Report On Electric Vehicle Charging

Submitted to the Governor,
the President of the Senate, and
the Speaker of the House of Representatives
To Fulfill the Requirements of Section 366.94, Florida Statutes

Florida Public Service Commission
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Table of Contents

List of Tables

List of Figures

Section 1. Executive Summary

By Section 366.94(4), Florida Statutes (F.S.), the Legislature directs the Florida Public Service Commission (FPSC) to conduct a study on the effects of electric vehicle (EV) charging on both energy consumption and the electric grid, as well as to examine the feasibility of off-grid solar photovoltaic (PV) charging. In order to meet this requirement, the FPSC has gathered information through Florida's electric utilities, a staff workshop, and independent research.

While EVs are still a niche product, they have become more commercially viable due to tax credits, the introduction of gasoline-electric hybrid technology, and improved battery technology. In part because of the higher up-front costs associated with batteries, EVs have faced challenges to expanded use. As the technology becomes more established, EVs may become a more realistic alternative to gasoline and diesel-fueled vehicles. The impact of EVs on energy consumption and demand on the electric grid will depend on a number of factors, including the rate of growth in EV sales, EV clustering, the impact of higher voltage "quick-charge" stations on local distribution systems, and the extent to which EV charging corresponds with times of electric system peak demand.

Background Data for Electric Vehicles

Current estimates of the number of EVs in Florida as provided by utilities and other organizations range from roughly 1,000 to 6,000. Because no agency tracks these figures formally, it is difficult to pinpoint the number more precisely, and future projections are even more speculative. Currently, while there are EV charging station locators, no source appears to provide a truly exhaustive list of public charging stations. Moving forward, government and manufacturer incentives, combined with rising Corporate Average Fuel Economy (CAFE) standards, may result in increased sales of EVs in the future. Additionally, technological breakthroughs or changes in commodity prices, especially oil prices, could affect EV adoption rates.

Effects on Energy Consumption

Because relatively few EVs are currently on the road in Florida, they are having very little impact on total energy consumption in Florida. Based on an estimate of 5,531 EVs, it is estimated that EVs will result in approximately 22.1 Gigawatt-hours (GWh) of energy consumption during 2012. Total energy consumption in Florida in 2012 is estimated at 238,645 GWh, so the additional amount due to EVs is less than 0.01 percent. The impact of EVs on electricity consumption is expected to rise to 909.3 GWh in 2021, which represents approximately 0.33 percent of the total 275,519 GWh of electricity expected to be consumed that year.

EVs are also expected to reduce gasoline consumption in Florida. Current FPSC estimates place gasoline savings at 356 gallons per year per plug-in hybrid EV and at 480 gallons per year per fully electric vehicle. As a result, it is estimated that approximately 2,131,728 gallons of gasoline may be saved by EVs in 2012, increasing to approximately 89,447,402 gallons in 2021.

Additionally, EVs are not expected to drive any new need for generation within the ten-year planning horizon. Current estimates place the impact on summer peak demand for the four generating investor-owned utilities (IOUs) and two largest municipal utilities (jointly referred to throughout this document as the large utilities) at approximately 4 megawatts (MW) in total in 2012.[1] Summer peak demand for these utilities was estimated at 39,127 MW in 2012, for an impact due to EVs of approximately 0.01 percent. Since reserves for those utilities are estimated at 11,860 MW for 2012, the additional load from EVs will not adversely impact reliability in the ten-year planning timeframe.

In 2021, the estimated impact of EV charging at peak is 185 MW, with reserves estimated at 10,062 MW. As a result, the FPSC does not envision EVs resulting in a need for new generation over the ten-year planning timeframe. Beyond the planning timeframe, if EVs do begin to significantly impact generation in Florida, increased use of rate structures such as time-of-use rates may help shift EV charging to hours of low demand.

Impact on the Electric Grid

While individual EV chargers are expected to have a negligible impact on grid reliability, clustering of EVs in residential neighborhoods could potentially require the replacement of equipment in the distribution system. Responses from Florida utilities indicate that the smaller residential transformers could exceed their design limits if multiple chargers, especially higher-voltage chargers, operate on a single transformer. Higher voltage home EV chargers, which may draw up to 20 kilowatts (kW), may result in the need for larger capacity distribution facilities depending upon a number of factors, including the location of the system and clustering of chargers.

Public "quick-charge" stations may also impact the distribution system. These stations are likely to create an electric demand of 50 kW or more, and may operate during times of peak demand. The installation and use of these higher voltage "quick-charge" stations may require upgrading distribution-level facilities to ensure reliability. Because EVs are such a new and emerging technology and higher-voltage chargers are only starting to be installed, the impacts on local distribution systems cannot be estimated at this time.

Feasibility of Solar PV for Off-Grid Charging

The use of off-grid solar PV for EV charging does not appear to be a feasible alternative to grid-tied solar PV systems at present. Solar production times do not align with expected EV charge times. In addition, to match charging demand with the requirements of high voltage charging stations would require large sized EV systems of substantial physical size. While energy storage would make off-grid solar PV car charging more practical, costs are estimated at roughly $10,000 for a battery that can charge one car per day, and larger batteries scale up at that amount as well. As a result, in Florida, the cost of energy storage will generally exceed the cost of tying a solar PV system to the electric grid.

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[1] The four generating IOUs are Florida Power and Light Company (FPL); Progress Energy Florida, Inc. (PEF); Tampa Electric Company (TECO); and Gulf Power Company (Gulf). The two largest municipal utilities are JEA (Jacksonville) and Orlando Utilities Commission (OUC).

Conclusion

EV charging is expected to have a negligible effect on electricity consumption in Florida within the ten-year planning horizon. At the same time, EV owners should reduce the consumption of gasoline in Florida by more than two million gallons in 2012. EVs are also not currently expected to cause a significant increase in electric demand or contribute significantly to a need for new generation until well past 2021. Clusters of electric vehicles charging simultaneously on a single residential transformer could potentially require upgrades to that transformer, but individual vehicles are not expected to affect the distribution system. "Quick-charge" stations may pose potential challenges for the distribution system. The use of off-grid solar photovoltaics for EV charging is technically feasible, but it may only be practical in unique circumstances due to economic considerations.

Section 2. Introduction

Section 366.94(4), F.S., reads as follows:

> The Public Service Commission is directed to conduct a study of the potential effects of public charging stations and privately owned electric vehicle charging on both energy consumption and the impact on the electric grid in the state. The Public Service Commission shall also investigate the feasibility of using off-grid solar photovoltaic power as a source of electricity for the electric vehicle charging stations. The commission shall submit the results of the study to the President of the Senate, the Speaker of the House of Representatives, and the Executive Office of the Governor by December 31, 2012.

During the 2012 Regular Session, the Florida Legislature enacted HB 7117, Chapter 2012-117, Laws of Florida, addressing energy policy in the State of Florida. Section 11 of the law created Section 366.94, F.S., instructing the FPSC to conduct a study of the potential effects of public charging stations and privately-owned electric vehicle charging on both energy consumption and the impact on the electric grid in the state. Additionally, the FPSC is required to investigate the feasibility of using off-grid solar photovoltaic power as a source of electricity for the electric vehicle charging stations. This report is due to the President of the Senate, the Speaker of the House of Representatives, and the Executive Office of the Governor by December 31, 2012.

In preparation for this report, the FPSC submitted a data request to many of Florida's electric utilities in May 2012. A workshop was also held in September 2012 to provide an opportunity for discussion on relevant issues. Entities presenting at the workshop included the Electric Power Research Institute, General Motors Company, General Electric Company, SPX Corporation, the Florida Solar Energy Center, four Florida IOUs, and the Orlando Utilities Commission. In addition, the FPSC conducted a literature and data search for relevant information.

Based on the research described above, the following report addresses electric vehicle charging's effect on: (1) energy consumption, focusing on increased electricity consumption and offsetting motor gasoline consumption, as well as electric demand, (2) impact on the electric grid, primarily the distribution system, and (3) the feasibility of using off-grid solar photovoltaic power for electric vehicle charging.

This report is organized into the following sections:

Section 3. Background Data for Electric Vehicles

The data used to prepare this report was primarily provided by Florida electric utilities' responses to the FPSC staff data request issued in May 2012. Where necessary, the FPSC extrapolated from utility data and from other reliable sources, such as other Florida or federal agencies. Data from automotive manufacturers also provided much of the background for specific EV models.

Electric Vehicles in Florida

While electric vehicles date back to the nineteenth century, the current wave of mass produced electric vehicles begins with the introduction of the Chevrolet Volt, from General Motors Company (GM), and the Nissan Motor Company (Nissan) Leaf in 2010. Although hybrid electric vehicles (HEVs), such as the original Toyota Motor Corporation (Toyota) Prius, existed prior to these models, HEVs use electricity generated by the gasoline engine and are not powered by electricity from the grid. Because HEVs are not charged through a connection to the electric grid, they are not addressed in this report. Instead, this report focuses on plug-in hybrid electric vehicles (PHEVs), which primarily rely on energy from the grid but can use gasoline for longer distances, and all-electric vehicles, which rely entirely on grid-provided energy. For purposes of this report, the term "EVs" will refer collectively to PHEVs and all-electric vehicles, but will exclude HEVs.

The Chevrolet Volt, a PHEV introduced in 2010, was the first of the current wave of EVs to become widely available. The Volt has an Environmental Protection Agency (EPA) estimated 38 mile range running solely on its battery power. It also has a gasoline engine for longer trips; GM estimates that Volt owners average 900 miles between fill-ups. The Nissan Leaf, which was released shortly after the Volt, is an all electric vehicle with an EPA-estimated 92 mile range. The Leaf will therefore be more reliant on public charging stations on longer trips, especially on "quick-charge" stations that function for EVs similarly to how gasoline stations work for gasoline vehicles.

Additionally, other EVs have become available in recent years or will become so in the near future. The Tesla Motors (Tesla) Roadster, released in 2008, is all-electric with a 245 mile range. Tesla also has a new model, the Model S, which was first delivered in June 2012. It is also all-electric with a range of 160-300 miles depending on which battery the owner chooses. Tesla also has a third model, the Model X, scheduled for release in 2014. Tesla is the only EV manufacturer at present to offer the largest at-home chargers, capable of charging a vehicle in only a few hours as opposed to the 8-12 hours many other EV chargers require. Because Tesla has a much smaller manufacturing capability than the large automotive manufacturers, its models generally require reservations and have long waiting lists.

Numerous other automobile manufacturers have released PHEVs or all-electric EVs during 2012. Mitsubishi Motors (Mitsubishi) released the i-MiEV, an all-electric vehicle with a 62 mile range. Toyota also released a PHEV version of the Prius with a 62 mile range, though it is only available in certain states in the Northeast and West. It is scheduled to be available nationwide in 2013. Ford Motor Company (Ford) released an all-electric version of the Focus in 2012 with a 100 mile range. The Focus EV also has been made available initially only in certain markets, including several throughout Florida, with more planned in the future. An all-electric version of the Toyota Rav4 with a 103 mile range has also been released, but only in California. It is unclear if the Rav4 EV will be made available in other states. Finally, Honda Motor Company (Honda) has released an all-electric version of the Fit, which is currently only available in California.

Other car manufacturers have models planned for release over the next few years, including smaller, specialty manufacturers like Coda Automotive (Coda), which released an all-electric sedan in 2012 with a 125 mile range. Additionally, traditional manufacturers have EVs scheduled for release in 2013 or 2014. These newer EVs are expected to contribute to the growth of the EV market, which to date has been dominated by the Volt and the Leaf. Table 1, below, compares several of the models released to date.

Table 1. EV Model Comparison

Make	Model	Year Released	Type	Electric Range (Miles)	Battery Size (kWh)	Home Charger Size (kW)	Availability
Chevrolet	Volt	2010	PHEV	38	16.5	3.3	Wide
Nissan	Leaf	2010	All-Electric	92	24	3.3	Wide
Tesla	Roadster	2008	All-Electric	245	56	16.8	Limited
Tesla	Model S	2012	All-Electric	160/230/300	40/60/85	20	Limited
Mitsubishi	i-MiEV	2012	All-Electric	62	16	3.3	Wide
Toyota	Prius EV	2012	PHEV	62	4.4	3.8	West and NE
Ford	Focus EV	2012	All-Electric	100	23	6.6	Includes Florida
Toyota	Rav4 EV	2012	All-Electric	103	41.8	9.6	California
Honda	Fit EV	2012	All-Electric	82	20	6.6	California
Coda	Sedan	2012	All-Electric	125	31	7.2	California

Source: Auto maker data

The number of EVs currently being driven in Florida is difficult to gauge. The Florida Department of Highway Safety and Motor Vehicles (FHSMV) keeps a listing of vehicles with the fuel type of "electric," but this listing is based on a voluntary check box and does not distinguish between EVs, PHEVs, and HEVs. FHSMV has 28,403 vehicles listed with that fuel type in Florida as of October 2012. This option was added to the car registration process in recent years and may not capture all EVs and HEVs registered in Florida.

