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Electric Vehicle Transportation Center

Electric Vehicle Sales for 2014 and Future Projections

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Electric Vehicle Transportation Center

Report on

Electric Vehicle Sales for 2014 and Future Projections

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1. Summary

The object of this research is to assess the current status and to predict the future penetration of electric vehicles (EVs) within the U.S. market. The prediction method is based on EV yearly sales giving the cumulative vehicles on the road for 2010 through 2014 and the growth rates for these five years. Using these growth values, the future ten year values are calculated. The EV sales results for 2014 in the U.S. show that 118,773 vehicles were sold as compared to 96,700 vehicles in 2013. This gives a one year sales growth rate of 23%. The total cumulative number of EVs sold over the five year sales period is now at 286,390 vehicles. If a conservative 20% growth rate is used, then the U.S. sales in 2024 will be 740,000 EVs per year with cumulative number of vehicles at 4.0 million.

The second part of the prediction analysis was to predict the EV sales and cumulative sales values of EVs for the states of interest. These predictions were done for Florida, Hawaii, Alabama, and for comparison purposes for Georgia, California and New York. Results are also presented on state actions and incentives to overcome the cost barriers and on the technical barrier achievements as compared to U.S. Department of Energy goals.

2. Electric Vehicle Definitions

Plug-in Electric Vehicle (PEV): This refers to any vehicle that plugs into the electric grid for all or part of its power source. PEVs are battery-electric vehicles (BEV) such as the Nissan Leaf, plug-in hybrid electric vehicles (PHEVs) such as the Chevy Volt, or extended-range electric vehicles (EREVs).

Hybrid Electric Vehicle (HEV): HEV vehicles are those that combine a conventional internal combustion engine (ICE) propulsion system with an electric propulsion system. HEVs do not receive energy from the grid and do not have the ability for grid recharging. The traditional Toyota Prius is an HEV. HEVs are not considered in this analysis.

3. Methodology

The prediction method is based on EV yearly sales giving the cumulative vehicles on the road for 2010 through 2014 and the growth rates for these five years. Using these growth values, the future ten year values are calculated. These calculations are also made for future sales and cumulative number of vehicles on the road, assume growth rate values of 10, 15, 20, 25, 30 and 35%.

4. Results Using Historical PEV Sales

Many references present the U.S. PEV sales for 2010 through 2014 (the only years PEVs were available). The historical U.S. data in table form is as follows[1]:

Table 1- PEV Sales by Year

YEAR	PHEV	BEV	YEARLY TOTAL	CUMULATIVE SALES
2010	326	19	345	345
2011	7,671	10,064	17,735	18,080
2012	38,584	14,251	52,835	70,915
2013	49,008	47,694	96,702	167,617
2014	55,357	63,416	118,773	286,390

Note the following 2014 statistics from the Table 1 data:

- Battery only vehicle sold more (53%) than plug-in (47%) for the first time
- The yearly sales growth was 23%
- The cumulative sales for 2014 increased by 71% over the past four years

In 2015, EV sales data for January and February 2015 show an increase of 34% over January and February 2014. A plot of PEV yearly and cumulative sales is shown below in Figure 1.

