AUSLEY & MCMULLEN

ATTORNEYS AND COUNSELORS AT LAW

123 SOUTH CALHOUN STREET
P.O. BOX 391 (ZIP 32302)
TALLAHASSEE, FLORIDA 32301
(850) 224-9115 FAX (850) 222-7560

April 23, 2021

VIA: ELECTRONIC MAIL

Mr. Michael Barrett
Economist Supervisor
Division of Economics
Florida Public Service Commission
Room 225L – Gerald L. Gunter Building
2540 Shumard Oak Boulevard
Tallahassee, FL 32399-0850
mbarrett@psc.state.fl.us

Re: Staff's First Data Request on Tampa Electric Company's 2020 DSM Annual Report

Dear Mr. Barrett:

Attached are Tampa Electric Company's responses to Staff's First Data Request (Nos. 1-13) dated April 9, 2021 regarding Tampa Electric Company's 2020 DSM Annual Report.

Also attached are four (4) excel spreadsheets with formulas intact related to this filing.

Thank you for your assistance in connection with this matter.

Sincerely,

Malcolm N. Means

Malcolm N. Means

MNM/bmp
Attachment
cc: Paula Brown (w/attachment)
Mark Roche (w/attachment)

1. Please describe how Tampa Electric Company (TECO or Company) monitors federal energy efficiency standards and Florida Building Code requirements. Address in your response how the Company modifies existing programs to reflect changes, when necessary.

A. Tampa Electric recognizes that staying on top of building codes and appliance efficiency standards is a challenge. To ensure that the Demand Side Management ("DSM") programs the company offers are aligned with building codes and appliance efficiency standards, Tampa Electric's Energy Management Services ("EMS") Department stay abreast and ahead of changing appliance efficiency standards and buildings codes including the current seventh version of the Florida Building Code that became effective on December 31, 2020. Tampa Electric is also closely monitoring the new Biden Administration for any new or proposed changes to building codes or appliance standards which would make it necessary to modify any of the company's existing Commission approved DSM programs. The Program Managers and select EMS team members ensure the DSM programs the company offers are correctly positioned to enhance energy efficiency above the base/minimum level required. Here are specific examples of the company's approach for monitoring any new federal energy efficiency standards/codes or Florida Building Code requirements and identifying the resultant future impact to the existing DSM Program:

- Tampa Electric's DSM Program Managers subscribe to the annual Florida Building Code - Energy Conservation Edition. The company has individual team members within EMS that serve as a designated team member who are associated with the Florida Department of Business Professional Regulations.
- Tampa Electric's Commercial Energy Management Team ("CEMT") members receive updates from the State of Florida's Energy Technical Advisory Committee ("TAC") and actively participate in webinars offered by the TAC.
- The CEMT belongs to several energy efficiency associations and consortiums such as the Association of Energy Engineers or the Consortium for Energy Efficiency.
- The CEMT will also attend national level training events which provide insight into current and future industry changes along with legislative changes that are scheduled to occur.
- Program Managers are responsible for charting a timeline comparison with the current program standards and identifying the

needed changes to ensure the program is in alignment with the new energy efficiency standard or building code.

- Program Managers meet annually with the company's Manager of Regulatory Rates to walk-through each DSM program to ensure the DSM program's standards are aligned with any new or upcoming changes to federal or state building codes or appliance energy efficiency requirements.
- Program Managers will reach out to recognized experts or vendors to discuss the impacts of changes and determine the most appropriate adjustments to make to the DSM program. A recent example of this is Tampa Electric's collaboration with the Environmental Protection Agency for the new ENERGY STAR Variable Speed Pool Pump program. This collaboration with industry experts helped directly guide the company's decision based on their input as to when and how they would recommend proceeding with new industry standards involving residential pool pump replacements. While manufacturing of single speed pool pumps will cease in July of 2021, it will take a number of years to cycle through all of the inventory of single speed pumps which will still be allowed to be installed until inventory runs out or when the new requirements expected in late 2024 will cause this program to be discontinued in the company's next DSM Plan.
- Program Managers that facilitate programs which have designated vendors ensure the vendor is aware of potential and future advancements in appliance energy efficiency standards and building codes and to position the supporting technology so that it is compatible, and it enhances the overall program.
- Program Managers and individual team members also achieve professional certifications by attending classes, participating in trade shows, formal meetings, conferences, or other training events which cover appliance energy efficiency standards and building codes such as:
  - Certified Energy Manager (CEM)
  - Business Energy Professional (BEP)
  - Commercial Energy Auditor (CEA)
  - Residential Energy Auditor (REA)
  - Demand Side Management Professional (CDSM)
  - Florida Building Engineering & Facility Maintenance Show
  - RESNET Certified Energy Rater seminars
  - Energy Management Congress events
  - EPA – ENERGY STAR training
  - ENERGY STAR Certified Homes Stakeholder meeting
  - Association of Energy Service Professionals (AESP)

- Association chapter meetings: Association of Energy Engineers (AEE), Tampa Bay Builders Association (TBBA), Refrigeration & Air Conditioning Contractors Association (RACCA) and American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE)

For any Commission approved DSM program modification that would change the contributions from that program (i.e., the winter or summer demand in kW or the annual energy in kWh), change the fundamental offering of the DSM program itself, or any changes to the DSM standards would require the company to obtain Commission approval for this modification through a petition.

2. Please answer the following regarding TECO's conservation research and development (CRD) initiatives that evaluate emerging DSM opportunities:

A. Identify and describe any new CRD initiatives that were launched in 2020.

B. Provide updates on the status of all on-going CRD initiatives that began before 2020, and if applicable, attach interim and/or final reports on work completed in 2020.

A. A. Tampa Electric did not initiate any new conservation research and development ("CRD") initiatives in 2020.

B. In 2020, Tampa Electric had several CRD initiatives underway with updates for each initiative below. In addition, with the Commission's approval of the company's DSM Plan, the large commercial electric vehicle battery storage CRD initiative was included as a part of the Integrated Renewable Energy System (Pilot) DSM program.

Small to mid-size Commercial Battery Storage: In 2020, this CRD project is still in a waiting status due to the COVID-19 pandemic, which is preventing the company from initiating the second phase of the original R&D Project plan. This second phase is the identification of one or two commercial facilities for potential battery installation which requires site visits and face-to-face interactions with customers.

In the last quarter of 2016, Tampa Electric partnered with the University of South Florida ("USF") College of Engineering to assist in the performance of this CRD project to evaluate the feasibility of potentially offering a battery storage DSM program for commercial/industrial customers. This CRD project will evaluate these small to mid-size commercial battery storage through research and field study with at least one battery being installed at a commercial/industrial customer's facility. Tampa Electric specified the size of battery for this CRD project to be between 10 kW and 150 kW with the project from inception to completion lasting approximately three-years. The original timeline was to afford enough time to study these batteries and potentially justify a DSM program within the company's 2020-2029 DSM Plan if the results were positive. The original R&D project was projected to cost approximately $250,000 to achieve the following objectives:

- Evaluate the potential for battery storage for the use of load shifting on demand savings.

- Evaluate the efficiency of load shifting from a battery storage system and the associated control and monitoring system.
- Evaluate the impact on the total energy consumption of the battery and facility when used in a load shifting capacity (versus reliability).
- Evaluate and compare batteries based on performance and cycling tolerance when used in Florida's climate.
- Examine the associated costs from cradle to disposition of battery.
- Evaluate the load profile impact on power vs. capacity tradeoffs.

To achieve these objectives, the small to mid-size Commercial Battery Storage project was broken down into the following four main phases:

1. Battery selection
2. Identify commercial facilities
3. Battery vendor selection
4. Installation of storage system

Phase 1 was completed by USF in 2017. Tampa Electric included a copy of the battery research study in the company's annual DSM report that was filed with the Commission on March 1, 2018. In 2017, after completion of the initial portion of the CRD project, the company sought product availability and costs and found that the prices were greater than the allocation of funds allowed as an R&D program and placed the pursuit of this CRD project on hold until the prices of the batteries dropped to an acceptable level. The company's Commercial Energy Management Team ("CEMT") has continued to keep a pulse on the market and monitors the prices of the batteries to continue the CRD project. In addition to monitoring the prices of the batteries to continue the CRD project, Tampa Electric also filed for an increase in the allowable funds to be used for CRD in the company's most recently filed and Commission approved 2020-2029 DSM Plan. In the 2020-2029 DSM Plan, the program costs were increased on an annual basis from $200,000 per year to $400,000 per year and increased the five-year period total allowable costs from $1,000,000 to $2,000,000.

Tampa Electric has had preliminary facilities identified for follow-up once the restriction of face-to-face engagement with customers that may be interested in participating in this CRD project is lifted. The two preliminary facilities include a 911-call center and a low-income community center. The company is hopeful that this CRD project will move forward in 2021.

Commercial small to mid-sized business Online Energy Audit: In 2020, the company determined that the ability to provide a high quality online energy audit to a very diverse range of customer business types is not feasible or cost-effective at this time. The company will consider reinitiating this CRD project if the technology to support this type of DSM program offering increases and the cost decreases. No reports have been provided by this CRD project at this time.

Home Energy Management System: In 2020, Tampa Electric is continuing with this CRD project that was implemented in November 2019, for home energy monitoring. The company installed home energy monitoring equipment in employee participant homes including a device that measures the split phase voltage, total current, and current of certain dedicated circuits within the home to record energy and usage data. The energy data gathered is communicated through the vendor’s software to provide users with a portal that’s accessible via an app on a smart device. Employees can view appliance on/off activity, kilowatt hour consumption, graphs and estimated electricity costs. The duration for this CRD project is two years. At the conclusion of the project, the company’s Load Research and Forecasting Department will analyze the participating employee electric consumption to determine any summer and winter demand and annual energy savings. The company will also survey these participating employees to determine feasibility and/or recommendations for any future DSM programs. The company will provide the results of the analysis and employee surveys when the CRD project is complete.

Large Commercial Electric Vehicle Battery Storage: In 2020, this CRD project was included as a component of the Integrated Renewable Energy System (Pilot) program that was approved by the Commission. The company began construction of the system in 2020 and is expected to be fully operational by June 2021.

In 2017, Tampa Electric partnered with USF’s Center for Urban Transportation Research (“CUTR”) to study the potential benefits that electric vehicles could provide to a DSM Program. The partnership developed two studies. The first study was the electric vehicle energy education study which has been fully implemented into three high schools in Hillsborough County. The second study was to perform in-depth research on the benefits that Tampa Electric could potentially realize if the company offered a DSM Program related to electric vehicles. As the performance of this report was being conducted, Tampa Electric began exploring the operational capabilities and characteristics of large commercial electric vehicle lithium-ion batteries and their potential capability to export power to the company’s electrical grid during peak times. The company explored developing a separate R&D project that would involve installing truck batteries (either a three (3) kW or 10 kW sized battery) within three of the company’s line trucks to evaluate the potential energy consumed by the charging stations and the amount of demand that can be exported to the grid. In addition, the ability to control the level of discharge to a specified point will also be evaluated to understand the operational impacts of performing these exports during the summer and winter peak season hours. Other items the project would analyze will include the following:

- Economics and cost-effectiveness
- Customer site integration
- Integration of multiple trucks

Because of the costs for batteries seen in the other small to mid-size Commercial Battery Storage project, Tampa Electric made the decision that this R&D project would be placed on hold until additional funding was available, or the battery and associated costs decreased to an acceptable level. In early 2019, the company decided that this CRD project would provide additional benefits if it were included as part of the Integrated Renewable Energy System (Pilot) Program proposed in the company’s 2020-2029 DSM Plan.

Tampa Electric believes that the Integrated Renewable Energy System (Pilot) program will be a very cost effective way to gain the knowledge regarding load shifting during current peak times, load shifting during changing peak times due to high solar penetration, and how to maximize the DSM benefits of these integrated systems (Solar Photovoltaic (“PV”) Array, Large Electric Vehicle Charging, Electric Vehicle Charging, Battery Storage). Another important part of the pilot is to make the technology available for viewing and education by potential commercial/industrial customers that are interested in these systems.

The Integrated Renewable Energy System will include the following components:

1. 800 kW (AC) solar PV array
2. 290 kW / 1,160 kWh battery energy storage system

3. 10 large electric vehicle access plugs for charging
4. Six (6) dual headed passenger vehicle charging stations

Heat Pump Water Heater inclusion into the Energy Planner Program: Tampa Electric is desiring to evaluate the inclusion of residential heat pump water heaters/hybrid water heaters into the Energy Planner Program as an electric thermal storage device. At this time, due to the company's installation of the advanced metering infrastructure ("AMI") project, the company is still waiting to start this evaluation so as to be able to take full advantage of the benefits when AMI becomes fully realized for Tampa Electric.

Electric Vehicle Potential Impacts: Tampa Electric utilized USF's Center for Urban Transportation Research ("CUTR") to assist in the development of the training program focused on high school students regarding electric vehicle usage and a Research and Development CRD project related to the potential impacts of electric vehicles ("EV") and the potential benefits that could be realized though DSM.

The CRD portion of this work was designed to complete the following:

- Researching benefits of EVs to utility companies and the public.
- Documenting the impacts of EV usage on energy conservation, energy security, emissions, and cost of electricity production for the utility company.
- Researching the cost-effectiveness of EV technologies.
- If warranted, assisting with the design of an effective vehicle rebate program to encourage EV purchases and higher EV usage in Tampa Bay.

