Electrified Vehicles

Product offerings - and market overview

Jeff Cobb
Editor-in-Chief
One million plug-in electrified vehicles sold worldwide by mid-September 2015

1 million PEVs
10 million HEVs
100 million AFVs
1.1B MVs on the road

U.S. - Approx. 400,000 by year’s end.

62% BEVs and 38% PHEVs
Electrification major players - (actually PEVs are industry wide)

Protagonist: Tesla CEO Elon Musk - making great cars that happen to be electric.

Protagonist: Renault-Nissan CEO Carlos Ghosn - bullish major automaker
Types of electrified vehicles

“All-of-the-above” approach

- Battery Electric Vehicle (BEV)
- Hybrid Electric Vehicle (HEV)
- Plug-In Hybrid (PHEV)
- Fuel Cell Vehicle (FCV)
Why Electrification?

- Peak oil - before “fracking” revolution
- Energy security - less dependence on imported oil
- Oil price - “global fungible commodity”
- U.S. thus still involved in Middle East
- Oil is effectively subsidized (too)
- Est. real cost for U.S. gas: $14/gallon +/- (?)
- Electricity is domestically produced
- Thus price independent from global markets
- And, more renewable electricity coming
- GHG emissions - curb climate change
- Air pollution - myriad health concerns, costs
- Better uses for oil than burning it
- Sustainability! - for future generations

The above in varying degrees justify Worldwide emissions/mpg regulations ...
U.S. EPA, CARB, Europe, China, Japan, India, etc.

Goal: Zero or low tailpipe emissions
Easier to control at power plant than cars.
Electrified Vehicles - Late 1800s-earlier 1900s

First production car - Karl Benz - 1894

First gasoline-electric hybrid - 1900
Lohner-Porsche Mixed Hybrid

Detroit Electric (1907-1939) 13,000 produced

First series production car - Ford Model T - 1913
Present EV age

GM EV1 1996-1999

GEM Neighborhood Electric Vehicle (NEV) - circa. 1990s

Tesla Roadster - 2008 - 2012

Tesla Model S and Smart ED - 2010s
Ultimate cars are being electrified

- La Ferrari (hybrid)
- McLaren P1 (PHEV)
- Porsche 918 Spyder (PHEV)
- Mercedes S-Class PHEV (production)
- Rolls Royce EV (experimental)
- BMW i8 PHEV (production)
Goal: Mainstream electrification

First-generation niche buyers:
- Upper socioeconomic strata “early adopters” bought first cars
- Some early adopters with more-modest incomes also committed primarily to subsidized $20-30k entry level cars
- How do we define “mainstream?” - 2-3 percent, 5 percent, 10, 15, 20, more?

Promised for $57,400. Sells for $76,200-$145,000

Avg. household income first buyers: $175k
# Global Top Selling Plug-in Cars

<table>
<thead>
<tr>
<th>Rank</th>
<th>Model</th>
<th>Sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Nissan Leaf</td>
<td>Almost 200,000</td>
</tr>
<tr>
<td>2</td>
<td>Chevy Volt</td>
<td>Almost 100,000</td>
</tr>
<tr>
<td>3</td>
<td>Tesla Model S</td>
<td>About 85,000</td>
</tr>
<tr>
<td>4</td>
<td>Toyota PHV</td>
<td>About 74,000</td>
</tr>
<tr>
<td>5</td>
<td>Mitsu Outlander PHV</td>
<td>Over 70,000</td>
</tr>
<tr>
<td>6</td>
<td>Mitsubishi i-MIEV</td>
<td>About 50,000 (incl. minivans, trucks in Japan)</td>
</tr>
<tr>
<td>7</td>
<td>BYD Qin</td>
<td>38,930</td>
</tr>
<tr>
<td>8</td>
<td>BMW i3</td>
<td>~30,612</td>
</tr>
<tr>
<td>9</td>
<td>Renault Zoe</td>
<td>30,437</td>
</tr>
<tr>
<td>10</td>
<td>Ford Fusion Energi</td>
<td>24,104</td>
</tr>
</tbody>
</table>

Source: HybridCars.com

*Over 50 models available worldwide*
Global Top PEV-buying Countries (through Aug. 2015)