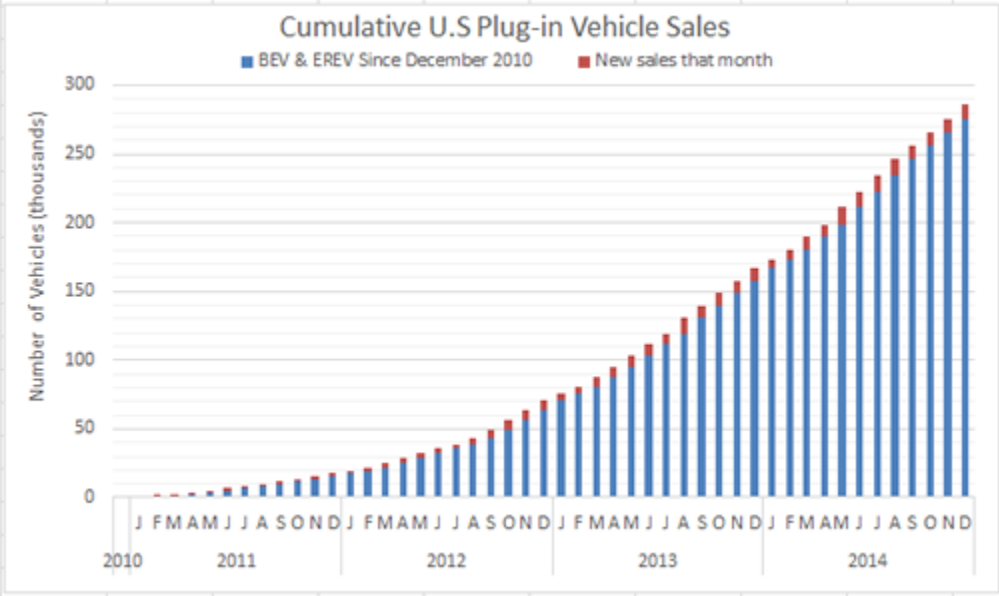

Figure 1 (from Reference 1)

4.2. Historical Sales of Hybrid Electric Vehicles (HEV)

Although this study does not involve hybrid vehicles (HEVs), the historical sale trends of HEVs are of interest in looking at future PEV trends. Hybrid vehicles were introduced in the U.S. in 1999 and 2013 was the largest sales year at 495,530 HEV vehicles. Table 2 below presents the yearly sales and the cumulative sales of HEVs.

Table 2. Yearly HEV Sales

Year	Sales	Cumulative
1999	17	17
2000	9,350	9,367
2001	20,287	29,654
2002	35,000	64,654
2003	47,525	11,2179
2004	88,000	20,0179
2005	215,000	415,179
2006	250,000	665,179
2007	352,274	1,017,453
2008	313,673	1,331,126
2009	290,292	1,621,418
2010	274,210	1,895,628
2011	266,329	2,161,957
2012	434,645	2,596,602
2013	495,530	3,092,132
2014	451,702	3,543,834

As presented in Table 2, the sales of HEVs were less in 2014 than 2013 and the sales appear to have leveled off at about 450,000 vehicles per year as compared to EVs at about 120,000 vehicles per year and growing.

4.3. Historical Total U.S. Vehicle Sales

The historical total of U.S. light vehicle sales is also of interest and is presented in Table 3.

Table 3. U.S. Total Vehicle Sales

YEAR	TOTAL U.S. SALES (million vehicles)	% HEV of Total	% PEV of Total
2007	11.8	2.99	--
2008	13.3	2.39	--
2009	10.5	2.78	--
2010	11.6	2.37	--
2011	12.7	2.09	0.14
2012	14.4	3.01	0.37
2013	15.5	3.19	0.62
2014	16.4	2.75	0.72

Table 3 shows an increase of sales from 15.5 million in 2013 to 16.4 million vehicles in 2014. Table 3 also presents the total sales of HEV and PEV vehicles (as a percentage) of total sales for each year.

4.4. Future PEV Sales Predictions

The prediction of future events relies on past events and an assumed future growth rate. In the above Sections 1, 2 and 3, past (historical) vehicle sales data have been presented. The work presented here is based on assuming growth rates of 10, 15, 20, 25 and 35% from the historical or 2014 values. Using these growth values, the future values are presented in Table 4 and in Figure 2. Using Table 4 and Figure 2, any assumed growth rate can then be placed on these growth curves which will give the reader the estimate of the future depending upon the growth rate assumed.