Estimating the number of plug-in EVs likewise is imprecise. Table 2 shows the large utilities' projections for EVs in their service area through 2021. It is important to note that these projections should be considered preliminary. Some of the utilities noted in their responses that these preliminary estimates may overstate the number of EVs likely to be deployed during the planning timeframe.

Table 2. Projected Number of EVs in Florida by Utility Service Area

Year	FPL	PEF	TECO	Gulf	OUC	JEA	Total
2012	3,024	238	*1,165	**380	293	431	**5,531**
2013	5,852	1,054	1,808	895	830	651	**11,090**
2014	10,021	2,361	2,634	1,553	1,624	876	**19,069**
2015	15,874	4,045	3,479	2,326	2,689	1,104	**29,517**
2016	23,811	6,274	4,541	3,220	4,037	2,006	**43,889**
2017	36,510	9,500	5,887	4,201	5,685	2,924	**64,707**
2018	49,289	13,816	7,407	5,342	7,646	3,860	**87,360**
2019	65,554	19,337	8,854	6,646	9,937	4,813	**115,141**
2020	98,332	26,204	10,292	8,117	12,574	5,783	**161,302**
2021	147,497	34,576	11,699	9,654	15,570	7,583	**226,579**

Source: Utility data responses

* TECO notes in its estimate that it estimated 55 vehicles in its service area at the time of the data response (May 2012). The 1,165 figure, as well as future projections, are based on a 2011 estimate.
** Gulf noted that it was aware of 8 EVs at the time of its response in its territory but did not consider that figure exhaustive.

The utility projections in Table 2 come from a variety of sources. Florida Power and Light Company (FPL) generated its own estimates for its own service area and for Florida as a whole using market forecasts. FPL estimated that 50 percent of EVs in Florida would be owned by customers in its service area. This figure is reported in Table 2. Progress Energy Florida, Inc. (PEF) used Electric Power Research Institute (EPRI) projections that included a range of three forecasts. PEF submitted the medium EPRI estimate for its service area. This estimate gave a value for 2012 (238) that was slightly above the range PEF estimated in its service area at the time of submission (150-200). Tampa Electric Company (TECO) had estimated EVs in its own territory in 2011 and noted that its projection for 2012 was much higher than the actual number it offered at the time of its data response (55). Gulf Power Company (Gulf) based its numbers through 2017 on a Pike research survey from 2011. For the rest of the period, Gulf estimated that EV penetration would reach 5 percent of all vehicles in its service area in 2023 and grow linearly until then. Orlando Utilities Commission (OUC) conducted its projection in 2010 and characterizes it as "overly optimistic" at present. JEA (Jacksonville) extrapolated from EPRI data, using the "low" scenario.

Table 3 compares the large utilities' forecast methodologies when extrapolated statewide. It includes both EPRI's and FPL's statewide estimates, including all three EPRI scenarios. It also includes an extrapolation of the statewide total from the IOUs' estimates, based on expanding the IOU-reported numbers to the portion of the state served by other utilities. Table 3 also includes an extrapolation of Gulf's assumption that EVs would reach 5 percent of all vehicles by 2023. This estimate incorporates FHSMV data of vehicles registered for 2011-2012, plus the 2.2 percent yearly census growth figure it uses for its own projections. Finally, Table 3 also includes the FHSMV projections of total vehicles in Florida for the forecast period.

Table 3. Comparison of EV Estimates

	EPRI Estimate (Low)	EPRI Estimate (Medium)	EPRI Estimate (High)	FPL Forecast	Gulf Estimate Method Extrapolation	Extrapolation from IOU Total	FHSMV Total Vehicles Statewide
2012	1,048	1,710	5,585	6,048	*5,531	6,222	18,735,044
2013	3,225	7,585	16,097	11,704	90,499	12,650	19,147,215
2014	7,165	16,986	33,341	20,042	179,203	21,324	19,568,454
2015	13,486	29,109	58,814	31,748	271,767	33,116	19,998,960
2016	22,902	45,145	94,531	47,622	368,316	48,924	20,438,937
2017	36,142	68,475	142,953	73,020	468,982	72,661	20,888,593
2018	53,928	99,814	207,105	98,578	573,899	98,386	21,348,142
2019	76,564	140,020	289,110	131,108	683,206	129,571	21,817,802
2020	104,210	190,133	391,042	196,664	797,044	184,709	22,297,793
2021	136,959	251,326	514,990	294,994	915,560	263,310	22,788,345

Source: Utility data responses, FPSC statistics, and FHSMV

*5,531 figure based on Table 2's total for 2012

As Table 3 shows, there are wide estimates for the rate of EV adoption in Florida. Additionally, there is no central source that reliably tracks EV sales in Florida. While official car registration data from FHSMV may help provide a baseline, it does not, at present, distinguish between HEVs and EVs. The U.S. Department of Energy (DOE) and other national organizations continue to provide forecasts but these must be viewed in light of market adoption uncertainties. Additionally, Florida utilities have no means of knowing when a customer purchases an EV aside from voluntary disclosure. In order to accurately track the registration and sales of the different types of EVs in Florida, either owners, dealers, or manufacturers will need to disclose additional data to FHSMV.

Projections of EV sales vary because of the uncertainty of many of the factors that will affect the market and contribute to the growth of EVs. These factors include the cost of ownership of an EV compared to the cost of a similar vehicle using petroleum-based fuel. For example, if the federal rebate program that gives EV buyers up to $7,500 for buying an EV is discontinued in the future, this would depress EV sales with all other factors being equal. High petroleum prices could help motivate EV sales, as could a reduction in the price of batteries. Any potential buyer who needs to make longer trips in an EV may be reluctant to purchase an EV until more infrastructure is in place to allow longer drives, however.

Electric Vehicle Chargers in Florida

EV chargers are the devices that transmit energy from the grid into the EV batteries. The National Electrical Code categorizes EV chargers broadly into three types. Level 1 chargers are rated at the lowest voltage and are primarily located at homes. Level 2 chargers have higher voltage, and they can serve as home chargers or public chargers. Level 2 chargers can be differentiated between Level 2 and Level 2+, as some of the larger chargers in the Level 2+ category draw more electricity and thus have shorter charge times than the more typical Level 2 chargers. Level 3 chargers are intended for stations that perform akin to a typical gasoline station, charging in very short periods of time. Table 4 provides the electric load requirements for each level of charger, along with a typical charge time. Charge times depend on both the capacity of the charger and of the EV battery, which will vary depending on the model of car, as shown in Table 1. Given charge times assume a 11 kilowatt-hour (kWh) typical daily charge.

Table 4. Charger Level Classifications

Charger Level	Load	Charge Time	Voltage in Alternating Current (VAC)
Level 1 (Home)	1.1-1.8 kW	6-10 hours	120
Level 2 (Home and Work)	3.3 kW	3-4 hours	208/240
Level 2+ (Home and Work)	6.6-19.2 kW	30 mins – 2 hours	
Level 3 (Recharging Station)	50-150 kW	15-30 minutes	480

Source: National Electrical Code Article 625

Level 1 chargers use 120 Voltage in Alternating Current (VAC), and thus can plug in to a standard wall socket. Level 1 chargers are the easiest to install. Level 2 and 2+ chargers require 208 VAC or 240 VAC, which many large appliances also require. Thus, Level 2 charging is available in most homes, but it will require the installation of the larger 208/240 VAC plug. Level 3 chargers draw much more current than Level 1 or 2 chargers. Because this much current is not generally available in residential areas, any installation of Level 3 chargers may be limited.

The FPSC asked Florida's electric utilities in its May 2012 data request to report the number of chargers presently installed in their service areas. Table 5 provides the numbers reported by Florida's large utilities. Table 5 does not differentiate between Level 2 and Level 2+ chargers.

Table 5. Number of Charging Stations by Utility Territory

Utility	Level 1	Level 2
FPL	490	408
PEF	76	198
TECO	90	80
GULF	8	0
OUC	1	108
JEA	0	0
Total	**665**	**794**

Source: Utility data responses

These numbers represent the best estimates available for this report. Utilities may have difficulties obtaining accurate estimates for numbers of privately-owned chargers in their service area. As a result, all of the caveats discussed regarding utility estimates of the number of EVs in their territory apply equally to estimates of the number of chargers. Additionally, many of the public charging stations were funded by grants from the American Recovery and Reinvestment Act (ARRA), and many are lightly utilized at present. Because this ARRA funding has come to an end, public charger growth may slow until demand from EV owners results in new investment.

To date, the utilities report that no Level 3 charging stations have been installed in Florida. As a result, any forecasts of both the numbers of Level 3 chargers and the effects on the electric grid are speculative. It is not clear whether enough EV owners will have a need for Level 3 quick-charging to incent a prospective investor to build infrastructure to support Level 3 charging stations in Florida. A few Level 3 stations are being installed elsewhere in the U.S., including several set for installation in Chicago. Information on these stations' utilization may provide a better glimpse into the demand for such stations when data is available. Currently, Florida utilities have no experience with Level 3 chargers.

Section 4. Effects on Energy Consumption

Section 366.94(4), F.S., directs the FPSC to study the effects of EV charging on energy consumption in the state of Florida. The net effect of EVs is expected to be an increase in the total consumption of electricity and a decrease in the total consumption of petroleum-based fuels. In addition, EVs may also increase the consumption of electricity at times of high demand.

This section of the report examines these changes in energy consumption patterns. Any impact on energy consumption will be a direct result of the actual number of EVs driven in Florida. As a result, the conclusions drawn in this report should be considered preliminary, and are dependant on actual EVs purchased.

Effect of Electric Vehicles on Electricity Consumption

The immediate effects of EV charging are expected to be an increase in total electrical energy consumption combined with a decrease in the consumption of petroleum-based fuels, primarily gasoline and diesel fuel. While the effect on both forms of energy consumption will be limited at first, they will grow proportionately as EV deployment increases. Table 6, below, shows the estimated additional electricity consumption attributable to EVs.

Table 6. EV Effect on Electricity Consumption

Year	Total EVs in Florida	Additional Electricity Consumption from EVs (GWh)	Total Electricity Consumption in Florida (GWh)	Percent Increase due to EVs
2012	5,531	22.1	238,645	0.009
2013	11,090	44.4	241,632	0.018
2014	19,069	76.3	245,318	0.031
2015	29,517	118.1	250,598	0.047
2016	43,889	175.6	254,549	0.069
2017	64,707	258.8	258,198	0.100
2018	87,360	349.4	261,484	0.134
2019	115,141	460.6	265,337	0.174
2020	161,302	645.2	270,297	0.239
2021	226,579	906.3	275,519	0.329

Source: Utility data responses and 2012 FRCC Load and Resource Plan

The increase in electrical energy consumption from EVs is minimal to date and is likely to be minimal for the next few years. Average electricity consumption per year is estimated to be approximately 4,000 kWh per EV, or approximately 11 kWh per day. In its data response, FPL reported an estimate of 12.3 kWh per day per EV, based on driving data for the Leaf and Volt. This figure equals approximately 4,490 kWh per year. For the sake of comparison, a typical Florida residence consumed 13,567 kWh per year in 2011. In its data response for total electric consumption from EVs, FPL used a higher value, which generally grew over time but averaged over 7,000 kWh per vehicle per year. FPL does not explain this discrepancy in its data response. Gulf estimated 10 kWh per vehicle per day, which is equivalent to 3,650 kWh per year. Gulf, however, included the Prius EV in its estimate in addition to the Volt and Leaf. Table 1 shows that the Prius EV has the lowest capacity battery of any EV listed.

In their workshop presentations, both FPL and Gulf included results from EV studies. Both utilities reported values of approximately 5.5 kWh per charging session. Assuming one charging session per day, these values result in a yearly average of approximately 2,000 kWh per vehicle per year. These values both come with caveats. FPL reports a median charging session of approximately 1.5 hours and 5.4 kWh per charge. For calculating total energy consumption, however, the average charging session would be a more accurate value than the median. Gulf's study was based on a single 2009 Prius converted into a PHEV, not a production model EV. As a result, it is unclear whether these figures can be extrapolated to estimate yearly kWh consumption. Neither FPL nor Gulf based their yearly estimates on a figure in line with a 5.5 kWh per day charging average.

Additionally, the DOE estimates 0.34 kWh per mile for the Leaf. If this value is applied to driving 12,000 miles per year, it equals 4,080 kWh per year. DOE also estimates 0.36 kWh per mile for the Volt. Since the Volt is a PHEV, DOE assumes 70 percent of its mileage is driven using electricity, resulting in approximately 3,024 kWh total electricity consumption for 12,000 miles per year driving. DOE does not provide estimates for any other EVs.