The CRD portion of the work on EVs was originally projected to be complete in the late part of 2018. Tampa Electric received the final electric vehicles and demand side management benefits study in 2020 and included this report as Appendix "B" of the company's 2020 DSM Annual Report that was filed with the Commission on March 1, 2021. A complete copy of the report is also included below.

CENTER FOR URBAN TRANSPORTATION RESEARCH

Benefits of Electric Vehicles to Tampa Electric Company

Final Report

Project # PO4500168634

PREPARED FOR
TECO Energy

August 2020

Center for Urban Transportation Research
University of South Florida
4202 E. Fowler Ave., CUT100, Tampa, FL 33620-5375

Benefits of Electric Vehicles to Tampa Electric Company

Final Report

PO4500168634

Prepared for:

TECO Energy

Kenneth Hernandez
Business Development Manager
Electric Transportation and Modernization

Prepared by:

USF Center for Urban Transportation Research

Alexander Kolpakov
Austin M. Sipiora

August 2020

Disclaimer

The opinions, findings, and conclusions expressed in this publication are those of the authors and not necessarily those of TECO Energy.

Metric Conversion

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
LENGTH				
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
VOLUME				
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
NOTE: volumes greater than 1000 L shall be shown in m^3				
MASS				
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
TEMPERATURE (exact degrees)				
ºF	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	ºC

Technical Report Documentation

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Benefits of Electric Vehicles to Tampa Electric Company		5. Report Date August 2020
		6. Performing Organization Code
7. Author(s) Alexander Kolpakov Austin M. Sipiora		8. Performing Organization Report No.
9. Performing Organization Name and Address Center for Urban Transportation Research 4202 E. Fowler Ave, CUT 100 Tampa, FL 33620		10. Work Unit No. (TRAIS)
		11. Contract or Grant No. PO4500168634
12. Sponsoring Agency Name and Address Tampa Electric Company (TECO) 6944 US Highway 41 North Apollo Beach, FL 33572		13. Type of Report and Period Covered Final Report
		14. Sponsoring Agency Code
15. Supplementary Notes		

16. Abstract

Electric utilities can realize significant benefits from increased number of EV/PHEV in their service territory, including possible reduction in GHG emissions, balancing the grid through off-peak charging, more efficient use of existing generating capacity, avoiding expensive grid upgrades through potential load control, building grid resilience through vehicle-to-grid (V2G) technologies and integrating renewable power sources. At the same time, widespread adoption of PEV technologies can also cause challenges to electric utility companies, related to potential increase in peak demand, unmanaged charging, grid overloading, costs of fast charging and other obstacles.

To maximize the potential benefit of increased EV adoption, utilities may consider combining EV incentives with effective time-of-use electric rates to ensure that additional load from EV charging is shifted to the periods when utility generating capacity is under-utilized.

17. Key Word Electric vehicle, plug-in hybrid, rebate, incentive, time-of-use, off-peak, electric rates	18. Distribution Statement

19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 62	22. Price

Form DOT F 1700.7 (8-72)

Acronyms

AFDC	Alternative Fuel Data Center
BEV	Battery electric vehicle
DCFC	Direct current fast charging
DOE	U.S. Department of Energy
EV	Electric vehicle
eVMT	Electric vehicle miles traveled
EVSE	Electric vehicle supply equipment
ICE	Internal combustion engine
kW	Kilowatt
kWh	Kilowatt-hour
PEV	Plug-in electric vehicle
PHEV	Plug-in hybrid-electric vehicle
TOU	Time-of-use
USABC	United States Advanced Battery Consortium
XFC	Extreme fast charging
ZEV	Zero-emission vehicle

Executive Summary

While gasoline- and diesel-powered internal combustion engine (ICE) vehicles continue to maintain dominant market share, electric vehicles (EV) are increasingly gaining market share as capital costs are falling while range and performance of EV technology continue to improve. Potential benefits from higher adoption of EV technologies include reduction in GHG emissions of the transportation sector, improved energy efficiency and lower vehicle operating cost realized by vehicle owners.

Plug-in electric vehicle (PEV) sales in Florida have grown considerably over the past several years as battery-electric vehicles (BEV) and plug-in hybrid electric vehicles (PHEVs) entered the marketplace, from 524 PEVs sold in 2011 to over 7,500 sold in 2017, for a total of over 37,000 PEVs sold to date. As of the end of 2018, there were 7,480 registered PEVs in the six-county Tampa Bay region, representing 20.0 percent of the total statewide PEV fleet. There are currently over 740 charge ports in the region, with the vast majority of those chargers available to the public.

Public utility companies across the U.S. often implement various energy conservation programs aimed at encouraging their customers to conserve energy. Tampa Electric Company (TECO) currently offers 12 energy-efficiency programs for residential customers and 19 programs for business customers helping them to reduce energy consumption and save money on energy costs. TECO is considering developing an EV rebate, that may be integrated into its conservation program and combined with time of use capabilities that would encourage customers to change their usage behavior and distribute the consumption of electricity more evenly.

In general, electric utilities can realize significant benefits from increased number of EV/PHEV in their service territory, including possible reduction in GHG emissions, additional electricity sales, balancing the grid through off-peak charging, more efficient use of existing generating capacity, avoiding expensive grid upgrades through potential load control, building grid resilience through vehicle-to-grid (V2G) technologies, integrating renewable power sources, and other potential benefits.

At the same time, widespread adoption of PEV technologies can also cause challenges to electric utility companies, related to potential increase in peak demand, unmanaged charging, grid overloading, costs of fast charging and other obstacles. For example, clustering of EVs in some sections of the grid may cause an overload of transformers due to on-peak charging, multiple off-peak charging, or from inadequate design of transformers that were initially assumed to be underused at night. The application of time-of-use (TOU) rates can help mitigate clustering problem up to a certain degree.

Rapid growth in solar generation in some markets (including Florida) can be associated with a particular challenge for grid operators known as a “duck curve”, that reflects timing imbalance in power production over the course of the day between peak demand and peak solar generation. In many markets, peak demand occurs after sunset when solar generation is unavailable or significantly reduced. If not managed, EVs charging in late afternoon (when

EV owners plug in their cars after arriving home from work) could aggravate the duck curve challenge.

Utilities see TOU rates as an effective tool to incentivize demand for electricity during off-peak hours when there is significant underutilized capacity, thus, moving the demand away from the peak hours when generating capacity is heavily utilized. At the same time, EV owners are likely to benefit the most from TOU rates when they can meter EV charging separately from their household electric use. This can allow EV owners to fully take advantage of lower off-peak electricity costs for charging their vehicles.

If combined with managed charging, incentivizing EV ownership can ultimately benefit all utility customers by allowing more efficient utilization of existing utility generating capacity and, thus, lowering electric rates to all customers. This argument is used by some utilities across the country to rate-base the costs of utility-provided incentives for EVs and charging infrastructure. At least two utilities in the U.S. have been successful in receiving an approval from their state utility commissions to recover the cost of EV incentive programs through electric rates paid by all customers.

Previous research and anecdotal evidence indicate that successful alternative fuel/technology incentives typically have the following seven characteristics: 1) focused on a specific goal; 2) incentive amount is large enough to entice investment in AFV; 3) grant-based; 4) easy for a potential applicant to use and for the provider to administer; 5) address the development of fueling infrastructure in addition to acquiring AFV; 6) include a cap or phase-out provision; and 7) monitoring the program's success or failure.

Forty three utility companies operating in 25 U.S. states currently offer various rebates for EVSE installation. The average utility-provided rebate amount is $471 for residential Level-2 EVSE, $4,069 for commercial Level-2 charger, and $43,286 for commercial DCFC. Sixteen utility companies operating in 10 U.S. states offer rebates to their customers for purchasing or leasing plug-in electric vehicles. The average utility-provided EV rebate across the country is $383 for PHEV and $954 for EV.

There are currently no state-funded financial incentives for EV or EV charging infrastructure in Florida. Three Florida utilities provide incentives for purchasing or leasing EVs that range from $100 to $1,000. Jacksonville Electric Authority offers, by far, the most generous incentive to EV owners among other Florida utilities, providing customers with $500 rebate for purchasing or leasing PHEV and $1,000 rebate for purchasing or leasing EV.

To maximize the potential benefit of increased EV adoption, utilities may consider combining EV incentives with effective time-of-use electric rates to ensure that additional load from EV charging is shifted to the periods when utility generating capacity is under-utilized.

Table of Contents

List of Figures

List of Tables

1. EV Market Analysis

This analysis presents an overview of the general trends in the statewide and regional electric vehicle (EV) market, including the state of technology, battery costs, vehicle operating costs, and other aspects of market development. This analysis also provides a brief overview of the electric vehicle market and corresponding electric vehicle charging infrastructure in Florida and in Tampa Electric's service area.

1.1. Literature Review

State of Technology

While gasoline- and diesel-powered internal combustion engine (ICE) vehicles continue to maintain majority market share, electric vehicles are increasingly gaining market share as capital costs are falling and improvements in performance and technology continue to improve. Battery electric vehicle (BEV) technology has been rapidly evolving since the introduction of the early model Nissan Leaf, with the most significant advancements being made in charging capacity and battery technology. Though plug-in electric vehicles (PEVs) have not reached parity with ICE vehicles, improvements in electric motor design, range extender systems, and charging infrastructure are also anticipated to enhance economic viability of BEVs as access to fast charging is a critical component of wider PEV adoption.

The U.S. Department of Energy (DOE) has outlined several key criteria necessary for commercializing BEV adoption, including: reducing production cost of battery systems to $80 per kilowatt-hour (kWh), raising the average EV range to 300 miles, and decreasing charge time to under 15 minutes (Howell et al., 2017). The literature has found that in areas where PEV drivers can charge at 50 kilowatt (kW) or 120 kW stations, annual electric vehicle miles traveled (eVMT) have increased by 25 percent (Howell et al., 2017). Ultra-fast charging systems, which use 350 kW and extreme fast charging (XFC), which begins charging at 400 kW, are capable of significantly decreasing total charge time.

Table 1 - Recharging Time and Range by Charging Infrastructure Type

Charger Type	Range Per Minute of Charging (miles)	Time to Charge 200 miles (in minutes)
Level 2 (220 V, 7.2 kW)	0.42	417
DC Fast Charger (480V, 50kW)	2.92	60
Tesla SuperCharger (480V, 140 kW)	8.17	21
XFC (800+V, 400 kW)	23.3	7.50

Reproduced from: (Howell et al. 2017)

Present challenges to the development and implementation of large-scale XFC include needs for materials research and development, particularly to address thermal management issues for battery preservation at higher voltages. In addition, there is a need to evaluate real-world application of XFC to identity standard operating limits as well as develop XFC siting requirements, including coding and station design (Howell et al., 2017). At present, most commercially-available PEV models are not able to charge at those higher kW levels, however, auto manufacturers have released plans indicating intent to manufacture BEV models capable of charging at ultra-fast levels by 2020 (Galeon, 2017; Evarts, 2018; Whitwam, 2018). At the end of 2017, the U.S. DOE announced plans to allocate $19 million to fund research projects focused on batteries and vehicle electrification technologies to facilitate extreme fast charging, and specifically projects that focus on developing electric vehicles that can recharge at higher power levels to reduce charging times to 15 minutes or less or utilize a wireless charging system (DOE, 2017).

Battery Costs

Factors that enhance market viability and extend vehicle range include considerations of energy density, power density, battery life, and cost per kWh (Burke et al., 2007). Battery cost is considered a crucial player in driving PEV adoption. There is some variation in the literature on the projected kWh cost at which PEV achieves widespread commercialization; estimates range from $150 to $300 per kWh (Teter et al., 2017; Andwari et al., 2017). The United States Advanced Battery Consortium (USABC) identifies several other technology factors, in addition to cost, that are necessary for driving BEV market uptake, including: 110-year/1000 cycles with 80 percent of discharge, calendar life of 15 years, and recharging capabilities with a J1772 connector seven-hour recharge and 15-minute charge time for direct current fast charging (DCFC) (Andwari et al., 2017).

Consumer Attitudes

There are a multitude of factors that impact PEV growth, which include policies and incentives, capital costs, charging times, availability of PEV models, and consumer attitudes. A review of the market research found that typical early PEV adopters tend to be young to middle-aged (18 to 34 years) educated, high earners ($65,000 to $100,000 annual income), and homeowners from single family suburban or urban households (Mohamed et al., 2016; Kiser & Essery, 2017). The Tesla market, which accounts for nearly half of the total BEV market share, tends to attract upper-income adopters, though that is expected to change with the introduction of the Tesla 3 base model in 2019. As PEVs become increasingly more affordable, it is anticipated they may expand into other light vehicle market segments.

Market Penetration Projections

EV market penetration projections vary significantly from source to source. There is no single agreed-upon projection of EV market development in the future. The Energy Information Administration (EIA) forecasts that sales of EV/PHEV will exceed 1.1 million vehicles per year, accounting for 7 percent of all light-duty vehicle sales in 2025. EV/PHEV sales are also projected to reach 14 percent of annual vehicle sales in 2050. The National Renewable Energy Laboratory (NREL) forecasts that EVs will account for 20 percent of all light-duty vehicle sales in the U.S. in 2030. More aggressive forecasts place the share of EV sales at 35 percent of new light-duty vehicle sales in 2040, and up to 60 percent of all light-duty vehicle sales in 2050.