Table 4. PEV Sales and Cumulative Growth Predictions

Yearly Predictions		**10%**	**15%**	**20%**	**25%**	**30%**	**35%**
2014	118,773						
2015		131,000	137,000	143,000	148,000	154,000	160,000
2016		144,000	158,000	172,000	185,000	200,000	216,000
2017		158,000	182,000	206,000	231,000	260,000	292,000
2018		174,000	209,000	247,000	289,000	338,000	394,000
2019		191,000	240,000	296,000	361,000	439,000	532,000
2020		210,000	276,000	355,000	451,000	571,000	718,000
2021		231,000	317,000	426,000	564,000	742,000	969,000
2022		254,000	365,000	511,000	705,000	965,000	1,308,000
2023		279,000	420,000	613,000	881,000	1,255,000	1,766,000
2024		307,000	483,000	736,000	1,101,000	1,632,000	2,384,000
Cumulative Growth							
2014	286,390						
2015		417,000	423,000	429,000	434,000	440,000	446,000
2016		561,000	581,000	601,000	619,000	640,000	662,000
2017		719,000	763,000	807,000	850,000	900,000	954,000
2018		893,000	972,000	1,054,000	1,139,000	1,238,000	1,348,000
2019		1,084,000	1,212,000	1,350,000	1,500,000	1,677,000	1,880,000
2020		1,294,000	1,488,000	1,705,000	1,951,000	2,248,000	2,598,000
2021		1,525,000	1,805,000	2,131,000	2,515,000	2,990,000	3,567,000
2022		1,779,000	2,170,000	2,642,000	3,220,000	3,955,000	4,875,000
2023		2,058,000	2,590,000	3,255,000	4,101,000	5,210,000	6,641,000
2024		2,365,000	3,073,000	3,991,000	5,202,000	6,842,000	9,025,000

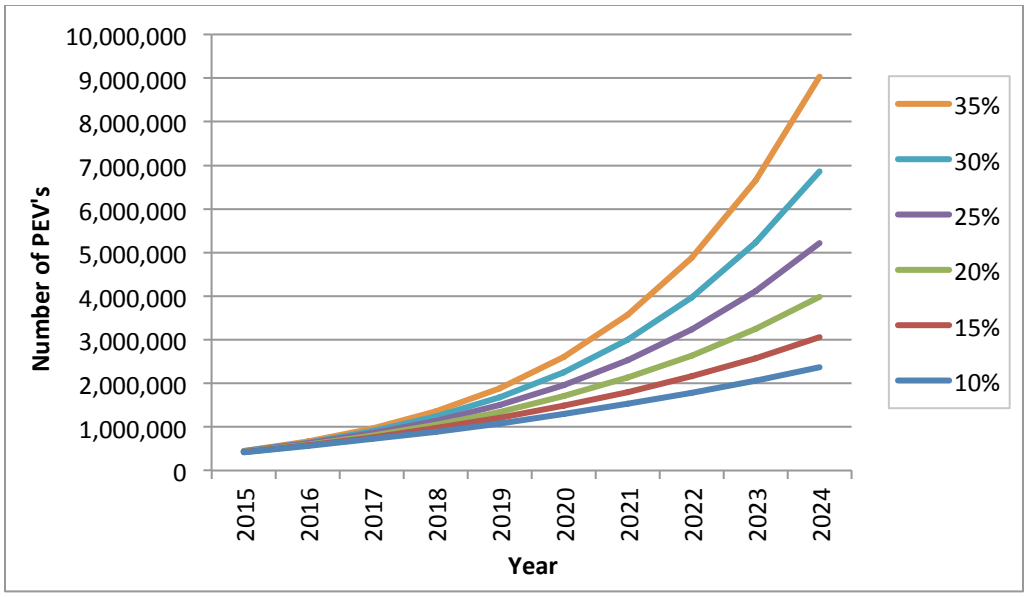

Figure 2. PEV Sales

From Table 4, the results show that in 2024, the 10-year U.S. yearly sales will be from 300,000 to 2.4 million per year and the cumulative number of vehicles on the roads would be from 2.4 to 9.0 million. As previously mentioned, the 2014 sales versus the 2013 sales gave a growth rate of 23%, thus, growth rates of 20% to 25% appears to be the most appropriate. If a 20% to 25% growth rate is used, then the U.S. sales in 2024 will be 740,000 to 1.1 million EVs per year with a cumulative number of vehicles on the road at 4.0 to 5.2 million.

