

# Will US Plug-In Cars “Peak” in 2015?

By Pat Murphy

Nissan Leaf



Chevy Volt



BMW i3



Tesla M

April 2015

## Contents

<b>Introduction</b>	<b>1</b>
<b>Conventional Hybrids Sales</b>	<b>1</b>
<b>Sales of Gasoline Hybrids vs. Plug-ins 1997-2003</b>	<b>2</b>
<b>Reviewing Conventional Hybrid Sales 2000-2014</b>	<b>4</b>
<b>Reviewing Successful Hybrids 2000-2014</b>	<b>6</b>
<b>Reviewing Least Successful Hybrid Models 2000-2014</b>	<b>7</b>
<b>Toyota's Dominance of the Hybrid Market</b>	<b>8</b>
<b>Hybrid Fuel Economy – How Much Better?</b>	<b>9</b>
<b>A Question of Value</b>	<b>10</b>
<b>Hybrid Sales and Trends by Company</b>	<b>12</b>
<b>Hybrid Share of Market</b>	<b>19</b>
<b>Plug-In (PHEV and BEV) Sales and Analysis – US</b>	<b>21</b>
<b>Plug-ins Worldwide Sales</b>	<b>22</b>
<b>CO<sub>2</sub> Emissions and Plug-Ins</b>	<b>22</b>
<b>Summary</b>	<b>24</b>

## **Introduction**

2014 marks the fourth full year of plug-in cars sales. “Plug-ins” include battery electric cars (BEVs) and plug-in hybrid vehicles (PHEVs). The period of plug-in-hybrid cars could be said to have begun when the Chevrolet Volt concept car debuted at the January 2007 North American Auto Show. The first production unit was shipped in December 2010, the same month the BEV Leaf was shipped.

In 2008, Barack Obama (a presidential candidate at the time) set a national goal of one million 150 miles per gallon (MPG) plug-in hybrid cars (PHEVs) on the road by 2015.<sup>1</sup> President Obama allocated billions of dollars to support the development of batteries, plug-in cars and manufacturing facilities for plug-ins. At the beginning of 2015, PHEV sales in the US were far below original expectations with 156,736 units shipped over a four year period. Plug-in cars are typically getting around 50 miles per gallon equivalent (MPGe) using Life Cycle Assessment measures that include the energy consumed and emissions created when generating electricity. Thus MPGe, when correctly calculated, is about a third of Obama’s projection of 150 MPG. The government later changed the goal from a million plug-in hybrids to a million alternative fuel vehicles, allowing accountants to add in the battery electric cars and other kinds of vehicles. Note that the EPA designed car window stickers do not provide an accurate MPGe since power plant energy consumption is ignored.

The major plug-in cars, including the Nissan Leaf, Tesla Model S, Chevrolet Volt, Prius Plug-In, Ford Fusion Energy, and Ford C-max Energi, have been technically successful. It is an impressive achievement to deliver almost three hundred thousand more or less complaint free cars from four major manufacturers – GM, Nissan, Toyota, and Ford – and an innovative start-up company, Tesla. Manufacturing costs remain higher than expected due mostly to the expense of lithium-ion batteries. But reliability, an even more important factor, has been good so far. Still, sales are far below early projections.

## **Conventional Hybrid Sales**

Toyota, inventor of the modern hybrid, sold over seven million conventional hybrids in the period 1997 through 2014.<sup>2</sup> Toyota has about a 70% share of the total hybrid market. A total worldwide inventory of all hybrids from all manufacturers is about eight and a half million hybrid cars compared to the roughly one third of a million plug-in cars delivered worldwide through 2014. The conventional hybrid car (best represented by the Toyota Prius family), still has significant economic and environmental advantages over plug-ins. This may be a partial explanation of the relative slow growth of the plug-in market compared to original expectations.

The roughly 10 percent drop in 2014 hybrid sales from 2013 shipments is likely due to a combination of significantly lower gasoline prices in 2014, MPG overstatement scandals for Ford and Hyundai/Kia hybrids (which resulted in penalties and fines), and the delay of the next generation Prius to late 2015 or early 2016.

## Sales of Gasoline Hybrids vs. Plug-ins 1997–2003

The issue for electric cars is not the difference in fuel economy performance between conventional cars and plug-in cars but rather the difference between conventional hybrid cars, like the Prius, and plug-in cars. Figure 1 shows the sales of zero emissions vehicle (ZEV) cars, such as the GM EV-1 and the Toyota RAV4-EV, beginning in 1997 and ending in 2001. Hybrids became available in 2000 and their sales grew rapidly, essentially killing off the ZEV cars. In 2003 hybrids sales were about 43,000 units; in 2014 hybrid sales were about 443,000, ten times the 2003 sales.

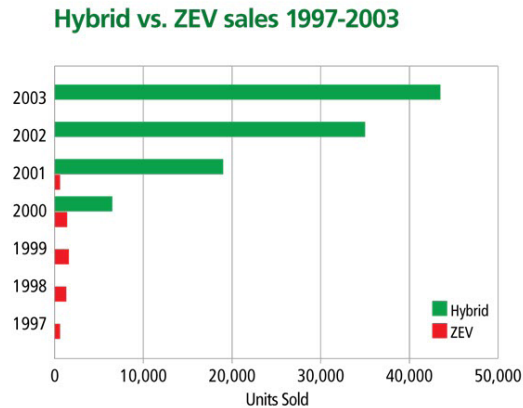


Figure 1: Early Sales History: Hybrid vs. ZEV

Production plug-in hybrids like GM’s Chevrolet Volt, were originally developed as a new technology that would replace conventional hybrids. But for the four year period during which they have been sold, 2011-2014, both plug-in and battery vehicles have not sold well relative to hybrids as shown in figure 2. This is significant considering that the federal government provides a \$7,500 dollar subsidy for plug-in car purchases. (Some states provide additional subsidies).

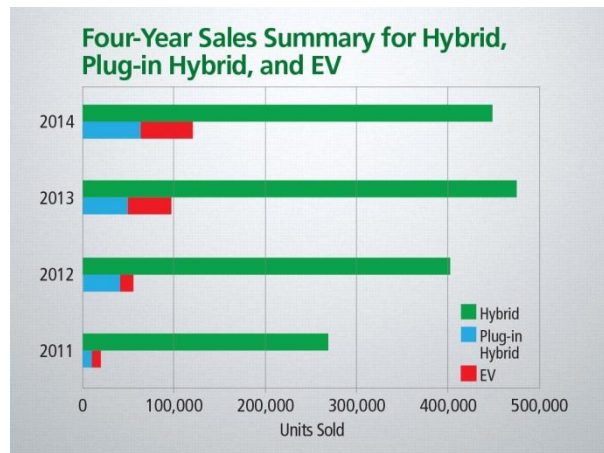


Figure 2: Recent Sales History-Hybrids vs. Plug-ins

The rate of increase of plug-ins sales has diminished. Total sales for both battery electric vehicles and plug-in hybrids for 2011-2014 were respectively 17,425, 52,607, 97,507 and 119,710 units. (Table 1) The sales growth rate from 2011 to 2012 was 202%, from 2012 to 2013 85%, and from

2013 to 2014 23%. The decline in the growth rate from 2013 to 2014 was surprising, particularly since there were many more models available and a massive increase in the number of charging stations has occurred in the last three years. Sales were not constrained by a lack of offerings – there were three plug-in cars being marketed in 2011, eight in 2012, sixteen in 2013, and twenty-two in 2014.

Sales Summary Hybrids and Plug-ins 2011-2014					
	2011	2012	2013	2014	Total
PHEVs	7,671	38,585	49,043	61,437	156,736
BEVs	9,754	14,022	48,464	58,273	130,513
All Plug-ins (PHEVs + BEVs)	17,425	52,607	97,507	119,710	287,249
Hybrids	268,479	403,260	471,880	443,119	1,586,738
Hybrids & All Plug-ins	287,915	457,879	571,400	564,843	1,882,037
All Cars	12,734,424	14,441,814	15,531,706	16,435,286	59,143,230
PHEV-%All Cars	0.06%	0.27%	0.32%	0.37%	0.27%
BEVs-%All Cars	0.08%	0.10%	0.31%	0.35%	0.22%
Hybrids-%All Cars	2.11%	2.79%	3.04%	2.70%	2.68%
Hybrids & Plug-ins-%All Cars	2.26%	3.17%	3.68%	3.44%	3.18%

Table 1: 2011-2014 Sales History of Hybrids, Plug-ins, and Conventional Cars

Some people agreed with GM that the plug-in hybrid would be a revolutionary product eventually replacing the hybrid car. More conservative people viewed the hybrid car as a more efficient gasoline car, not to be confused with electric cars or plug-in hybrids that obtain their energy from the regional power grids in the U.S. Comparing the sales for the most recent year (2014) for plug-in hybrids versus conventional hybrids shows that conventional hybrids outsold plug-in hybrids by a factor of seven.

An obvious question from a review of this table would be “why have hybrid sales flattened out?” Total hybrid sales for the 2011-2014 were respectively 268,479, 403,260, 471,880 and 443,119. Growth rate for hybrids from 2011 to 2012 was 50%, from 2012 to 2013 17%, and from 2013 to 2014 a decline of 6%.

The decline in hybrid sales was roughly 27,000 units. The increase in plug-in sales was 22,000 units. Does this mean more people chose plug-ins over hybrids? The answer is not clear. Some people argue that both hybrids and plug-ins have been affected negatively by decreasing gasoline prices. Conventional car sales were up by about 900,000 units from 2013 to 2014, 6% growth over 2013. And the consumer is buying more SUV gas guzzlers, a reversal of recent trends.

But another important factor may be Toyota’s delay in shipping its next generation of the Prius, delayed by six months to a year for more engineering and design. Rumors are that it will ship in late 2015 or early 2016.

## Reviewing Conventional Hybrid Sales 2000-2014

Table 2 shows conventional hybrid model sales in the U.S. beginning in the year 2000. The different models are ordered from top to bottom, first by year of introduction and second by sales volume. The first appearance of a sales number in a row represents the year of first shipment of the model.