Overall, the reviewed industry forecasts imply short-to medium-term (10-15 years) annual growth rates of EV sales ranging from 20.6 percent to 25.1 percent per year and long-term (20+ years) growth rates ranging from 7.5 to 16 percent per year. The projections found in the literature regarding the stock of EVs range from 7 million vehicles in 2025, to 15 million vehicles in 2030 and to 41 million EVs in 2040. Even the most aggressive forecasts, however, indicate that the electric vehicle fleet is not expected to exceed 15 percent of the overall U.S. vehicle stock in 2040.

1.2. EV Market Overview

1.2.1 State EV Market Overview

Florida PEV Stock

The Florida Department of Motor Vehicles reported 29,433 plug-in vehicles registered in Florida as of June 2018[1]. Of those registrations, 2,253 (7.7 percent) are considered commercial vehicles and the remaining 27,180 (92.3 percent) are individually owned. PEV registrations grew by 6,057 units or 25.9 percent from 2017 to 2018, reflecting an average of 1.72 PEVs per 1,000 residents (Atlas Public Policy 2018). The figure below depicts PEV density per 1,000 residents by county, with Miami-Dade, Broward, Palm Beach, Orange, Hillsborough, and Pinellas Counties leading the state with the highest electric vehicle market shares.

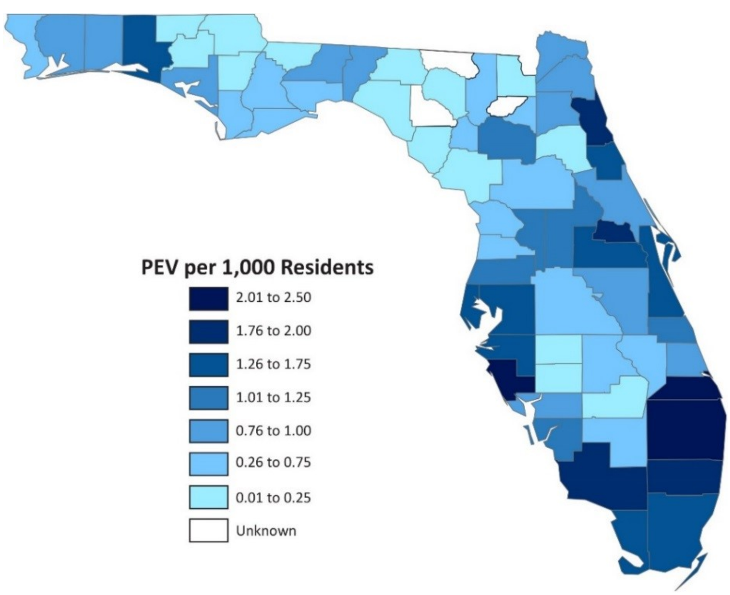


Figure 1 - PEV Density by County

[1] Florida Department of Motor Vehicles data obtained through personal communication on September 20, 2018.

Table 2 - Top Ten Counties in Florida by PEV Market Share

County	PEV Registration Count	Market Share (in percent)
Miami-Dade	4,198	14.3
Palm Beach	3,521	12.0
Broward	3,424	11.6
Orange	2,230	7.6
Hillsborough	1,914	6.5
Pinellas	1,587	5.4
Duval	919	3.1
Sarasota	892	3.0
Brevard	821	2.8
Seminole	812	2.8

PEV registrations in Florida as of June 2018 (29,433 units) are reported at a lower volume than PEV sales during the same time period—as of June 2018, Auto Alliance reports a cumulative 31,790 PEV units sold, a difference of 2,357 PEVs, or 7.41 percent. The difference may be due to several factors, including migration of PEVs as Florida population changes, as well as minor inconsistencies in reported sales data.

Florida PEV Sales

While gasoline-powered vehicles make up nearly 97.5 percent of the total light-duty vehicle sales in Florida, PEV sales have grown considerably over the past several years as BEVs and plug-in hybrid electric vehicles (PHEVs) entered the marketplace, from 524 PEVs sold in 2011 to over 7,500 sold in 2017, for a total of 34,410 PEVs sold to date. Plug-in hybrid electric vehicles led the market until 2013, when battery electric vehicle sales surpassed those of PHEVs. As of August 2018, Florida BEV sales made up 54 percent of total PEV sales.

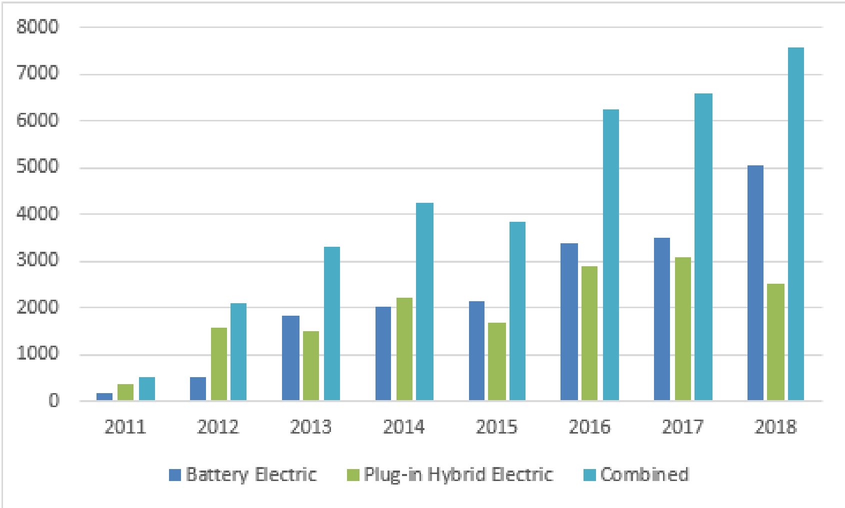


Figure 2 - Florida PEV Sales by Year
Source: (Auto Alliance, 2018)

While plug-in electric vehicle sales make up a relatively small share of the total light-duty vehicle market in Florida, both BEVs and PHEVs have grown in market share at similar rates, with PEVs increasing from 0.31 percent of total share in 2013 to 0.93 percent in the first half of 2018. As of August 2018, Florida ranked fourth in total PEV sales, behind California, New York, and Washington, and represents approximately 3.2 percent of the total cumulative PEV sales in the United States (Atlas EV Hub, 2018).

Table 3 - Top States by PEV Sales

State	Total PEV Units Sold
California	441,679
New York	38,480
Washington	35,517
Florida	34,410
Georgia	31,200
Texas	28,796
New Jersey	21,090
Oregon	18,523
Illinois	18,343
Massachusetts	17,859

Source: (Auto Alliance, 2018)

Florida has experienced significant growth in PEV sales during the first half of 2018, with 7,567 PEV units sold as of August 2018 compared to 6,573 units sold in 2017 during the same timeframe, resulting in 15 percent growth from 2017.

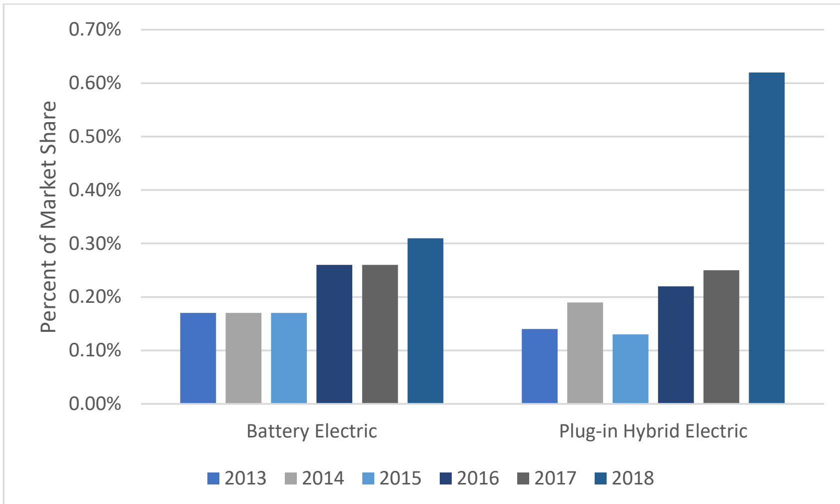


Figure 3 - PEV Market Share in Florida by Year
Source: (Auto Alliance, 2018)

Florida PEV Market in Comparison to ZEV Mandate States

California has the right to implement vehicle emissions standards that are more stringent than federal standards due to authority granted in Section 209 of the Clean Air Act, which also provides that other states can adopt California's standards (C2ES, 2019). The California Advanced Clean Cars program requires that auto manufacturers must sell a certain percentage of zero-emission vehicles (ZEV) electric vehicles, or purchase credits from other auto manufacturers to make up those percentages. Nine other states have adopted the California Advanced Clean Cars program, including Connecticut, Maine, Maryland, Massachusetts, New Jersey, New York, Oregon, Rhode Island, and Vermont, and Colorado is in the process of establishing a similar low emission vehicle mandate (Stainken, 2018). In 2013, California, Connecticut, Maryland, Massachusetts, New York, Rhode Island, and Vermont established a memorandum of understanding to establish a goal of putting 3.3 million zero emission vehicles on the road by 2025 (CARB, 2014). Florida initially lagged in PEV sales during the initial market introduction of commercially available PEVs, however, historical sales data and trends suggest more robust growth in PEV market share even in comparison to ZEV mandated states (Kolpakov et al., 2018).

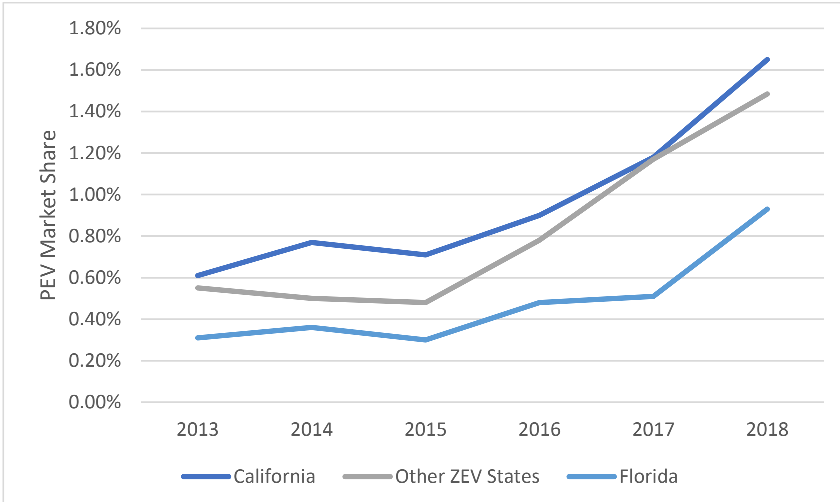


Figure 4 - Total PEV Market Share by Year
Source: (Auto Alliance, 2018)

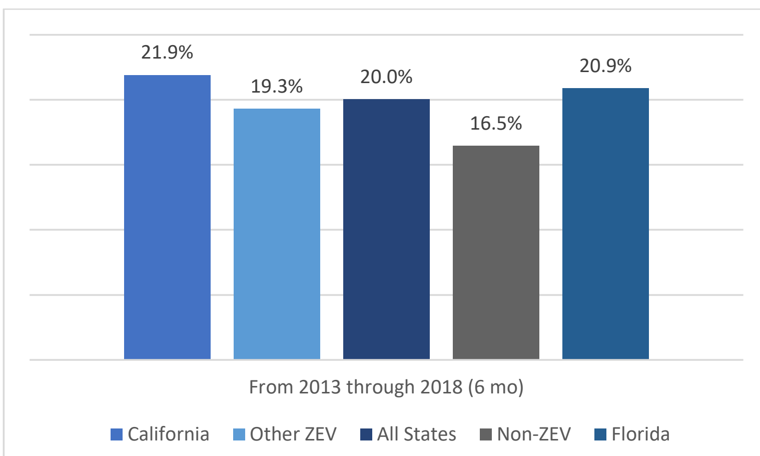


Figure 5 - Average Annual Growth Rate in PEV Market Share
Source: (Auto Alliance, 2018)

Electric Vehicle Charging Infrastructure in Florida

Though most electric vehicle charging occurs at home and at the workplace, public charging is an important component of the charging infrastructure system for increasing visibility of electric vehicles and relieving range anxiety (Kwan et al., 2016). Charging infrastructure is assessed using data from the U.S. Department of Energy's Alternative Fuel Data Center (AFDC) Station Locator and the Atlas Public Policy EV Hub Charging Deployment dataset from December 2018. The dataset downloaded in December 2018 reflects the number of charging stations to date. There are 176 direct current fast charging (DCFC) stations with 636 ports and over 1,400 Level 2 stations with 3,341 ports in the State of Florida, which averages 0.16 Level 2 charging ports per 1,000 people and 0.03 DCFC charging ports per 1,000 people (AFDC, 2019a). Figure 6 provides the number of EVSE connectors added by type by year from 2010 – 2018 in Florida. Most of the charging stations are concentrated along highway corridor routes, coastal areas, and in the densely populated urban centers of Miami, Orlando, Tampa, and Jacksonville.