4.5. Future PEVs by State

The next phase of this report is to predict the sales and cumulative values of PEVs for the states of interest. These predictions were completed for Florida, Hawaii, Alabama and for comparison purposes for Georgia, California and New York. The process used was the same as conducted above for the U.S. sales beginning with known values for 2014 and then using 10, 15, 20, 25 and 35 percent growth rates.

EV sales values for states were found in many sources. The primary sources were Wikipedia, the California New Car Dealers Association, and Ms. Danielle Pickard of Florida Power & Light. Using these references plus making some educated estimates, the following sales values are constructed (see Table 5).

Table 5. EV Sales Values for States

	2011	2012	2013	2014	Cumulative Total	Reference
US	17,735	52,835	96,702	118,773	286,390	1
FL	500	2,500	3,377	3,766	10,143	2,3
HA	581	386	584	1,400	2,951	4,5,6
AL			200	800	1,000	
GA			4,000	10,000	14,000	4,7,8
CA	6,984	20,093	42,545	59,471	129,470	4,9
NY		1,000	3,000	7,000	11,000	4

In the above Table 5, the California sales for 2014 represented 50% of the U. S. total and 45% of total EV sales over the five year period. California drives the market. The EV values for Florida are determined by FPL and are the total number of EVs registered in the state of Florida as of a specific date. The numbers are taken as registered vehicle from the Florida Department of Motor Vehicles and the number was 10,143 EVs as of January 1, 2015, and 6,377 as of January 1, 2014.

The PEV sales for the six states use the sales and cumulative total values in Table 5 and the assumed growth rates as before. Using these values gives the state sales and cumulative sales results for ten years in the future (2024) which is presented in Tables 6 and 7 below.

Table 6. PEV Sales for year 2024 by State

Sales	2014	10%	15%	20%	25%	30%	35%
US	118,773	308,000	481,000	735,000	1,106,000	1,637,000	2,388,000
FL	3,766	10,000	15,000	23,000	35,000	52,000	76,000
HA	1,400	4,000	6,000	9,000	13,000	19,000	28,000
AL	800	2,000	3,000	5,000	7,000	11,000	16,000
GA	10,000	26,000	40,000	62,000	93,000	138,000	201,000
CA	59,471	154,000	241,000	368,000	554,000	820,000	1,196,000
NY	7,000	18,000	28,000	43,000	65,000	97,000	141,000

Table 7. Cumulative Sales by State for year 2024 by State

Cum. Growth	2014	10%	15%	20%	25%	30%	35%
US	286,000	2,369,000	3,060,000	3,986,000	5,223,000	6,867,000	9,040,000
FL	10,143	76,000	98,000	127,000	167,000	219,000	288,000
HA	2,951	27,000	36,000	47,000	61,000	81,000	106,000
AL	1,000	15,000	20,000	26,000	34,000	45,000	60,000
GA	14,000	189,000	249,000	326,000	430,000	586,000	751,000
CA	129,470	1,172,000	1,518,000	1,982,000	2,601,000	3,424,000	4,512,000
NY	11,000	134,000	174,000	229,000	302,000	399,000	527,000

From the above results and if the same 20% growth rate is used to project to 2024, then the 2024 sales in Florida, Hawaii and Alabama are predicted to be 23,000, 9,000 and 5,000, respectively. The cumulative vehicle numbers in 2024 for these three states are then 127,000, 47,000, and 26,000 vehicles. In 2024, California, at 20% growth, is predicted to sell 386,000 vehicles per year with a cumulative number of 2 million vehicles.

