PEV Markets and Users, Lessons Learned

Learning from the California Experience Alternative Fuels, Vehicles, and Infrastructure

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Gil Tal gtal@ucdavis.edu

The Center collaborates closely with California utilities, automakers, regulators, and other research institutions on research aimed at developing a sustainable market for plug-in vehicles.
SUSTAINABLE TRANSPORTATION ENERGY PATHWAYS

PLUG-IN HYBRID & ELECTRIC VEHICLE RESEARCH CENTER

CHINA CENTER FOR ENERGY AND TRANSPORTATION

POLICY INSTITUTE FOR ENERGY, ENVIRONMENT AND THE ECONOMY

NATIONAL CENTER FOR SUSTAINABLE TRANSPORTATION
PH&EV Center “Roll-out & ramp-up research”

Studying the interaction of policy, technology, energy systems and consumer culture

- Dr. Gil Tal
- Dr. Alan Jenn
- Dr. Mike Nicholas

- Dr. Ken Kurani
- Dr. Turrentine

US PEV buyer studies

US car buyers & PEVs

PEV household use patterns

The world PEV market

- Dr. Mike Nicholas
- Dr. Gil Tal

Dr. Tom Turrentine
Dr. Gil Tal
Dr. Scott Hardman
A few of our past PEV projects

- 1991 Household PEV purchase interest & range estimation interviews (PIREG)
- 1991 Rose Bowl drive test of electric, natural gas, methanol fueled vehicles, 10 focus groups
- 1994 UCD survey of California households on alternative fuels
- 1997 Neighborhood electric vehicle trials in Davis
- 2002 Nissan Hypermini and Toyota Fuel-cell Vehicle trials in Davis
- 2007-13 PH&EV center funded by the California Energy Commission
- 2008-14 Plug in Conferences series with EPRI
- 2008-9 ARB funded test of PHEVs in California households (Dr. Kurani)
- 2010-11 BMW MINI E field study (Dr. Turrentine)
- 2011-13 Chrysler PHEV pick-up field study
- 2011-13 San Diego PEV Infrastructure Study (surveys & focus groups)
- 2014-15 Surveys of future market with 10 MOU states (Dr Kurani)
- 2014 Survey with EPRI of PEV buyers in 13 states
- 2015 Survey of 5000 California PEV drivers
- 2015-17 ARB / CEC data acquisition of 240 households (Nicholas)
- 2015 Survey of “used” PEV buyers (Tal)
- 2016 Survey of 5000 California PEV drivers (Tal)
- 2016 Survey of 2000 California car buyers (Kurani)
PH&EV Center Data Collection

24,000 New car Buyers surveys
- 2010-2016
- 12 US states
- Focus groups
- Interviews

27,000 Electric car buyer surveys
- 2010-2016
- 12 US states, China, Germany
- Used PEV buyers
- Focus groups and Interviews

PEV and ICE on road data collection
- OBD data 264+ vehicles over a year
- GPS data 27,000 vehicles over 2.5 years
- 4,000 Vehicles second by second dataset for California

US Infrastructure Charging data 2012-2016
- 9,000,000 Level 2 charging events
- 1,300,000 DC fast charging events
- Vehicle reported charging events
And a market is developing, with early buyers influencing the next segment of buyers.

Diffusion of Innovation Framework

Innovators
- Technology Enthusiasts

Early Adopters
- Visionaries

Early Majority
- Pragmatists

Late Majority
- Conservatives

Laggards
- Skeptics

origins in anthropology & formalized in rural sociology, now popular in high tech marketing.
A plausible California scenario based on laws, incentives & history of previous technology rollouts.

1st generation: policy, vehicles, "innovators" & infrastructure 200,000 PEVs

2nd generation: batteries, vehicles, "followers" 500,000 PEVs

3rd generation: batteries, vehicles, "core market" 800,000 PEVS

California 2025 ZEV goal = 15% / 1.5 million BEVS, FCV & PHEVs

4th generation: 3 - 4 million???

Main market 15-25%

Early core market: 6-15%

3-5% of market

1-2%

Lithium pack prices per
The main market task is to assist this diffusion process.