This table provides a visual reference of historical first customer shipment and sales histories. The right-most column shows the total cars sold over a model's life time (through 2014) and allows comparisons of the sales of different models. For example, the table shows that total Prius Liftback lifetime sales were slightly more than 1.5 million cars while the total Chrysler Aspen lifetime sales were 46 cars. (Liftback is the term for the current Prius, used to distinguish this model from the Prius c, Prius v, and Prius PIP). The bottom row shows annual sales of all hybrids.

Most early entrants in a new market do not succeed. In addition, some cars that have been classified as hybrids do not fit in the high-mileage mainstream hybrid architecture. These include the so-called mild hybrids (Saturn Aura, Saturn Vue, Chevrolet Malibu, Chevrolet Tahoe, GMC Yukon) made by GM. Of the 60 models listed in table 2, 41 of them fit in the categories of low sales, canceled models, or are not really hybrids but so called "mild" hybrids. This is a relatively high number of unsuccessful models for a new drive train concept but it may be typical of a new technology introduction.

Some very recent cars are not included in this table since they were announced in late 2014 and have very limited sales to date.

The cars in Table 2 have an asterisk concatenated with the car name. The asterisk identifies a group of cars which are summarized in Table 5. An example from the Vehicle (MPG) column is the Honda Insight. Its entry is written as Honda Insight 1(53)\*. Two thirds of the models have an asterisk designation and mark the least popular models. Cars without asterisks are summarized in table 3. About a third of the models in Table 2 are not marked with asterisks and identify the more popular models

U.S. Hybrids Sales by Date of Introduction 2000-2014 (in 1,000s)												
Vehicle(MPG)	2000-2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Total
Toyota Prius(41)	120	108	107	181	159	140	141	136	148	145	123	1,507
Honda Insight 1(53)*	13	1	1								0	14
Honda Civic(40)	61	26	31	33	31	15	7	5	7	8	5	229
Ford Escape(27)*	3	19	20	21	17	15	11	10	1		0	118
Honda Accord 1(28)*	1	17	6	3	0.2						0	27
Lexus RX400/450h(25)		21	20	17	15	14	15	11	12	11	9	147
Toyota Highlander(27)		18	31	22	19	11	7	5	6	5	4	129
Mercury Mariner(28)*		1	3	4	2	2	1				0	13
Toyota Camry(34)			31	54	46	23	15	9	46	44	40	308
Lexus GS 450h(23)*			2	2	1	0.5	0.3	0.3	1	1	0.2	6
Nissan Altima(34)*				8	9	9	7	3	0.1		0	37
Saturn Vue(26)*				4	3	3	0				0	10
Lexus LS600hL(21)				1	1	0.3	0.1	0.1	0.1	0.1	0.1	3
Saturn Aura(27)*				1	0.3	1	0.1				0	2
Chevy Malibu(27)*					2	4	0.4	0.02	17	14	1	38
Chevy Tahoe(21)*					4	3	1	1	1	0.4	0.1	10
GMC Yukon(21)*					2	2	1	1	1	0.3	0	7
Cadillac Escalade(20)*					1	2	1	1	1	0.4	0	6
Chrysler Aspen(21)*					0.05						0	0.05
Ford Fusion(39)						16	21	11	14	37	35	134
Honda Insight 2(41)						21	21	16	6	5	4	72
Lexus 250h(35)*						2	11	3	1	0.01	0	16
Chevy Silverado(21)*						2	2	1	0.5	0.1	0	5
Mercury Milan(39)*						1	1				0	3
Honda CRZ(37)							5	11	4	5	4	29
Lincoln MKZ(39)							1	6	6	7	10	31
Porsche Cayenne(21)*							0.3	2	1	1	1	4
Mercedes S400HV(21)*							1	0.3	0.1	0.1	0	1
Mazda Tribute(32)*							1	0.5	0.1	0.0	0	1
GMC Sierra(21)*							1	0.2	0.5	0.1	0	1
Mercedes ML450H(22)*							1	0.0	0.0	0.0	0	1
BMW X6(18)*							0.2	0.04			0	0.3
BMW Hybrid 7(20)*							0.1	0.3	0.2	0.03	0	1
Toyota Prius v(42)								8	41	35	31	115
Hyunda Sonata(36)								20	21	22	21	83
Lexus CT200h(42)								14	18	15	18	65
Kia Optima(36)								0.40	10	14	14	38
Buick Lacrosse(29)*								2	12	7	7	28
Buick Regal(29)*								0.12	3	3	1	6
infiniti m35h(29)* (Q70)								0.38	1	0.5	0.2	2
VW Touareg(21)*								0.39	0.3	0.1	0	1
Porsche Panam.(25)*								0.05	1	0.1	0	1
Toyota Prius c(50)									36	42	41	118
Ford C-Max(43)									11	28	19	58
Lexus ES 300h(40)									7	17	15	38
Toyota Avalon(40)									1	16	17	34
VW Jetta(45)									0.2	6	2	8
Acura ILX(38)									1	1	0.4	3
BMW 335ih(26)*									0.4	1	0.2	1
Audi Q5(26)*									0.3	1	0.3	1
BMW 535ih(26)*									0.4	1	0.1	1
Honda Accord 2(47)										1	14	15
Infiniti QX60(26)*										1	2	2
Nissan Pathfinder(26)*										0.3	2	2.8
Infiniti Q50(31)*										0.3	3	3.8
Mercedes E400H(26)*										0.3	0.2	0.4
Chevrolet Impala(29)*										0.1	1	0.6
Subaru Crosstrek Hybrid (31)											8	8
Lexus NX 300 h (33)											0.4	0.4
Acura RLX Hybrid (30)*											0.1	0.1
Total	197	210	253	352	314	286	275	278	434	496	452	3,547

Table 2: US Hybrid Sales History and First Customer Ship Years

## Reviewing Successful Hybrids 2000-2014

Table 3 represents a subset of 19 of the 60 hybrid cars listed in Table 2. These are the most successful cars in terms of sales. These 19 are the “hybrid winners” of the period 2000-2014.

U.S. Hybrids Sales by Date of Introduction 2000-2014 Most Successful												
Vehicle(MPG)	2000-2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Total
Toyota Prius(41-50)	120	108	107	181	159	140	141	136	148	145	123	1,507
Honda Civic(40-45)	61	26	31	33	31	15	7	5	7	8	5	229
Lexus RX400/450h(25-30)		21	20	17	15	14	15	11	12	11	9	147
Toyota Highlander(27-28)		18	31	22	19	11	7	5	6	5	4	129
Toyota Camry(34-41)			31	54	46	23	15	9	46	44	40	308
Ford Fusion(42)						16	21	11	14	37	35	134
Honda CRZ(37)							5	11	4	5	4	29
Lincoln MKZ(40)							1	6	6	7	10	31
Toyota Prius v(42)								8	41	35	31	115
Hyunda Sonata(38)								20	21	22	21	83
Lexus CT200h(42)								14	18	15	18	65
Kia Optima(36)								0.4	10	14	14	38
Toyota Prius c(50)									36	42	41	118
Ford C-Max(43)									11	28	19	58
Lexus ES 300h(40)									7	17	15	38
Toyota Avalon(40)									1	16	17	34
VW Jetta(45)									0.2	6	2	8
Honda Accord 2(47)										1	14	15
Lexus NX 300h (33)											0.4	0.4
Subtotal-19 mdls-88% of sales	181	172	221	308	271	219	213	237	387	458	420	3,087
Toyota/Lexus-80% of sales	120	147	190	275	240	188	178	184	313	331	297	2,462

Table 3: Most Successful Hybrids

The top four models in terms of lifetime sales are the Prius Liftback, the Toyota Camry, the Honda Civic (one of the very first hybrids made), and the Lexus RX 4xx series. The “Vehicle” column includes the miles per gallon (MPG) in parenthesis next to the name. For the four models just noted, the MPG includes both the original mileage of these cars as well as the most recent mileage for 2015 models. For example the Toyota Prius MPG field is written as (41-50), showing the MPG in 2000 was 41 while the latest 2015 model has a 50 MPG rating. There has been about a 20% improvement in MPG from the early versions of a model to the current 2015 versions. (See table 4)

Model	2003-2005 MPG	2015 MPG
Toyota Prius	41	50
Honda Civic	40	44
Lexus 4xxh	25	30
Toyota Camry	34	41

Table 4: Hybrid MPG Improvements in a Decade

Note that the combination of Toyota and Lexus car sales (Lexus being the luxury car division of Toyota Motor Corporation) represent about 80% of total sales of the 19 cars listed. Since the Toyota Corporation (including Toyota brands and Lexus brands) has about 70% of the total market, the 80% market share of the more successful models implies Toyota has even a higher percentage of the market for its products.



## Reviewing Least Successful Hybrid Models 2000-2014

Table 5 is a list of the less successful hybrid models. There are 41 models that fit in this category. Note that Toyota share of market for this group is only 6% of sales.