<table>
<thead>
<tr>
<th>Rank</th>
<th>Country</th>
<th>Sales and Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>United States</td>
<td>363,265 passenger cars since 2008</td>
</tr>
<tr>
<td>2.</td>
<td>China</td>
<td>157,354 cars since 2011 (plus over 65,000 HD vehicles)</td>
</tr>
<tr>
<td>3.</td>
<td>Japan</td>
<td>121,000-plus passenger cars and vans since 2009</td>
</tr>
<tr>
<td>4.</td>
<td>Norway</td>
<td>65,958 passenger and vans since 2003</td>
</tr>
<tr>
<td>5.</td>
<td>Netherlands</td>
<td>61,025 passenger and vans</td>
</tr>
<tr>
<td>6.</td>
<td>France</td>
<td>over 59,000 passenger and vans since 2010</td>
</tr>
<tr>
<td>7.</td>
<td>UK</td>
<td>39,616 passenger cars</td>
</tr>
<tr>
<td>8.</td>
<td>Germany</td>
<td>38,154 passenger cars</td>
</tr>
<tr>
<td>9.</td>
<td>Canada</td>
<td>14,429 passenger cars since 2011</td>
</tr>
<tr>
<td>10.</td>
<td>Sweden</td>
<td>12,786 passenger cars</td>
</tr>
</tbody>
</table>

Imbalance: California accounted for just over 50-percent of 118,682 total 2014 U.S. PEV sales. Several “compliance” PEVs sold in Calif. not sold nationwide - a decision made by automakers. Case example: Norway. Pop. 5.2 million - almost one-in-four (22%) new cars sold in 2015 is a PEV.

Most influential ZEV regulators: California and China. Both make automakers develop cars just for them. Automakers can then turn around and sell the mandated electrified vehicle tech in other markets as able.
### U.S. Battery Electric sales for September 2015

<table>
<thead>
<tr>
<th>Mfr</th>
<th>Model</th>
<th>9-15 Sales</th>
<th>vs. 8-15</th>
<th>8-15 vs. 9-14</th>
<th>CY 2015</th>
<th>CY 15 vs 14</th>
<th>CY 2014</th>
<th>Current Month U.S. Share</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tesla</td>
<td>Model S</td>
<td>2,600</td>
<td>+50.0%</td>
<td>+34.4%</td>
<td>17,100</td>
<td>+41.7%</td>
<td>11,900</td>
<td>35.80%</td>
</tr>
<tr>
<td>BMW</td>
<td>i3</td>
<td>1,710</td>
<td>+115.9%</td>
<td>+67.1%</td>
<td>7,883</td>
<td>+154.3%</td>
<td>3,104</td>
<td>25.51%</td>
</tr>
<tr>
<td>Nissan</td>
<td>Leaf</td>
<td>1,247</td>
<td>+10.5%</td>
<td>+50.7%</td>
<td>13,650</td>
<td>-37.9%</td>
<td>21,822</td>
<td>18.60%</td>
</tr>
<tr>
<td>Fiat</td>
<td>500e</td>
<td>347</td>
<td>-4.2%</td>
<td>-15.6%</td>
<td>3,841</td>
<td>-19.0%</td>
<td>4,743</td>
<td>5.11%</td>
</tr>
<tr>
<td>VW</td>
<td>e-Golf</td>
<td>363</td>
<td>-13.0%</td>
<td>-4.2%</td>
<td>2,555</td>
<td>-</td>
<td>N/A</td>
<td>-</td>
</tr>
<tr>
<td>Chevrolet</td>
<td>Spark</td>
<td>157</td>
<td>+16.3%</td>
<td>+207.6%</td>
<td>2,154</td>
<td>+136.4%</td>
<td>895</td>
<td>5.12%</td>
</tr>
<tr>
<td>Mercedes</td>
<td>B-Class</td>
<td>147</td>
<td>+14.5%</td>
<td>+126.3%</td>
<td>1,687</td>
<td>976.6%</td>
<td>157</td>
<td>2.11%</td>
</tr>
<tr>
<td>Ford</td>
<td>Focus EV</td>
<td>145</td>
<td>+17.4%</td>
<td>+17.0%</td>
<td>1,267</td>
<td>-17.4%</td>
<td>1,324</td>
<td>2.14%</td>
</tr>
<tr>
<td>Kia</td>
<td>Soul EV</td>
<td>135</td>
<td>+12.9%</td>
<td>+10.0%</td>
<td>727</td>
<td>-</td>
<td>N/A</td>
<td>-</td>
</tr>
<tr>
<td>Smart</td>
<td>forTwo EV</td>
<td>94</td>
<td>+11.3%</td>
<td>+40.8%</td>
<td>955</td>
<td>-66.3%</td>
<td>1,780</td>
<td>1.60%</td>
</tr>
<tr>
<td>Tesla</td>
<td>Model X</td>
<td>5</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>-</td>
</tr>
<tr>
<td>Mitsubishi</td>
<td>i3</td>
<td>3</td>
<td>-50.0%</td>
<td>-100.0%</td>
<td>59</td>
<td>-207.6%</td>
<td>149</td>
<td>0.04%</td>
</tr>
<tr>
<td>Honda</td>
<td>Fit EV</td>
<td>-</td>
<td>N/A</td>
<td>+100.0%</td>
<td>1</td>
<td>-96.9%</td>
<td>347</td>
<td>0.00%</td>
</tr>
<tr>
<td>Toyota</td>
<td>RAV4 EV</td>
<td>-</td>
<td>N/A</td>
<td>+100.0%</td>
<td>17</td>
<td>-98.2%</td>
<td>967</td>
<td>0.00%</td>
</tr>
<tr>
<td>Total BEV</td>
<td>6,704</td>
<td>+38.2%</td>
<td>+7.0%</td>
<td>+52.506</td>
<td>10.8%</td>
<td>42,356</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Auto</td>
<td>1,495,124</td>
<td>+8.6%</td>
<td>+15.5%</td>
<td>12,095,877</td>
<td>5.1%</td>
<td>12,364,848</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall BEV</td>
<td></td>
<td>+0.47%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BEV Take Rate</td>
<td></td>
<td>+0.40%</td>
<td></td>
<td></td>
<td></td>
<td>+0.38%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Breakdown between BEV and PHEV is not available.