Collectively, these various sources provide an average of approximately 4,000 kWh per vehicle per year, which is close to several of the estimates. This estimate assumes an average charge of approximately 11 kWh per vehicle per day, or approximately 30 miles driven on electricity per day for a Volt or Leaf based on DOE values. The values in Table 6 are based upon that figure.

The increase in total electricity consumption will not necessarily result in higher costs for any ratepayers except EV owners. If EV charging is primarily done off-peak, it could lead to better use of existing generation assets. Thus, while EV owners would incur higher electric bills due to their own higher energy use, EV charging may result in no other charges to other ratepayers and could even contribute to improved system utilization. If EVs are charged at peak, it could cause a need for new generation. This potential impact is discussed below.

Effect of Electric Vehicles on Motor Fuel Consumption

The increase in consumption of electricity is also expected to result in a decrease in the consumption of petroleum-based fuels in Florida. One of the primary arguments by EV advocates for investment in electric vehicles has consistently been to reduce American dependence on oil imports. It is estimated that a plug-in hybrid electric vehicle, such as the Chevy Volt, driven 12,000 miles per year, saves approximately 356 gallons of petroleum-based fuel per year. A fully electric vehicle would save 480 gallons of petroleum-based fuel per year. Both of these values assume they are replacing a vehicle getting 25 miles per gallon of petroleum-based fuel and driven 12,000 miles per year. Table 7, below, uses these assumptions to determine how many gallons of gasoline will be saved statewide based on the projected EV adoption rates. The gasoline savings assume a fifty/fifty mix of PHEVs and all-electric vehicles.

Table 7. EV Effect on Florida Motor Fuel Consumption

Year	Total EVs	Gasoline Saved (gallons)	Percentage of 2011 Motor Fuel Consumption Saved
2012	5,531	1,969,036	0.024
2013	11,090	4,024,438	0.050
2014	19,069	7,051,292	0.087
2015	29,517	11,118,070	0.137
2016	43,889	16,833,870	0.207
2017	64,707	25,264,489	0.311
2018	87,360	34,711,040	0.428
2019	115,141	46,542,551	0.574
2020	161,302	66,313,044	0.817
2021	226,579	94,710,022	1.167

Source: Utility data responses and FPSC Staff calculations

Table 7 shows 2.0 million gallons of petroleum-based fuel saved in Florida due to EV use in 2012. The Florida Department of Agriculture and Consumer Services reports that 8,114 million gallons of motor fuel were consumed in Florida in 2011, down slightly from 2010.[2] As a result, estimated 2012 EV motor fuel savings are about 0.024 percent in 2012. In 2021, Floridians in the areas served by the large utilities are expected to avoid using nearly 90 million gallons of petroleum-based fuel, or approximately 1.167 percent of 2011 usage of motor fuel. Additionally, any reduction in demand for petroleum-based fuels should help place downward pressure on its prices for everyone, which could provide further benefit for the economy.

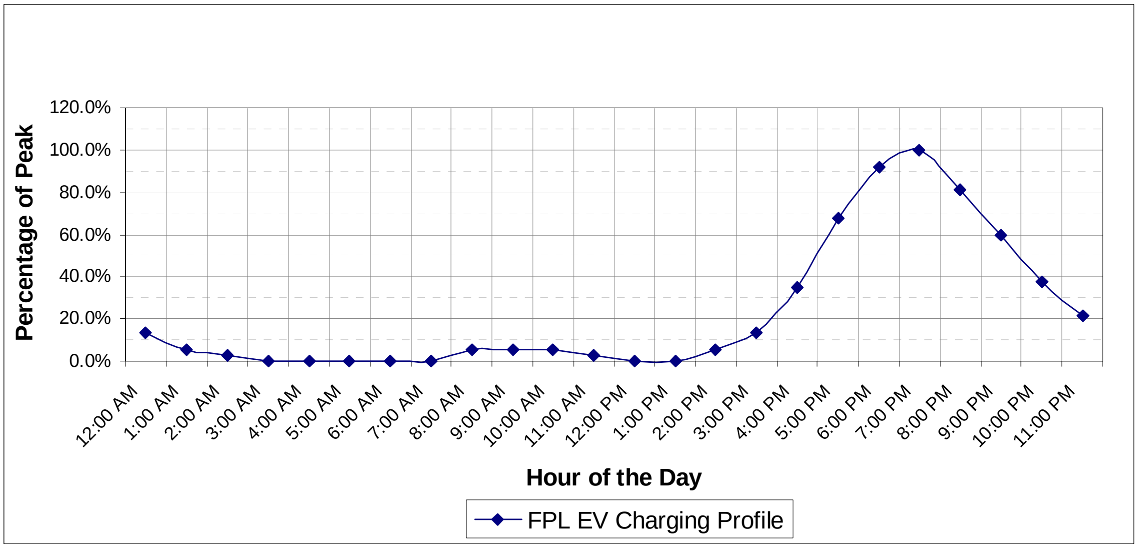
DOE data provides a value for EV electricity consumption of approximately .35 kWh per mile. A gasoline-fueled car that gets 25 miles per gallon uses 0.04 gallons per mile. At an electricity cost of 10 cents per kWh, and a gasoline cost of $3.50 per gallon, the EV will cost 3.5 cents per mile to drive, while a gasoline-fueled car will cost 14 cents per mile. An EV owner driving 12,000 miles per year, saving 10.5 cents per mile, saves approximately $1,260 per year in fuel costs.

Effect of Electric Vehicles at Times of Peak System Demand

Utility data responses suggest that most EV owners are likely to begin charging their vehicles when they return home from work. As a result, vehicle charging is likely to have the greatest effect on generation demand during the evening period. Figure 1, below, shows actual EV charging data provided by FPL. It shows a typical EV charge profile for a customer taking service under non-time-of-use rates.

[2] The Balmoral Group, "2011 Florida Motor Gasoline and Diesel Fuel Report," prepared for the Florida Department of Agriculture and Consumer Services, August 2012.

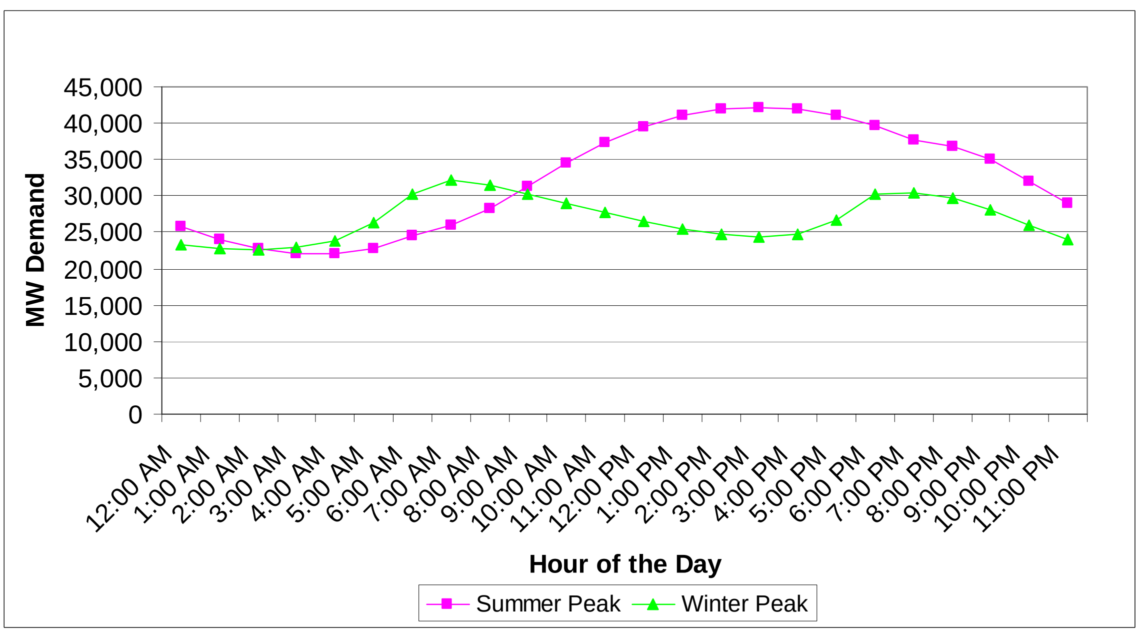
Figure 1. FPL EV Charge Profile



Source: FPL data response

EV owners are typically charging their vehicles on weekdays after work, which results in an increase in demand starting at approximately 5:00 p.m. and peaking around 7:30 p.m. before declining. As a result, the period of EV peak demand shown in Figure 1 may correspond closely with the system's summer peak. Figure 2, below, shows when summer and winter peaks occurred in 2011 for Florida utilities.

Figure 2. Summer and Winter Peak Values



Source: Utility Ten-Year Site Plan data

As Figure 2 shows, summer peak demand runs generally from 2:00 PM to 7:00 PM, while, as displayed in Figure 1, EV charging typically begins around 4:00 PM and ends around midnight. Because many EV owners are likely to plug their vehicles in as they get home from work, EVs will likely add to this peak demand period. While Figure 1's charge profile does not overlap with the entirety of the summer peak period, it does show some overlap with the last two hours, from approximately 6:00-8:00 PM. If EVs emerge in substantial quantities, this later period is where utilities will experience the greatest impact on generation demand.

This overlap between summer peak and EV charging periods may limit the beneficial aspects of EVs for the grid at peak. During the initial rollout for EVs, some believed that EV batteries could be used to store electricity that could then be sold back to the grid at peak, thus using EV batteries to lower need for generation at peak. Because EVs are likely to need their batteries for the drive home from work around that period, it seems unlikely at present that EVs can be used to reduce summer peak. Even during winter peak, coming roughly 7:00 AM to 9:00 AM, EV batteries will frequently be either in use, about to be in use, or drained due to the morning commute.

As previously discussed, electric demand from EVs is expected to be insignificant at both peak and non-peak periods. Florida's large utilities estimate that the impact of EVs is approximately 4 MW at peak demand in 2012. Summer peak demand for these utilities is estimated at approximately 39,000 MW in 2012, thus the impact from EVs is approximately 0.01 percent. The IOUs expect that effect to grow exponentially over the next decade, reaching 185 MW by 2021. Table 8, below, shows the projected total impact on peak demand to Florida's large utilities from EVs through 2021.

Table 8. EV Contribution to Summer Peak in MW

Year	FPL	PEF	TECO	GULF	OUC	JEA	Total
2012	2.9	0.1	0.4	0.1	0.2	0	**4**
2013	6.0	0.3	0.6	0.3	0.3	0	**8**
2014	11.1	0.8	0.9	0.5	0.5	0	**14**
2015	19.2	1.3	1.1	0.8	0.4	0	**23**
2016	29.8	2.1	1.5	1.1	0.5	1	**36**
2017	44.3	3.1	1.9	1.4	0.6	1	**52**
2018	60.6	4.6	2.4	1.8	0.7	1	**71**
2019	80.8	6.4	2.9	2.2	0.8	1	**94**
2020	114.8	8.6	3.4	2.7	0.9	2	**132**
2021	162.6	11.4	3.9	3.2	1.0	3	**185**

Source: Utility data responses

Need for New Generation Due to Electric Vehicle Deployment

As Table 8 shows, the projected impact on peak demand from EVs ranges from 4 MW in 2012 to 185 MW in 2021. Even the 185 MW statewide figure does not represent a concern or impact the need for new generation. Due in part to the softer economy in recent years, reduced customer growth, and a trend of electricity use per customer declining, Florida presently has ample generation capacity. Table 9, below, shows the projected reserve margins for each of Florida's large utilities through 2021. Reserve margin is defined as the amount of total generation capacity available that exceeds the expected peak demand of the system.

Table 9. Summer Reserve Margin in MW

Year	FPL	PEF	TECO	Gulf	OUC	JEA	Total
2012	6,238	3,081	1,019	367	416	739	**11,860**
2013	6,329	3,186	949	340	388	734	**11,926**
2014	6,454	3,009	910	693	362	698	**12,126**
2015	6,113	2,972	874	662	333	660	**11,614**
2016	5,739	2,231	810	635	295	630	**10,340**
2017	5,281	1,999	952	600	264	691	**9,787**
2018	5,268	1,839	912	564	305	747	**9,635**
2019	5,032	2,195	898	515	273	1,078	**9,991**
2020	4,683	2,037	856	466	241	1,028	**9,311**
2021	4,572	3,068	817	424	208	973	**10,062**

Source: Utility Ten-Year Site Plan data

Table 9 indicates that the large utilities expect to have sufficient capacity to reliably serve the incremental demand created by the deployment of EVs. In 2021, the EV impact on peak demand is projected to represent only 1.8 percent of that year's expected reserve margin. Even in the years when the EV impact is at its highest, there appears to be little chance of an impact on reliability. In 2021, FPL projects an impact of 162.6 MW from EVs and has a reserve margin of 4,572 MW. In 2021, EV impact is at its highest and reserve margin is at its lowest, and the EV impact is only 3.6 percent of the reserve margin. In no other year does this percentage reach a higher figure, either for a given utility or in total.