**1st generation**
1-3 % of market, 200,000 PEVs

150,000 PEV innovator households

**2nd generation**
3-5% of market, 500,000 PEVs

“Early adopters” also called “Fast Followers”
Innovators from 1\textsuperscript{st} Generation market will be buying some portion of the 2\textsuperscript{nd} Generation market – perhaps 100,000

- **1\textsuperscript{st} generation**
  - 1-3% of market, 200,000 PEVs
  - 150,000 PEV innovator households

- **2\textsuperscript{nd} generation**
  - 3-5% of market, 500,000 new PEVs

- And a growing used PEV market

**“Innovators”** from 1\textsuperscript{st} Generation market will be buying some portion of the 2\textsuperscript{nd} Generation market – perhaps 100,000

**“Early adopters”** also called **“Fast Followers”**

**“Innovators 2\textsuperscript{nd}, 3\textsuperscript{rd} PEV purchases”**

Used PEVs
NEW CAR BUYERS AND PEV BUYERS: PEV BUYERS ARE COMING BACK FOR SECONDS

- 21% bought 1 car = 72% of new car purchases
- 75% of the households did not purchase new car in the last 3 years
- 4% of HH purchased 2+ cars = 28+% of new cars

• 4% of the households are responsible for almost one third of the market over the last 3 years 2010-2012
• Up to 15% of PEV buyers are on their second PEV
Have you considered a vehicle that runs on electricity for your household?

- Orange: I (we) already have a vehicle powered by electricity
- Blue: Shopped for an electric vehicle, including a visit to at least one dealership to test drive
- Purple: Started to gather some information, but have not really gotten serious yet
- Green: The idea has occurred, but no real steps have been taken to shop for one
- Red: I (we) have not considered buying a vehicle that runs on electricity but maybe some day we will
- Gray: I (we) have not and would not consider buying a vehicle that runs on electricity

Kurani 2016
Population estimates of new car buyers with positive PHEV, BEV, or FCEV valuation

<table>
<thead>
<tr>
<th>State</th>
<th>Occupied housing units x 1,000 (US Census)</th>
<th>Vehicle available (ACS)</th>
<th>% buy new (est. from past UCD surveys)</th>
<th>% Design PEV or FCEV Game 3</th>
<th>Population Estimate x 1,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oregon</td>
<td>1,523</td>
<td>92%</td>
<td>33%</td>
<td>38.7%</td>
<td>181</td>
</tr>
<tr>
<td>California</td>
<td>12,617</td>
<td>92%</td>
<td>33%</td>
<td>38.1%</td>
<td>1,476</td>
</tr>
<tr>
<td>Washington</td>
<td>2,645</td>
<td>93%</td>
<td>33%</td>
<td>35.9%</td>
<td>295</td>
</tr>
<tr>
<td>Maryland</td>
<td>2,156</td>
<td>91%</td>
<td>33%</td>
<td>31.4%</td>
<td>204</td>
</tr>
<tr>
<td>Delaware</td>
<td>339</td>
<td>94%</td>
<td>33%</td>
<td>28.0%</td>
<td>30</td>
</tr>
<tr>
<td>NESCAUM</td>
<td>16,078</td>
<td>81%</td>
<td>33%</td>
<td>26.6%</td>
<td>1,151</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3,337</td>
</tr>
</tbody>
</table>

Kurani 2016
New Car Buyers Perspectives

• Most households with negative ZEV valuation have yet to ask themselves, “Is a PEV right for my household?”

• The importance of awareness, knowledge, Promotional policies that mitigate up-front costs still leave the “new-technology averse” with an expensive unknown.

• The effects of incentives Among those who did not design a PEV or FCEV is very low.

• Those with positive ZEV valuations have multiple motivations, Everyone highly motivated by fuel cost savings is highly motivated by something else, too.

• Despite low awareness, knowledge, experience, and prior consideration, 24% to 39% of respondents design a PEV or FCEV as their next new vehicle.

Kurani 2016
Plug in Electric Vehicle (PEV) Purchase Motivations

- Not using gas
- MPG
- Performance
- Range
- Electric experience
Vehicle Choice Without the Federal Tax Credit

- **ALL**: 71.5%
- **TESLA MODEL S**: 86.1%
- **TOYOTA PRIUS PLUG-IN**: 84.7%
- **FORD FUSION ENERGI**: 82.3%
- **FORD C-MAX ENERGI**: 76.2%
- **CHEVROLET VOLT**: 59.7%
- **NISSAN LEAF**: 50.9%

The diagram shows the percentage of respondents who would buy a PEV, buy an ICE (Internal Combustion Engine) or would not buy a new car, for different vehicle models. The labels for the bars indicate the percentage of respondents for each option.
The Impact of $1000 price Change on the Potential Market

100%=16 million vehicles
What Will a PHEV Driver Buy Without the Green Sticker?

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>phev</th>
<th>BEV</th>
<th>ICE</th>
<th>Not to Buy</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMW i3 REX</td>
<td>90%</td>
<td>10%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chevrolet Volt</td>
<td>80%</td>
<td>20%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ford C-Max Energi</td>
<td>70%</td>
<td>30%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ford Fusion Energi</td>
<td>60%</td>
<td>40%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toyota Prius Plug In</td>
<td>50%</td>
<td>50%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
<td></td>
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</tr>
</tbody>
</table>
PEV Models in Norway

Weight tax deduction increased to 26%

Weight tax deduction increased to 15%

Mitsubishi Outlander PHEV
Total cost (Including all taxes)
Before any incentive: $63,400
After incentive: $57,700
ICE Outlander: $46,000

Q1 Q2 Q3 Q4 Q1 Q2 Q3 Q4 Q1 Q2 Q3 Q4 Q1

2013 2014 2015 2016
Price comparison 3-series sedan models.