U.S. Hybrids Sales by Date of Introduction 2000-2014 Least Successful												
Vehicle(MPG)	2000-2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Total
Honda Insight 1(53)*	13	1	1	0	0	0	0	0	0	0	0	14
Ford Escape(27)*	3	19	20	21	17	15	11	10	1	0	0	118
Honda Accord 1(28)*	1	17	6	3	0	0	0	0	0	0	0	27
Mercury Mariner(28)*		1	3	4	2	2	1	0	0	0	0	13
Lexus GS 450h(23)*			2	2	1	0	0	0	1	1	0	6
Nissan Altima(34)*				8	9	9	7	3	0	0	0	37
Saturn Vue(26)*				4	3	3	0	0	0	0	0	10
Lexus LS600hL(21)				1	1	0	0	0	0	0	0	3
Saturn Aura(27)*				1	0	1	0	0	0	0	0	2
Chevy Malibu(27)*					2	4	0	0	17	14	1	38
Chevy Tahoe(21)*					4	3	1	1	1	0	0	10
GMC Yukon(21)*					2	2	1	1	1	0	0	7
Cadillac Escalade(20)*					1	2	1	1	1	0	0	6
Chrysler Aspen(21)*					0.05	0	0	0	0	0	0	0.05
Honda Insight 2(41)						21	21	16	6	5	4	72
Lexus 250h(35)*						2	11	3	1	0	0	16
Chevy Silverado(21)*						2	2	1	0	0	0	5
Mercury Milan(39)*						1	1	0	0	0	0	3
Porsche Cayenne(21)*							0.3	2	1	1	1	4
Mercedes S400HV(21)*							1	0	0	0	0	1
Mazda Tribute(32)*							1	0	0	0	0	1
GMC Sierra(21)*							1	0	0	0	0	1
Mercedes ML450H(22)*							1	0	0	0	0	1
BMW X6(18)*							0.25	0.04	0	0	0	0.3
BMW Hybrid 7(20)*							0.10	0.34	0.23	0.03	0	1
Buick Lacrosse(29)*								2	12	7	7	28
Buick Regal(29)*								0.1	3	3	1	6
infiniti m35h(29)* (Q70)								0.4	1	0	0	2
VW Touareg(21)*								0.4	0.3	0.1	0	1
Porsche Panam.(25)*								0.1	0.6	0.1	0	1
Acura ILX(38)									1	1	0	3
BMW 335ih(26)*									0.4	0.9	0.2	1
Audi Q5(26)*									0	0.9	0.3	1
BMW 535ih(26)*									0.4	0.5	0.1	1
Infiniti QX60(26)*										0.7	1.7	2
Nissan Pathfinder(26)*										0.3	2.5	3
Infiniti Q50(31)*										0.3	3.5	4
Mercedes E400H(26)*										0.3	0.2	0
Chevrolet Impala(29)*										0.1	0.6	1
Subaru CrstrekHyb. (31)*											8	8
Acura RLX Hybrid (30)*											0.1	0.1
Subtotal-41 mdls-12% of sales	17	37	31	45	43	67	62	41	48	37	32	460
Toyota/Lexus-6% of sales	0	0	2	3	2	3	11	3	1	1	0	25

Table 5: Least Successful Hybrids

Comparing the two groups, that is, the 19 successful models to the 41 least successful ones, 3.1 million units were sold of the most successful hybrid group of 19 cars versus 0.46 million cars sold for the 41 least successful cars. Average sales per model for the 19 successful cars were 162,473 units. On average the 41 least successful cars sold about 11,200 cars each.

## Toyota's Dominance of the Hybrid Market

Toyota's original hybrid effort in Japan began as a result of a Clinton/Gore program called Partnership for a New Generation of Vehicles (PNGV), from which Toyota was excluded. The PNGV program began in 1993 with the goal of developing cars with a fuel economy near 80 MPG. With government subsidies, GM, Ford and Chrysler each built a diesel-fueled prototype hybrid car that achieved MPG values between 72 MPG and 80 MPG. Toyota had asked to join the PNGV but was turned down. This led Toyota and Honda to initiate their own gasoline hybrid programs. In 2001, the PNGV program was cancelled by the incoming administration of George Bush. Both Toyota and Honda had maintained their focus on the gasoline hybrid car and by 2001 it was clear their products would be successful (figure 1). Early Japanese hybrids in the U.S. included the Toyota Prius, the Honda Civic, and the Honda Insight. Toyota eventually dominated the market because its hybrid technology was superior to Honda's.

The major national purchaser of Toyota hybrids has been Japan (3.5 million), followed by the U.S. (2.6 million)<sup>3</sup> Europe has been slower to adopt the technology, partially because of the high number of diesel-powered high MPG cars available in that region of the world. Table 6 shows yearly sales for four regions (2014 projection based on actual sales in first three quarters of 2014.) In recent years (2012-2014) hybrid sales in Japan have been twice those in the U.S.

<b>Toyota Hybrid World Wide Sales by Region 1997-2014 (in 1000s)</b>				
	Global	Japan	North America	Europe
Year				
1997-1999	33.1	33.1	--	--
2000	19.0	12.5	5.8	0.7
2001	36.9	18.5	16.0	2.3
2002	41.3	20.0	20.3	0.8
2003	53.3	27.2	24.9	0.9
2004	134.7	68.7	55.9	8.1
2005	234.9	58.5	150.0	23.4
2006	312.5	72.4	197.6	36.0
2007	429.4	82.0	287.8	49.0
2008	429.7	104.4	255.0	57.8
2009	530.1	251.1	205.3	54.7
2010	690.2	392.2	195.9	70.2
2011	629.0	316.4	185.1	82.8
2012	1,219.1	678.0	344.7	106.9
2013	1,279.2	679.1	358.2	152.9
2014e	1,303.8	711.4	340.7	167.4
<b>Total</b>	<b>7,376.2</b>	<b>3,525.5</b>	<b>2,643.2</b>	<b>813.9</b>

Table 6: Toyota Annual Sales by Region 1997-2014

Table 7 shows the cumulative Toyota hybrid sales worldwide by model through 2014. Note that the Prius family dominates sales, with about 70% of the market.

Toyota Hybrid World Wide Sales by Model 1997-2014e (in 1000s)					
Hybrid Models	Global	Japan	North America	Europe	Rest of World
Prius	3,360	1,490	1,505	274	92
Prius α, Prius v, Prius +	498	350	117	27	4
Aqua, Prius c	854	712	117		25
Camry Hybrid	475	42	329		104
Alphard Hybrid*2	49	48			2
Auris Hybrid	181			175	6
Yaris Hybrid	118			115	3
Avalon Hybrid	31		31		
Highlander Hybrid, KlugerHyb.	142	3	137		2
Vellfire Hybrid	21	21			
Sai	85	85			
Estima Hybrid	110	110			
Crown Hybrid	101	101			
Harrier Hybrid	41	41			
Crown Mild Hybrid	7	7			
Crown Majesta (hybrid only)	7	7			
Corolla Axio Hybrid	22	22			
Corolla Fielder Hybrid	57	57			
Voxy Hybrid	32	32			
Noah Hybrid	23	23			
Lexus LS 600h/LS 600hL	38	25	3	5	5
Lexus GS 450h/GS 300h)	45	17	7	14	7
Lexus RX 400h/RX 450h	305	31	153	90	32
Lexus HS 250h	64	42	22		
Lexus CT 200h	208	45	66	49	48
Lexus ES 300h	75		36	0	38
Lexus IS 300h	33	15		13	5
Lexus NX 300h	3	2		1	1
Prius PHV	65	19	37	9	
TOTAL	7,049	3,345	2,559	772	373

Table 7: Toyota Hybrid Sales History by Model <sup>4</sup>

Japan, with a population of 128 million people, has far more Toyota hybrids on the road (3.3 million units) than the U.S. with a population of 314 million people (2.5 million units). 2013 sales of all cars in Japan were 5.38 million units – in the U.S. 15.6 million units.<sup>5</sup> The U.S. has three times the sales volume of Japan for all cars but buys fewer Toyota hybrids. In terms of all hybrid models, in 2012 20% of Japanese car purchases were hybrids (all models) compared to 3% in the U.S. and 1% in Europe.<sup>6</sup>

Toyota intends to provide a hybrid version for every one of its conventional models. It has followed this technology strategy since 1993 and it may be very difficult for other companies to catch up. Some companies, including Ford and Nissan, originally bought Prius technologies for their early hybrid models. It may be that the Toyota Hybrid Synergy Drive could be sourced to other manufacturers.

### Hybrid Fuel Economy – How Much Better?

The evaluation of hybrids has often been based on a five-year financial payback period. Typically hybrid payback time (or period) is determined by the number of years required for the savings in the cost of gasoline to equal the difference between the purchase price of a conventional model and the purchase price of its hybrid equivalent.

The Prius has no equivalent conventional model; sometimes comparisons are made between a Prius and a different, but similar-sized Toyota conventional car. Other analysis compares only the hybrids that have a conventional model equivalent, such as the Toyota Camry. The “apple to orange” comparisons of two cars that are not the same model often show a much greater cost for a hybrid than an “apple to apple” comparison of a conventional model that has a hybrid version.

The Department of Energy (DOE), EPA and plug-in car advocates consistently compare plug-ins to conventional gasoline cars, emphasizing the advantages of plug-ins in terms of MPGe and CO<sub>2</sub> emissions. But plug-in cars compete with hybrids, not just with ordinary gasoline cars. Toyota conventional models that also have a hybrid version with the Hybrid Energy System drive train show a significant fuel economy improvement – in the range of 40% energy savings.

The second most popular hybrid that is not a member of the Prius family is the Toyota Camry (Table 3), with a MPG rating from the EPA’s [fuelconomy.gov](http://fuelconomy.gov) web site of 41 MPG. Another more recent popular Toyota model is the Avalon (40 MPG). Honda’s major offerings now are the Civic and Accord hybrids. Ford’s Focus has a conventional and hybrid model. Table 8 shows the miles per gallon rating, hybrid and conventional, for each of these cars taken from [fuelconomy.gov](http://fuelconomy.gov) using 2015 model ratings.

Model (2015 year)	Conventional MPG	Hybrid MPG	Ratio
Toyota Camry	28	41	1.46
Toyota Avalon	24	40	1.67
Honda Civic	33	45	1.37
Honda Accord	29	47	1.62
Ford Focus	26	42	1.61

Table 8: MPG Comparison Conventional compare with Hybrid version

The fuel economy of hybrids compared to conventional models is rarely discussed in the media. For Toyota, a 35-40% fuel economy advantage seems to be the average for its models. For most hybrid buyers, the most important metric is miles per gallon (MPG). Some observers suggest that Toyota hybrids are bought for economic reasons such as lower gasoline bills. Others suggest that the purchase is based on environmental reasons, since better fuel economy means a reduction in CO<sub>2</sub> emissions.

Hybrids cost more to make than an equivalent non-hybrid car; they have both a gasoline engine and an electric motor. Hybrids also have an extra battery to store energy when the car is decelerating – energy later used to accelerate the car. Both add to the manufacturing cost of the vehicle. But the question is not one simply of the initial costs of the car but of “value” – a vague concept sometimes used in the automobile industry.

