“Catching the second wave” of the Plug in Electric Vehicle Market

PEV market update from ITS PHEV Center and NextSTEPS

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First some terminology…..

- **ICE** = *Internal combustion engines* run on gasoline, diesel, natural gas, biofuels and other liquid or gaseous fuels.
- **HEV** = *Hybrid electric vehicles* combine ICE and electric motors in a variety of designs. They have bigger batteries than ICES, but do not “plug-in” to the grid, and rely entirely on fuels like gasoline.
- **PHEVs** = *Plug in Hybrid Electric Vehicles* are like HEVs, but have bigger batteries, and can store electricity from plugging into the grid.
- **BEVs** = *Battery Electric Vehicles* use only batteries, electric motors and rely on the grid.
- **EREV** = *Extended Range Electric Vehicles* are PHEVs that emphasize electric driving (like the Volt).
- **BEVx** = BEV with a small ICE to extend vehicle range.
- **PEVs** = *Plug-in Electric Vehicles* include all PHEVs, BEVs, EREVs and BEVx.
The development of the PEV market-ecosystem is a complicated, decades long process, with many sectors to encourage

- **Regulatory goals, systems & incentives**: development to support long term process (at national and local levels)
- **Rollout of Vehicles**:  
  - Generation 1, 2 and 3 designs  
  - PHEVs, EREVs, BEVs, BEVx  
  - Batteries, carbon fiber, etc...  
  - Parts, manufacturing and assembly systems
- **Market demand**: Consumer knowledge, experience, desire
- **Charging infrastructure**: charge locations, networks, utility side support
- **Retail system**: dealer profit and support for customers
- **Used PEV market**: eventually 2/3s of vehicle sales
Regulatory Goals, Systems & Incentives:

California Air Resources Board Zero Emission Vehicle Program and Governor’s Executive Order 2013
Incentives: Federal tax credits, state rebates, discount utility rates, HOV lane access…
PEV market development is a complex process that will take decades of adaptive policy. How does an market innovation process fit with a regulatory goal?

INNOVATION MARKET PROCESS
It usually takes decades for consumer innovations to grow a market, faster in recent years, but slower in vehicles.
Classic “diffusion” theory tells us that markets for innovations is segmented into groups over time that influence the next group.
In the EV market, we have been primarily selling to that first segment—usually called “innovators” and “enthusiasts”

- **Innovators/Enthusiasts**: Technology “gadget lovers” who are willing to buy even early-release versions; generally less worried about product quality/reliability; often want to work with developers to identify bugs or defects, a source of pride in their own techno-intelligence; important for endorsement about viability of the category, but not a large enough market segment to be a long-lived significant source of revenue
The next segment, according to diffusion theory, are the early adopters or “visionaries” who learn from the “innovators” and go on to influence the “majority buyers”.

- **Early Adopters/Visionaries**: Less concerned about price and more motivated by “psycho-social benefits” of visibility in his/her peer group based on purchase; more affluent, younger, cosmopolitan than other categories; willing and motivated to address early problems including service and infrastructure challenges—which become a source of pride. Competition for the dollars spent on this purchase is typically not within the product category (say, a different make or model of car), but some other major purchase
The first years of the HEV market in Japan and California offer insights to this process for new vehicle technologies

**Japan**: HEV sales reached 20% in 2013, Prius top selling vehicle 4 years : 2 million registered

**California**: 10% 3rd quarter of 2013, Prius best selling vehicle in 2012-13 (60,000)

**USA**: 3.5% first half 2013, 2.9 million registered
Can the PEV market follow a similar trajectory to HEVs?

To understand how this can happen, the PH&EV center is studying:

- Generation two vehicles and “wave two” buyers
- Household use patterns for PEVs
- Development process for:
  - Integration of vehicles and the electric grid
  - Infrastructure rollout and optimization
  - PEV retail system evolution
  - PEV used car market
  - Optimal incentives systems
PEVs are a much wider range of technologies than the HEV market, with variations in charging needs

- **Plug in Hybrid Electric Vehicle (PHEV)**
  - Varying electric range – battery 5-10 kWh
  - Low EV performance, High MPG
  - Charging speed 3-12 miles per hour

- **Extended Range Electric Vehicle (EREV)**
  - Increased electric range – medium battery 10-16 kWh energy
  - High EV and ICE performance, medium MPG
  - Charging speed 3-12 miles per hour
  - DC fast capability (Mitsubishi Outlander)