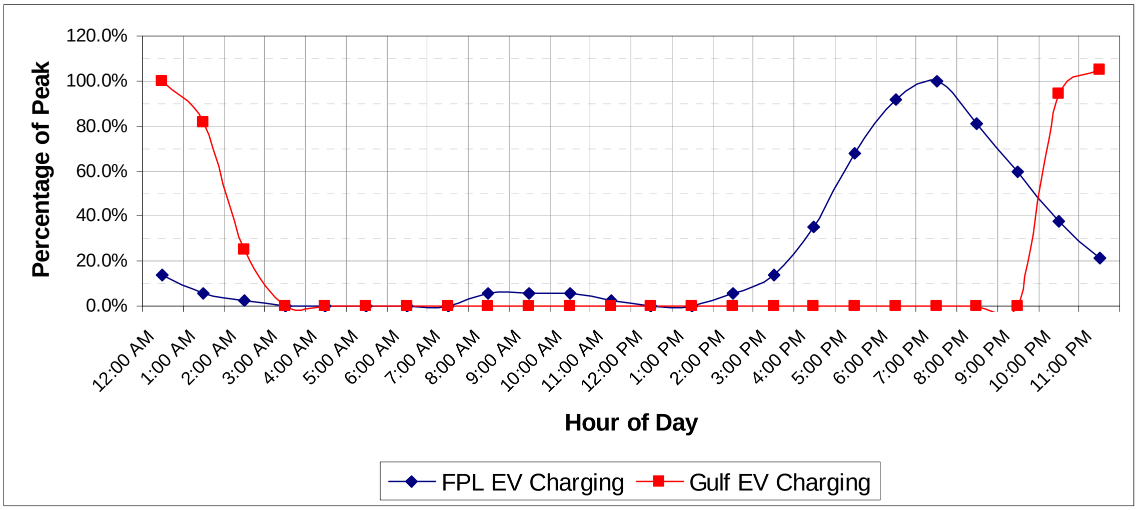
Accordingly, Florida's utilities are unlikely to add new generation during this period solely due to EVs. Distribution expenses will be addressed in the next section of the report.

Time-of-Use Rates and Electric Vehicle Charging

If significant deployment of EVs did create additional demand for new capacity, time-of-use rates could help shift EV charging times away from peak to off-peak periods. A time-of-use rate is a rate structure under which a customer pays a reduced rate for consuming electricity at off-peak times, while paying a higher rate at peak times. Time-of-use rates can be structured to reflect the costs of generating energy at different times. Implemented correctly, time-of-use rates can help manage peak demand with beneficial consequences for customers and the utility.

Figure 3 shows the potential impact of a time-of-use rate on customer EV charging behavior. The blue line is the FPL charger use profile shown earlier as Figure 1. This line can be considered a typical usage pattern under a traditional rate. The red line is the usage for a Gulf customer on a time-of-use rate.

Figure 3. FPL and Gulf Charging Times



Source: FPL and Gulf data responses

Figure 3 shows that the Gulf customer completely avoids charging during the peak period. Usage first registers at approximately 11:00 PM, which is when Gulf's time-of-use rate kicks into the lowest rate period. While this is a limited example, it does illustrate the potential of using time-of-use rates if EV charging significantly exceeds estimates.

Conclusion

EV charging will affect energy consumption in Florida by increasing electricity consumption and lowering petroleum-based fuel consumption. While EVs will add new demand to the grid in Florida, the high reserve margins of Florida's large utilities should stave off any need for new generation for some time. EV charging does coincide with the tail end of the period of peak electric demand, however, which could potentially cause some upward pressure on generation past the current ten-year planning horizon. Time-of-use rates could be a valuable tool for mitigating any potential increase in peak demand.

Section 5. Impact on the Electric Grid

In the short term, EVs are likely to have a more significant effect on the electric distribution network than they will on the generation or transmission systems. The distribution system moves power from the transmission system to end-use customers and consists of local distribution lines, transformers, and other equipment to transform high-voltage power in the transmission system into the lower voltage power carried to end-use electric customers. To use a metaphor, the transmission system is akin to the Federal highway system, while the distribution system is the system of surface roads.

The electric grid consists of three primary areas: generation, transmission, and distribution systems. The generation system consists of a mixture of power plants and generates electricity from a variety of fuel types that will be consumed by end-use customers. This electricity is generated at high amperage but a low voltage, with larger units in the range of 13,800 to 26,000 Volts (V). The generation system also consists of transformers to "step up" the electricity to the higher voltage used by the transmission system to minimize losses. The transmission system consists of transmission lines that move electricity between the generation and distribution systems. The transmission system carries electricity at voltages ranging from 69,000 V to 500,000 V. The distribution system consists of substations and transformers, which step this electricity back down to a level usable by end-use customers, usually 120 V or 240 V, though larger for some commercial and industrial customers.

As a single contributor to new demand, EVs will not affect the timing or size of new transmission facilities. If additional transmission facilities are installed, they would follow additional generation needs, which are not anticipated at this time. Thus, this section of the report will focus instead on the expected impact of EVs on the distribution network.

Two elements of EV charging could affect distribution systems. The first element is the clustering of electric vehicle chargers. Multiple EV chargers operating simultaneously on a single residential transformer can collectively draw a fairly high electric load. Therefore, some residential transformers may need to be upgraded or replaced in order to handle this higher demand. While this effect is unlikely to result from a single Level 1 or Level 2 charger, multiple EV chargers operating simultaneously on a single transformer may exceed the design limitations of certain residential transformers.

The second element is public “quick-charge” Level 3 EV charging stations. The best information currently available indicates that none of these stations are operating in Florida. However, any future installations have the potential to require upgrades to the distribution network. “Quick-charge” stations can draw a very high electric load of 50 kW or more and may need that power at times of high demand. This section will also examine other factors that can impact the electric grid, including public charging.

Impact on Residential Transformers from Clustering of Electric Vehicles

Most EVs currently on the market and available in Florida use Level 1 or Level 2 chargers. While Tesla vehicles are compatible with larger Level 2+ chargers, these EVs still have very limited availability. As a result, most EVs generally available in Florida can charge only at 3.3

kW or below, with the Teslas and the Ford Focus EV at 6.6 kW or more. Most residential EV charging can thus be expected to take place at Level 1 or Level 2, with a smaller amount of Level 2+ charging. No Level 3 residential charging is anticipated.

A single EV charging at 3.3 kW or below is unlikely to pose any real challenge to even a small residential transformer. Even a 15 kilovolt-ampere (kVA) transformer, which is the smallest commonly-deployed size, is capable of handling the extra load required by an EV charging at 3.3 kW or below. For comparison's sake, a typical microwave oven, hair dryer, or space heater can run at 1 kW, only slightly less than a Level 1 charger. A 3.3 kW charger draws an amount of electricity comparable to running three of those devices at once, or a single typical electric dryer.

Multiple EVs charging simultaneously on the same transformer, even at 3.3 kW or below, could potentially exceed the design limitations of a transformer. Table 10 contains an initial estimate made by PEF of the number of chargers of a particular size that can be supported by each class of transformer in addition to its normal load. It is important to note, however, that the data in Table 10 represents an initial estimate and should not be considered definitive. In their post-workshop comments, representatives of FPL, PEF, and TECO all cautioned that this data might overstate the need for utility upgrades to the distribution system because of EVs. Nevertheless, in the absence of other data, it can be considered a starting point from which to analyze the grid impact of EVs.

Table 10. Number of Chargers Supportable Simultaneously by Transformer Class

Transformer kVA Class	1.4 kW (Level 1) EV Charger	3.3 kW (Level 2) EV Charger	6.6 kW (Level 2+) EV Charger
15	1	1	0
25	2	1	1
50	3	2	1
75	4	2	1
100	5	2	1

Source: PEF data response

Table 10 shows that even the lowest-capacity transformers should be adequate to handle any additional load from a single Level 1 or even 3.3 kW Level 2 EV charger. However, multiple 3.3 kW or larger chargers operating simultaneously could exceed a smaller transformer's design limits, requiring it to be replaced with a larger unit. Additionally, larger Level 2+ chargers, especially the 19.2 kW chargers that Tesla is making available to their customers, could potentially overwhelm even larger residential transformers. While there are no reports of EVs overloading transformers to date, they could begin to in neighborhoods with clusters of EVs.

Florida's three largest IOUs provided data in their post-workshop comments on the prevalence of residential transformer sizes. These data, shown below in Table 11, illustrates the number of transformers that could potentially be overloaded by larger or multiple EV chargers.

Table 11. Number of Transformers Reported by Size

Transformer kVA Class	FPL	*PEF	TECO	Total	Percent
10	7,364	0	0	7,364	1.00
15	39,905	83	9,265	49,253	6.66
25	142,592	13,060	22,746	178,398	24.11
37.5	77,918	16,833	17,114	111,865	15.12
50	204,739	29,461	16,273	250,473	33.85
75	79,615	9,589	3,600	92,804	12.54
100	35,849	3,310	953	40,112	5.42
125	0	6	0	6	0.00
167	8,143	1,502	0	9,645	1.30
Total	596,125	73,844	69,951	739,920	100.00

Source: Utility post-workshop comments
**PEF noted that it did not include some 25 kVA overhead transformers in its reported figures.*

Table 11 shows that roughly 80 percent of transformers in Florida are in the 25 to 50 kVA class. These transformers could potentially need to be upgraded once Level 2+ or larger chargers begin to emerge in significant numbers. The smaller Level 2 chargers are unlikely to require utility action unless several of them are operating simultaneously on a single transformer.

TECO, in its post-workshop comments, indicated that a single residential transformer can serve the equivalent of anywhere from 1-12 1,500 to 2,000 square foot homes. TECO noted that a 15 kVA transformer can serve from 1-3 such homes and a 100 kVA transformer can serve 10-12 such homes. Larger homes are also likelier to be served by larger transformers and smaller homes by smaller transformers, so a typical residential transformer might serve 3-4 homes.

There is no information indicating the presence of EV clustering in Florida. Eventually, however, either due to neighbors that share a transformer both buying EVs or individual households buying multiple EVs, clustering will likely eventually affect some transformers in Florida. As Florida's utilities gain more experience with EVs, they can be expected to refine their data and better project any effects EV clustering may have on the distribution system.

Impact of Public Charging Stations on the Transmission and Distribution Network

Currently, all public charging stations in Florida are Level 1 to Level 2+ stations. Some of these chargers were built for EV fleets, while others are located at businesses to serve employees or customers. Data on the use of these chargers is not available, but anecdotal information suggests that many are used infrequently. As EVs become more common, these chargers will probably see greater usage. Because of the low power requirements of these chargers, as well as their placement on the typically larger commercial and industrial transformers, they are unlikely to drive a need for transformer upgrades.

Level 3 stations are likely to function as the EV equivalent of gasoline filling stations and may see similar times of use. Gasoline filling stations frequently see their highest weekday usage during morning and evening commutes, which coincide closely with winter and summer peak demand periods, respectively. As a result, Level 3 charging stations may place upward pressure on the generation system at times of peak demand as well. Also, similar to gasoline stations, quick-charge stations may prove essential for long-distance driving in electric-only EVs.

Because most charging in the near-term is likely to be either residential or lower voltage at-work charging, sufficient demand for quick-charge stations may not emerge in Florida for some time. The demand for quick-charge stations is expected to be driven both by EV owners who want to take longer trips in their EVs, and by EV owners who lack a garage or other reliable location to charge their vehicles both at home and at work. Once this demand emerges, utilities and other stakeholders will be able to gain better knowledge regarding their operation.

At-Work Charging

All known currently installed public EV chargers in Florida are Level 1 to Level 2+ chargers. Because EVs charging at these levels likely require multi-hour charges, they will probably see usage mainly from people parking their cars while at work. At present, most information on the usage of these chargers appears to be anecdotal, but it indicates that the majority of these chargers also see limited use.

The 4-8 hour charge times required by Level 1 and Level 2 chargers is convenient for the typical work schedule. Higher level chargers cost more and may require more extensive electrical upgrades, resulting in greater costs to their owners. As such, there is currently no reason to expect higher-level chargers to become commonplace for workplace charging. Because the distribution system equipment that serves commercial and industrial customers usually includes larger transformers capable of handling a much greater electric load, it is unlikely that the clustering of several EVs at one workplace will cause the same concerns it does for residential transformers. Additionally, many workplaces are demand metered and have meters that measure capacity, meaning that their utility can track any higher loads being drawn as a result of EVs and perform any needed upgrades to the distribution network. As EVs become more common, there is no reason to expect workplace charging at Level 1 to Level 2+ to drive the need for any upgrades to the distribution system.