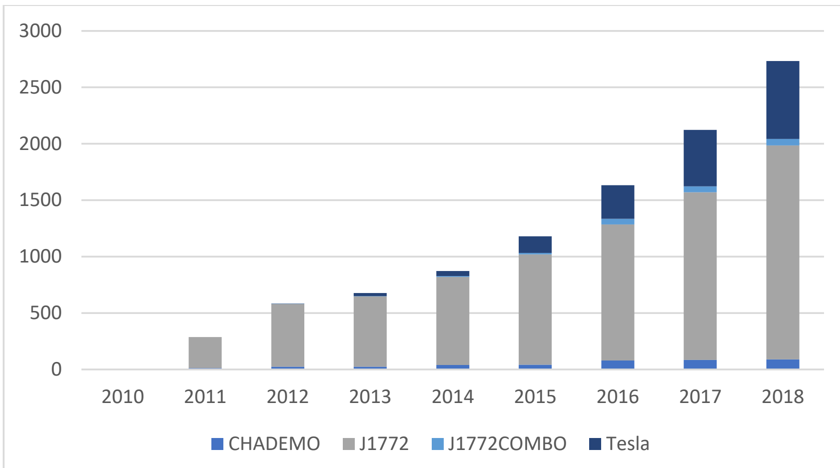


Figure 6 - Number of EVSE Connectors Added by Type Per Year

Figure 7 depicts the distribution of Level 2 and DCFC charging ports in the Florida counties with the highest electric vehicle share by county. As shown, Miami-Date County has the highest charging availability compared to the other counties, followed by Orange, Broward, and Hillsborough Counties. Figure 8 provides a map illustrating the statewide distribution of electric vehicle charging stations.

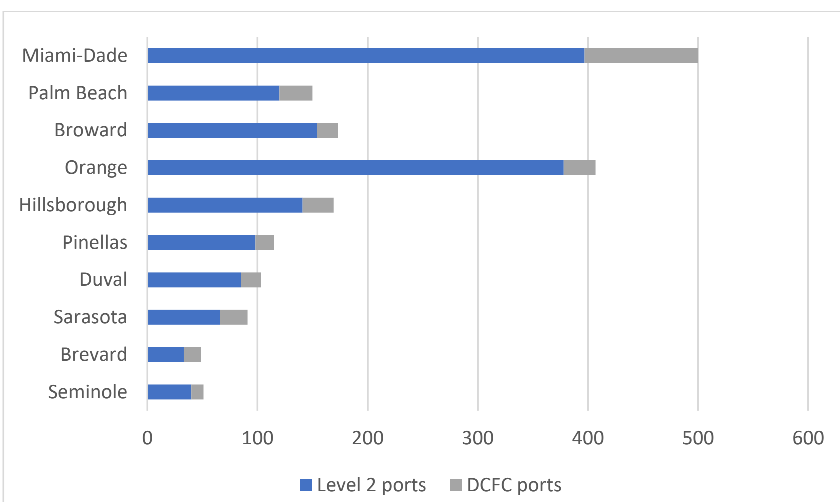


Figure 7 - Number of Charging Ports in Highest PEV Density Florida Counties

Source: (Atlas Public Policy 2018)

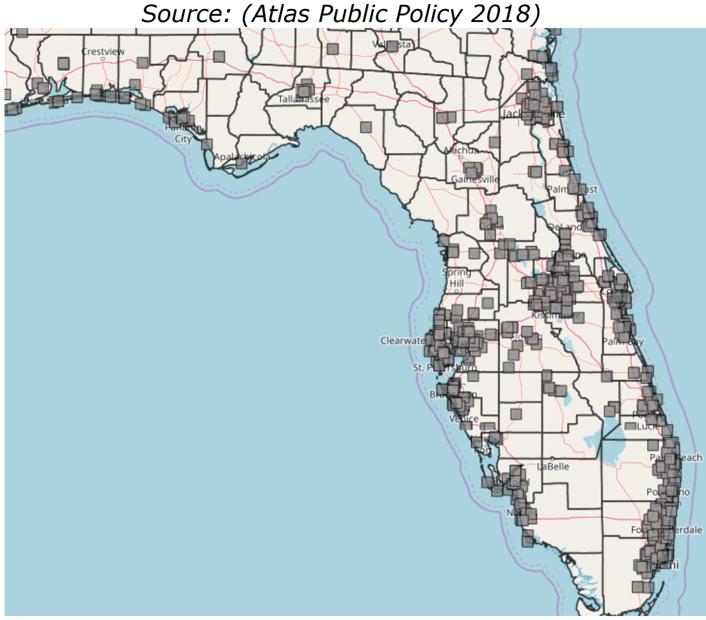


Figure 8 - Charging Station Density by County

Reproduced from: (DOE, 2018)

There are several ongoing initiatives and funding opportunities that are expected to expand existing publically-available EV charging in Florida. The Duke Energy Park and Plug Program is expected to add an additional 530 public EV charging stations through 2022 (Walton, 2018). The State of Florida will also allocate $24.9 million from the Volkswagen Environmental Mitigation Trust for additional electric vehicle supply equipment (EVSE) infrastructure (FDEP, 2019). Additionally, Miami was selected to receive community charging stations through the Electrify America program, which could potentially add additional Level 2 and DCFC through the greater Miami metro area. Electrify America has already installed 23 DCFC stations in the State of Florida along the I-75, I-95, I-10, and I-4 corridors through the Electrify America highway corridor fast charging program, and more stations are planned for the next cycle of investment (Electrify America, 2019).

1.2.2 Tampa Electric EV Market Overview

The Tampa Bay region, including Pinellas, Polk, Pasco, Hillsborough, Manatee, and Sarasota Counties, has experienced a relatively healthy growth in electric vehicle fleet and infrastructure. As of the end of 2018, there were 7,480 registered PEVs in the six-county Tampa Bay region, representing 20.0 percent of the total statewide PEV fleet (FLHSMV, 2018). Charging infrastructure in Tampa Bay is developing to accommodate the growth of PEVs. There are currently over 740 charge ports in the region, with the vast majority of those chargers available to the public.

Tampa Bay PEV Stock

Tampa Electric services nearly 1 million customers in a 2,000 square mile territory in West Florida, which includes Hillsborough County and sections of Polk, Pasco, and Pinellas Counties. Hillsborough County is the mostly densely populated county served, with over 1.3 million residents in 1,266 square miles (U.S. Census Bureau, 2018). The table below provides an overview of the number of PEV models by type registered in Hillsborough County as of June 2018. Through June 2018, Tesla Model 3, X, and S accounted for nearly half (44 percent) of the total registered PEVs in Hillsborough County, followed by the Chevrolet Volt (14.7 percent), and the Nissan Leaf (7.2 percent). Hillsborough County contains approximately 6.5 percent of the total registered PEVs in the state as of June 2018 figures (FLHSMV, 2018), and averages 1.42 PEVs per 1,000 people (Atlas Public Policy, 2018).

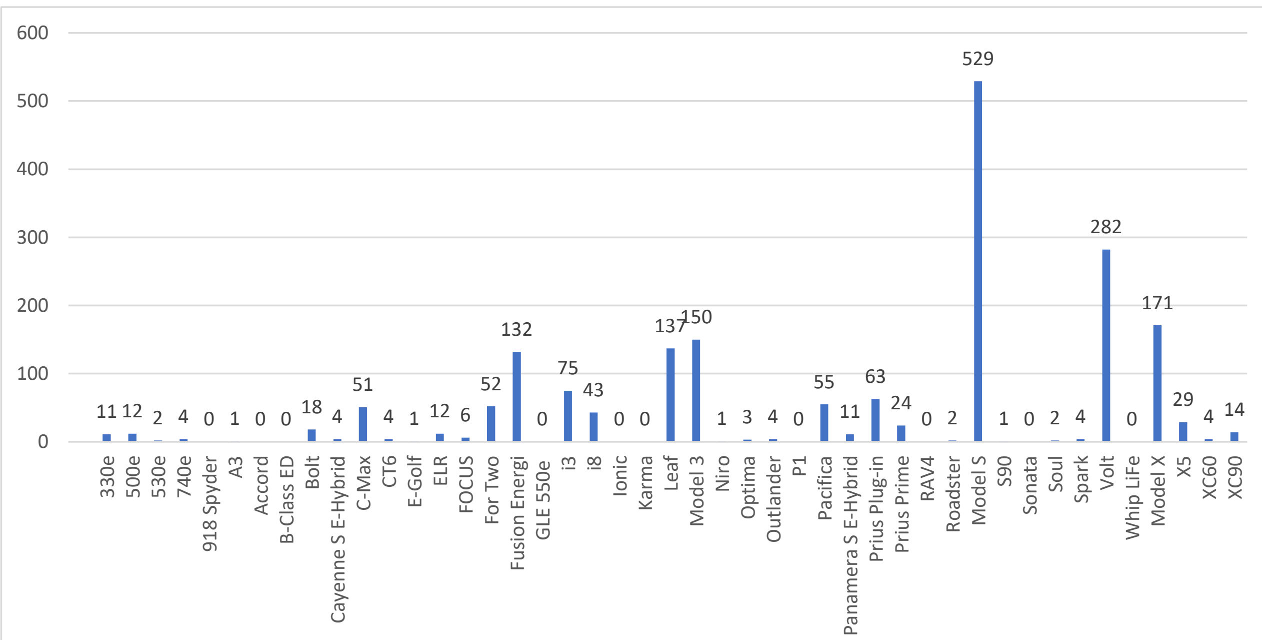


Figure 9 - Count of Registered PEV Models in Hillsborough County
Source: (Florida Department of Highway Safety & Motor Vehicles, 2018)

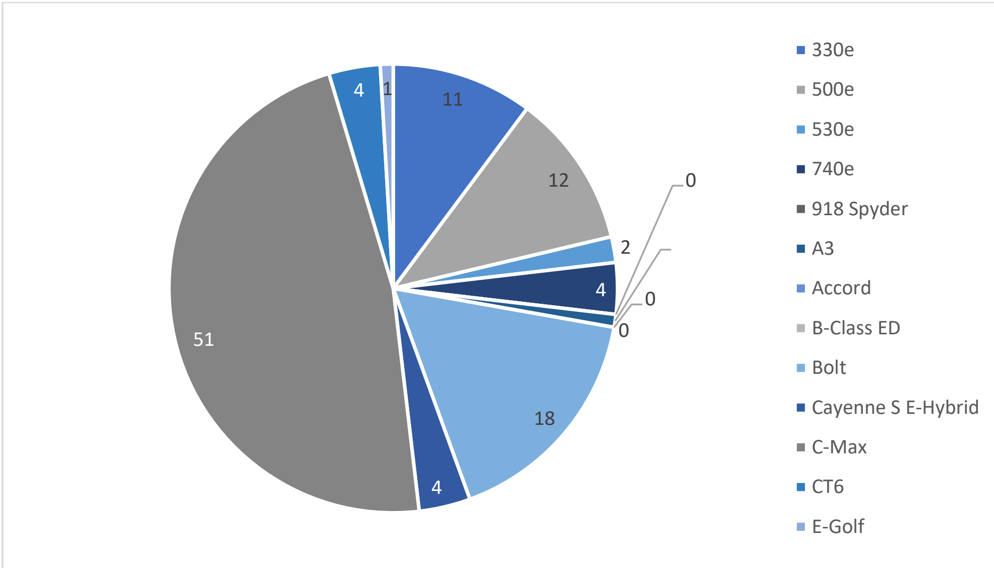


Figure 10 - Percentage of PEV Registrations by Model in Hillsborough County
Source: (Florida Department of Highway Safety & Motor Vehicles, 2018)

Tampa Bay EV Charging Infrastructure

Alternative Fuel Data Center (AFDC) reports that there are 201 Level 2 charging ports (190 public and 11 private ports) and 54 DCFC in Hillsborough County, averaging 0.14 Level 2 charging ports per 1,000 people and 0.04 DCFC ports per 1,000 people, which are comparable to statewide averages.

In addition to Hillsborough County, Tampa Electric serves portions of Polk and Pasco County. Polk County has 22 Level 2 charging ports (17 are public) and 5 DCFC ports, averaging 0.03 Level 2 chargers per 1,000 residents and 0.007 DCFC per 1,000 residents. Pasco county has 38 Level 2 charge ports (30 of them are open to the public) and 3 DCFC, averaging 0.07 Level 2 charge ports per 1,000 residents and 0.006 DCFC per 1,000 residents.

2. Impact and Benefits of EVs

The transportation sector in the United States is the largest contributor to carbon emissions among other sectors of the economy, including electric power, residential, commercial, industrial, and manufacturing sectors (Bonitz et al., 2018). In 2016, greenhouse gas emissions from the transportation sector surpassed the emissions from the electric power generation sector for the first time since 1970s.

High dependence of the transportation sector on petroleum-based fuels contributes significantly to emissions. Petroleum products account for over 90 percent of total energy used by the U.S. transportation sector. Biofuels, such as ethanol, and biodiesel account for approximately 5 percent of total energy consumed by the transportation sector. Natural gas accounts for approximately 3 percent of energy while electricity accounts for less than 1 percent of total energy consumed by transportation (EIA, 2017).

2.1. Emissions Reduction

With the increased domestic petroleum production and the recent trend of the U.S. becoming a net energy exporter, energy security aspect of alternative fuel vehicles may become less significant. However, the predominant use of petroleum-based fuels for transportation is the primary reason for greenhouse gas (GHG) emission from the transportation sector. In 2016, transportation sector accounted for 28.5 percent of the total U.S. GHG emissions, making it the largest contributors to country’s GHG emission among other sectors (EPA, 2016). Light-duty vehicle account for the majority of GHG emission from the transportation sector. Wider use of electric vehicles (both battery-electric and plugin hybrids), that don’t rely on petroleum-based fuel, can result in a significant reduction in greenhouse gas (GHG) emissions.