4.6. Activities to Overcome Barriers

4.6.1. Barriers

The growth of PEVs are dependent upon the types of barriers and the actions or incentives to overcome the barriers. The barriers to large scale PEVs usage can be stated as follows:

1. Vehicle cost.
2. Vehicle mileage between charging.
3. Availability of charging stations.

4. Charging time.
5. Resale value.
6. Vehicle maintenance and, in particular, battery life.
7. Infrastructure, standards, and permitting.
8. Public knowledge and education.

4.6.2. Actions to Overcome Barriers

The critical barriers can be thought of as barriers related to cost and barriers as related to technology. The cost barriers on the negative side are vehicle cost where an EV costs more than the comparable ICE, as well as little to no experience on resale values. These negative features are balanced on the positive side by an EV cost per mile at about $1 per gallon equivalent for electricity at 12 cents/kWh and minimal to very little maintenance costs. It is also noted that U.S. electricity costs are much more stable than oil prices giving an EV a more predictable future fuel value.

Another cost barrier is the number of charging stations which has been heavily subsidized by the federal government. Charging stations are now being supported by state government or private firms. Data shows that there are 9187 charging stations supplying 23,157 public charging outlets in the U.S[1]. Again, California leads the U.S. with over 20% of the charging stations and outlets. The total charging station number continues to increase.

Both the federal and state governments have passed laws and regulations that give incentives to assist EVs with regard to cost reductions. At the federal level, there are personal income tax credits for EV purchase at between $2,500 to $7,500 depending upon battery size. Both the Leaf and Volt qualify for the $7,500 value. Presented in Table 8 is a listing of EV incentives by state[10].

Table 8. EV Incentives by State

Alternative Fuel & Vehicle Incentives	CA
Alternative Fuel or Plug-in Vehicle Rebates	CA, IL, MA, PA, TX
Alternative Fuel Vehicle Funding/Grants/Incentives	CT, LA, MA, MS, NE, OH, PA, TX
Alternative Fuel Vehicle Tax Exemption	AZ, DC, RI, WA
Electric Vehicle Equipment Tax Credit	AZ, MD
Electric Vehicle Supply Equipment Financing	FL
Electric Vehicle Supply Equipment Rebate/Credit	CA, FL, IL, IN, MI, TX, WA
Free Parking	CA, CT, HI, NV, UT
HOV Lane Expemption	AZ, CA, FL, GA, HI, MD, NV, NY, NC, TN, UT, VA
Income or Other Tax Credit/Exemption	CO, DC, GA, LA, MD, MO, MT, NC, NJ, NY, OK, OR, RI, UT, VT
Insurance Discount	CA
PEV Charging Rate Reductions/Incentives	CA, GA, IN, MI, MN, VA
Plug-In Electric Vehicle and Electric Vehicle Supply Equipment Grants	CO
Plug-In Electric Vehicle Charging Rates	AZ, HI, IN, NV, UT

Plug-in Electric Vehicle Rebate	MA, PA
Pollution Control Equipment Exemption	OR
Reduced Alternative Fuel Vehicle License Tax	AZ
Reduced Registration Fees	DC, IL,
Sales Tax Exclusion for Manufacturers	CA
Vehicle Inspection Exemption	AZ, ID, MI, MO, NV, NC, VA, WA
Vehicle Replacement Vouchers	TX
Vehicle to Grid Energy Credit	DE
Vehicle Toll Incentive	NJ

Table 8 shows a list of 23 different types of incentives covering all aspects of EV usage. Again, the Income or Other Tax Credit/Exemption incentive is most important and is offered in 15 states. There are incentives in 37 states.