### A Question of Value

Consumer Reports Magazine writes extensively on cars and focuses on overall value. In their December 2013 report the magazine noted “The Prius’ 44 MPG overall (Consumer Reports uses its own method of determining MPG which differs from the EPA methods) is the best fuel economy of any non-plug-in car that Consumer Reports has tested. Though it’s not particularly cheap to buy, the Prius’ depreciation is so low that it costs less to own over the first five years

than its initial MSRP (manufacturer's suggested retail price). We call that a bargain.”<sup>7</sup> The values are explained in the February 2014 issue of the magazine in an article entitled “What makes a great value?” The magazine considers three factors – road test score, predicted reliability score, and five-year owner cost. The road test score reflects how good a vehicle is overall. It includes measures for performance, comfort, convenience, fuel economy, fit and finish, and cargo space. The predicted reliability score forecasts how well new models are likely to hold up over time. This information comes from a history of subscribers’ ratings. Five-year owner costs include all major expenses during a five-year period. Included are depreciation, fuel, insurance premiums, interest on financing, sales tax, maintenance and repairs. Depreciation is by far the largest owner-cost factor.

Consumer Reports often seems to be torn between the values of economy and low CO<sub>2</sub> emissions and the values of high performance and high technology. In their April 2015 issue they rated the Tesla S as the Best Car Overall, a car with a price of \$89,650 and CO<sub>2</sub> emissions of 250 grams per mile. The Prius was rated as the best Green Car with a price of \$29,230 and CO<sub>2</sub> emissions of 218 grams per mile, beating the Tesla. The Prius was also given a higher reliability rating than the Tesla. In the Ratings section the Prius had a cost per mile rating which takes several of the values noted previously and derives a cost per mile. The Prius cost per mile was \$0.49 and the Prius c was \$0.40 per mile, the lowest in the issue. Consumer Reports has consistently been negative on the Prius c, focusing on what it implies is a “cheap” interior.

The same issue of the magazine developed a payback comparison table as part of an article entitled “Are Green Cars Still Worth the Money?” (See Table 9)

Hybrids: The Payback Calculator						
Make & Model	Purchase Price	MPG	Total 5-yr Owner Cost	Total 5-Yr Cost Savings or Loss	Years to Pay Back	Fuel Cost for 5-Yr Payback
Toyota Prius Two	\$25,025	44	\$27,750	(\$2,250)	More than 8	\$6.46
Toyota Corolla LE	\$19,340	32	\$25,500			
Toyota Camry XLE Hybrid	\$31,565	38	\$34,500	(\$1,250)	More than 8	\$4.44
Toyota Camry XLE (4-cyl.)	\$28,580	28	\$33,250			
Honda Accord Hybrid	\$30,125	40	\$34,250	(\$3,000)	More than 8	\$8.10
Honda Accord Sport	\$25,485	30	\$31,250			
Ford Fusion Hybrid SE	\$27,715	39	\$33,000	\$0	5	\$2.24
Ford Fusion SE	\$25,165	24	\$33,000			

Table 9: Consumer Reports Five Year Payback Analysis

This is a familiar form used for hybrid evaluations, which focuses only on the first five years of a car’s product life rather than its total product life, which is approximately 14 years. Similar articles cast doubt on the value of hybrids by only analyzing the first five years usage. The difference in price between a conventional car and its hybrid version is not analyzed. The article includes the comment “The Ford Fusion Hybrid breaks even because of its far better fuel economy and narrower price gap.” Countering this comment is the fact that the Prius is rated at 44 MPG by Consumer Reports (50 MPG by the EPA) and the Fusion Hybrid is rated at 39 MPG by Consumers Reports (42 MPG by the EPA).

As previously noted Ford recently downgraded its MPG ratings for six of its cars and made payments to owners reflecting their additional costs of gasoline. During the same period, they reduced their incremental costs of the hybrid over their conventional versions. This may have been done to reflect declining sales from the MPG issue. (Figure 3)

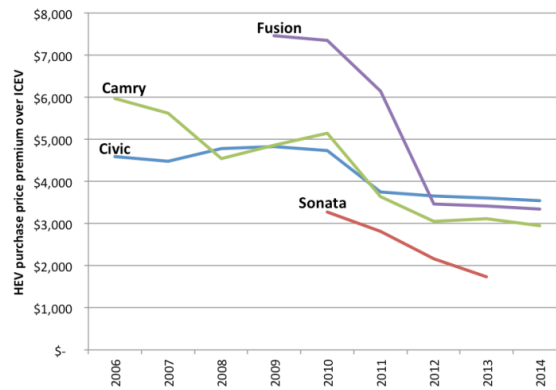


Figure 3: Changing Price Premium of Hybrids over Time<sup>8</sup>

True value should be based on a Life Cycle Assessment which covers the car’s total product life. Eventually the question of one person’s right to drive a high CO<sub>2</sub> car such as a SUV over a low CO<sub>2</sub> car such as a Prius must be debated.

### Hybrid Sales and Trends by Company

The following tables show comparisons of hybrid cars by company. Each table shows the units sold yearly for the period 2010-2014. This information is taken from table 2. The bottom row, entitled Take Rate–Hybrids and Take Rate–All Cars, are the percent of the total hybrid sales captured and the percent of the total of all cars captured for each year. The order presented is by manufacturer, beginning with hybrid market leader, Toyota. It includes the miles per gallon for each model. The cars are listed from top to bottom in order of 2014 sales.

Each table is divided into two sections – “sustaining/growing” and “declining/disappearing”. Some of the models have been withdrawn by the manufacturer – others have been removed based on the author’s projections. The Sustaining/Growing category includes the 19 models shown in Table 3. The Declining/Disappearing category consists of the 41 models from Table 5.

### Toyota

Table 10 shows the units sold in the five year period from 2010-2014. Toyota hybrid cars are available under two different brand names – Toyota and Lexus. Toyota has three other brands that do not include hybrid versions.

TOYOTA						
Models	2010	2011	2012	2013	2014	5 yr.Total
	Units	Units	Units	Units	Units	Units
<b>Sustaining/Growing</b>						
Toyota Prius (50)	140,928	136,463	147,503	145,172	122,776	692,842
Toyota Camry(41)	14,587	9,241	45,656	44,448	39,515	153,447
Toyota Prius c(50)			35,733	41,979	40,570	118,282
Toyota Prius v(42)			40,669	34,989	30,762	106,420
Toyota Avalon(40)			747	16,468	17,048	34,263
Lexus CT 200h(42)		14,381	17,671	15,071	17,673	64,796
Lexus ES 300h(40)			7,041	16,562	14,837	38,440
Lexus RX400/450h(30)	15,113	10,723	12,223	11,307	9,351	58,717
Sub Total	170,628	170,808	307,243	325,996	292,532	1,267,207
<b>Declining/Disappearing</b>						
Toyota Highlander(28)	7,456	4,549	5,921	5,070	3,621	26,617
Lexus 250H(35)	10,663	2,864	649	5	0	14,181
Lexus GS450H(31)	305	282	607	522	183	1,899
Lexus 600HL(20)	129	84	54	115	65	447
Sub Total	18,553	7,779	7,231	5,712	3,869	43,144
Total	189,181	178,587	314,474	331,708	296,401	1,310,351
Take Rate - Hybrids	68.85%	66.44%	72.38%	66.92%	65.55%	
Take Rate - All Cars	1.63%	1.40%	2.18%	2.14%	1.80%	
All Hybrids	274,763	268,807	434,498	495,685	452,152	
All Vehicles	11,588,783	12,734,356	14,441,814	15,531,609	16,435,286	

Table 10: Toyota/Lexus Sales 2010-2014

The fourth row from the bottom, Take Rate – Hybrids, shows Toyota’s decrease in market share from 72% in 2012 to 66% in 2014. The decrease is partially due to the initial success of the Ford Fusion and C-Max hybrids as well as the early success of the Kia Optima and Hyundai Sonata. These four cars suffered a downgrading of their miles per gallon rating which led to penalties and fines as well as payments to purchasers. Toyota would have done better in the last two years of their competitors had not stated bogus MPG numbers for their hybrid cars.

Toyota makes the third most popular plug-in car – the Prius Plug-in. But the company sees the future as hybrid cars and is reducing its investments in plug-in development, both pure battery and plug-in hybrids. From the perspective of Toyota management, the market appears to have shown a clear preference for conventional hybrids over plug-ins.

### Ford

Ford took hybrid market share from Toyota in the US in 2013 and 2014 with high sales of the Fusion and C-Max. Sales for these two cars more than doubled from 2012 to 2013. But sales declined for both models from 2013 to 2014 reflecting the reduction in actual MPG ratings. The first column of tables 10-19 show the MPG of the cars in parenthesis. In the case of Ford (table 12), two numbers are shown, one representing the original MPG and the second the downgraded numbers. Toyota’s market share decline of 7% of 2013 sales is reflected in Ford’s increase in market share for that year of slightly more than 7%.