Electric vehicles that operate solely on electricity have zero tailpipe emissions. However, generating electricity does produce emissions that can be associated with operating EVs. Environmental benefits of EVs and PHEVs depend heavily on the source of electricity generation. Electric vehicles operating in regions that use low-polluting sources for electricity generation have significant emissions reduction advantages over conventional vehicles. In areas when electric generation is heavily reliant on traditional fossil fuels, electric vehicles may not be able to demonstrate significant life-cycle emissions benefits.

On average though, the use of EVs can potentially reduce carbon dioxide (CO_2) emissions by up to 60 percent compared to internal combustion engines. Based on the U.S. energy mix for electricity generation, EVs produce approximately 141 grams of CO_2 per mile, on a lifecycle basis (over 57 percent less than gasoline-powered vehicles), compared to 329 grams per mile for regular gasoline vehicles (WEF, 2018). Based on the electricity generation mix in Florida, a light-duty battery electric vehicle in Tampa Bay area produces 43.0 percent lower life cycle GHG emissions than comparable gasoline vehicle (AFLEET, 2018).

2.2. Energy Efficiency

EVs tend to be more energy efficient than conventional vehicles due to the difference in the way the electric engine converts fuel into vehicle propulsion energy. The internal combustion engine converts the chemical energy from burning liquid or gaseous fuel (e.g., gasoline or diesel) into mechanical energy that moves the vehicle. During the combustion process, a large portion of energy is lost in the form of heat. As a result, conventional gasoline combustion vehicles typically convert only 17% to 21% of the energy stored in the gasoline to propulsion energy at the wheels. On the other hand, electric motors convert electric power into mechanical power to propel the vehicle without significant heating. EVs are able to achieve 59% to 62% efficiency in converting electric energy to propulsion energy at the wheels (DOE, 2018).

Due to higher energy efficiency of electric propulsion, electric vehicles demonstrate significantly higher fuel economy, compared to internal combustion engines. EV models that are currently on the market demonstrate an average fuel economy of 104.3 miles per gallon equivalent (MPGE), which is over 4 times higher than an average fuel economy of 2017 model year light-duty vehicles in the U.S. (25.2 MPG). Plug-in hybrid models demonstrate an average combined (electric plus gasoline) fuel economy of 78.5 MPG, over three times higher than the average fuel economy of light-duty vehicles produced in 2017 (EPA, 2018).

Grid Impacts

The impact of EV charging to the electrical grid depends on the type (level) of charging used. Level-1 charging uses 110 volts and imposes about 1-2 kW of demand over a long period of time (10 hours or more per full charge). Level-2 charging uses 240 volts and creates 7-10 kW of demand for a few hours (typically, 4-8 hours per full charge). DCFC can typically draw 50-350 kW of demand but it usually takes less than an hour to fully charge an EV (often can charge in 20 minutes to 80% state of charge).

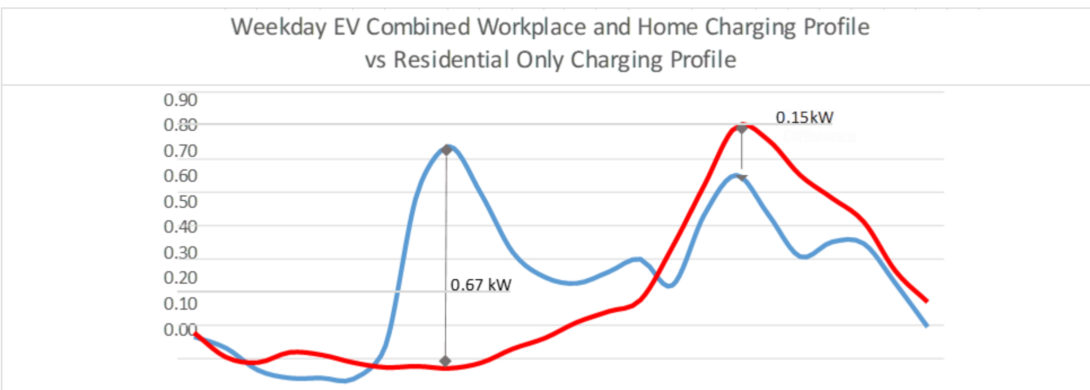
The higher the power of the charging station, the more "peaky" the demand is. This means that the grid needs to create that power over very short intervals to adjust to big spikes. This is a tough thing to do. The Level-1 and Level-2 are much lower demand over longer periods, so these levels of charging require less adjustment by the grid compared to DCFC.

Long flat curves are easy to predict and serve, whereas short peaks are more difficult. Since electricity must be produced the moment it is consumed, generation on the system must match the load. In general, it is easier to plan for long slow shifts in demand rather than short peaky bursts. It becomes even more complicated as the generation on the system is shifting from traditional fossil fuel that can be ramped up and down faster to renewable resources.

Since charging over Level-1 takes so long (10-12 hours), it is difficult to shift it to off-peak period (it will most likely not be able to fit entirely inside an off-peak period). At the same time, Level-2 charging requires less time for full charge, without imposing excessive short-term power demand as DCFC. Therefore, Level-2 charging is better suited than Level-1 for applying utility rates aiming to incentivize off-peak charging.

Since charging away from home often occurs during on-peak, the design of DCFC stations may include strategies to minimize or manage the impact to the grid. The use of energy storage is often a preferred method of managing grid impact because it enables demand reduction and load balancing. The energy storage system can be designed to charge at a relatively low constant rate (independent of vehicle charging) to ensure flat load profile over time and reduce electricity cost by keeping demand charges down. Some of the drawbacks of such energy storage systems include high capital and operating costs, as well as the fact that the system is designed to discharge (to provide power to vehicles) faster than it is charged by the grid. As a result, if vehicles arrive for charging when the energy storage system is fully depleted, the system will either need to draw higher power from the grid (negatively impacting the grid and increasing demand charges for station operator), or reduce the power provided to the vehicles (increasing charging time) (Francfort et al., 2017).

Availability of various charging options can significantly alter charging behavior and translate into material impact to the electric grid. A recent electric vehicle charging pilot study involving collecting data from 439 EVSE charge ports over three-year period demonstrated that EV commuters with both workplace and residential charging availability charged less at home than those with only residential charging, causing reduced evening peak load. At the same time, this also increased peak load from workplace charging in the morning during colder winter temperatures. The data collected by the pilot project demonstrated that commuters with access to workplace charging create two peaks during an average workday. The highest peak of 0.7 kW occurs at workplace chargers at 8 am, with a second smaller peak of 0.46 kW occurring at home, at 5 pm. As a result, the availability and use of workplace chargers reduces the average residential peak demand by 0.15 kW in the evening, but also increases the morning peak by 0.63 kW (Farley et al., 2019).



	12 A	1 A	2 A	3 A	4 A	5 A	6 A	7 A	8 A	9 A	10 A	11 A	12 P	1 P	2 P	3 P	4 P	5 P	6 P	7 P	8 P	9 P	10 P	11 P
Combined Charging	0.16	0.13	0.06	0.04	0.04	0.03	0.13	0.60	0.74	0.59	0.42	0.34	0.32	0.36	0.40	0.32	0.53	0.65	0.53	0.40	0.45	0.44	0.32	0.19
Residential Only Charging	0.18	0.10	0.09	0.12	0.11	0.09	0.07	0.07	0.07	0.08	0.13	0.16	0.21	0.24	0.28	0.44	0.62	0.80	0.76	0.65	0.58	0.51	0.36	0.27

Hour Beginning

Figure 11 – Effect of Workplace Charging on Charging Profile
Source: (Farley et al., 2019)

Charging behavior can be affected by climate in a given geographic area, as well as the season. A recently completed study by FleetCarma examined how regional climates impact charging and driving behavior, comparing southern states and northern states of the U.S. during winter and summer months. The study demonstrated that short-range EVs and PHEVs operating in southern U.S. states tend to charge more than once per day to meet their driving needs both in the summer and winter months. At the same time, long-range EVs charged less frequently, than other EV types (FleetCarma, 2020).

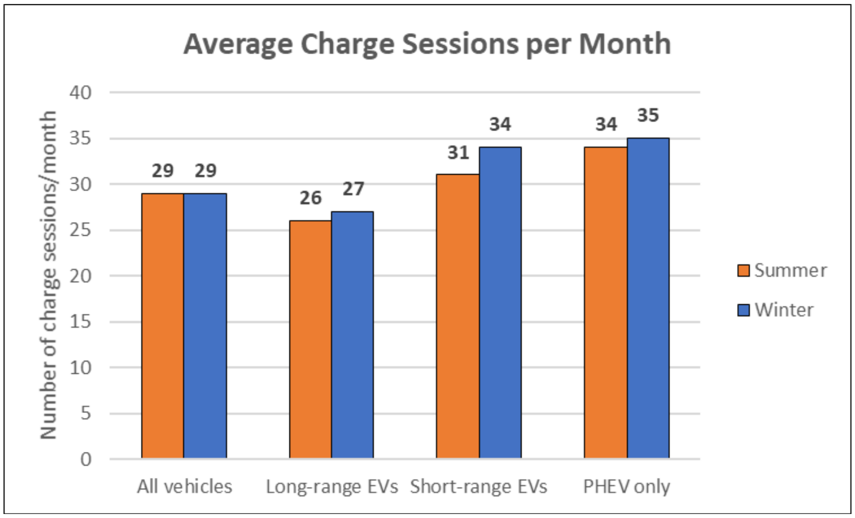


Figure 12 – Average Charging Sessions per Month – Southern U.S.
Source: (FleetCarma, 2020)

The above study by FleetCarma showed that approximately 70% of charging (in terms of energy use), both in winter and summer months, occur at home, with Level-2 accounting for the majority of energy used and charge sessions. The data also demonstrated that DCFC and home Level-1 usage increased during the summer months, while home Level-2 charging decreased (FleetCarma, 2020).

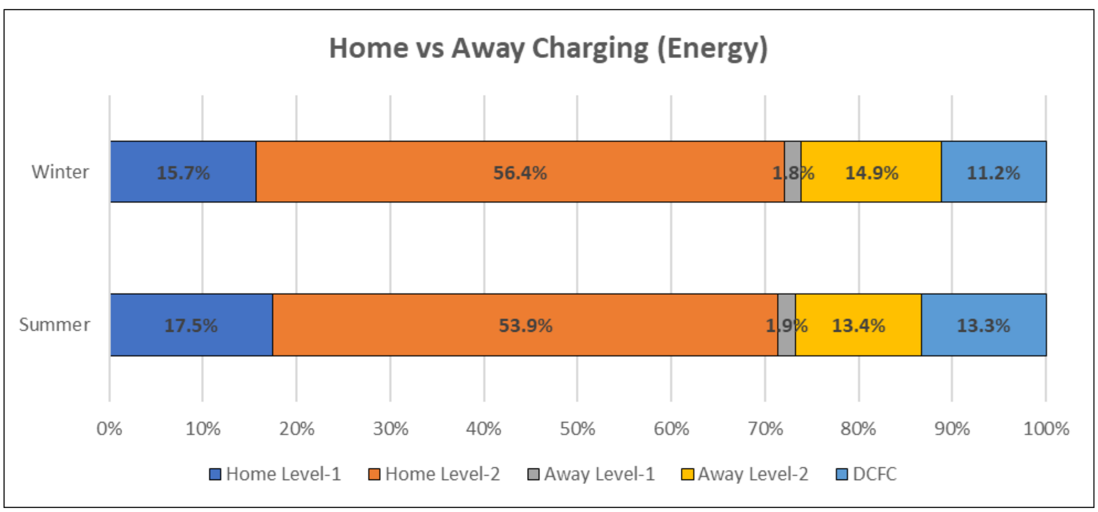


Figure 13 – Home vs. Away Charging by Type – Southern U.S.
Source: (FleetCarma, 2020)

2.3. Operating Costs

Alternative fuel vehicles can often provide operating costs savings due to lower fuel cost and lower maintenance costs. Electric vehicles require less maintenance since they have fewer moving parts than conventional vehicles. While internal combustion engines have hundreds of moving parts, an electric motor has only one moving part, the shaft, rotated by an electric magnet. Additionally, while conventional vehicles use multi-speed transmissions, EVs often have no gearboxes and use only one lowering gear ratio.

Based on the current fuel prices in Florida, a light-duty battery-electric vehicle operating in Tampa Bay is expected to demonstrate 12.0 percent lower maintenance and repair costs and 50.0 percent lower fuel cost over the life of the vehicle, compared to a similar gasoline vehicle. A light-duty PHEV in Tampa Bay is expected to provide a 5.0 percent lower lifetime repair and maintenance cost and 33.0 percent lower lifetime fuel cost, compared to similar gasoline-powered vehicle (AFLEET, 2018).

Due to the higher acquisition cost of EVs and PHEVs, their total cost of ownership still remains higher than regular vehicles. However, the total cost of ownership of EVs and PHEVs has been decreasing dramatically over the past few years. As battery prices continue to fall and more government incentives/rebates are implemented, EVs/PHEVs are expected to reach parity in the total cost of ownership with gasoline vehicles in the near future.