Next are the EV technical barriers. The technical barriers are related to vehicle design and battery technology and are addressed by the U.S. Department of Energy (DOE) and product manufacturers. Many references that include the EVTC researchers have reached the conclusion that the most critical barrier to EV usage is battery cost and range. President Obama announced the EV Everywhere Grant Challenge in March 2012. This announcement led the U. S. Department of Energy to set a technical action plan[11].

The technical targets for the DOE program fall into four areas: battery R & D; electric drive system R & D; reducing vehicle weight; and advanced climate control technologies. Specific goals include:

- Cutting battery costs from their current $500/kWh to $125/kWh and increasing energy density from 50 Wh/L to 400 Wh/L
- Eliminating almost 30% of vehicle weight through light weight materials
- Reducing the cost of electric drive systems from $40/kW to $8/kW

The program is now at end of the third year and the published results are as follows:

1. Battery cost and range – From the June 2014 U.S. DOE Annual Merit Review Meeting in advanced battery R & D, David Howell, DOE Program Manager, stated that over the past five years, the cost of batteries has dropped by 70%, while the energy density has doubled[12](see Figure 3) . This is a result of research into novel electrode materials, particularly at the cathode. Research into novel anode materials (such as silicon nano-wires) as well as high voltage electrolytes will continue to advance toward the 2022 goals of $125/kWh and 400 Wh/L. The DOE results assume the manufacturing of 100,000 battery/year and the DOE goals are for 2022. Other results show lithium-ion battery cost per kWh for 2014 are about $300-$400/kWh and continue to reduce[13].

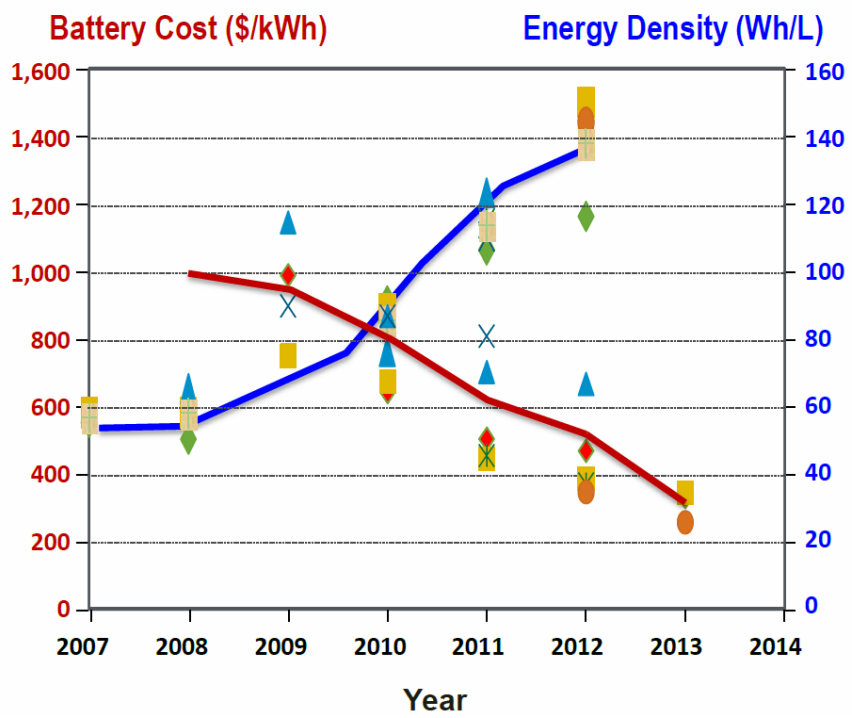

Figure 3. Battery Costs and Energy Density

2. Reducing vehicle weight – Efforts within the DOE Vehicle Technologies Office (VTO) Lightweight Materials subprogram to reduce vehicle weight are focused on research in the following areas[14]:

    - Magnesium – improved production and manufacturing technologies for base material and novel alloys
    - Advanced High Strength Steels (AHSS) – improved processing of high strength/low ductility steel
    - Carbon fiber materials – decreasing manufacturing costs
    - Aluminum – decreasing machining costs and increasing weight reductions through alloys
    - Joining technologies – improved ability to join dissimilar metals with good durability and low galvanic corrosion rates

    All areas are seeking to decrease costs associated with the production and assembly of light-weight vehicles.