FORD						
Year	2010	2011	2012	2013	2014	5 yr.Total
	Units	Units	Units	Units	Units	Units
<b>Sustaining/Growing</b>						
Ford Fusion(47-42)	20,816	11,286	14,100	37,270	35,405	118,877
Ford C-Max(47-40)			10,935	28,056	19,162	58,153
Lincoln MKZ(45-40)	1,192	5,739	6,067	7,469	10,033	30,500
Subtotal	22,008	17,025	31,102	72,795	64,600	207,530
<b>Declining/Disappearing</b>						
Ford Escape(32)	11,182	10,089	1,441			22,712
Mercury Milan(39)	1,416					1,416
Mercury Mariner(27)	890					890
Subtotal	13,488	10,089	1,441			25,018
Total	35,496	27,114	32,543	72,795	64,600	232,548
Take Rate - Hybrids	12.92%	10.09%	7.49%	14.69%	14.29%	
Take Rate - All Cars	0.31%	0.21%	0.23%	0.47%	0.39%	
All Hybrids	274,763	268,807	434,498	495,685	452,152	
All Vehicles	11,588,783	12,734,356	14,441,814	15,531,609	16,435,286	

Table 11: Ford Family Sales 2010-2014

Ford has a long history in conventional hybrids. It successfully developed and marketed the Ford Escape Hybrid, selling about 117,000 units over its lifetime from 2004 through 2012. The Ford Fusion Hybrid and the C-Max Hybrid are the company's latest hybrid offerings but, as noted earlier, their mileage ratings were overstated by the EPA based on information provided by Ford. According to Consumer Reports, the Ford Fusion Hybrid and Ford C-Max Hybrid have, of all current hybrid models, the largest discrepancies between overall MPG results and the estimates published by the EPA.<sup>9</sup>

Ford will continue to have some success with its hybrids but not based on exceptional mileage performance as was earlier claimed. In October 2014, the company changed its ads for the C-Max from "high MPG performance" to "fun to drive".<sup>10</sup> In March of 2015, Raj Nair, Ford group vice president of Global Product Development announced that the company is "very well established" with its hybrid and electric-drive technology, so well established that it's now time for Ford to turn its attention to performance, meaning acceleration not miles per gallon. Nair noted that sales of performance vehicles are up 70% in the US since 2009, Nair said that the high performance vehicles draw customers that in general are younger and better educated.<sup>11</sup> Ford may abandon hybrids as GM seems to have done.

## Honda

Honda was the second manufacturer to develop hybrid cars, delivering its Insight shortly after Toyota delivered the Prius. Its hybrid cars were eventually outclassed by Toyota and its sales have declined steadily (table 12). Insight sales have declined to the extent that the model was discontinued at the end of the 2014 model year. The venerable Civic is still sold in hybrid and conventional versions. Newer Honda models have a more efficient drive train and Honda may be able to make a comeback.



HONDA						
Year	2010	2011	2012	2013	2014	5 yr.Total
	Units	Units	Units	Units	Units	Units
<b>Sustaining/Growing</b>						
Honda Civic(44)	7,336	4,703	7,156	7,719	5,070	31,984
Honda CRZ(35)	5,249	11,330	4,192	4,550	3,562	28,883
Honda Accord(47)				979	13,977	14,956
Subtotal	12,585	16,033	11,348	13,248	22,609	75,823
<b>Declining/Disappearing</b>						
Honda Insight 2(42)	20,962	15,549	5,846	4,802	3,965	51,124
Acura ILX(38)			972	1,461	379	2,812
Subtotal	20,962	15,549	6,818	6,263	4,344	53,936
<b>Total</b>	<b>33,547</b>	<b>31,582</b>	<b>18,166</b>	<b>19,511</b>	<b>26,953</b>	<b>107,872</b>
Take Rate - Hybrids	12.21%	11.75%	4.18%	3.94%	5.96%	
Take Rate - All Cars	0.29%	0.25%	0.13%	0.13%	0.16%	
All Hybrids	274,763	268,807	434,498	495,685	452,152	
All Vehicles	11,588,783	12,734,356	14,441,814	15,531,609	16,435,286	

Table 12: Honda and Acura Sales 2010-2014

Beginning in the late 1990s, with the birth of the hybrid, Honda sold about 2/3rds as many hybrids as Toyota. But since 2005, Toyota has increased its hybrid market share relative to Honda due to much better technology. In the first half of 2014, Toyota sold 665,740 hybrid vehicles globally, compared to Honda's 158,696 hybrids globally.<sup>12</sup>

Although the company has sold over one million hybrid units around the world<sup>13</sup>, its overall hybrid market share dropped from 12% in 2010 to 4% in 2013. However, its share jumped two percentage points from 2013 to 2014 with the success of a new version of the Honda Accord hybrid. This car, at 47 MPG, is second only to the Prius Liftback and Prius c in terms of MPG.

### Hyundai/Kia

These two Korean manufacturers share a common drive train. The Kia Optima is a version of the Hyundai Sonata. (table 13) Hyundai holds a significant stock position in Kia. Both companies have admitted to overstating MPG ratings for several models and paid massive penalties.<sup>14</sup> This experience points out that MPG testing is not done by the EPA but by the manufacturer. The MPG for both cars has been restated and both cars continue to sell reasonably well. However, their performance is lower than their main competitors, both of their hybrid models getting 38 MPG. The main Ford hybrid models get 40-42 MPG, the main Honda hybrid models get 44-47 MPG, and the main Toyota hybrid models get 40-50 MPG.

HYUNDIA/KIA						
Year	2010	2011	2012	2013	2014	6 yr.Total
	Units	Units	Units	Units	Units	Units
<b>Sustaining/Growing</b>						
Hyundai Sonata(38)		19,673	20,754	21,761	21,052	83,240
Kia Optima(38)		403	10,084	13,919	13,776	38,182
Total	0	20,076	30,838	35,680	34,828	121,422
Take Rate - Hybrids	0.00%	7.47%	7.10%	7.20%	7.70%	
Take Rate - All Cars	0.00%	0.16%	0.21%	0.23%	0.21%	
All Hybrids	274,763	268,807	434,498	495,685	452,152	
All Vehicles	11,588,783	12,734,356	14,441,814	15,531,609	16,435,286	

Table 13: Hyundai/Kia Sales 2010-2014

### General Motors (GM) – Conventional Hybrids

GM conventional hybrid sales have declined steadily, as shown in table 14. This is not surprising since GM made a vital strategic decision to focus on plug-in hybrids and did not develop conventional hybrid models. Their Take Rate for hybrids (the percent of hybrid sales to all car sales) and all cars is near zero. What is surprising is GM's recent March 2015 announcement of a full hybrid Malibu. This may imply a strategic shift for the company.<sup>15</sup>

GM						
Year	2010	2011	2012	2013	2014	5 yr. Total
	Units	Units	Units	Units	Units	Units
<b>Declining/Disappearing</b>						
Chevy Silverado(21)	1,871	1,001	469	104	24	3,469
GMC Sierra(21)	522	164	471	65	6	1,228
Chevy Tahoe(21)	1,426	519	533	376	65	2,919
Cadillac Escalade(21)	1,210	819	708	372	41	3,150
GMC Yukon(21)	1,221	598	560	288	31	2,698
Saturn Aura(27)	55	0	0	0	0	55
Saturn Vue(26)	50	0	0	0	0	50
Total	6,355	3,101	2,741	1,205	167	13,569
Take Rate - Hybrids	2.31%	1.15%	0.63%	0.24%	0.04%	
Take Rate - All Cars	0.05%	0.02%	0.02%	0.01%	0.00%	
All Hybrids	274,763	268,807	434,498	495,685	452,152	
All Vehicles	11,588,783	12,734,356	14,441,814	15,531,609	16,435,286	

Table 14: GM Conventional Hybrid Sales 2010-2014

### General Motors (GM) – Mild Hybrids

GM attempted to enhance its hybrid position by offering what is called a Mild Hybrid. These cars provide one or two of the functions of a high fuel economy hybrid. Sales peaked in 2012 and declined in 2013. (Table 15) It is not expected that mild hybrids will affect hybrid sales since they represent only a tiny part of the hybrid market. They include the Chevy Malibu and Impala as well as the Buick Lacrosse and Regal. The mileage numbers are all 29 MPG, hardly competitive. The Impala shows a sales jump in 2014 but the Impala ECO version has since been taken off the market so the number may be irrelevant.

GM Mild Hybrids						
Year	2010	2011	2012	2013	2014	5 yr. Total
	Units	Units	Units	Units	Units	Units
<b>Declining/Disappearing</b>						
Chevy Malibu(29)	405	24	16,664	13,779	1,018	31,890
Buick Lacrosse(29)	0	1,801	12,010	7,133	7,353	28,297
Buick Regal(29)	0	123	2,564	2,893	662	6,242
Chevy Impala(29)	0	0	0	56	565	621
Total	405	1,948	31,238	23,861	9,598	67,050
Take Rate - Hybrids	0.15%	0.72%	7.19%	4.81%	2.12%	
Take Rate - All Cars	0.00%	0.02%	0.22%	0.15%	0.06%	
All Hybrids	274,763	268,807	434,498	495,685	452,152	
All Vehicles	11,588,783	12,734,356	14,441,814	15,531,609	16,435,286	

Table 15: GM Mile Hybrid Sales 2010-2014

Some vehicles have been introduced to the car market as hybrids, or will be introduced in the future, but are only using some conventional technology improvements to gain marginal fuel economy improvements. Such improvements would be useful if introduced as standard options throughout a model fleet even though the improvements would not be impressive. For a company to make these improvements to only a small number of vehicles and use the "hybrid label" as a sales or marketing device detracts from the integrity of the hybrid market. Some writers label these vehicles as "hollow hybrids." GM vehicles that fit this category include the Sierra and Silverado pickups as well as the old Saturn Vue and Acura models. The Malibu model also fits in this category. But the recently announced new Malibu hybrid is a full hybrid.

## Nissan

Nissan made a major strategic decision to compete in the conventional battery electric car with its Leaf product just as GM did for the plug-in hybrid at about the same time. Nissan U.S. Leaf sales were slower to grow than GM's Volt sales since early Leaf sales were in Japan. But in 2013, the Leaf sales surpassed those of the Volt. From 2007-2012 Nissan sold 36,613 units of its Altima hybrid but withdrew it from the market after 2012. The Altima is being reintroduced in 2014 utilizing an all-new, Nissan-developed hybrid drive train option. The new drive train will also be used on the 2014 Pathfinder model. Nissan hybrid sales are shown in table 16.

Pre-2011 Ford and Nissan hybrids used technology from the Toyota Prius under a licensing agreement, including technology for the transmission, power inverter, battery, and charging control unit. Nissan has focused so long on the Leaf and BEV technology that it is unlikely to be able to compete effectively with a conventional hybrid in the near future.