- **Battery Electric Vehicle (BEVx)**
  - All electric range – large battery >16 kWh energy
  - High EV, low ICE performance, low MPG
  - Charging speed 3-24 miles per hour and DC fast capability

- **Battery Electric Vehicle (BEV)**
  - All electric range – large battery >16 kWh energy
  - Exclusively electric operation
  - Charging speed 3-24 miles per hour and DC fast capability

- **“ICE Range” Battery Electric Vehicle (BEV)**
  - All electric range – large battery 85 kWh energy
  - Charging speed 3-50 miles per hour and DC fast capability

Partially based on slide from Dan Santini
PEV sales are stronger than HEV sales over the first 36 months, (although there are more PEV models & incentives)

First 36 months of market

Graph from DOE –Jake Ward /data from EDTA
The prices of most PEVs (before incentives) in USA are above the $30,000 average for ICEs

<table>
<thead>
<tr>
<th>MSRP</th>
<th>PHEVs</th>
<th>EREVs</th>
<th>BEVs</th>
<th>ICE range BEVs</th>
</tr>
</thead>
<tbody>
<tr>
<td>$22,995</td>
<td></td>
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<td>Mitsubishi I Miiev</td>
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<tr>
<td>$19,990</td>
<td>$80 mo</td>
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<td>Smart EV</td>
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<tr>
<td>$27,495</td>
<td>limited avail</td>
<td></td>
<td>Chevy Spark</td>
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<tr>
<td>$28,800</td>
<td></td>
<td></td>
<td>Nissan Leaf</td>
<td></td>
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<tr>
<td>$29,990</td>
<td>Toyota Prius PHEV</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>$32,200</td>
<td>limited avail</td>
<td></td>
<td>Focus Electric</td>
<td></td>
</tr>
<tr>
<td>$32,950</td>
<td>Ford C-Max Energi</td>
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<tr>
<td>Lease $259</td>
<td>limited avail</td>
<td></td>
<td>Honda Fit EV</td>
<td></td>
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<tr>
<td>$31,800</td>
<td>limited avail</td>
<td></td>
<td>Fiat 500E</td>
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<tr>
<td>$34,185</td>
<td></td>
<td></td>
<td>Chevy Volt</td>
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<td>$38,700</td>
<td>Ford Fusion Energi</td>
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<tr>
<td>$41,350</td>
<td></td>
<td></td>
<td>BMW i3</td>
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<tr>
<td>$39,780</td>
<td>limited avail</td>
<td></td>
<td>Honda Accord PHEV</td>
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<tr>
<td>$41,450</td>
<td></td>
<td></td>
<td>Mercedes BEV</td>
<td></td>
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<tr>
<td>Japan $33,000</td>
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<td></td>
<td>Mitsubishi Outlander</td>
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<tr>
<td>$49,800</td>
<td></td>
<td></td>
<td>Toyota RAV 4 EV</td>
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<td>$71,700</td>
<td></td>
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<td>Tesla S</td>
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<td>$75,000</td>
<td></td>
<td></td>
<td>Cadillac ELR</td>
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<tr>
<td>$99,000</td>
<td>Porsche Panamera</td>
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<tr>
<td>$135,700</td>
<td></td>
<td></td>
<td>BMW i8</td>
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</tr>
</tbody>
</table>
The development of PEVs is a true world market process, with many regional variations in policy, incentives and vehicles.

WORLD MARKET
World PEV market: 6 of the 10 best selling PEVs in 2014 are available in the USA