Total price incl. registration tax

<table>
<thead>
<tr>
<th>Model</th>
<th>Year 2014</th>
<th>Year 2015</th>
<th>Year 2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>330iA xDrive</td>
<td>€ 69,882</td>
<td>€ 70,849</td>
<td>€ 64,527</td>
</tr>
<tr>
<td>320dA</td>
<td>€ 46,434</td>
<td>€ 47,277</td>
<td>€ 45,366</td>
</tr>
<tr>
<td>330e PHEV</td>
<td>€ 49,286</td>
<td>€ 48,503</td>
<td>€ 46,065</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Feature</th>
<th>Year 2014</th>
<th>Year 2015</th>
<th>Year 2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price w/o tax</td>
<td>€ 39,300</td>
<td>€ 32,000</td>
<td>€ 42,500</td>
</tr>
<tr>
<td>Total power (kW)</td>
<td>185</td>
<td>140</td>
<td>185</td>
</tr>
<tr>
<td>CO₂ (g/km)</td>
<td>138</td>
<td>104</td>
<td>49</td>
</tr>
</tbody>
</table>

Reg. tax

**Note:** The registration tax is included in the total price.
Where/do they Charge?

<table>
<thead>
<tr>
<th>Car Model</th>
<th>Only at Home</th>
<th>Both home and Public</th>
<th>Only at public</th>
<th>Not plug in</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMW i3</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Ford Focus Electric</td>
<td></td>
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<tr>
<td>Toyota RAV4 EV</td>
<td></td>
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<tr>
<td>Tesla Model S 85</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Honda Fit EV</td>
<td></td>
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<tr>
<td>Nissan LEAF</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>BMW i3 REX</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Fiat 500e</td>
<td></td>
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<tr>
<td>Chevrolet Spark EV</td>
<td></td>
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<tr>
<td>Chevrolet Volt</td>
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</table>
Overlapping Incentives

No Need of any Incentives
22%-50%

Monetary Incentives
25%-50%

Non monetary Incentives (HOV)
5%-20%

Public infrastructure
2%-8%
Charging
Most Charging can be done at Home
Longer Range Vehicles Have More Level 2

March 2015
Source: 2015 eVMT HH Study Recruitment Survey

•arch 2013
Source: ARB CVRP Survey
Everyone Likes Free Charging

Workplace Charging Events per 100 Vehicles by Electric Range (Survey)

March 2015
Source: 2015 eVMT HH Study Recruitment Survey

Teslas will almost never Plug in if more than home

Free
1x Home
2x Home
What do Users Report about congestion? About 20%.
Nobody goes there anymore. It's too crowded.

• If public charging is free we need about 60 chargers per 100 PEVs.

• If public charging is congested nobody goes there anymore.
  • Especially not those who need it in order to go back home.
  • The only one who can use it are does who can charge at home anyway.

• Paid public charging may reduce market share but increase the usability of BEVs.
Because Low-Range PHEVs Provide Little Cost-Benefit, They are More Likely to Never Be Plugged in, even for free

Source: Nicholas, Michael and Tal Gil. 2017 (Forthcoming), January 8-12. You Can't Take It With You: Examining The Role Of Phev Range In The Decision To Plug In. In Transportation Research Board. Washington DC.
Use Cases for Fast Chargers

- Destination fast charger perhaps near regional centers.
  - “I have to meet someone for dinner and I won’t spend long enough at dinner to charge”

- Level 2 backup
  - “I have the time to charge, but I can’t find an open L2 charger”

- Home charger/home backup
  - “I have no home charger”
  - “I only have level 1 at home”

- Corridor fast charger
  - “I don’t have the range and need to charge”
Fast Charging by BEV80-BEV90 is Currently Close to Home

- Analyzed 1.2 Million Sessions From Evgo
- Calculated the Euclidean distance from home zip code to charge event
- Differentiated from Home to free
- Median Distance from home for free charger is 5 miles
- Median Distance from home to paid charger is 10 miles

PG&E Scenario 2025

- Home dominates in urban areas (10 AM peak)
- Work centers have work based demand (noon and 6pm peak)
- Corridors draw from far away (5-8 pm peak)

- Corridors are the most speculative. Depends on confidence of availability and increase in battery Size

Conclusions

- Awareness
- Education
- Vehicle sales/availability
- Dependable infrastructure
- Price
- Incentives
- Home charging
Thank you

Questions?

Gil Tal
gtal@ucdavis.edu