Workplace charging may reduce the need for utility investment in both the distribution and generation systems. Workplace charging could shift demand away from the evening peak times currently expected to see the heaviest amounts of EV charging. Workplace charging could also effectively double the electric range of EVs. These facilities would permit partial to full recharging for the return trip home.

Workplaces concerned about any upward pressure EVs place on their overall power usage may wish to establish a method for recovering costs from employees if EVs become commonplace. Alternately, employers could view EV charging as an employee benefit. In the foreseeable future, workplace charging can be expected to be more beneficial to the electric grid in comparison to either at-home charging or public quick-charging, by shifting charging times away from peak hours and reducing pressure on residential transformers.

Conclusion

EVs are more likely to require utility investment in upgrades to the distribution system than to trigger any need for additional generation. However, any needs for distribution upgrades that do emerge are likely to be localized and isolated. The two aspects of EV charging most likely to require action by electric utilities on the distribution system are clustering of electric vehicles in residential areas and quick-charge stations elsewhere. At-work charging could ameliorate any chance of home charging exceeding the design limits of residential transformers.

Section 6. Feasibility of Solar PV for Off-Grid Charging

Section 366.94(4), F.S., also directed the FPSC to "investigate the feasibility of using off-grid solar photovoltaic power as a source of electricity for the electric vehicle charging stations." Solar photovoltaic (PV) technology transforms sunlight directly into electricity through the use of solar panels. Solar PV is a different type of technology than solar thermal power or concentrated solar power (CSP). The latter types of solar power directly convert the light from the sun into heat. This heat can be used to heat water, in the case of solar thermal power, or to generate steam to turn a turbine to generate electricity, as in CSP.

Off-grid solar PV refers to installations in which the solar system is not connected to the electric grid and are frequently located in remote locations without electrical service. Most solar PV systems in Florida are connected to the grid. Solar PV benefits homeowners and business owners by reducing the amount of energy purchased from the utility. Excess solar PV energy not consumed by the customer may be sold back to the utility by those interconnected systems. The interconnection with the utility ensures a reliable source of electricity during times when solar PV energy production cannot meet a customer's requirements.

This section of the report will first examine the amount of solar energy an off-grid station would need in order to adequately charge an EV and then will compare the solar PV energy production curve to EV demand as shown earlier in the report. Finally the report presents options for utilizing energy from solar PV for EV charging.

Generation Needed per Station

The physical dimensions of solar panels required to meet the wattage demands of EV chargers is relatively large compared to other power generation technologies. For example, a 220 watt solar panel is approximately 18 square feet, or approximately 12 watts per square foot. For the sake of comparison, a 1,210 MW natural gas combined cycle (NGCC) plant site (including all facilities) requires approximately 38 acres, or 1,655,280 square feet, for a value of 731 watts per square foot. A 1,210 MW solar plant would take up approximately 2,315 acres, or 3.6 square miles, for the panels alone. Despite the much larger footprint, the solar plant would actually produce only a fraction of the energy (MWh) of the NGCC plant due to its much smaller capacity factor.

Solar PV installed at a site with full sun exposure usually has a capacity factor in the range of 20-25 percent. Capacity factor is the percentage of energy a generator produces divided by the theoretical maximum it could produce running at full capacity all of the time. To explain the application of capacity factors further, a 100 kW facility operating at 100 percent capacity factor would produce 2400 kWh in a 24-hour period. A 100 kW facility operating at 25 percent capacity factor for 24 hours would only produce 600 kWh. A typical base load electric plant usually has a capacity factor of 80-85 percent and some nuclear plants achieve a 95-99 percent capacity factor.

Table 12 describes how many solar panels and how much minimum area would be required to generate a given EV charge value at peak output. It is important to note that these values are the minimums needed to generate the given charge value at their peak of production.

Table 12. Area Required for Solar PV EV Charging

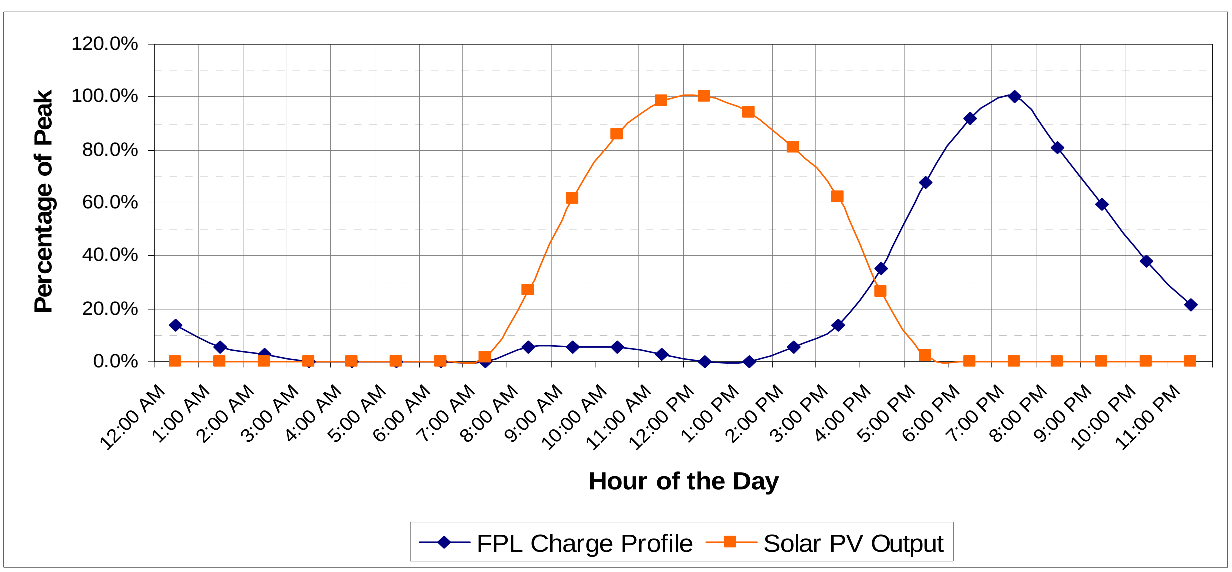
Charger Type	220 W Panels	Area (Sq. Ft.)
1.2 kW (Level 1)	4-6	89
3.3 kW (Level 2)	10-15	213
6.6 kW (Level 2+)	20-30	444
10.2 kW (Level 2+)	47	835
19.2 kW (Level 2+)	88	1563
25 kW (Level 2+)	114	2025
50 kW (Level 3)	151-228	3375

Source: Utility data responses

Relationship between Solar Production Times and Charging Demand Times

EV charging capacity powered by solar PV is maximized during full solar radiation. As Figure 4 below demonstrates, optimal output is limited chiefly to the middle hours of the day, and it does not align with the typical EV charge profile introduced earlier. In addition, high humidity, dust, and other atmospheric conditions limit the full output of solar panels.

Figure 4. Solar PV Energy Production and EV Charging



Source: FPL data response and FPL Space Coast Next Generation Solar Energy Center

While there is some concurrence between the end of the maximum solar PV energy production and the primary period for EV charging, this overlap is minimal. To overcome the limitations of "live" solar PV charging, owners of these stations will need to find a way to decouple times of energy production from charge times. Provided that these stations remain off-grid, this approach would require some kind of energy storage.

Additionally, limiting EV charging at these stations to the solar PV energy production schedule could make the stations less available. These stations would produce more power in the summer than in the winter, which could mean that power goes to waste at certain times and is insufficient at others. Also, an extended cloudy period could depress solar PV energy production for an extended period of time, again limiting the stations' ability to meet demand. A tie to the electric grid provides a back-up source of power that helps overcome these difficulties.

Potential for Energy Storage

Energy storage is any technology that allows electricity generated at one time to be used later. While there are many different energy storage technologies, batteries are likely to be the most useful for solar PV EV charging. Most utility-scale energy storage technologies - such as pumped water storage, pumped air storage, flywheels, and fuel cells - are either unsuited to Florida's geography, unsuited to this scale, or still too new to be deployed at reasonable cost.

One specific form of energy storage that has been proposed is battery swaps. Under this method, EVs have interchangeable, standardized batteries which can be removed from the vehicle and replaced with a fully charged one, while the spent battery is charged over time until it is placed in a different vehicle. The EV models in the United States do not appear to have been designed with battery swaps in mind, which limits this method's deployment. Without an industry-wide attempt at standardizing EV batteries and their installation in order to facilitate battery swaps, they are unlikely to be an option for energy storage over the near term.

An alternative strategy is central battery energy storage offered near the charging station. General Electric Corporation (GE) provided estimates of the costs of this type of storage. GE estimated current energy storage costs at approximately $600 per kWh, with about two-thirds of that for the cost of the battery and one-third for other equipment. Furthermore, these estimates indicate a cost per vehicle served by a given charging station at approximately $10,800 per vehicle, which is approximately 18 kWh of storage per vehicle at the cited costs.[3] This cost is solely for the energy storage and does not include any of the costs of the solar system itself, and scales up proportionately. The storage costs for a typical worksite charger capable of serving eight vehicles per day would be approximately $86,400. Sufficient energy storage to serve a public EV quick-charge station that serves 40 vehicles per day would cost approximately $432,000. These costs are for energy storage only and do not include the costs of solar panels or other equipment. Additionally, by keeping these systems off-grid, charger owners would be limiting the number of EVs they could charge in a given day to the size of the system.

[3] This 18 kWh figure was provided by GE and is higher than the 11 kWh assumed by the FPSC in energy consumption calculations. Off grid charging behavior is likely to differ from that of EV owners charging at home. The 18 kWh figure is probably more reflective of how these batteries will be used.

Energy storage costs are sufficiently high that it is probably more efficient to tie these stations to the electric grid. Running a service line to an area already served by electric utilities in Florida will likely only cost hundreds of dollars in most situations. Running distribution lines to all but the most remote areas of Florida is likely to cost less than installing energy storage sufficient for an EV charging station and will offer more options to the charging station owner.

Off-grid solar PV charging will only be economically viable in areas not currently served by electric service. While the most isolated islands of the state might be able to justify the costs of making an off-grid EV charging station, the cost of grid-tying a solar PV system will be lower than the cost of energy storage for nearly the entire state of Florida.

Conclusion

While solar PV may be used to charge EVs, solar energy production is limited to daytime hours with adequate solar exposure. Energy storage allows the stations to overcome that limitation, but the costs of energy storage typically exceed the costs of connecting a charging station to the electric grid. Off-grid solar PV installation may be sited in remote locations for purposes such as signage or lighting. Individuals and businesses using solar PV for EV charging will reap greater benefits by interconnecting with the grid to take advantage of utility net metering programs.

The use of off-grid solar PV for EV charging may be limited given that the hours of maximum generation from solar PV do not entirely match the peak hours of EV charging, which are expected to occur primarily during evening hours at residential locations. An increase in EV sales and expansion of EV charging stations may result in additional opportunities for solar PV as a source of electricity. Daytime charging at work locations or other non-residential locations would better align with the availability of solar energy. The cost of solar PV, while at historically low levels, remains a higher cost resource compared to traditional sources of electricity. Off-grid solar PV will face the challenge of being entirely dependent on solar exposure cycles and thus is not expected to be a feasible option, with the possible exception of remote locations without grid access.

Section 7. Conclusion

Electric vehicle charging is still a new frontier in Florida. Prior to the introduction of the most recent wave of mass-market models, EVs remained a niche product that did not exist in large enough numbers to affect the electric grid. While information on EVs at present is very limited, as the market grows, methods of estimating the numbers of EVs being charged in Florida should become easier to determine, as well as their effects on energy consumption and the electric grid.

EVs do not appear to pose any chance of contributing significantly to driving a need for new generation in Florida over the ten-year planning horizon. The electricity needed to charge EVs will contribute relatively little to Florida's total energy consumption. EVs should help reduce Florida's dependence on imported oil for gasoline and diesel fuel. While EV charging may align with the later hours of peak demand, the combination of adequate utility reserves and limited aggregate effects from EVs should limit generation effects, even at peak. If and when EVs do drive the need for new generation, rate structures such as time-of-use pricing may serve as valuable tools for shifting EV load to off-peak times.

EV charging could require utilities to address the capacity of certain elements of the distribution system. Multiple EVs charging simultaneously on the same transformer could potentially overload the design limits of some transformers. Any required utility action is only likely to emerge with smaller residential chargers. Utilities will have a better sense of how significant the likelihood is once they have gained more EV charging experience. Quick-charge stations may also require utility attention on transformers that primarily serve industrial and commercial customers. No quick-charge stations have been installed in Florida, and few have been installed nationwide, so their future impact is still uncertain.