NISSAN						
Year	2010	2011	2012	2013	2,014	5 yr.Total
	Units	Units	Units	Units	Units	Units
<b>Sustaining/Growing</b>						
Infiniti Q50s(30)				307	3,456	3,763
Nissan Pathfinder(26)				334	2,480	2,814
Infiniti Qx60(26)				676	1,678	2,354
Subtotal				1,317	7,614	8,931
<b>Declining/Disappearing</b>						
Nissan Altima(33)	6,710	3,236	103	0	0	19,406
Infiniti M35h - Q70(29)		324	691	475	180	1,490
Subtotal	6,710	3,560	794	475	180	22,213
<b>Total</b>	<b>6,710</b>	<b>3,560</b>	<b>794</b>	<b>1,792</b>	<b>7,794</b>	<b>22,213</b>
Take Rate - Hybrids	2.44%	1.32%	0.18%	0.36%	1.72%	
Take Rate - All Cars	0.06%	0.03%	0.01%	0.01%	0.05%	
All Hybrids	274,763	268,807	434,498	495,685	452,152	
All Vehicles	11,588,783	12,734,356	14,441,814	15,531,609	16,435,286	

Table 16: Nissan Hybrid Sales 2010-2014

## BMW

BMW has only a token position in the conventional hybrid market. (table 17) Their commitment is now to electric cars with the “i” series.

BMW						
Year	2010	2011	2012	2013	2014	5 yr.Total
	Units	Units	Units	Units	Units	Units
<b>Declining/Disappearing</b>						
BMW Hybrid 7(20)	101	338	231	31	45	746
BMW 335ih(26)			402	905	151	1,458
BMW 535ih(26)			404	520	112	1,036
BMW X6(18)	248	43	4	0	0	295
Subtotal	349	381	1,041	1,456	308	3,535
Total	349	381	1,041	1,456	308	6,324
Take Rate - Hybrids	0.13%	0.14%	0.24%	0.29%	0.07%	
Take Rate - All Cars	0.00%	0.00%	0.01%	0.01%	0.00%	
All Hybrids	274,763	268,807	434,498	495,685	452,152	
All Vehicles	11,588,783	12,734,356	14,441,814	15,531,609	16,435,286	

Table 17: BMW Hybrid Sales 2010-2014

## VW/Porsche

Hybrid Porsches, Audis and early VWs have not been successful. Surprisingly the Jetta, with good MPG is in decline. VW is committed to electrification at this point. See table 18)

VW/PORSCHE						
Year	2010	2011	2012	2013	2014	5 yr.Total
	Units	Units	Units	Units	Units	Units
<b>Sustaining/Growing</b>		-				
VW Jetta Hybrid(45)			162	5,655	1,639	7,456
Subtotal			162	5,655	1,639	7,456
<b>Declining/Disappearing</b>		-				
Porsche Cayenne(21)	344	1,571	1,180	615	650	4,360
Porsche Panamera(25)	0	52	570	78	0	700
Audi Q5 Hybrid(26)			270	854	283	1,407
VW Touareq Hybrid(21)		390	250	118	30	788
Subtotal	344	2,013	2,270	1,665	963	7,255
Total	344	2,013	2,432	7,320	2,602	14,711
Take Rate - Hybrids	0.1%	0.7%	0.6%	1.5%	0.6%	
Take Rate - All Cars	0.0%	0.0%	0.0%	0.0%	0.0%	
All Hybrids	274,763	268,807	434,498	495,685	452,152	
All Vehicles	11,588,783	12,734,356	14,441,814	15,531,609	16,435,286	

Table 18: VW/Porsche Hybrid Sales 2010-2014

## Mercedes

Mercedes does not offer a good hybrid contender and may choose not to compete in this market. See table 19.

MERCEDES						
Year	2010	2011	2012	2013	2014	5 yr.Total
	Units	Units	Units	Units	Units	Units
<b>Declining/Disappearing</b>						
Mercedes S400(21)	955	309	121	64	10	1,459
Mercedes ML450(22)	766	1	20	11	20	818
Mercedes E400H(26)				282	158	440
Subtotal	1,721	310	141	357	188	2,717
Total	1,721	310	141	357	188	2,717
Take Rate - Hybrids	0.63%	0.12%	0.03%	0.07%	0.04%	
Take Rate - All Cars	0.01%	0.00%	0.00%	0.00%	0.00%	
All Hybrids	274,763	268,807	434,498	495,685	452,152	
All Vehicles	11,588,783	12,734,356	14,441,814	15,531,609	16,435,286	

Table 19

Information is not provided on Subaru, who entered the market in 2014.

## Hybrid Share of Market

Hybrid sales grew rapidly from 2005 to 2009.<sup>16</sup> The percent of sales respectively for 2005, 2006, 2007, and 2008 were 1.4%, 1.8%, 2.5%, and 2.6%. The U.S. hybrid market declined from 2009 to 2011 but sales increased dramatically from 2011 to 2012. Sales grew substantially from 2012 to 2013 but declined by about 9% in 2014. Market share increased from 2.37% in 2010 to 3.19% in 2013. Market share decreased from 3.19% in 2013 to 2.75% in 2014. The five year total percent of market was 2.72%, about the same as the percent of market in 2014. Today sales are more or less flat. Table 20 shows this information.

SUMMARY DATA						
Year	2010	2011	2012	2013	2014	5 yr.Total
Total All Hybrids	274,763	268,807	434,498	495,685	452,152	1,925,905
Total All Cars	11,588,783	12,734,356	14,441,814	15,531,609	16,435,286	70,731,848
Market Share	2.37%	2.11%	3.01%	3.19%	2.75%	2.72%

Table 20: All Hybrids compared to All Cars Sales

The 19 models listed in Table 3, when considering their high MPG, may support an increase in sales in 2015, although there is no evidence of this in the first quarter of 2015. A new Prius generation from Toyota due in late 2015 may also regenerate hybrid market growth. Toyota will likely continue to dominate the hybrid market worldwide.<sup>17</sup> Hybrid fuel-economy performance continues to improve from all vendors. Price differences between conventional and hybrid versions of the same model are decreasing.<sup>18</sup> (About 12% of US Camry purchases are hybrids).<sup>19</sup>

A relatively small 3.0% “take rate” at a time of rapidly increasing worldwide concern about global warming is not encouraging. The average light duty vehicle car sold in America today has a fuel economy of about 25 MPG. Almost all the Toyota hybrid models are in the 40-50 MPG range with the Prius Liftback and Prius c averaging 50 MPG. A historical perspective of MPG changes in recent years is shown in Figure 4.



Figure 4: MPG History<sup>20</sup>

Note this is only about twice the MPG of a car made in 1975. Table 21 shows the MPG changes beginning in 1975. In 40 years MPG has not quite doubled.

Year	1975	1980	1985	1990	1995	2000	2005
Fleet MPG	13.1	19.2	21.3	21.2	20.5	19.8	19.9

Table 21: MPG improvements 1975-2014<sup>21</sup>

Consumer Report’s Annual Auto Issue (April 2015) lists the Prius as the best “green car” noting it has been a Top Pick for 12 years. The Prius c is the best value according to this magazine at \$0.40 per mile. As noted earlier, the Prius Liftback rating is \$0.49 per mile. Value is the summation of all costs (including purchase, maintenance, insurance, and fuel) divided by miles driven. The Prius has been in first or second place for some years in terms of the value rating in Consumer Reports, which typically reviews over 300 cars in its annual car issue. Yet only a very small portion of the population is buying these low-energy vehicles. Value and fuel economy are not yet important enough to most American citizens for them to change their approach to car purchases.

It is surprising to see a sales decline in a year when the climate news was so frightening. Surveys show Americans are concerned about climate change. But personal actions show that large powerful cars are still in vogue, demonstrating the American level of concern about climate change.

## Plug-In (PHEV and BEV) Sales and Analysis – US

Tesla Motors was formed in 2003 to build an electric car using lithium-ion batteries. The company introduced its first product, the Roadster, in 2006 and shipped its first production version of that model in 2008. (Tesla delivered about 2,800 Roadsters and discontinued the product when Model S production began in 2012.) GM began its plug-in hybrid Volt effort in 2006, demonstrated a concept vehicle in January 2007, introduced the production version in September 2008, and shipped the first production cars in December 2010.<sup>22</sup> A rough total development time estimate based on this data is five years to first shipment followed by four full years of production (2011-2014); thus plug-ins represent a nine year program. Table 22 lists the cars sold in the 2011-2014 period. The table is divided into Battery Electric Vehicles (BEVs) and Pluggable Electric Hybrid Vehicles (PHEVs) also known as plug-in hybrids.

BEV AND PHEV SALES – 2011-2014								
Manufacturer	Model	2011	2012	2013	2014	Total	% Sales	% Sales
		Units	Units	Units	Units		Total	2014
<b>BEVs</b>								
Nissan	Leaf	9,674	9,819	22,610	30,200	72,303	53.2%	47.0%
Tesla	Model S		2,400	18,650	16,550	37,600	27.7%	25.8%
BMW	i3				6,092	6,092	4.5%	9.5%
Ford	Focus		685	1,738	1,964	4,387	3.2%	3.1%
Mercedes	SmartFor2 EV	388	139	923	2,594	4,044	3.0%	4.0%
Toyota	RAV4 EV		192	1,096	1,184	2,472	1.8%	1.8%
Mitsubishi	i	80	588	1,029	196	1,893	1.4%	0.3%
Fiat	500e			405	1,503	1,908	1.4%	2.3%
Chevrolet	Spark			539	1,145	1,684	1.2%	1.8%
Honda	Fit EV		93	569	407	1,069	0.8%	0.6%
Porsche	Panamera			86	879	965	0.7%	1.4%
Mercedes	B-Class Electric				774	774	0.6%	1.2%
VW	e-Golf				357	357	0.3%	0.6%
Kia	SoulEV				359	359	0.3%	0.6%
Total		10,142	13,916	47,645	64,204	135,907		
<b>PHEVs</b>								
Chevrolet	Volt	7,671	23,461	23,094	18,805	73,031	48.5%	34.0%
Ford	Fusion Energi			6,089	11,550	17,639	11.7%	20.9%
Toyota	Prius PlugIn		12,750	12,088	13,264	38,102	25.3%	24.0%
Ford	C-Max Energi		2,374	7,154	8,433	17,961	11.9%	15.2%
Cadillac	ELR			6	1,310	1,316	0.9%	2.4%
Honda	Accord Plug-in			526	449	975	0.6%	0.8%
Porsche	PanameraEhyb				879	879	0.6%	1.6%
BMW	i8				555	555	0.4%	1.0%
Porsche	Cayenne Ehyb				112	112	0.1%	0.2%
Total		7,671	38,585	48,957	55,357	150,570		

Table 22: Sales History of Plug-ins 2011-2014

## Plug-ins Worldwide Sales

Jose Pontes, author of the web site EV Sales, maintains plug-in sales for almost all countries in the world. His latest numbers (table 23) show the total world sales for plug-ins to be about 318,000 units.