3. Reducing cost of electric drive systems – Figure 4 illustrates the progress towards lower cost electric drive systems. The increased cost observed in 2012 is due in part to the significant increase in cost for rare earth metals at that time (Figure 5). The DOE program is supporting research into non-rare earth metal magnets for electric motors and in increasing cooling efficiencies of advanced inverters[15-18].

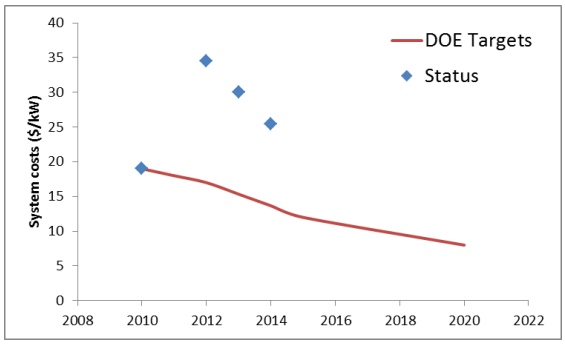

Figure 4. Progress Towards Lower Cost Electric Drive System, as Compared to DOE Targets

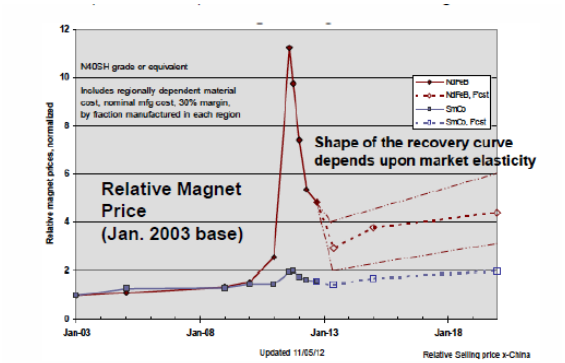

Figure 5. Change in Magnet Price Since 2003.
Image from "Permanent Magnet Development for Automotive Traction Motors", Iver E. Anderson, DOE Annual Merit Review June 18, 2014. Project ID: APE015

As a final note, the President's goal of 1 million vehicles on the road by 2017 now appears to not be achievable. Results presented here show 800,000 to 850,000 vehicles by 2017. However, as noted above, the DOE technical goals are progressing as according to schedule.

5. Concluding Remarks

Predicted values of PEV yearly sales and cumulative sales have been presented based on 2014 data. As additional sales data is received, the results will be updated. The results for the U.S. show that the cumulative sales of EVs through 2014 is 286,390 vehicles with 118,773 sold in 2013. Depending upon the escalation rate selected, the 10 year future U.S. sales (2024) are predicted to be from 307,000 to 2.4 million per year and the cumulative vehicles on the roads would be from 2.4 to 9 million vehicles. Comparing the presented results with predictions from other sources, a growth rate of 20% appears to be the most appropriate. A 20% growth rate will give U.S. sales of approximately 236,000 PEVs per year and cumulative sales of 4.0 million vehicles for 2024. This same 20% growth rate will give sales in Florida, Hawaii and Alabama of 23,000, 9,000 and 5,000, respectively. The cumulative vehicles on the road for these three states are 127,000, 47,000, and 26,000 vehicles. California is predicted to sell 368,000 vehicles per year with cumulative sales of 2 million vehicles.

The work also evaluated the types of barriers to EV usage and the actions or incentives to overcome the barriers. The barriers to large scale EV usage are vehicle cost, mileage between charging, perceived battery life, availability of charging stations, charging time, resale,

infrastructure and public knowledge and education. State incentives and technical results from Department of Energy research are presented showing progress to overcome the barriers.

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