Off-grid solar photovoltaic EV charging may be technically feasible, but economically impractical, at present. Solar PV charging stations are more economical if tied to the electric grid, because the high energy storage costs necessary for an off-grid system to function throughout the day cost significantly more than the costs to interconnect with the electric grid. Off-grid solar energy on that scale might be practical in islands and other isolated areas removed from the electric grid, but not throughout most of mainland Florida.

Appendix A. Bibliography

The FPSC relied primarily on three sources of information for this report: a literature review, a data request sent to many of Florida's electric utilities in May 2012, and a staff workshop held on September 6, 2012. Staff also consulted internet resources as well. These sources will each be discussed in depth in this appendix.

Literature Review

The purpose of the literature review was primarily to familiarize FPSC staff with the basics of EV charging. While much of the technical information found by the FPSC was useful for background information, relatively little from this initial review was directly applicable to the tasks assigned to the Commission under 366.94(4) F.S. Rather, the literature review helped formulate the staff data request and resulted in more Florida-specific information.

The list that follows contains some of the sources that best helped to inform FPSC staff in developing both its background information and in creating the information request sent to Florida's electric utilities. While this list is by no means exhaustive, it contains a number of reports and articles that might provide a good starting point for anyone wishing to learn more about EVs nationwide.

Edison Electric Institute, "The Utility Guide to Plug-in Electric Vehicle Readiness," November 2011.

Electric Power Research Institute, "Transportation Electrification: A Technology Overview," 2011.

Markel, T. "Plug-in Electric Vehicle Infrastructure: A Foundation for Electrified Transportation," National Renewable Energy Laboratory, April 8, 2010.

Serra, João Vitor Fernandes, *Electric Vehicles: Technology, Policy, and Commercial Development.* Earthscan, London 2012.

U.S. Department of Energy, "Plug-In Hybrid Electric Vehicle R&D Plan," June 2007.

U.S. Department of Energy, "One Million Electric Vehicles by 2015: February 2011 Status Report," February 2011.

Staff Data Request

Responses to the FPSC staff data request were the most significant source of information used in this report. On May 1, 2012, FPSC staff submitted a data request consisting of 27 questions, some of which were multi-part, to many of Florida's electric utilities. The recipients included: Florida's five IOUs, the five largest municipal utilities (JEA, OUC, Tallahassee, Lakeland, and

Gainesville), Florida Electric Cooperatives Association (FECA), Florida Municipal Electric Association, Florida Municipal Power Agency (FMPA), and Seminole Electric Cooperative, Inc. The FECA also distributed the request to its members.

Responses to the data request were due June 1, 2012. FPSC staff received responses from the five IOUs, the five municipal utilities listed, Seminole, FMPA, and six cooperative utilities. The most extensive responses came from the six large utilities cited throughout the report. These responses formed the backbone of the report as written. The nature of the responses helped shape the scope of the report as well. For example, the utilities were reluctant to conjecture about the effects of EV deployment significantly beyond the range of projections, largely because they considered such examination too speculative and unrealistic. As a result, the scope of the report is limited to the range of projections for the EV rollout.

Much of the data in the final report originated from these utility responses. Utility responses were used for EV projections, charger deployment, charger usage data, and other critical pieces of the report. PEF's data on transformer EV capacity served as the starting point for estimates related to residential transformer EV charger capacity. The data from the large utilities also strongly informed FPSC staff's presentation at the September workshop.

Staff Workshop

A workshop was conducted on September 6, 2012, to provide an opportunity for a discussion on issues relevant to the study. Parties presenting at the workshop included the Electric Power Research Institute (EPRI), General Motors Company (GM), General Electric Company (GE), SPX Corporation, the Florida Solar Energy Center (FSEC), four Florida IOUs, and OUC. The workshop began with presentations by each of the ten presenters, followed by a roundtable discussion, and closed with a brief public comment period.

Information on this workshop, including presentations, a transcript, audio and video coverage of the event, and post-workshop comments, can be found at the following webpage:
http://www.floridapsc.com/utilities/electricgas/electricvehicles/09_06_2012/index.aspx

Mark Duvall of EPRI gave a general overview of EV sales and electrical system impacts nationwide and in Florida. He spoke first on the growth of EV sales, noting that EVs are actually selling faster than HEVs did by the same time following their launch. He also discussed system impacts, noting that the distribution system would be affected first, and that this impact would be based on charge levels, not time of day. He also spoke regarding system costs and charger deployment, noting that the latter will follow EV sales.

Britta Gross from GM discussed her company's Chevy Volt PHEV and its capabilities and sales figures. She then discussed her company's partnerships with EPRI and the Edison Electric Institute in promoting EVs. Ms. Gross then discussed some more general information relating to EV charging, including types of chargers and GM's projections of where charging takes place. She closed her presentation by discussing some of GM's outreach activities.

Joshua Caillavet from GE discussed GE's EV chargers, how they are used, and some of their interface options. He then discussed some of his company's forecasts for EV sales, which included an estimated 11,000 EVs in Miami by 2019. Mr. Caillavet also provided information on load management, in conjunction with solar power and energy storage, to flatten out load curves and reduce the peak impact of EVs. He closed his presentation by introducing the possibility for solar carports and energy storage to assist in managing load.

Charlie Yankitis, from SPX, a company that manufactures and installs EV chargers, noted his company's installations in Florida, which include 97 homes and 425 chargers in total. He also described SPX's support of its chargers and the services it offers to potential customers. Mr. Yankitis shared some statistics regarding the types of homes on which SPX has performed installations, and regarding the nature of the installations. The presenter concluded with a description of some of the charger options offered by his company.

Robert Reedy, of FSEC, focused primarily on solar PV charging. He noted the cost savings offered by EVs, showing that EV charging costs an estimated equivalent of 97 cents a gallon of gasoline. He also noted that the price of solar PV has been dropping for some time and claimed that it offered the equivalent of $1.08/gallon of gasoline. He also noted that the price of gasoline was rising as the price of solar was falling and projected gasoline costs of $8.60/gallon in 2025. Mr. Reedy then examined the advantages and disadvantages of various kinds of solar installations including grid-tied and off-grid.

The final five speakers represented Florida's large utilities: Brian Hanrahan from FPL, Christopher Gillman from PEF, Keith Gruetzmacher from TECO, Bob McGee from Gulf, and Jennifer Szaro from OUC. Each of these speakers discussed their utility's experiences with EVs including any expectations, studies, and programs. The presentations had a certain degree of overlap but each brought a unique utility perspective. All speakers expressed confidence that generation shortfalls would not develop. Some did express concern that distribution system upgrades could potentially be required during the planning timeframe. Most of the speakers also discussed their own EV fleets and how those fleets were giving them knowledge that would help inform them going forward.

Mr. Hanrahan described an ongoing EV study FPL was conducting, though the results would not be complete in time for this report. He also noted that his company saw benefits to solar PV EV charging, but that grid-tying was a requirement for it to be effective. Mr. Gillman noted PEF's outreach activities and the opportunities offered by the merger with Duke Energy. Mr. Gruetzmacher noted TECO's residential grid impact survey that indicated that it is likely to be years before any significant utility action is required. Mr. McGee discussed Gulf's time-of-use rate option and how an EV owner using that option shifted his charging times to off-peak hours. Finally, Ms. Szaro discussed OUC's partnership with Charge Point America. Through this partnership, OUC has installed 78 utility-owned public EV charging stations in Orlando, and has identified numerous challenges that will help them adapt when EVs become more common.

Following the morning presentations, a roundtable discussion was held with all of the presenters. This discussion kept largely to the structure of the report, with the discussion divided into the same four sections as the body of the report: background data for EVs, effects on energy consumption, impact on the electric grid, and the feasibility of solar PV for off-grid charging. Staff discussed with presenters many of the same ideas that are found in the report. Specifically, discussion included the difficulty of getting reliable data, the limited effect EVs will have on generation, the potential for EV clustering to overload residential transformers, the effects of quick-charge stations, and whether making solar PV stations off-grid was worth the cost and difficulty. Speakers reached a consensus on most of these issues, which are reflected in this report. Notably, some of the utility representatives expressed some hesitation using PEF's data on residential transformer EV charging limits, but they did not have better data to substitute.

The workshop closed with a brief public comment period. Only one speaker, Helda Rodriguez, asked to speak. She discussed her business, NovaCharge, a Florida-based business that installs charging stations. She also shared some of her experiences with EV charging installations in Florida. One of her points of emphasis was that, because many of her customers lacked garages, she found that commercial charging stations were receiving a higher percentage of use than had been anticipated. She also advocated for a streamlining of the permit process to make EV charging installations easier.

At the workshop, post-workshop comments were requested to be submitted by September 27, 2012. Additional data was requested on any possible challenges to the distribution system, data from utilities on numbers of types of residential transformers deployed, and information on energy storage. Responses from FPL, PEF, and TECO were received on the due date, while GE provided information on energy storage in October. In their post-workshop comments, all three utilities expressed concern with PEF's chart regarding the number of EV chargers supportable by residential transformers. Accordingly, staff noted this concern in the report. All three utilities also provided a breakdown of the numbers of types of residential transformers they have deployed in their territory. FPL also noted their ongoing EV study, and stated that they could better answer some of the distribution questions when it was completed. PEF, who provided the original slide on transformers, noted that they provided it for discussion purposes and it did not reflect real-world data. TECO wrote that their own study indicated that any significant grid effects from EVs were years away. These comments are available on the PSC website at the link on page 34.

Internet Resources

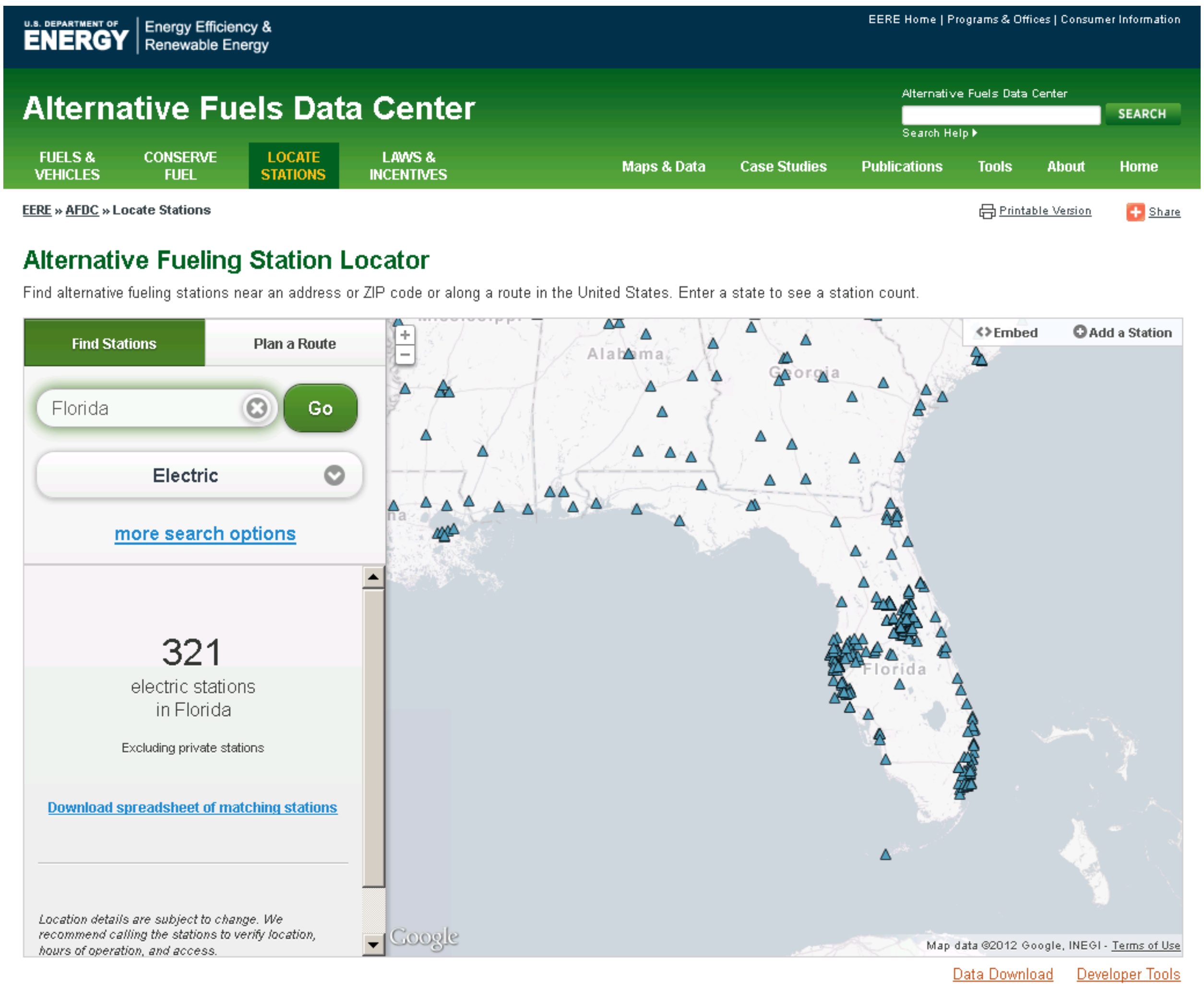
Most of the information for statistics on individual models of EVs came from the websites of their automotive manufacturers as of October 2012. In most cases, this data reflects the most recent model of the EV.