### U.S. Plug-In Hybrid sales for September 2015

<table>
<thead>
<tr>
<th>Mfr</th>
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<th>CY 15 vs 14</th>
<th>CY 2014</th>
<th>Current Month U.S. Share</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chevrolet</td>
<td>Volt</td>
<td>949</td>
<td>-31.2%</td>
<td>-31.9%</td>
<td>9,264</td>
<td>-36.3%</td>
<td>14,540</td>
<td>31.24%</td>
</tr>
<tr>
<td>Ford</td>
<td>Fusion Energi</td>
<td>808</td>
<td>-14.9%</td>
<td>+26.3%</td>
<td>6,899</td>
<td>-26.0%</td>
<td>9,323</td>
<td>26.60%</td>
</tr>
<tr>
<td>Ford</td>
<td>C-Max Energi</td>
<td>719</td>
<td>-0.6%</td>
<td>+6.2%</td>
<td>5,678</td>
<td>-12.5%</td>
<td>6,486</td>
<td>23.67%</td>
</tr>
<tr>
<td>Toyota</td>
<td>Prius Plug In</td>
<td>216</td>
<td>-37.2%</td>
<td>-38.8%</td>
<td>4,034</td>
<td>-65.1%</td>
<td>11,642</td>
<td>7.11%</td>
</tr>
<tr>
<td>BMW</td>
<td>i8</td>
<td>182</td>
<td>-13.3%</td>
<td>+213.8%</td>
<td>1,342</td>
<td>1,903.0%</td>
<td>97</td>
<td>5.99%</td>
</tr>
<tr>
<td>Porsche</td>
<td>Cayenne S E-Hybrid</td>
<td>70</td>
<td>-15.7%</td>
<td>N/A</td>
<td>779</td>
<td>N/A</td>
<td>N/A</td>
<td>-</td>
</tr>
<tr>
<td>Porsche</td>
<td>Panamera S E-Hybrid</td>
<td>41</td>
<td>13.9%</td>
<td>-50.0%</td>
<td>330</td>
<td>-52.4%</td>
<td>694</td>
<td>1.35%</td>
</tr>
<tr>
<td>Cadillac</td>
<td>ELR</td>
<td>36</td>
<td>-20.0%</td>
<td>-67.6%</td>
<td>760</td>
<td>-16.4%</td>
<td>885</td>
<td>1.18%</td>
</tr>
<tr>
<td>Mercedes</td>
<td>S550 Plug In</td>
<td>17</td>
<td>20.9%</td>
<td>N/A</td>
<td>37</td>
<td>N/A</td>
<td>N/A</td>
<td>0.56%</td>
</tr>
<tr>
<td>Honda</td>
<td>Accord Plug In</td>
<td>-</td>
<td>-100.0%</td>
<td>-100.0%</td>
<td>62</td>
<td>-79.9%</td>
<td>309</td>
<td>0.00%</td>
</tr>
<tr>
<td>Volvo</td>
<td>XC90 Plug In</td>
<td>-</td>
<td>-100.0%</td>
<td>N/A</td>
<td>4</td>
<td></td>
<td></td>
<td>0.00%</td>
</tr>
<tr>
<td>Total PHEV</td>
<td></td>
<td>3,038</td>
<td>-19.8%</td>
<td>-9.5%</td>
<td>29,169</td>
<td>-33.9%</td>
<td>44,146</td>
<td></td>
</tr>
<tr>
<td>Total Auto</td>
<td></td>
<td>1,430,124</td>
<td>-8.6%</td>
<td>15.9%</td>
<td>12,995,877</td>
<td>5.1%</td>
<td>12,364,848</td>
<td></td>
</tr>
<tr>
<td>Overall PHEV Rate</td>
<td>+0.21%</td>
<td></td>
<td>+0.22%</td>
<td>+0.36%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Top three PEVs
38-percent of global sales