2.4. Conservation Program

Public utility companies across the U.S. often implement various energy conservation programs aimed at encouraging their customers to conserve energy. Such programs come in different shapes and forms and promote residential upgrades, installation of energy-efficient equipment, materials and insulation, as well as various incentives to residential and business customers. Tampa Electric Company (TECO) currently offers 12 energy-efficiency programs for residential customers and 19 programs for business customers helping them to reduce energy consumption and save money on energy costs. TECO programs for residential customers include energy audits to identify energy waste, installation of high-efficiency heating and cooling systems, encouraging ceiling and exterior wall insulation, repairing and sealing leaking air ducts, HVAC maintenance and motor replacement, offering variable electricity rates to encourage off-peak consumption, and other programs.

An electric vehicle rebate has a potential to be integrated into TECO conservation program if combined with time of use and/or vehicle-to-grid (V2G) capabilities that would encourage customers to change their usage behavior and distribute the consumption of electricity more evenly. While such a program might not be able to reduce the overall energy use, it has the potential to shift demand from peak hours to off-peak when excess generating capacity is available and energy costs are generally lower. This can benefit both the utility company, as well as electric customers, including the ones that do not own EVs.

2.5. Benefits of EVs to utility company

With the increased market penetration rates of electric drive technologies, especially in the light-duty sector, electric utilities can realize significant benefits that can range from reduction in GHG emissions to higher electricity sales, grid resilience and management of peak demand.

Specifically, potential benefits of having higher number of EV/PHEV in utility's service territory typically include possible reduction in GHG emissions, additional electricity sales, balancing the grid through off-peak charging, more efficient use of existing generating capacity, avoiding expensive grid upgrades through potential load control, building grid resilience through vehicle-to-grid (V2G) technologies, integrating renewable power sources, and other potential benefits. Utilities may have differences in the local markets and regulation environment that may limit their ability to take advantage of some of these benefits. The above potential benefits of EVs to the utility companies are discussed in more detail below.

2.5.1 Reduction in GHG emissions

Wider use of EVs could result in significant reductions in GHG emissions. Electric vehicles today produce approximately 50 percent lower lifetime carbon emissions compared to gasoline vehicles. As electricity sources shift away from coal towards natural gas and renewable sources, the emissions advantage of EVs will continue тo increase, despite improvements in emissions and efficiency of the new gasoline vehicles.

The declining trend of the U.S. grid emissions per kilowatt-hour of electricity produced, that had been observed in the past, is expected to continue in the future. From 2003 to 2013, CO_2 emission intensity of the U.S. electric grid decreased by 15 percent, SO_2 emission intensity decreased by 70 percent and NOx emission intensity decreased by 50 percent. At the same time, electricity generation increased by 6 percent during the same period. The study by the Electric Power Research Institute (EPRI) and Natural Resources Defense Council (NRDC) forecasts that by 2050, plug-in electric vehicles can produce up to 70 percent fewer lifetime GHG emissions than comparable gasoline vehicles with 48 MPG fuel efficiency (Alexander et al., 2015).

Encouraging transportation technologies with lower environmental impact may put utilities in positive light with customers, regulators and community stakeholders, and can potentially benefit them in the long run.

2.5.2 More energy sales

Over the past two decades, utilities across the U.S., as well as in Florida, have seen considerable slowdown in electricity sales growth rates. In 2017, sales of electricity to ultimate customers in the U.S. was down 1 percent compared to 2016, with the largest decline observed in the residential sector (2.3 percent decline compared to 2016).

In Florida, sales of electricity grew by a total of 0.9 percent from 2007 through 2017, with the residential sector growing 3.1 percent over the same period. This is a significant reduction in electricity consumption from the decade before. Over the period from 1997 through 2007, total electricity consumption in Florida increased by 32.0 percent, while the consumption in the residential sector grew by 34.1 percent over the same period. Electricity consumption is also projected to remain flat in the next decade due to continued improvements in energy efficiency and higher reliance of utility customers on solar energy generation (EIA, 2018a). This presents challenges for utility companies.

EVs offer an opportunity for utility companies to increase electricity sales in the long run. A study by the Idaho National Laboratory (INL) estimates that, based on the current EV driving profile, an average EV/PHEV consumes approximately 261 kWh of electricity per month

(Salisbury and Toor, 2016). This implies that an EV can increase an average U.S. household's electricity demand by about 30 percent, or 24 percent for an average Florida household (EIA, 2018b).

This new source of revenue may be very important for utilities to maintain their profitability and growth. Potential business models can include selling energy for charging EVs at their residences and/or managing public charging stations. Some utilities even consider leasing electric cars to their customers as a service, and combining energy use and car rental into one bill.

However, utilities need to manage this additional potential demand wisely in order to avoid overloading the grid. Some utilities offer time-of-use varying electric rates that encourage EV owners to charge their cars during off-peak times. This helps utilities to manage peak demand and shift some of the demand to off-peak when the utility has underutilized generating capacity. For example, San Diego Gas & Electric company managed charging pilot program offers EV owners lower rates to charge their vehicles at the time when the company has excess capacity and electricity supply is cheap (Schmidt, 2018).

A 2015 California Electric Transportation Coalition study assessing net benefit of the California's zero emission vehicle program found that California utility customers can benefit from increased adoption of electric vehicles in the form of lower electricity rates for all customers. The study estimated that the net revenue to the utility companies associated with EVs over the life of the vehicle ranged from $2,788 to $9,800, depending on the residential rate structure used (tiered rates vs. TOU rates). The study concluded, that at least part of these net revenues, received by the utilities from EV charging, can be shared with all utility customers in the form of reduced electric rates (Ryan and Lavin, 2015).

2.5.3 More efficient use of utility assets during off-peak

In order to meet peak load demand, that occurs only at certain times of day, and seasonally (typically in the summer), utilities have significant amounts of generating capacity that is typically underutilized during other times, especially during early morning or late night hours. For some utilities, peak demand can be more than double the average demand over the year, meaning that more than half of utility's generating capacity can be underutilized during off-peak periods. Utility load factor, measured as the ratio of average electric demand to utility's peak demand, shows the magnitude of utility's underutilized capacity during off-peak that may be used more efficiently by employing time of use incentives.

Underutilized capacity is a burden for the utility because it costs extra to maintain that capacity that is used only during short period of peaks. Extra capital costs of this capacity are recovered through higher electricity rates paid by all utility customers. When excess generating capacity is used more frequently (during off-peak), capital costs are spread over more electric production, reducing the cost of electricity. Therefore, more off-peak charging by electric vehicles allows to utilize excess generating capacity more efficiently and can help reduce electricity rates for all customers. Consequently, utility companies can justify offering favorable electric rates to EV owners to charge during off-peak since this can benefit all rate-payers, even the ones that do not own an EV. Additionally, higher utility payments from EV owners can help cover a larger share of grid costs, lowering the rates for everybody else.

However, the benefits depends heavily on the ability of utility companies to incentivize EV owners to charge during off-peak periods, when demand is low, to make better use of the existing utility assets. If, on the other hand, EV owners decide to charge their EVs in late afternoon after coming home from work, this could exacerbate peak demand issues and put upward pressure on the rates.

Utilities can incentivize EV owners to charge their vehicles during off-peak periods by using time-of-use (TOU) electric rates. Since 80 percent of EV charging occurs at the vehicle owners' residence, utility companies can focus mainly on the residential sector to address peak demand issues resulting from EV charging (Farrell, 2014). Time-of-use pricing system can work well due to the ability of the EV owners to program their EVs to start charging when electricity prices drop.

Another approach may involve informing customers in real time when electricity prices drop, encouraging them to charge their EVs when supply is abundant and cheap. For example, under San Diego Gas & Electric managed charging program, EV owners are informed via mobile apps throughout the day about the planned changes in charging price so they could take advantage of lower energy cost and help the utility company manage its peak demand. In either case, though, the off peak electric prices have to be significantly lower for EV owners to switch their charging behavior. The research by Idaho National Laboratory determined that when the peak electric rate is six times higher than the off-peak rate, customers would be expected to charge their vehicles during off-peak periods 90 percent of the time (INL, 2015a). Across the country, electricity demand for EV charging peaks at midnight, indicating that EV owners are taking advantage of off-peak charging (Schey et al., 2012).

2.5.4 Avoid expensive upgrades

Managing peak demand with incentivizing off-peak EV charging can eliminate the need for investing in additional generating capacity that would be required to meet unmitigated demand peak. It is significantly cheaper for utility companies to shift demand to off-peak instead of building more capacity to accommodate the peak. Unlike other electric needs of residential customers, EV charging can be easily planned and scheduled for the time of day when utility companies have excess generating capacity.

Managed charging is extremely important. Poorly managed EV charging can result in overloading of transformers threatening the stability of the grid. A study commissioned by Sacramento Municipal Utility District estimates that unmanaged charging, coupled with high penetration rate of EVs, will require the utility to replace/upgrade 17 percent of its transformers due to overloading. This is approximately 12,000 transformers, at the cost of over 7,000 per transformer (Myers, 2017). These expenses can be avoided by effectively incentivizing EV owners to charge during off-peak with a combination of time-of-use variable electric rates and/or load control programs.

Integrating additional electric demand from EVs into the grid poses both challenges and opportunities for utility companies. Given the limited quantities of EVs, they are not expected to affect the grid at the system level in the near future. However, the impact of unmanaged charging on peak demand can be rather significant at the distribution-feeder level.

A 2013 analysis prepared for the International Council on Clean Transportation (ICCT) concluded that, if 5 percent of all vehicles in the U.S. charged at 4 kW rate (Level-2), or one percent of all vehicles charged at 20 kW rate (Level-3), EV charging load would stay within 10 percent of maximum potential peak load, which is typically within utility reserve margin (ICCT, 2013).

At the same time, uncontrolled EV charging may cause issues at the distribution-system level. Since distribution transformers generally serve 4-10 households and one EV uses about 1/3 of the household's annual energy consumption, even a relatively small number of vehicles charging at the same time on the same distribution system could significantly increase peak period loading of the transformer (VEIC, 2013).

A 2016 study by Rocky Mountain Institute that looked at the load profiles of select five states (including California, Hawaii, Texas, New York and Minnesota) and modeled electric vehicle charging demand under various EV adoption scenarios, emphasized the importance of effective electric rate design to achieve optimal electric system load distribution. The model demonstrated, that 23 percent of all vehicles doing uncontrolled charging in Hawaii is projected to increase state's peak load by 9 percent, compared to 1.34 percent increase when charging is managed and optimized. Shifting EV charging load to fill valleys and reduce peaks is capable of creating a more uniform load profile across the entire system. This finding demonstrated that controlled charging can help optimize the use of utility resources, reduce the need to invest in new peak generation capacity and integrate more renewable sources (wind and solar) (Fitzgerald et al., 2016).

2.5.5 Load control

Grid load can be controlled by a combination of infrastructure and communication signals send directly to a vehicle or through a charger to control charging event. These communication signals enable utility or a third party to increase or reduce the rate of charging, or completely stop charging to accommodate the needs of the grid. Charging loads can be controlled directly by the utilities, grid operators or charging equipment, based on the parameters programmed by the customer. This approach would allow proper charging management of distributed resources to optimize grid load.

Many EV owners are open to such load control programs as long as they can ensure that the vehicle will finish charging at a specified time. This is sometimes called intelligent, smart or adaptive charging and allows utilities to remotely control vehicle charging to achieve various goals of the grid, including emergency load reduction, capacity management, peak distribution or absorption of excess generation from renewable sources during certain time of day.

However, managing EV charging load through direct utility control will require utilities, EVs and charging equipment to implement bidirectional communication systems. The deployment of such systems and smart meters has been rather slow (Fitzgerald et al., 2016).

2.5.6 Vehicle-to-Grid (V2G)

Going a step further than regular managed charging, vehicle-to-grid (V2G) technology allows to integrate plugged-in EVs into the electrical grid as distributed storage sources with the capability to pull energy from EV batteries into the grid. While V2G technology has been tested in few pilot demonstrations and proved to be viable, there are still some unresolved technical and regulatory obstacles that prevent this technology from wide-spread adoption. One of the major obstacles includes faster battery degradation of the EVs actively employed for V2G communication. Automakers are not willing to cover the additional cycle wear of the batteries involved in V2G operations of EVs. Therefore, consumers will need to be adequately reimbursed by the utility companies for allowing their EVs to be employed in V2G operations for the purpose of providing stability to the electrical grid.

While these obstacles have not been fully addressed yet, V2G and other managed charging approaches present opportunities for utilities and their customers for smarter use of EVs that can benefit both electric customers and the grid. In 2017, the average annual electric consumption from EVs represented approximately one terawatt-hour. Annual EV electric consumption is projected to increase to 33 terawatt-hours by 2025 (BNEF, 2016). Given this projected growth in electric demand from EVs, more utilities are considering implementing various forms of managed charging programs as the low-cost solutions to accommodating additional demand.

2.5.7 Integration of renewable sources

Renewable power generation sources, such as solar and wind, typically produce electricity during times when demand may be relatively low. Solar farms produce most of the power during the day, while wind tend to peak overnight. This generation, especially wind power, can often exceed demand, resulting in wasted energy. Using managed EV charging can shift electric demand towards the times when renewable sources are most prevalent, taking the full advantage of the renewable energy. For example, smart workplace charging can increase EV charging during the day to meet peak solar generation. The availability of managed charging makes it easier to justify the addition of renewable sources since the utility company can shift the demand from EV charging throughout the day to match the timing of renewable generation and maximize its efficiency.