<table>
<thead>
<tr>
<th>Model</th>
<th>2014 Rank</th>
<th>2014 sales YTD</th>
<th>2014 % sales YTD</th>
<th>2013 Total</th>
<th>2013 Rank</th>
<th>Total all years</th>
<th>Rank all years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nissan Leaf BEV*</td>
<td>1</td>
<td>17,296</td>
<td>23 %</td>
<td>47,484</td>
<td>1</td>
<td>114,753</td>
<td>1</td>
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<tr>
<td>Mitsubishi Outlander PHEV</td>
<td>2</td>
<td>8,228</td>
<td>11 %</td>
<td>18,444</td>
<td>5</td>
<td>26,276</td>
<td>6</td>
</tr>
<tr>
<td>Tesla Model S BEV*</td>
<td>3</td>
<td>8,187</td>
<td>11 %</td>
<td>22,186</td>
<td>4</td>
<td>33,039</td>
<td>4</td>
</tr>
<tr>
<td>Toyota Prius PHEV*</td>
<td>4</td>
<td>4,160</td>
<td>8 %</td>
<td>23,075</td>
<td>3</td>
<td>56,153</td>
<td>3</td>
</tr>
<tr>
<td>Chevrolet Volt EREV*</td>
<td>5</td>
<td>4,119</td>
<td>8 %</td>
<td>28,252</td>
<td>2</td>
<td>70,651</td>
<td>2</td>
</tr>
<tr>
<td>BYD Qin</td>
<td>6</td>
<td>3,294</td>
<td>4 %</td>
<td>(new)</td>
<td>40</td>
<td>(new)</td>
<td>(new)</td>
</tr>
<tr>
<td>Ford Fusion Energy*</td>
<td>7</td>
<td>2,994</td>
<td>4 %</td>
<td>6,206</td>
<td>9</td>
<td>9,200</td>
<td>NA</td>
</tr>
<tr>
<td>BMW i3*</td>
<td>8</td>
<td>2,814</td>
<td>4 %</td>
<td>1,318</td>
<td>20</td>
<td>4,132</td>
<td>NA</td>
</tr>
<tr>
<td>Chery QQ3 EV e</td>
<td>9</td>
<td>2,616</td>
<td>3 %</td>
<td>5,007</td>
<td>11</td>
<td>7,623</td>
<td>NA</td>
</tr>
<tr>
<td>Volkswagen e-Up</td>
<td>10</td>
<td>2,311</td>
<td>3 %</td>
<td>1,465</td>
<td>18</td>
<td>2,933</td>
<td>NA</td>
</tr>
</tbody>
</table>

Source: evblogspot
World PEV Sales (2012 versus 2013)

**EV Sales by Continent/Region in 2012**

- North America, 56510, 43%
- Europe, 48633, 37%
- Asia, 26177, 20%
- Oceania, 253, 0%

**World Total 131,573**

**EV Sales By Continent/Region in 2013**

- North America, 99148, 47%
- Europe, 66346, 31%
- Asia, 47453, 22%
- Oceania, 304, 0%

**World Total 213,252**

World EV Sales (2012 versus 2013)

Total PEV registrations in world around 500,000

- UNITED STATES
- CANADA
- MEXICO
- NETHERLAND
- FRANCE
- NORWAY
- GERMANY
- UK
- SWEDEN
- ITALY
- SWITZERLAND
- SPAIN
- AUSTRIA
- BELGIUM
- DENMARK
- RUSSIA
- PORTUGAL
- FINLAND
- ICELAND
- LUXEMBOURG
- CZECH REPUBLIC
- JAPAN
- CHINA
- SOUTH KOREA
- AUSTRALIA

Sales (Thousands)

Countries
Some small nations have reached 5-15% of market
Norway incentivizes private owner BEVs
Netherlands incentivizes business car PHEVs

<table>
<thead>
<tr>
<th>Country</th>
<th>Most recent month</th>
<th>2014</th>
<th>Leaders (sales over 100)</th>
<th>Sales TD</th>
<th>PEV Incentives</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Netherlands</strong></td>
<td>April 1560 units</td>
<td>4.21%</td>
<td>Mitsubishi Outland. Volvo V60 PHEV</td>
<td>2,940</td>
<td>PHEV Incentive through Dec.</td>
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<tr>
<td></td>
<td></td>
<td>5802 units</td>
<td>VW e-UP</td>
<td>1,585</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Tesla S</td>
<td>444</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>BMW i3</td>
<td>256</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>Nissan Leaf</td>
<td>253</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>193</td>
<td></td>
</tr>
<tr>
<td><strong>Norway</strong></td>
<td>April 12.2% units</td>
<td>15.2%</td>
<td>Tesla S</td>
<td>2,227</td>
<td>Multiple Incentives for BEVs</td>
</tr>
<tr>
<td></td>
<td>7,399 TD</td>
<td></td>
<td>Nissan Leaf</td>
<td>2,010</td>
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<td></td>
<td></td>
<td></td>
<td>VW e-UP</td>
<td>977</td>
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<td></td>
<td></td>
<td></td>
<td>BMW i3</td>
<td>882</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Mitsubishi Outland.</td>
<td>622</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>Citroen C-Zero</td>
<td>168</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Mitsubishi I-Miev</td>
<td>159</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Peugeot Partner EV</td>
<td>105</td>
<td></td>
</tr>
</tbody>
</table>
French and German markets are not growing as fast