#1 Nissan Leaf Dec. 2010-present

#2 Chevy Volt Dec. 2010-present

#3 Tesla Model S June 2012-present
Fourth through sixth globally best selling PEVs

#4 Toyota Prius PHV

#5 Mitsubishi Outlander PHEV*  
(*20-30 mile range. Not yet sold in U.S. - anticipated.)

#6 Mitsubishi i-MiEV
Ford Fusion Energi (PHEV)

Porsche Panamera S E-Hybrid (PHEV)

Fiat 500e (EV) (Calif.)

Mercedes B-Class Electric

Ford C-Max Energi

BMW i3 (EV)

Hyundai Sonata PHEV (Pending)

VW e-Golf (limited mkt.)
Challenges PEVs are overcoming

- Purchase price perceived too high
- Some won’t buy first-gen product
- Distrust of batteries (lifespan, cost)
- Some don’t want long charge time
- Range anxiety
- Insufficient charging infrastructure
- Public’s lack of knowledge/unaware
- Assumption of poor performance
- Dealers insufficiently compensated
- Manufacturers marketed cars poorly
- Some manufacturers virtually haven’t marketed them at all
- Politics/disbelief in climate change, etc.
- Mixed messages make people take pause
- Negative articles - biased, slanted
- Some ineligible for fed tax credit
- Some states offer no incentives
- (Unforeseen) cheap U.S. gas
- More high-end cars catering to more financially well-off buyers

Consumer behavior is a complexity.

Justifiable or not, these are issues the general public has grappled with. First-generation PEVs, especially when leased, can have a great value proposition, but consumers sometimes have to pick through a minefield of conflicting information and other concerns to get to that place of discovery.
Consumer awareness?

Are PEVs ready for prime time?

How do they work?

Why should I buy one?

Consumer quiz results

(Many wrong answers
On very basic questions)

Accurate education needed!

More-effective marketing needed.

Mixed messages disseminated by media and by some automakers themselves since the beginning.

Survey results from 1,898 new car buyers. Extended Range Electric Vehicles (EREV) were not surveyed, but analysis can be applied to such examples as the Chevy Volt.
Batteries are mainly holding up

Standout example: GM study of first-generation Volt owners (with LG Chem cells): Almost no loss of range or performance even after three (3) years of ownership, said GM Vice President of Transmissions and Electrification, Larry Nitz.

“We’ve seen what I would call pharmaceutical levels of quality in cell production. Of the more than 20 million cells that have been produced for the first generation Chevy Volt, we’ve seen less than 2 problems per million cells produced.”
Negative publicity / politicization
I believe the future is electric, and that comes down to strong economics. We have to overcome the range anxiety,” said Andy Palmer, CEO Aston Martin.

Volvo says it will electrify its entire range, have an all-electric vehicle by 2019. “We believe that the time has come for electrified cars to cease being a niche technology and enter the mainstream,” said Håkan Samuelsson, President and CEO of Volvo Cars. “We are confident that in two years’ time, 10 percent of Volvo’s global sales will be electrified cars.”