Additionally, with V2G capabilities, electric vehicles can be used to store energy produced by renewable sources (solar or wind) and release it back to the grid during peak demand times, increasing the utility’s reliance on “cleaner” energy. Finally, being environmentally conscious, EV buyers may be more likely to support the integration of renewable sources into power generation by the utility companies and may be willing to pay for various “green power” programs that improve environmental profile of electricity consumed by their EVs.
There may also be other ways in which electric vehicles and the power grid can support each other.

2.6. Challenges and barriers

Any new technology brings not only potential benefits, but also different obstacles that can hinder technology implementation. Widespread adoption of plug-in electric vehicle technologies can cause challenges to electric utility companies, related to potential increase in peak demand, unmanaged charging, grid overloading, costs of fast charging and other obstacles.

The larger number of EVs enter the market, the more crucial becomes the ability of utility companies to influence when these vehicles are charged. While varying time of use rates have shown their effectiveness in managing electric demand in small-scale demonstrations, there is no guarantee that these programs will be as successful when the numbers of EVs on the market increases significantly. Even if a small percentage of EV owners prove to be not very responsive to time-of-use incentive programs, this may create challenges in meeting peak demand for the utilities, given a large total number of EVs on the market.

The majority of EVs currently charge at home with Level-1 outlets. But, as longer-range EVs become more common, a higher percentage of them may need to be charged with higher voltage either at workplace or at public charging sites. This may also cause DC fast charging to rise during peak times (although, there is no definitive conclusion if that will happen). Utilities may need to apply significantly higher rates during peak times and impose substantial demand charges on fast charging locations do discourage peak charging, or invest in local storage or generating capacity to accommodate potential increases in peak electric demand from more EVs.

DCFC can use up to 400 kW of electricity and can cause a sharp spike in otherwise low utilization profile of the station (Trabish, 2017). Therefore, DCFC owners often face high demand charges, that make operating these stations uneconomical. In order to be economical, many DCFCs currently require some form of subsidies and will likely require them in the near future. Additionally, as more DC fast charging stations are installed, especially when concentrated in high-usage charging areas in the city core or along heavily-travelled corridors, local distribution lines may experience significant spikes in demand.

Increase in the total number of EVs on the market may not result in an even spatial distribution of the vehicles. Some areas may see more EVs per capita than others. This clustering of EVs in some sections of the grid may cause an overload of transformers due to on-peak charging, multiple off-peak charging, or from inadequate design of transformers that were initially assumed to be underused at night. The application of time-of-use rates can help mitigate clustering problem up to a certain degree. But eventually, some transformers will have to be upgraded to accommodate uneven growth in the EV market (INL, 2005b).

Based on the experience from California, the need for electric system upgrades has been rare, at least at the early stages of EV adoption. However, as more EVs enter the market, especially long-range EVs with large batteries requiring less frequent, but faster charging, the increase in electric demand may require distribution-level upgrades to the grid. A 2015 U.K. pilot project studying the impact of EV clustering demonstrated that, if 40 percent of customers owned EVs, about one third of all low-voltage feeders would have to be upgraded to accommodate EV charging demand, assuming 3.5 kW charging. Faster charging rates (newer EVs can charge at 20 kW rate or faster) would require more upgrades to the electric system (Saunders et al., 2015).

A simulation study modeling potential impact of EVs on electric grid in New England, showed that, if 5 percent of all vehicles in New England were EVs and charging was not managed, this would result in a 3.5 percent increase in peak demand. At the same time, if 25 percent of all cars in New England were EVs and were charged in uncontrolled manner, peak demand could increase by up to 19 percent, requiring significant investment in new generation, transmission and distribution capacity. The same study also concluded, that the use of managed charging to spread demand over evening hours or shift to off-peak periods could cut peak demand increase to 6 percent or eliminate the increase altogether (Fitzgerald et al., 2016).

Rapid growth in solar generation in some markets (including Florida) can be associated with a particular challenge for grid operators known as a “duck curve”, that reflects timing imbalance in power production over the course of the day between peak demand and peak solar generation. Solar generation typically peaks during early afternoon hours, lowering utility’s net load during that time. At the same time, in many markets, peak demand occurs after sunset when solar generation is unavailable or significantly reduced.

In locations with substantial amount of solar capacity, power generation by the utility company is significantly reduced during late morning and early afternoon (when solar generation is peaked), followed by a need to significantly increase generation from sources other than solar after sunset when solar generation tapers off and peak demand occurs. This produces a power production graph that resembles a silhouette of a duck. In the absence of energy storage, utility companies must rapidly increase power output around sunset to compensate for reduced solar generation and meet peak demand.

If not managed, EVs charging in late afternoon (when EV owners plug in their cars after arriving home from work) could aggravate the duck curve challenge. To minimize duck curve phenomenon, utility companies can employ time-of-use rates to discourage home charging in late afternoon and encourage workplace charging during the early afternoon hours to match peak solar generation timing.

Utilities with large wind generation capacity can face a challenge of energy generation exceeding demand at night time when wind generation typically peaks. Incentivizing EV owners to charge at night during peak production of wind energy can ensure that there is no wasted wind generation.

2.7. Price mechanisms employed by utility companies for EVs

2.7.1 Time-of-use rates

Time-of-use (TOU) electricity rates are rates that change throughout set periods of the day to reflect varying costs of providing electricity. The cost of generating and delivering additional kilowatt-hour of electricity is higher during the period of peak demand when a utility company has little or no excess capacity. During the off-peak periods, utilities typically have underutilized capacity and providing additional kWh of electricity costs significantly less. TOU rates reflect these fluctuations in costs by time of day and are also used to incentivize shifting the demand to off-peak periods.

While TOU rates have existed in some markets for quite a while, given the higher adoption of electric vehicles in the past few years, utilities across the country are staring to specifically target households with EVs. Residential EV charging can produce a noticeable increase in the household’s electric demand. For example, a Level-2 home charger can produce up to seven kilowatts of demand and can exceed the maximum demand of a typical home. Faster charging technologies, that are becoming more and more available in public places, can present an even larger challenge for the utilities. A DC fast charger can draw as much as 120 kilowatts of electric demand (Hledik et al., 2019).

If not managed properly, the new demand from EVs could put a significant strain on the grid, especially if EVs are geographically clustered. Utilities see TOU rates as an effective tool to incentivize demand for electricity during off-peak hours when there is significant underutilized capacity, thus, moving the demand away from the peak hours when generating capacity is heavily utilized. Multiple case studies demonstrated that well-designed TOU rates can be very effective at influencing EV charging behavior, shifting charging demand to off-peak hours. TOU rates also provide benefits to EV owners that can benefit from less expensive electricity prices during off-peak periods.

Typically, the larger the differential between peak and off-peak hours, the more effective TOU rate is at shifting EV charging demand. One notable example of an effective TOU rate is from Nevada Energy that offers rates that may vary from 42.8 cents/kWh during summer peak (1 pm to 6 pm) to 6.1 cents/kWh during summer off-peak hours (10 pm to 6 am) (NV Energy, 2019).

An experimental rate study by Idaho National Laboratory (INL) and San Diego Gas and Electric (SDG&E) found that while drivers connected EVs immediately after coming home, they typically delayed charging until super-off-peak period with lowest electric prices. The study, involving different rate schedules, also concluded that customers with larger price differential between peak and off-peak, typically, charged their vehicles during super off-peak hours, while participants on other two rate schedules gradually shifted towards super off-peak during a learning phase in the first few months of the study. This finding emphasized the importance of influencing customers' charging behavior in the first few months of EV ownership. Finally, simulations, performed as part of the study, suggested that a price ratio of 6 to 1 between peak and super off-peak periods was sufficient to shift 90 percent of charging to super off-peak, and that further increasing electric rate differential would have minimal effect on charging behavior (INL, 2015a).

Power companies across the country use different approaches with implementing TOU rate programs. Some offer TOU rates only to EV owners while others offer TOU rates to all residential customers. Some EV TOU rate programs require the installation of a separate meter for EV charging, while others offer TOU rates for the entire house employing a single household meter. There are currently 30 utilities, located in 16 states, that offer special electric rates to EV owners. Eighteen of these utility companies are investor-owned, nine are member-owned cooperatives and three are municipally-owned. Five of the 30 utilities offering special rates to EV owners also allow TOU rates for all their residential customers (regardless if they own an EV). There are currently no utilities in the state of Florida that offer special electric rates to EVs. More details about EV-specific rates offered by utility companies across the country are provided in Table A-1 in the Appendix.

2.7.2 Dynamic pricing

Higher levels of EV penetration or higher density of EVs on the electric grid may require more precise management of charging than TOU rates can provide in order to avoid negative impacts on the local distribution system. Under dynamic pricing, electric rates can vary more frequently than TOU rates (e.g. hourly or with higher frequency) to more accurately reflect real-time cost of electricity generation and delivery. The effectiveness of such program will depend on the responsiveness of EV owners to dynamic changes in electricity prices throughout the day. San Diego Gas and Electric is in the process of implementing a pilot program that involves posting dynamic electric rates for EV charging for the next day to give customers the ability to plan their charging (Fitzgerald et al., 2016).

However, the complexity of dynamic pricing may limit the ability of customers to react to price changes. The use of smart meters and automatic charge controllers, that can be programmed to adjust charging based on real-time price signals from the utility, can help to address this issue. Dynamic pricing arrangements for EV charging are still in the testing phase and their real-life application has been rather limited.

2.7.3 Demand charges

In addition to per-kWh charge, some commercial customers may also be subject to demand charges that are based on the highest level of electricity demand over 15-minute period during a billing cycle. So, even if an electric customer has a brief spike in electric consumption one day of the month but a much lower consumption level throughout the rest of the billing period, he will still be charged based on the highest per-kilowatt demand rate for the entire month (Salisbury and Toor, 2016). This may present challenges for public charging station owners, especially DC fast charging stations, because they can create very high level of peak demand in the short period of time. In fact, demand charges can make operating DC fast charging stations economically unfeasible.

Electric utilities may provide electric rates for commercial customers that do not impose demand charges. But when demand charges are imposed, they are often rather significant. A study by the U.S. DOE states that an EVSE site can incur monthly demand charges in excess of $2,000 (DOE 2015). Another research also concluded that demand charges can increase a business's utility bill by as much as four times (INL, 2015c). In certain cases, however, demand charges can be avoided by charging during off-peak periods, staggering vehicle charging during high consumption periods or employing other approaches to manage charging at the site.

Hawaiian Electric Company offers special rates for commercial customers with EVSE that eliminate or mitigate demand charges. While there may be other examples of utility companies waiving demand charges to commercial EVSE providers, no such examples were found in Florida.

2.7.4 Electric Transit

As more transit agencies shift to battery-electric buses, utilities may experience challenges in meeting additional electric demand. Currently, this is not a pressing issue since most electric bus fleets are rather small. However, as the number of electric buses in operation increases, utilities may need to invest in grid upgrades as well as aggressively encourage managed charging. This can be especially relevant in the case of on-route charging that usually occurs during the day (e.g. electric demand peak period).

Transit agencies, operating electric buses are also expected to face challenges related with vehicle charging. On-route charging in the midst of operation is likely to incur significant demand charges, that may reduce or eliminate any operational savings that electric buses can provide to the agencies. Transit agencies, planning to switch large percentage of their fleets to electric buses, need to plan ahead, work with the utility company to negotiate a rate plan that minimizes or eliminates demand charges and/or consider managing vehicle charging.

2.7.5 Second EV meter vs. whole-house rates

Customers are likely to benefit the most from special EV rates when they can meter EV charging separately from their household electric use. This can allow EV owners to fully take advantage of lower off-peak electricity costs for charging their vehicles without having their entire electricity consumption (which can be difficult to adjust throughout the day) subject to TOU rates. However, the amount of potential benefit will also depend on who pays for purchasing and installing a second meter. The cost of purchasing and installing a separate meter for EV charging may be prohibitive to certain drivers or outweigh the benefits to the consumer.

Five of the 24 utilities in the country that offer special EV rates, require a separate meter to be installed, while 19 utilities either apply TOU EV rate to the entire house or allows the customer to choose the metering approach (AFDC, 2019b). It is a good practice by the utilities to offer both whole-house rates and separate-meter TOU rates for EV charging that allows the customers to decide which plan is more beneficial for them. Utilities can also decide to share the costs associated with the separate EV meter with the customer (e.g. utility pays for the meter and installation while the customer is responsible for necessary upgrades to the electrical system, or other arrangements). Additionally, some EVSE equipment contains embedded meters enabling utilities to bill EV electric usage separately using subtractive billing (Salisbury and Toor, 2016).

2.7.6 Cost Recovery and Rate-basing

Rate-basing allow utilities to recover the cost of investment in EV infrastructure or EV incentives by charging a fee to all utility customers. Recovering a portion of infrastructure cost through customer rates helps reduce barriers for EV adoption. Regulated utilities need to get an approval from their state utility commission to include EV subsidies into the rate by demonstrating the benefit to all customers (even the ones that will not be using EVs). At least two utilities in the U.S. – Puget Sound Energy (PSE) and Hawaiian Electric Company (HECO) – have been successful in receiving an approval from their state utility commissions to recover the cost of EV incentive programs through electric rates paid by all customers.