<table>
<thead>
<tr>
<th></th>
<th>Most recent month</th>
<th>2014</th>
<th>Leaders (100 plus)</th>
<th>Sales TD</th>
<th>PHEV Incentives</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>France</strong></td>
<td>April 1,212 units</td>
<td>.61%</td>
<td>Renault Zoe</td>
<td>994</td>
<td>Mostly BEVs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3748</td>
<td>Renault Kangoo</td>
<td>712</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Nissan Leaf</td>
<td>539</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>Bolloroe</td>
<td>344</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>Smart EV</td>
<td>166</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>Groupil G3</td>
<td>148</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>BMW i3</td>
<td>135</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>Opel Ampera (Volt)</td>
<td>119</td>
<td></td>
</tr>
<tr>
<td><strong>Germany</strong></td>
<td>April 1,054</td>
<td>.33%</td>
<td>BMW i3</td>
<td>911</td>
<td>No incentives</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3,340</td>
<td>VW e-up</td>
<td>577</td>
<td></td>
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<td></td>
<td>Smart ED</td>
<td>401</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>Tesla MS</td>
<td>287</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>Renault Zoe</td>
<td>285</td>
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<td></td>
<td></td>
<td></td>
<td>Nissan Leaf</td>
<td>272</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>Renault Twizy</td>
<td>152</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Volvo V60 PHEV</td>
<td>149</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mitsubishi Outlander</td>
<td>135</td>
<td></td>
</tr>
</tbody>
</table>

Annual market 1.8 million 2012
15% of Europe

Annual market 3 million 2012
25% of Europe
Importance of various incentives in Norway
From a survey of PEV buyers by Norwegian gov. research group

**Most Important EV Incentives in Norway**

- Low fuel Costs: 25%
- Access to bus lanes: 20%
- Free charging: 15%
- Free toll roads: 15%
- Free ferries: 10%
- Free parking: 10%
- Charging network: 10%
- Low annual road fee: 10%
- No purchase tax: 5%
California has awarded High Occupant Vehicle (HOV) lane access stickers for an incentive.

High Occupancy Vehicle (HOV) lane access is the most important reason to acquire a PEV.

[Graph showing HOV lane access as a very important motivation across different areas and vehicle models.]

Household income

Household income by sticker and vehicle model.

[Graph showing household income distribution for EV models with and without stickers.]
US MARKET
US PEV Market 2011–2013
US all types of vehicle sales = 15 million annually

Total USA PEV registrations 200,000 as of May 2014

About .65 % of US sales
California Market 2013-2014 -data from CVRP and CNDA-
Total PEV registrations in CA approaching 100,000

Market Drivers:
• New car sales are going up but not much for passenger cars
• Running out of HOV stickers for PHEVs creates demand
• OEM supply, supply and supply (Tesla, BMW)
The used PEV market is just beginning, but will grow fast in next few years. We will be studying it in detail.

**Wholesale Transactions**
**First quarter 2014**

- A third of the sales are in California, more than half in the West Coast.
- 70% are off lease, 10% Factory.
New car buyers are in general affluent.

- 7% of the households are responsible for one third of the market
- New car purchases are highly correlated with income, but not all high income households buy new cars & some lower income household purchased one or more new cars.

7% of HH purchased 2+ cars = 35% of new cars

27% bought 1 car = 65% of new car purchases

66% of the households did not purchase new car in the last 5 years

$0-9,999
$10-24,999
$25-34,999
$35-49,999
$50-74,999
$75-99,999
$100-149,999
$150-199,999
$200-249,999
$250,000+
PEV buyers in 2012-13 were more affluent than other new car buyers