“The Volkswagen brand is repositioning itself for the future,” said CEO Dr. Herbert Diess. “We are becoming more efficient, we are giving our product range and our core technologies a new focus, and we are creating room for forward-looking technologies by speeding up the efficiency program.”

“The fuel consumption targets will become very stringent, and that will kick in at around 2019/2020, especially in the United States,” said Nissan corporate officer Hiroto Saikawa. “Suddenly there will be a surge of demand.” Nissan aims for EV sales to rise to 5 percent of its total, and to 10 percent “in the near future,” said Saikawa. “And if we would use a wider definition of electrification and also count hybrids, more than half will be electric cars,” Saikawa added.
Infrastructure: Charging stations (EVSE)

The EV Project
Ecotality -> Blink
ChargePoint
EVGo
Misc. private
State initiatives
Municipal
More ...

Public spaces - EU, U.S. Canada

Sun Country Highway @ an Ontario Hotel
Charging stations

Level 1 – 120 volts
Level 2 – 240 volts
Level 3 – 480 volts/Superchargers

Wireless – L1/L2/L3 possible

Momentum Dynamics - wireless

Tesla Supercharger - up to 135 kW - free for life

Clipper Creek L2 - home unit
Solar, Wind, Hydro …
A natural fit for PEVs

Solar Volt - Hawaii

Solar Volt - California

Gen-one RAV4 EV and solar
To go PEV, you need a place to charge!

(Many people do, some do not)

Future construction needs to be made PEV-compatible.
An ambitious pilot demonstration project by Honda in California.
GM - Chevy Volt battery re-use demonstration project.
Apps - for computer, smartphone, infotainment screen, etc.

Examples:
PlugShare
Open Charge Map
Misc. from all OEMs
ChargePoint
Torque app
Misc apps for L2 EVSEs
Etc.

PlugShare on computer

Watch app
Nissan Leaf app

Model S - iPhone app

BMW i3 app

Chevy Volt OnStar App
Future trends

Lower battery costs

More energy density

Affordable cars

More range


LG Chem cells $145/kWh

This is one-quarter the price of a few years ago. Will enable more PEVs to follow much more cost effectively!

2016 Chevy Volt EREV. Gen 2. First PEV to undergo full redesign.
In common:

200-250 mile EV range
Priced mid-30s pre-subsidy
All projected for 2017

More-than double today’s range for same price = progress!
BEV & PHEV truck/ family haulers

Tesla Model X

Mitsubishi Outlander PHEV (closest to “mainstream”)

Audi electric crossover

VIA Motors - extended-range EV
200 – Mile BEVs

Still Li-ion

Will need DC quick charging

Subsidized, High $20,000s–plus

Mass market?

Compatible / competing?

$5B Tesla Gigafactory battery plant, Reno, Nev. To drive battery prices down; enable Tesla.

CHAdeMO DC quick L3

SAE Combo L1,2 and L3
Hydrogen Fuel Cell Vehicles (FCVs)

Infrastructure scant

SoCal only

Northeast corridor next

“Long-term play” - Bob Carter, Toyota
Autonomous/Self-Driving Cars

PEV compatible
Not solely PEV

Levels
- **Level 0**: Driver controls vehicle.
- **Level 1**: Individual controls are automated, such as electronic stability control or automatic braking.
- **Level 2**: At least two controls can be automated in unison, such as adaptive cruise control in combination with lane keeping.
- **Level 3**: Driver can fully turn over control of all safety-critical functions under certain conditions. Car senses when conditions require the driver to retake control and provides a "sufficiently comfortable transition time" for the driver to do so.
- **Level 4**: The vehicle performs all safety-critical functions for the entire trip, with the driver not expected to control the vehicle at any time. As this vehicle would control all functions from start to stop, including all parking functions, it could include unoccupied cars.

L3 Time frame? – This decade
L4 Time Frame – ASAP

Mercedes-Benz
Tesla
BMW
Google
Apple
Nissan
Lexus
Etc...

Google fully autonomous prototype

Lexus GS

Audi “Bobby” RS7
Summary points:
Passenger PEVs = 0.75 percent U.S. market
Up from almost 0 percent five years ago.
Synergies are happening …
Automakers making commitments
Consumers seeing the benefits
We’re over the negative perception hump
Demand increasing
Supply increasing

Resistance remaining:
Cheap U.S. gas
More public charging needed
Vehicle selection must increase
Price must decrease

These are all in progress now
Thank You