The DOE has internet resources for alternative fuel vehicles, including EVs, which FPSC staff consulted in preparation for the study. The DOE's Alternative Fuels Data Center includes numerous publications on EVs, including general guides to terminology and technology, and references for consumers considering purchase of an EV. The website also includes a summary of state incentives and policies regarding EVs.

The DOE also offers an EV charging station map that updates every two weeks. As of October 18, 2012, the locator lists 321 EV charging stations in Florida, clustered heavily in the Miami, Tampa, and Orlando areas, but existing statewide. The data does appear to be incomplete, at least regarding certain fuels. The website, which tracks all alternative fuels, is available at: http://www.afdc.energy.gov/locator/stations/

The following picture is a screenshot of the site, showing where it lists stations in Florida. More detailed information listing specific locations for individual station sites is available from the website.

Figure 5. Alternative Fuels Data Center



(Site was accessed October 18, 2012)

Appendix B. Corporate Average Fuel Economy Standards

The recently-approved Corporate Average Fuel Economy standards (CAFE standards) require vehicle manufacturers to significantly improve fuel economy. Manufacturers that do not achieve these standards are subject to substantial financial penalties. One strategy for vehicle manufacturers to meet these more stringent fuel economy standards is to increase production and sales of alternative fuel vehicles, such as EVs. As a result, rising CAFE standards will likely spur car manufacturers to promote greater EV sales in coming years as a means to comply with the new CAFE standards.

CAFE standards were introduced in the wake of the 1973 OPEC Oil Embargo when Congress enacted the Energy Policy and Conservation Act of 1975, which established the CAFE standards. The purpose of these standards is to improve the manufacturer's fleet average fuel economy of new cars and light-duty trucks (including vans and sport utility vehicles) sold in the United States. CAFE standards set the average fuel economy for each new vehicle model year, measured in miles per gallon (MPG), that each car manufacturer's fleet is required to achieve. Vehicle manufacturers that fail to meet the standard are subject to financial penalties. The current penalty is $5.50 per 0.1 MPG under the standard, multiplied by the manufacturer's total production for the domestic market. In addition, a "gas guzzler tax" is imposed on manufacturers of new cars (not minivans, sport utility vehicles, or pick-up trucks) that do not meet required fuel economy levels, to discourage the production and purchase of fuel-inefficient vehicles. The tax is collected by the Internal Revenue Service and paid by the manufacturer. The amount of the tax is displayed on the vehicle's fuel economy label (the window sticker on new cars). [4]

The first CAFE standards were set to increase passenger vehicle efficiency to 27.5 MPG within 10 years (1975-85). The National Highway Traffic Safety Administration was given the authority to set a separate standard for light trucks, which resulted in raising fuel economy for these vehicles from 11.6 to 19.5 MPG by 1985.

New CAFE Standards

On January 26, 2009, President Obama directed the Department of Transportation (DOT) to review relevant technological and scientific considerations associated with establishing a more stringent fuel economy standard. On May 19, 2009, President Obama also proposed a new national fuel economy program that adopts uniform federal standards to regulate both fuel economy and greenhouse gas emissions while preserving the legal authorities of the DOT, the Environmental Protection Agency (EPA), and the State of California.[5]

On July 29, 2011, an agreement was reached between the federal government, state regulators, the United Auto Workers, and thirteen large automakers to increase CAFE Standards to 54.5

[4] Environmental Protection Agency, "Gas Guzzler Tax Overview," September 2012.
[5] National Highway Traffic Safety Administration, "Average Fuel Economy Standards Passenger Cars and Light Trucks Model Year 2011: Final Rule," March 30, 2009.

MPG for cars and light-duty trucks by model year 2025. The agreement will result in the most significant fuel efficiency improvements in more than 30 years and the first-ever global warming pollution standards for light-duty trucks. The CAFE standards will be expressed as mathematical functions depending on each vehicle's "footprint," a measure of vehicle size determined by multiplying the vehicle's wheelbase by its average track width. For example, under the CAFE standards, the 2012 Honda Fit with a footprint of 40 square feet (sq. ft.) must achieve fuel economy of 36 MPG, while a Ford F-150 truck with its footprint of 65–75 sq. ft., must achieve CAFE fuel economy of 22 MPG. The fuel economy performance of advanced technology vehicles, such as EVs, is typically higher than a manufacturer's CAFE standard. For example, the 2017 CAFE target fuel economy for passenger cars of 39.5 MPG compares to the 2012 actual advanced vehicle performance of a Prius hybrid at 50 MPG, a plug-in Prius hybrid at 95 miles per gallon gasoline equivalent (MPGe), and a LEAF electric vehicle at 99 MPGe.[6]

Table 13 displays examples of footprint targets for popular vehicle models. The table demonstrates that different vehicle sizes will have varying fuel economy targets under the footprint-based standards.

Table 13. Model Year 2025 Fuel Economy Targets for Representative Vehicles

Vehicle Type	Example Models	Example Model Footprint (sq. ft.)	NHTSA Fuel Economy Target (MPG)
Example Passenger Cars			
Compact car	Honda Fit	40	61.1
Mid-size car	Ford Fusion	46	54.9
Full-size car	Chrysler 300	53	48.0
Example Light-duty Trucks			
Small SUV	4WD Ford Escape	43	47.5
Mid-size crossover	Nissan Murano	49	43.4
Minivan	Toyota Sienna	56	39.2
Large pickup truck	Chevy Silverado (extended cab)	67	33.0

Source: Environmental Protection Agency, "EPA and NHTSA Set Standards to Reduce Greenhouse Gases and Improve Fuel Economy for Model Years 2017-2025 Cars and Light Trucks." EPA-420-F-12-051, August 2012

Current federal regulations set a performance target for every vehicle model, which includes both the CAFE fuel economy standards discussed above and CO_2 emissions standards set by the EPA based on the vehicle's footprint. Each manufacturer's fleet average performance is then determined by the production-weighted footprint average of those targets.

[6] NHTSA Press Release: "President Obama Announces Historic 54.5 mpg Fuel Efficiency Standard," July 29, 2011.

Incentives for Alternative Fuel Vehicles

In order to encourage early adoption and introduction in the marketplace of EVs and other alternative fuel vehicles, the CAFE standard will provide manufacturers with extra credit for sales of EVs, PHEVs, and fuel-cell vehicles. These vehicles have high CAFE ratings, as they use little or no gasoline. To further encourage their sales, the government will factor each sale of an all-electric vehicle by 2.0 beginning in model year 2017. In other words, if a manufacturer sells 10,000 all-electric vehicles, either battery powered or fuel cell, these vehicles will be counted as 20,000 when calculating that company's fleet fuel economy. This incentive factor will phase down to a multiplier of 1.5 by 2021. For PHEVs, the factor will start at 1.6 in 2017 and phase down to 1.3 in 2021.[7]

The table below displays the incentive multipliers established by the new CAFE standards for all-electric, fuel cell (FCV) and PHEVs.

Table 14. All-Electric, FCV and PHEV Incentive Multipliers for Model Years 2017-2021

Model Year(s)	All-Electric and FCVs	PHEVs
2017-2019	2.0	1.6
2020	1.75	1.45
2021	1.5	1.3

Source: Federal Register/ Vol. 77 No. 199 / Monday, Oct. 15, 2012 / Book 2 of 2 page 62813

Major auto manufacturers are developing advanced technologies that can significantly reduce fuel use and greenhouse gas emissions beyond the existing model year 2012-2016 standards. The high CAFE standards of EVs, along with the incentive multipliers, are designed to encourage manufacturers to produce these alternative fuel vehicles in order to meet the more-stringent CAFE standards. In addition, a wide range of technologies are currently available for automakers to meet the new standards, including advanced gasoline engines and transmissions, vehicle weight reduction, lower tire rolling resistance, improvements in aerodynamics, diesel engines, more efficient accessories, and improvements in air conditioning systems.

In addition to incentive multipliers for EVs, the CAFE standard program also includes targeted incentives to encourage early adoption of other advanced technologies to dramatically improve vehicle performance, including the following:

- Incentives for hybrid technologies for large pickups and for other technologies that achieve high fuel economy levels on large pickups;
- Incentives for natural gas-fueled vehicles; and
- Credits for technologies with potential to achieve real-world greenhouse gas reductions and fuel economy improvements that are not captured by the standards' test procedures.

[7] Berkowitz, Justin, and Csaba Csere, "The CAFE Numbers Game: Making Sense of the New Fuel-Economy Regulations," *Car & Driver*, August 29, 2012.

Conclusion – Expected Impact of CAFE Standards on EV Sales

The recently-approved CAFE standards require vehicle manufacturers to significantly improve the fuel economy of their fleets. Manufacturers that do not achieve these standards are subject to substantial financial penalties. One strategy for manufacturers to meet these more stringent standards is to increase the production and sales of alternative fuel vehicles, including EVs. The fuel economy performance of advanced technology vehicles, such as all-electric vehicles and PHEVs, are typically higher than a manufacturer's CAFE standard. In addition, manufacturers will be further encouraged to increase production and sales of EVs due to the incentive factors included in the new CAFE program.

Appendix C. State Policies Related to Electric Vehicles

In order to collect information on state policies in the U.S. regarding EVs, the FPSC sent a survey to all 49 other state public utility commissions. The survey requested information concerning laws, rules, and procedures dealing with EVs, EV charging stations, and the potential impact on electric reliability. The distribution of the survey was facilitated by the staff of the National Association of Regulatory Utility Commissioners.

The FPSC received 17 responses to the survey. Out of the 17 responses received, only 6 states indicated that they have written rules or promulgated laws concerning the subject. These states are: Alabama, Hawaii, New York, North Carolina, South Carolina, and Virginia. The following states returned surveys indicating that they currently have no EV policies in place: Kansas, Kentucky, Maine, Missouri, Montana, Nebraska, North Dakota, Ohio, Oklahoma, South Dakota, and Vermont.

Although California and Illinois did not respond to the survey, the FPSC staff was aware that these states have significant EV activities and conducted independent research on these states. A discussion of EV-related policies in Georgia is also included due to its shared border with Florida.

In addition to the survey, the FPSC also reviewed other sources of information regarding the EV policies in other states. In particular, the FPSC made use of the DOE's Alternative Fuels Data Center website, which includes a summary of state incentives and policies regarding EVs.

Alabama

In February 2012, the Alabama Legislature established a "Green Fleets Policy" designed to increase fuel economy and reduce greenhouse emissions of the state vehicle fleet. The policy could result in an increase in EV demand in the state because it requires each state agency to take fuel economy into account when purchasing vehicles. State fleet managers must classify their vehicle inventory for compliance with the policy and submit annual plans for procuring fuel-efficient vehicles. These plans must reflect a 4 percent annual increase in average fleet fuel economy for light-duty vehicles, a 3 percent annual increase in average fleet fuel economy for medium-duty vehicles, and a 2 percent annual increase in average fleet fuel economy for heavy-duty vehicles per fiscal year.

The Alabama Public Service Commission has approved a time-of-use rate for Alabama Power for charging EVs owned by businesses. Alabama Power offers the Business Electric Vehicle Time-of-Use rate for electricity purchased to charge EVs used for non-residential purposes. The electricity used for vehicle charging is metered separately from all other electricity use. By providing lower rates for off-peak hours, the time-of-use rate encourages business customers to avoid charging during peak demand periods.

Alabama, Georgia, and South Carolina are participating in an initiative to develop a tri-state plan to enable EVs. The initiative is funded by the U.S. Department of Energy and is being coordinated by the South Carolina Institute for Energy Studies.

California

California has multiple EV-related policies and programs that are designed to encourage adoption of EVs, including state laws, state incentives, and electric utility programs. For example, in 2011, the California Legislature amended Section 216 of the Public Utilities Code to remove a regulatory barrier to EV charging stations. The amendment provides that a corporation or individual that owns, controls, operates, or manages a facility that supplies electricity to the public exclusively to charge light-duty battery electric and plug-in hybrid electric vehicles is not defined as a public utility.