<table>
<thead>
<tr>
<th>Income Range</th>
<th>ICE</th>
<th>Hybrid</th>
<th>PRIUS PLUG-IN</th>
<th>VOLT</th>
<th>LEAF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than $24,999</td>
<td>4%</td>
<td>1%</td>
<td>1%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>$25,000 to $49,999</td>
<td>12%</td>
<td>7%</td>
<td>1%</td>
<td>1%</td>
<td>2%</td>
</tr>
<tr>
<td>$50,000 to $74,999</td>
<td>17%</td>
<td>10%</td>
<td>1%</td>
<td>5%</td>
<td>3%</td>
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<tr>
<td>$75,000 to $99,999</td>
<td>18%</td>
<td>14%</td>
<td>4%</td>
<td>7%</td>
<td>7%</td>
</tr>
<tr>
<td>$100,000 to $149,999</td>
<td>25%</td>
<td>30%</td>
<td>17%</td>
<td>21%</td>
<td>18%</td>
</tr>
<tr>
<td>$150,000 to $199,999</td>
<td>12%</td>
<td>17%</td>
<td>18%</td>
<td>16%</td>
<td>15%</td>
</tr>
<tr>
<td>$200,000 or more</td>
<td>13%</td>
<td>22%</td>
<td>36%</td>
<td>35%</td>
<td>33%</td>
</tr>
<tr>
<td>No answer</td>
<td>0%</td>
<td>0%</td>
<td>22%</td>
<td>15%</td>
<td>21%</td>
</tr>
</tbody>
</table>
In 2014, PEV buyers are still affluent, some very affluent.
About ½ California PEV buyers lease

*CVRP survey data 2014 (missing 2 years lease)
And among PEV buyers, we indeed have found that both “new car” buyers & PEV buyers in California live in and mostly own single detached homes.
PEV owners are often clustered, with surprising density in some neighborhoods.
The primary challenge now is increasing congestion at often free public chargers.
More BEVs are found in urban core areas while higher numbers of PHEVs are in the suburbs.
Women’s rate of participation in the US and California market for PEVs is much lower than in the market for ICE vehicles (Niccolette Caparello)

Percent of vehicle transactions made or influenced by women

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>New</th>
<th>Used</th>
<th>Influence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leaf</td>
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<tr>
<td>Volt</td>
<td></td>
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<tr>
<td>Tesla S</td>
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Source: NBCUniversal; individual manufactures, various news reports
We make the following conclusions based on broad findings from many studies at UC Davis, some of which were not presented in these slides.

CONCLUSIONS
Lessons from the market so far...

• **Regulatory goals, systems & incentives:**
  – Diffusion theory and history of HEV rollout tells us this will be a decades long, multi-staged process.
  – To reach goals, systems and incentives must be develop for long term and adapt to historical scale events and at least three generations of vehicle design.
  – Systems of data collection on market needed to inform adaptive management systems so as to evolve effective incentives and strategies.

• **Rollout of Vehicles**
  – PEV technology is a wide window of products, which must spread over many consumer segments, this also takes time.
  – PEVs offer a good consumer experience, but are expensive technologies, so will proliferate in luxury models.
  – There are vehicle models for sale now in other world markets that could expand market in USA.
Lessons from the market so far…

• Developing market demand:
  – Given diffusion processes, market grows in regional pockets for at least two generations where innovators are affluent, educated, techies, and keeps growing faster in these zip codes, where these enthusiasts influence the next segment of visionaries.
  – Current PEV owners are also next buyers (and creators of used PEVs).
  – Homeowners are the low hanging fruit given vehicle purchase and charging opportunities.
  – Relying on Innovators not enough to kick off market (Germany has plenty) you need incentives to move market like Norway or Netherlands.
  – California and Norway show that private market must be central (even indirectly like Netherlands) Fleets and procurement can help but should not be primary.
  – Second wave must reach women buyers.
  – If the market continues strong, we will be moving into the second wave of buyers, “visionaries” or fast followers who depend on the innovators to experiment.
Lessons from the market so far

• **Charging infrastructure:**
  – Public infrastructure development will not be a dominant factor to speed up market, but too little infrastructure could hold back market. Infrastructure should follow market, but not race ahead.
  – Visionaries need more optimized infrastructure.

• **Retail system**
  – The sales structure is still evolving, with innovative dealers learning how to sell these vehicles.
  – Visionaries will need better customer support, but are similar in income to innovators.

• **Used PEV market:**
  – We are just beginning to observe and measure the development of this market.
  – Higher percentages of leasing will accelerate growth of used PEV market.