PI	World Plug-in Sales	2014
1	Nissan Leaf	61,027
2	Mitsubishi Outlander PHEV	31,689
3	Tesla Model S	31,623
4	Chevrolet Volt	21,293
5	Toyota Prius Plug-In	19,018
6	BMW i3	16,052
7	BYD Qin	14,747
8	Ford Fusion Energi	11,719
9	Renault Zoe	11,323
10	Kandi K10 (2-Seater EV)	10,022
11	Ford C-Max Energi	8,705
12	Chery QQ3 EV	7,866
13	Zotye E20	7,341
14	Smart Fortwo ED	5,824
15	Volkswagen e-Up!	5,448
16	BAIC E150 / E200 EV	5,234
17	Volvo V60 Plug-In	5,149
18	Renault Kangoo ZE	4,257
19	Mitsubishi I-Miev (2)	3,936
20	BYD e6	3,611
	TOTAL	317,895

Table 23: 2014 World Sales of Plug-ins<sup>23</sup>

Inside EVS is a website covering sales in America. It publishes a world total at the end of each year. The site estimates 320,713 worldwide unit sales in 2014,<sup>24</sup> very close to the number from Pontes. 88 million cars and light trucks were sold worldwide in 2014, suggesting a plug-in capture rate of less than one half of one percent (0.38%).

## CO<sub>2</sub> Emissions and Plug-Ins

Government agencies and car manufacturers have misrepresented plug-ins as “clean cars”. TV advertisements emphasize the lack of “tailpipe” emissions. The EPA MPGe (e for equivalent) methodology for calculating plug-ins has been challenged repeatedly. To create consumer interest, plug-in cars are normally shown with a MPG equivalent in excess of 100 MPGe. The high MPGe is arrived at by ignoring the energy used to generate electricity, mostly from coal and natural gas. As more plug-in cars become available consumers are becoming much more aware of the implications of how electricity is generated. Although the window sticker on the car does not give correct numbers for CO<sub>2</sub> emissions, it can be found on the EPA fueleconomy.org website.

In comparisons with non-hybrids, plug-in cars do have an advantage over conventional cars, although it is not as great as many imagine. Briefly summarized, the efficiency of electric cars equals the efficiency of the power plant and transmission lines multiplied by the efficiency of electric motors. Roughly, power plant and transmissions line efficiency is about 33% and the



efficiency of electric motors is about 80%. The product of the two numbers is about 26%, greater than the typical gasoline engine, often estimated as 15-25%. But hybrid engines are much more efficient than conventional car engines, almost 40%, so that plug-in power trains do not have an advantage over hybrids cars on a national basis. This becomes more apparent when CO<sub>2</sub> emissions are compared.

As the nation's electric grid becomes more efficient, the CO<sub>2</sub> emissions for electric cars are reduced with no action on the customer's part. The Union of Concerned Scientists prepared a report that shows comparisons of plug-ins to hybrids<sup>25</sup> taking power plant emissions into consideration. One of the report's most valuable contributions is to show that such comparisons are dependent on the part of the country in which the driver lives. This area comparison is not an analysis of weather or topographic features but of the kinds of fuels used to generate electricity in each area.

A Carnegie Mellon report on life-cycle air emissions<sup>26</sup> leads to the conclusion that hybrids and small-battery PHEVs are preferred car architectures. A report from researchers at the Norwegian University of Science and Technology<sup>27 28 29</sup> suggests that plug-ins energized by grid electricity rather than by renewable technologies contribute much more to environmental problems than gasoline cars. A more recent report models plug-in vehicle deployment in the US and finds there is not a clear consistent trend toward lower CO<sub>2</sub> emissions.<sup>30</sup>

Such information adds uncertainty to the car-buying decision. A plug-in car is a major investment, even if partially subsidized by governments. It is much safer (and cheaper) for the environmentally-concerned purchaser to buy a conventional hybrid. Finally, resale values for plug-in cars are not as good as conventional cars or hybrids.

The Union of Concerned Scientists (UCS) has done an excellent job of showing how plug-in cars energy performance is regional. UCS continues to update their comparisons of plug-in cars to the Toyota 50 MPG Prius. Figure 5 is taken from their original State of Charge Report.

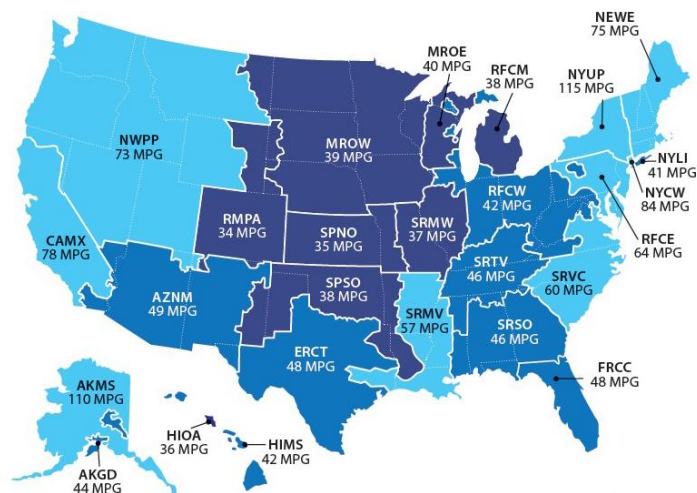


Figure 5: 2012 Map of MPG EV to Prius Comparison

Figure 6 shows an update to this report with data three years later from the first data set.<sup>31</sup>

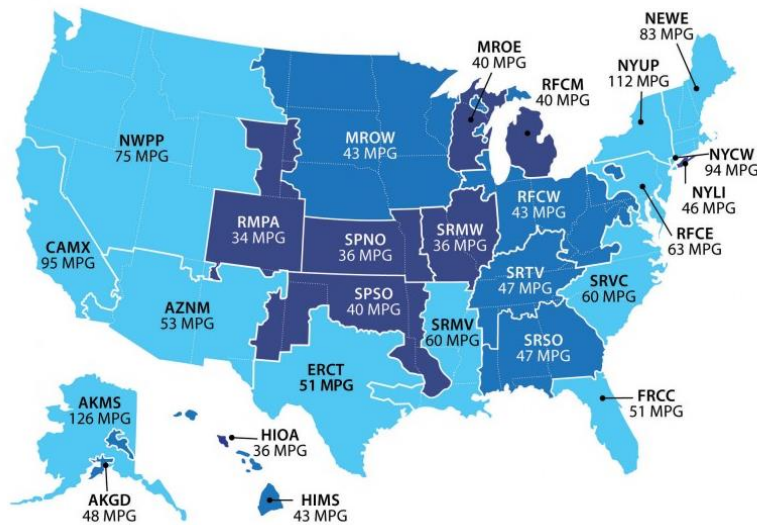


Figure 6: 2014 Map of MPG EV to Prius Comparison

Figure 6 shows a trend, but the exact rate of improvement of MPGe is not clear. However, the point is helpful and possibly increasing marketing and education in geographical areas where the plug-ins show a significant advantage over the Prius would be useful. However, thinking in terms of the amount of CO<sub>2</sub> generated rather than energy consumed is not yet widespread in the population.

## Summary

There were 88 million cars shipped worldwide in 2014.<sup>32</sup> There are somewhere in the range of 400-800 different models. R and D expenditures for the automotive industry in 2014 was approximately 100 billion dollars, representing about 4% of sales.<sup>33</sup> There were more plug-in cars sold in the rest of the world than in the U.S. Government programs for new development such as those which support plug-ins are not particularly expensive when evaluated in terms of all automotive R&D. In November, 2012, the Congressional Budget Office published a report on the government's funding of the EV.<sup>34</sup> It noted that \$7.5 billion would eventually be expended, but no significant benefit would be achieved. Figure 7 illustrates the continued expansion of the market for conventional cars.<sup>35 36</sup>

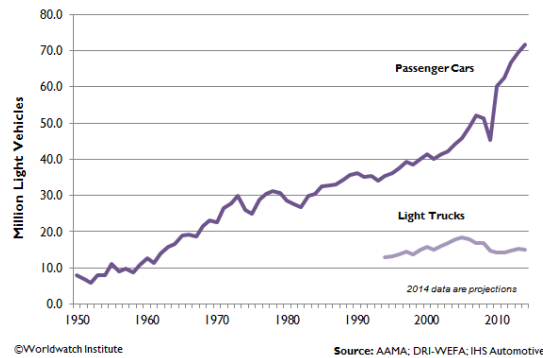


Figure 7: World Light Vehicle Production, 1950-2014

Among the risks of bringing a product to market prematurely and overselling it to consumers is the cost to early adopters. There are about 300,000 consumers who spent somewhere in the range of \$30,000 after rebates to purchased plug-ins, a national investment in the range of \$6,000,000,000. Resale values of plug-ins are lower than hybrids or conventional cars and much of this investment will be lost prematurely.

Plug-in cars are at a disadvantage relative to their main competitor – the gasoline hybrid. The high MPG, low CO<sub>2</sub> market belongs to the Toyota Hybrid Synergy Drive for at least another generation. It does not appear that fuel cells, diesel cars, or electric drive trains will be able to provide the benefits of this innovative idea anytime in the near future. Meanwhile, as pointed out in an earlier white paper, the Prius<sub>eqv</sub> Proposal,<sup>37</sup> environmentally concerned consumers' contribution is to buy a conventional Prius. The Prius and other Toyota hybrids will offer greater value than conventional cars or plug-ins for some time. Until electric power utilities can generate much cleaner electricity in large volumes (decades away), conventional hybrids will continue to significantly outsell plug-in cars.

