicles
  - Used by single car households
  - Used when charging infrastructure is not reliable
- PHEVs are not better than HEVs if not plugged in. when:
  - Purchased from a single reason that is not collated with charging the vehicle (HOV lanes, Registration fees, purchase cost)
  - Low benefit to plugging in (short range, no electric performance)
  - Gas price is close to electricity price
- Home or work charging are important
- Longer range and EV performance reduce the probability for not plugging in.

- Without PHEV we are less likely to meet the sales and GHG goals
Thank you

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