The California Air Resources Board administers the State's Zero Emission Vehicle (ZEV) program. This program is designed to assist California in meeting its greenhouse gas and ozone reduction goals by encouraging the adoption of low emission vehicles, including EVs. The program defines ZEVs as new passenger cars, light-duty trucks, and medium-duty passenger vehicles that produce zero exhaust emissions of any criteria pollutant (or precursor pollutant) under any and all possible operational modes and conditions. Manufacturers with annual sales greater than 60,000 vehicles must produce and deliver for sale in California a minimum percentage of ZEVs for each model year as follows:

- 11 percent during 2010-2011
- 12 percent during 2012-2014
- 14 percent during 2015-2017
- 16 percent during 2018 and beyond

Manufacturers with annual sales between 4,501 and 60,000 vehicles have multiple alternative compliance options to meet the ZEV requirements, including obtaining ZEV credits. Manufacturers with annual sales of 4,500 vehicles or less are not subject to the ZEV regulation. As of December 2011, all manufacturers subject to the ZEV regulations appear to be meeting the required goals.[8]

Beginning in 2012, manufacturers subject to the policy that do not meet the minimum percentage goals or obtain sufficient credits are penalized $5,000 per unit underage.[9] The production and sales requirements for manufacturers, coupled with these steep penalties, may encourage manufacturers to offer ZEVs at discounted prices in California. Increased production could also provide economies of scale, resulting in further downward pressure on vehicle prices. This could have implications for ZEV adoption in other states, as residents from other states may purchase lower-priced ZEVs in California.

[8] *Staff Report: Initial Statement of Reasons, Advanced Clean Cars, 2012 Proposed Amendments to the California Zero Emission Vehicle Program Regulations*; California Environmental Protection Agency Air Resources Board; December 7, 2011.

[9] California Air Resources Board, AB 32 and the Cap-and-Trade program, "Air Quality Legislation," October 2012, page 103.

In March 2012, Governor Edmund Brown, Jr. issued an Executive Order requiring all state agencies to support and facilitate the rapid commercialization of ZEVs in California. The Executive Order also required the California Air Resources Board, the California Energy Commission, the Public Utilities Commission and other relevant agencies and collaboratives to establish benchmarks to achieve the specified goals outlined in the order. These benchmarks include the following:

- By 2015, all major metropolitan areas in California must be able to accommodate ZEVs and have infrastructure plans and streamlined permitting in place;

- By 2020, the state must have established adequate infrastructure to support one million ZEVs;

- By 2025, there must be 1.5 million ZEVs on the road in California and clean, efficient vehicles must displace 1.5 billion gallons of petroleum fuels annually; and

- By 2050, greenhouse gas emissions from the transportation sector must be 80 percent less than 1990 levels.

Governor Brown also directed state agencies to increase the number of ZEVs in the fleet through gradual vehicle replacement. By 2015, ZEVs should make up at least 10 percent of fleet light-duty vehicle purchases and by 2020, at least 25 percent of fleet light-duty vehicle purchases should be ZEVs.[10]

California SB 209, enacted in 2011, addresses EV charging stations at common interest developments. The bill prohibits Home Owners Associations from unreasonably restricting the installation of charging stations. Specifically, the bill provides that any covenant, restriction, or condition contained in any deed or contract affecting the transfer or sale of any interest in a common interest development that effectively prohibits or restricts the installation or use of an EV charging station is void and unenforceable.

California also directed a national effort to coordinate the design of EV charging and supply equipment by industry with safety as the primary concern. This effort has resulted in new EV supply equipment intended to meet safety, durability, and convenience concerns. Additionally, this effort has helped to revise equipment standards with the Society of Automotive Engineers (SAE) and Underwriters Laboratories, and safety standards with the National Fire Protection Association, the National Electrical Code (NEC), and California Building Codes.

The NEC and California Building Codes require four main safety devices and constructional features to address shock hazards and battery off-gassing concerns. The codes require approved or listed equipment be used for charging electric vehicles. New plug-in EVs must be equipped with a conductive charger inlet port that meets the specifications contained in SAE Standard J1772. EVs must be equipped with an on-board charger with a minimum output of 3.3 kilovolt amps. These requirements do not apply to EVs that are only capable of Level 1 charging, which

[10] California Executive Order No. B-16-2012; Governor Edmund G. Brown, Jr.; Issued March 23, 2012.

has a maximum power of 12 amperes, a branch circuit rating of 15 amperes, and continuous power of 1.44 kW.

Other California EV-related policies include the following:

- Electric vehicle purchasers in California are eligible for a $2,500 rebate from the Clean Vehicle Rebate Project during Fiscal Year 2011-2012 or until funds are exhausted,

- Electric car owners can use California's High Occupancy Vehicle (HOV) lanes without meeting the occupancy restriction, and

- The California Department of Motor Vehicles may disclose to an electrical corporation or local publicly-owned utility an EV owner's address and vehicle type if the information is used exclusively to identify where the vehicle is registered.

Georgia

Georgia offers a state income tax credit to individuals who purchase or lease a new ZEV. The tax credit is 20 percent of the vehicle cost, up to $5,000. For the purpose of this credit, a ZEV is defined as a motor vehicle that has zero tailpipe and evaporative emissions, including a pure electric vehicle. Any portion of the credit not used in the year the ZEV is purchased or leased may be carried over for up to five years. Eligible businesses may also receive an income tax credit for the purchase or lease of qualified electric vehicle supply equipment provided that the equipment is located in the state and accessible to the public. The amount of the credit is 10 percent of the cost of the EVSE, up to $2,500.

EVs are eligible to use HOV lanes under Georgia's Alternative Fuel Vehicle HOV Lane Exemption. Alternative fuel vehicles displaying the proper alternative fuel license plate may use HOV lanes, regardless of the number of passengers.

Georgia is also participating with Alabama, and South Carolina in the tri-state initiative discussed earlier.

Hawaii

Hawaii began enacting supportive EV-related public policies in the late 1990s. According to the survey response, the following policies adopted by the Hawaii State Legislature were the first of their kind in the U.S. and have significantly contributed to the decision of EV manufacturers to target Hawaii as an early market for the introduction of EVs:

- Free EV parking at government facilities, including meters for vehicles with specialized EV plates,

- Limited exemptions from HOV lanes,

- Public accommodations with at least 100 parking spaces available for use by the general public shall have at least 1 parking space exclusively for EVs and be equipped with an EV charging system, and

- EV charger requirements in multi-family residential dwellings.

Illinois

The Illinois Commerce Commission (ICC) Initiative on Plug-In Electric Vehicles (EV Initiative) was formed in September 2010, to ensure that the ICC is proactive in assessing the potential impacts of EVs on the state's electric system. The EV Initiative was also designed to guide the ICC in future regulatory considerations necessary to accommodate EVs.

As a part of the Initiative, the ICC held five EV policy-related stakeholder workshops focused on:

- The ICC's Integrated Distribution Company rules,
- Customer education and outreach plans for EV purchasers,
- Potential reliability impacts of EV usage,
- Rate options for EV users, and
- The legal status of public charging stations.

The ICC also asked workshop participants to address several other specific areas that the ICC noted required further exploration, including reliability impacts and the potential need for revisions to the rules governing the utility marketing of EV-related programs. The Illinois EV Study Initiative has largely reaffirmed that many existing policies in Illinois are well suited for the introduction of EVs and that the regulatory issues that need to be addressed are either narrowly focused or longer-term in nature. The initial assessments, comments, transcripts, and other documents of the EV Initiative can be located at:
www.icc.illinois.gov/Electricity/PEV.aspx.

New York

EPRI conducted a comprehensive study to assess the energy, environmental, and distribution impacts of EVs in New York State. The study was a part of an initiative with the New York State Energy and Research Development Authority and Consolidated Edison. The final report, issued in June 2011, presents potential roles for electric utilities to consider when developing plans to accommodate the commercialization of EVs. The roles for electric utilities addressed in the report were designed with the objective of enabling utilities to: (1) demonstrate regional leadership in planning for transportation electrification, (2) support customer adoption of plug-in vehicles and supporting charging infrastructure, and (3) understand and minimize the system impacts from vehicle charging.

Key issues addressed in the study include the following:

- Identification of the ‘base case’ and realistic EV penetration scenarios of transmission/distribution capacity assuming no EV penetration,

- EV distribution impacts on the largest secondary network in Manhattan and another radial circuit in New York,

- Understanding the economic and emission impacts of EVs in New York State,

- Understanding the power quality impact of on-board charger systems to the grid, and

- Implications of EVs as a distributed resource for vehicle to grid applications or utility aggregated load control.

North Carolina

During the 2011 Legislative session, the North Carolina Legislature enacted House Bill 222 to encourage EV adoption. The bill authorized EVs to operate in HOV lanes and exempted EVs from state emissions inspections.

Several studies are also being conducted on EVs and the expected impact on North Carolina’s grid. On March 22, 2011, the North Carolina Utilities Commission issued an order approving Duke Energy Carolina, LLC’s (Duke) request to conduct a study on the impact of charging EVs on the North Carolina electric grid. The purpose of the study is to collect information regarding EV charging behavior. Duke intends to use this information to assist the utility in preparing for the increase in EVs such that the costs associated with meeting increased customer demand and installing potential system upgrades is lessened. As a part of the study, Duke will pay up to $1,000 toward the installation costs of Level 2 charging stations for 150 of its residential customers.

Progress Energy Carolinas is participating in EV-related research with EPRI and the National Resources Defense Council. The study will examine the environmental, greenhouse gas emissions, and air quality impacts associated with EVs.

Advanced Energy is also collecting EV-related data from customers that received a rebate for Nissan Leafs. Advanced Energy offered a $7,500 rebate to 40 Nissan LEAF owners if the vehicles were purchased or leased by December 30, 2011, in the Greater Triangle, North Carolina area. Recipients of the rebates were required to allow Advanced Energy to monitor their vehicle usage and charging activity over a two-year period.

South Carolina

The South Carolina Energy Office has provided funding for a study to develop a statewide plan for EVs and EVSE rollout. The study is being conducted by the South Carolina Institute for Energy Studies (SCIES) at Clemson University, the Palmetto State Clean Fuels Coalition, and

Plug-In Carolina. Greenville County, South Carolina will serve as the pilot region to validate the planning process. In another project funded by the U.S. Department of Energy, SCIES is working with the same partners and representatives from Georgia and Alabama to develop a tri-state plan to enable EVs. See: http://www.clemson.edu/scies/Projects.htm

Virginia

In March 2011, the Virginia Legislature amended Sections 56-1 and 56-1.2, Code of Virginia, to address EVs and EV charging. The amendments remove a regulatory barrier to EV charging stations by excluding from the definition of a public utility any non-utility person that owns EV charging equipment or sells electricity at retail strictly for transportation purposes. This exclusion requires that the electricity used for EV charging must be procured from the public utility that is authorized by the Virginia State Corporation Commission (VSCC) to engage in the retail sale of electricity within the exclusive service area in which the service is provided. Providing electric vehicle charging service is also declared to be a permitted electric utility activity of certificated electric utilities in the State.

The amendments bar the VSCC from setting the rates, charges, and fees for the provision of retail EV charging service provided by non-utilities. In addition, public utilities are directed to evaluate options to develop and offer off-peak charging rates or other incentives to encourage owners of an electric vehicle to charge or recharge its battery during nonpeak times. Finally, the amendments authorize the VSCC to approve pilot programs conducted by public electric utilities. The pilot programs may offer special rates, contracts, or incentives to determine the feasibility of allowing time-of-use rates that encourage EV owners to charge vehicles during nonpeak periods. An electric utility that participates in a pilot program will be entitled to recover its program costs from ratepayers.

In 2011, the VSCC approved a pilot program offered by Dominion Virginia Power. The program is designed to collect information on EV charging and the impact of time-of-use rates. As a part of the pilot program, the VSCC approved two voluntary time-of-use rates for residential customers, including: (1) a time-of-use rate applied strictly to the energy used for EV charging, and (2) a "whole house" time-of-use rate that also allows customers to isolate the energy used for EV charging. Both rate options are designed to encourage residential customers that own EVs to shift EV charging to off peak hours.

Conclusion

The FPSC reviewed EV-related policies in each state that responded to the FPSC's survey and several additional states of interest totaling 20 states. California is clearly taking the lead in developing policies to encourage EV development, both in the number and breadth of state initiatives. California's programs, particularly its ZEV initiative, could have implications for EV adoption beyond the state's borders. New York, Illinois, South Carolina, and North Carolina have initiated significant studies designed to determine the expected impact of EVs and to develop plans to accommodate the growth of these vehicles. Additional studies are being performed by individual or coalitions of electric utilities. These studies often utilize customer data obtained from Public Utility Commission-approved pilot programs that establish time-of-use rates for EV charging or rebates for EV purchases.

Both California and Virginia have removed a regulatory barrier to EV adoption by exempting from state utility resale laws any non-utilities that own EV chargers or resell electricity strictly for transportation purposes. Several states also offer state rebates or income tax credits in order to encourage individuals and businesses to purchase EVs. Further, several states offer free parking or the use of HOV lanes to EV owners. A number of states also have policies that require or encourage state agencies to add EVs to their vehicle fleets.