<sup>1</sup>New Energy for America by Barack Obama election committee, Result of Internet Search for “Barack Obama .and. New Energy for America”. No URL. Accessed 020314

<sup>2</sup> Toyota is Global Hybrid Leader with Sales of 7 Million, Toyota Company, October 14, 2014  
<http://corporatenews.pressroom.toyota.com/releases/toyota+global+hybrid+leader+sales+7mm.htm>

<sup>3</sup> Worldwide sales of Toyota hybrids top 6 million units by Green Car Congress, January 15, 2014,  
<http://www.greencarcongress.com/2014/01/20140115-tmc.html>

<sup>4</sup> Toyota is Global Hybrid Leader with Sales of 7 Million, Toyota Company, October 14, 2014  
<http://corporatenews.pressroom.toyota.com/releases/toyota+global+hybrid+leader+sales+7mm.htm>

<sup>5</sup> Japan auto sales up 0.1 pct in 2013 at 5.38 mln vehicles, TOKYO, Jan 6, 2014  
<http://www.reuters.com/article/2014/01/06/japan-autos-sales-idUSL3N0KG0NS20140106>

<sup>6</sup> Toyota Parks Corolla Hybrid in Key Market Space by Yoshio Takahashi, WSJ, August 7, 2013,  
<http://m.us.wsj.com/articles/BL-JRTB-14607>

Japan's Love of Tiny Cars Creates a New Galapagos by Yoshio Takahashi, Wall Street Journal, December 17, 2013

<sup>7</sup> Consumer Reports Names Prius Best Value For Second Straight Year by Jeff Cobb, HybridCars.com, December 18, 2013  
<http://www.hybridcars.com/consumer-reports-names-prius-best-value-for-second-straight-year/>  
<http://pressroom.consumerreports.org/pressroom/2013/12/my-entry.html>

Consumer Reports Magazine, February 2014, page 52.

<sup>8</sup> *Explaining Stagnation in the Hybrid Electric Vehicle Market* dated February 6, 2015 by Will Sierzchula  
<http://blogs.scientificamerican.com/plugged-in/2015/02/06/explaining-stagnation-in-the-hybrid-electric-vehicle-market/>

<sup>9</sup> Ford hybrids fail to meet gas mileage ratings, Consumer Reports says: by John Voelcker, December 9, 2012  
[http://www.greencarreports.com/news/1080580\\_ford-hybrids-fuel-economy-failing-to-live-up-to-epa-ratings](http://www.greencarreports.com/news/1080580_ford-hybrids-fuel-economy-failing-to-live-up-to-epa-ratings)

<sup>10</sup> 2015 Ford CMax Ads To Downplay Twice Cut Gas Mileage Focus On Fun Tech 102714  
[http://www.greencarreports.com/news/1095135\\_2015-ford-c-max-ads-to-downplay-twice-cut-gas-mileage-focus-on-fun-tech](http://www.greencarreports.com/news/1095135_2015-ford-c-max-ads-to-downplay-twice-cut-gas-mileage-focus-on-fun-tech) by Stephen Edelstein, Green Car Reports, Oct 27, 2014

- 
- <sup>11</sup> Ford To Focus On Performance Not Electric Drive Technology 030415 by Eric Loveday, Inside EVs, March 4, 2015 <http://insideevs.com/ford-focus-performance-electric-drive-technology/>
- <sup>12</sup> Toyota Continues To Dominate Global Hybrid Sales, No Surprise There by Antony Ingram, Green Car Reports August 29, 2014 [http://www.greencarreports.com/news/1094125\\_toyota-continues-to-dominate-global-hybrid-sales-no-surprise-there](http://www.greencarreports.com/news/1094125_toyota-continues-to-dominate-global-hybrid-sales-no-surprise-there),
- <sup>13</sup> Cumulative Worldwide Sales of Honda Hybrid Vehicles Reaches 1 Million Units by Honda World, October 15, 2012, <http://world.honda.com/news/2012/c121015Hybrid-Vehicles-Reaches-1-Million-Units/index.html>
- <sup>14</sup> Hyundai & Kia overstate MPG ratings for 2011-2013 vehicles: will make refunds by James Nelson, November 2, 2012, <http://www.examiner.com/node/54866696>
- <sup>15</sup> 2016 Chevrolet Malibu Hybrid announced, will use Volt-related hardware. <http://www.worldcarfans.com/115032591092/2016-chevrolet-malibu-hybrid-announced-will-use-volt-related>
- <sup>16</sup> Hybrid Vehicles Lose Market Share in 2010, Vehicles and Fuel Facts, Fact #703: November 28, 2011, [http://www1.eere.energy.gov/vehiclesandfuels/facts/2011\\_fotw703.html](http://www1.eere.energy.gov/vehiclesandfuels/facts/2011_fotw703.html)
- <sup>17</sup> Cumulative sales of Toyota Motor hybrids top 2M units in Japan, 4.6M worldwide; 1.02M from Jan to Oct. Green Car Congress, November 8, 2012 <http://www.greencarcongress.com/2012/11/tmchbrids-20121108.html>
- Worldwide sales of Toyota Motor hybrids top 4M units; Prius family accounts for almost 72%, Green Car Congress, May 22, 2012 <http://www.greencarcongress.com/2012/05/tmc-20120522.html>
- <sup>18</sup> Information obtained from fueleconomy.gov.
- <sup>19</sup> May 2012 Dashboard by Jeff Cobb, HybridCars.com, June 5, 2012, <http://www.hybridcars.com/may-2012-dashboard-46746/>
- <sup>20</sup> UMTRI: new vehicle fuel economy down in February, Green Car Congress, March 4, 2015 <http://www.greencarcongress.com/2015/03/20150304-umtri.html>
- <sup>21</sup> New Light Vehicle Fuel Economy Continues to Rise, Vehicles and Fuel Facts, Fact #813: January 20, 2014, [http://www1.eere.energy.gov/vehiclesandfuels/facts/2014\\_fotw813.html](http://www1.eere.energy.gov/vehiclesandfuels/facts/2014_fotw813.html)
- <sup>22</sup> Charging into the Future by Larry Edsall, Motor Books, 2010
- <sup>23</sup> <http://www.ev-sales.blogspot.ch/search?updated-max=2015-02-15T11:56:00Z&max-results=7&start=7&by-date=false>
- <sup>24</sup> <http://insideevs.com/monthly-plug-in-sales-scorecard/>
- <sup>25</sup> State of Charge: Electric Vehicles' Global Warming Emissions and Fuel-Cost Savings Across the United States by Don Anair and Amine Mahmassani, Union of Concerned Scientists, June 2012, [http://www.ucsusa.org/clean\\_vehicles/smart-transportation-solutions/advanced-vehicle-technologies/electric-cars/emissions-and-charging-costs-electric-cars.html](http://www.ucsusa.org/clean_vehicles/smart-transportation-solutions/advanced-vehicle-technologies/electric-cars/emissions-and-charging-costs-electric-cars.html)
- <sup>26</sup> Valuation of plug-in vehicle life-cycle air emissions and oil displacement benefits, by J. Michalek, M. Chester, P. Jaramillo, C. Samaras, CSN.Shlau .and L. Laave, PNAS Oct 4, 2011, Volume 108, No 40 pages 16554-16558, <http://www.pnas.org/content/early/2011/09/19/1104473108.abstract>
- <sup>27</sup> Hawkins, T. R., B. Singh, G. Majeau-Bettez, and A. H. Strømman. 2012. Comparative environmental life cycle assessment of conventional and electric vehicles. *Journal of Industrial Ecology* DOI: 10.1111/j.1530-9290.2012.00532.x. *Journal of Industrial Ecology*.doi: 10.1111/jiec.12011 <http://onlinelibrary.wiley.com/doi/10.1111/j.1530-9290.2012.00532.x/full>
- <sup>28</sup> Are Electric Cars Bad for the Environment? by Leo Hickman, The Guardian, <http://www.guardian.co.uk/environment/blog/2012/oct/05/electric-cars-emissions-bad-environment>
- <sup>29</sup> What We Should Learn from a Lifecycle Assessment of EVs in the EU by Don Anair, October 12, 2012, <http://blog.ucsusa.org/what-we-should-learn-from-a-lifecycle-assessment-of-evs-in-the-eu/>
- <sup>30</sup> Comprehensive modeling study finds electric drive vehicle deployment has little observed effect on US system-wide emissions by Green Car Congress, January 15, 2014. <http://www.greencarcongress.com/2014/01/20140115-baabee.html>
- <sup>31</sup> How do EVs Compare with Gas-Powered Vehicles? Better Every Year... by Don Anair, Union of Concerned Scientists September 16, 2014 <http://blog.ucsusa.org/how-do-electric-cars-compare-with-gas-cars-656>
- <sup>32</sup> <http://www.oica.net/wp-content/uploads/total-sales-2014.pdf>
- <sup>33</sup> <http://www.autoalliance.org/auto-innovation/overview>
- <sup>34</sup> Effects of Federal Tax Credits for the Purchase of Electric Vehicles by Congressional Budget Office, September 2012, <http://www.cbo.gov/publication/43576>
- <sup>35</sup> Auto Production Sets New Record, Fleet Surpasses 1 Billion Mark by Michael Renner, June 4, 2014 Vital Signs, Worldwatch Institute. [http://vitalsigns.worldwatch.org/sites/default/files/cars\\_figure\\_1\\_0.png](http://vitalsigns.worldwatch.org/sites/default/files/cars_figure_1_0.png)
- <sup>36</sup> [http://vitalsigns.worldwatch.org/sites/default/files/cars\\_figure\\_1\\_0.png](http://vitalsigns.worldwatch.org/sites/default/files/cars_figure_1_0.png)
- <sup>37</sup> The Priuseq Proposal by Pat Murphy, Community Solutions, April 2012 <http://www.pluginscam.org/wp-content/uploads/2011/11/Prius-Paridym-Plan-April-2012.pdf>