PSE estimated that, over their 15-year life, an EV would generate a net benefit of $770 to the utility through additional electricity sales. PSE has originally asked for an incentive of $600 for Level-2 chargers installed by customers, but Washington utilities commission reduced the incentive to $500 per charger and limited the incentive to the first 5,000 applicants (Salisbury and Toor, 2016).

Recognizing potential benefits to all utility customers from increased number of EVs, regulators in the West coast states considered allowing utilities to fund expenditures related to EV charging infrastructure with conservation or renewable energy funds, or by absorbing these costs into electric rates to all customers. For example, Washington state law allows utilities to subsidize EV charging infrastructure up to a maximum impact to non-participants of 0.25% increase in electricity rate (Fitzgerald et al., 2016).

Utilities in different states proposed to provide rebates for EVSE or lower rates for EV charging arguing that incremental revenue will exceed incremental costs and will benefit all customers. In some cases, utilities treat EV/EVSE incentives as economic development rates offered in some states to new or expanded industrial sites in anticipation of further development and increased customer/revenue base (Fitzgerald et al., 2016).

3. Designing EV rebate

3.1. Things to consider while designing an incentive/rebate

Nissan claims that states with an EV incentive, on average, sell twice as many EVs compared to states without an incentive, and states with two or more incentives typically sell three times as many EVs (Frades, 2014). While utilities cannot provide tax credits, such state-provided incentives are extremely cost-effective to utilities. Since EVs typically have higher acquisition costs, compared to conventional vehicles, incentives that reduce up-front EV costs typically have the highest practical value to consumers. Cash rebate at the time of the purchase is the most effective financial incentive with a significantly higher value than a tax credit (Gallagher and Muehlegger, 2011). While point-of-sale rebates are typically the most favored by consumers, they also involve careful coordination with automotive dealers and require the funds to be available in advance. Mail-in rebates, on the other hand, allows utilities to avoid working with dealers, but may also be less effective than point-of-sale rebates as consumers may discount the value of the rebate, especially if there is a significant time lag between vehicle purchase and receiving the rebate amount.

A mail-in EV rebate offered by the utility can provide additional benefits to the utility company in the form of establishing reliable communication channel with the new EV owner. Utilities often have flexibility to offer the full amount of rebate either up-front or take it off future electric bills of the customer. While the effectiveness of providing the rebate through future electric bills is lower than providing cash up-front, the utility does not have to allocate all funds for the rebate in advance of the program (CalETC, 2016).

Evaluating the data for vehicle sales in California suggests that new vehicle elasticity rate is -3.6, implying that a one percent reduction in the price of the vehicle results in a 3.6 percent increase in vehicle sales. California EV mail-in rebate of $2,500 reduced the average price of EVs after federal tax credit by 9 percent and, therefore, should have been responsible for increasing EV sales by over 30 percent. A 2012 evaluation of the impact of federal incentive program on electric vehicle sales by the U.S. Congressional Budget Office estimated price elasticity of EVs in the range of -1.6 to -2.0 (Lawrence, 2015).

While consumers value the incentives that lower the purchase price of EVs more than incentives reducing operating costs, incentives that reduce operating costs are often preferred by utility companies. An incentive that is paid over time during the operation of the vehicle does not require allocation of incentive funds up-front, and can motivate EV owners to keep an EV within utility service territory longer rather than moving into a different area.

Time-of-use electric rates for EVs are a good example of incentive that lowers operating costs, lowering the cost of electricity to EV owners and also encouraging them to charge during off-peak period, which is typically beneficial to utility companies. TOU EV rates may also include a monitoring provision, allowing the utility to monitor electric usage, plan growth, implement load control and communicate better with EV customers.

While early adopters of electric vehicles were not very concerned about electricity rates to charge their EVs, 85 percent of later adopters considered electricity rates as part of their buying decision (Dubin et al., 2011). Additionally, a multi-state survey of EV owners found that 22 percent would not have purchased their EVs without a residential EVSE subsidy, while additional 39 percent stated that EVSE subsidy was a very important part of their purchase decision (INL, 2015a).

The above findings emphasize the importance of both rebates that reduce purchase price of EVs, as well as the incentives that lower vehicle operating costs, including lower electric rates to EVs and financial incentives to purchase/install charging infrastructure.

3.2. Best Practices in AFV Incentives

Alternative fuel vehicle/technology incentives are designed to change established behavior and motivate individuals and organizations to perform actions desirable to the entity offering the incentive and the public. While there are multiple reasons that may contribute to the success or failure of an incentive (and some of them may be unrelated to the incentive itself), the incentive program design is an important consideration.

Previous research and anecdotal evidence indicate that successful alternative fuel/technology incentives typically have the following seven characteristics (Brown and Breckenridge, 2001):

1. Focused on a specific goal
2. Incentive amount is large enough to entice investment in AFV
3. Grant-based
4. Easy for a potential applicant to use and for the provider to administer
5. Address the development of fueling infrastructure in addition to acquiring AFV
6. Include a cap or phase-out provision
7. Monitoring the program’s success or failure

Focused on a specific goal
Whether it is the state of a utility company, incentive provider should clearly identify the goals of the program and design the incentive in the best way to meet those goals. For most utilities, the goal is to increase the number of EVs in their service territory and ultimately increase electricity sales. A proper EV incentive encourages participants to maximize their electric driving rather than simply promotes ownership of EV/PHEV (e.g. a customer may own a EV/PHEV but do most of the driving on gasoline).

Incentive amount is large enough
Successful incentives should be large enough to offset much or all of the incremental cost of alternative fuel technologies/vehicles. Aside from a few enthusiasts, most individuals and businesses do not want to pay a higher price just to test new alternative fuel technologies. Even potential tangible benefits of the new technology, such as reduction in operation and maintenance costs, are not always able to convince buyers to pay the higher up-front acquisition cost. Theoretical studies of consumer behavior, as well as the survey of fleet managers, support this conclusion.

Smaller incentives such as fuel price discount and sales tax exemption are typically ineffective unless packaged with bigger incentives. Except in rare cases, fuel price discount or sales tax reduction (or even exemption) typically yield insignificant savings and fail to provide a strong enough incentive. At the same time, offering incentives that are too large is also not recommended. There is rarely a good reason to offer an incentive that covers more than the incremental cost of the new technology.

Grant-based
The most effective incentives are often grants or rebates. Previous research found that consumers more readily take advantage of grant and rebate programs than tax-based incentives, and the findings indicate a clear preference for this incentive type. Grants/rebates offer immediate benefits and certainty, since customers know how much the grant or rebate is worth. Additionally, customers value point-of-sale rebates higher than the ones that they need to apply for later.

An example of an ineffective incentive is Florida's Electric Vehicle Supply Equipment (EVSE) financing program, which does not provide any financial incentive per se. Instead, the program allows property owners to apply for funding with local jurisdictions for qualified EVSE improvements, and allows local jurisdictions to impose tax assessments to finance those improvements. Without a dedicated source to finance the program, the incentive is unlikely to noticeably affect EVSE installations. A direct grant or a rebate, covering a portion or the entire amount of the incremental cost of EVSE installation, would more likely achieve the program goals.

Easy to use and administer
Successful incentives typically are easy to apply for and do not require burdensome reporting, which often discourages potential applicants. In addition, a good incentive should dedicate adequate resources (including financial support) for marketing and administering the program. California's South Coast Air Quality Management District offers a successful, easy-to-use incentive that provides a rebate for acquiring AF vehicles and is administered through auto manufacturers in cooperation with auto dealers. The dealer advertises the vehicle price including the incentive, passes the invoice to the manufacturer, the manufacturer immediately reimburses the dealer, and then applies for the incentive. This design keeps the incentive in the background for the consumer, yet provides an immediate benefit. While utility companies may not always be able to achieve similar level of application simplicity, it is recommended to minimize the burden for the customer to apply to an incentive as much as possible.

Focused on fueling infrastructure in addition to AFV
Infrastructure incentives are critical to the success of any AFV program. Previous consumer opinion studies and fleet manager surveys concluded that the availability of fueling infrastructure significantly impacts the decision of individuals and fleets to acquire AFVs. Similarly, many industry participants agree that the lack of fueling infrastructure is a critical barrier to the growth of AFVs. In addition to EV incentives, utilities are recommended to provide charging infrastructure incentives to facilitate the development of EV market.

A cap or phase-out provision
Utilities should be aware of the potential fiscal impact of incentives and make provisions to cap their total liability under the program. Policy makers need to balance the cost and benefits of incentive programs, keeping in mind that achieving a high benefit/cost ratio may be unattainable and impractical given the existing constraints.

Since the goal of an incentive program is to temporarily support the rollout of new technology until it becomes competitive, incentive programs often include a phase-out provision, allowing for declining support as time passes or as the market for the technology matures. It is generally recommended that the entities implementing incentive programs commit and release funding in a way that ensures program continuity for a specified period of time (e.g. a certain number of years). This allows local markets to develop and stabilize with relatively steady funding. Utilities may also consider establishing a gradually declining funding level, zeroing out after certain period of time or after reaching a certain number of program subscribers. Such an approach allows to set the maximum program cost and to correct annual payments in future years if the initial incentive level was too high.

Monitoring the program
It is a good practice to monitor the progress of an incentive program, evaluate its success in achieving the stated goals, and make adjustments to improve program performance. A good incentive program should be designed with provisions for collecting data to monitor its success, and should have the tools to make adjustments to program funding and incentive structure.

3.3. Overview of utility EV incentives nationwide

EV Infrastructure investment

Various utility companies in California developed pilot programs to help accelerate EV adoption and EV charging infrastructure deployment, using different cost recovery models. San Diego Gas and Electric recover the costs of "Power Your Drive" program, providing for the installation of low-cost EVSE, through general rates from all customers and through fees to participating EVSE site hosts. The company estimates that this program will increase consumer electric bill by 18 cents during the first year (0.02%) and by the $2.75 per year by the end of three-year pilot period. Southern California Edison's "Charge Ready Pilot" program, providing for utility service and make-ready installations of EVSE at the sites of customer participants, will also be rate-based, increasing an average customer electricity bill 0.1 to 0.3 percent, or $0.001 per kWh (MJB&A, 2017).

Utility-provided EV and EVSE incentives in the U.S.

Table A-2 in the Appendix provides a list and a brief description of all the incentives offered by utility companies across the U.S. for plug-in electric vehicles (including PHEV and EV) and electric vehicle charging infrastructure.

Forty three utility companies operating in 25 states currently offer various rebates covering the cost of equipment, installation or site preparation for residential or commercial EVSE. The typical rebate amount for residential Level-2 EVSE ranges from $100 to $1,000, with an average rebate amount of $471. Additionally, three utilities offer free Level-2 EVSE for residential customers.

The typical utility rebate amount for commercial EVSE installations ranges from $250 to $32,000 for Level-2 stations and from $6,000 to $120,000 for commercial DC fast charging stations. The average utility rebate for commercial Level-2 charging station is $4,069 while the average rebate for commercial DCFC is $43,286. Additionally, two utilities offer free level-2 charger or DCFC to commercial customers, while 2 utility companies offer Level-2 chargers with 50% discount to commercial customers. A more detailed summary of utility-provided EVSE incentives available to residential and commercial customers is provided in Table A-3 in the Appendix.

Sixteen utility companies operating in 10 U.S. states offer rebates to their customers for purchasing or leasing plug-in electric vehicles, including battery-electric vehicles and plug-in hybrids. The terms and mechanisms or EV rebates offered by various utility companies across the country vary, sometimes significantly. While some utilities offer the rebate in the form of electric bill credit, others send the customer a check for the full amount of rebate. Some utilities also offer lower rebates for purchasing or leasing pre-owned plug-in electric vehicles, while others offer larger rebates to customers with lower income.

A review of utility-provided EV rebates in the U.S. shows that a typical EV rebate ranges from \$50 to \$1,000 for plug-in hybrids and from \$50 to 2,500 for battery-electric vehicles. The average utility-provided EV rebate across the country is \$383 for PHEV and \$954 for EV. A more detailed summary of utility-provided EV rebates is presented in Table A-4 in the Appendix.

Utility-provided incentives in Florida

There are currently no state-funded financial incentives for EV or EV charging infrastructure in Florida. Four of the state's utilities offer financial incentives for EVs or EV charging infrastructure. The existing incentives offer free Level-2 of DCFC chargers, or cover the cost of hardware, networking services and warranties to commercial site hosts. Yet, there are little incentives for residential EVSE installations. Only one utility (Kissimmee Utility Authority) offers a rather small incentive (\$100) to residential customers for installing an EV charger. Three Florida utilities provide incentives for purchasing or leasing EVs that range from \$100 to \$1,000. Jacksonville Electric Authority offers, by far, the most generous incentive to EV owners among other Florida utilities, providing customers with \$500 rebate for purchasing or leasing new plug-in electric vehicles with the battery capacity of less than 15 kWh, and \$1,000 rebate for new electric vehicles with larger than 15 kWh battery capacity. Table 4 summarizes EVSE and EV incentives currently offered by Florida utility companies.

Table 4 – EVSE and EV Incentives Provided by Florida Utilities

Utility	EVSE Incentive		EV Incentive	
	Residential	Commercial	PHEV	EV
Brickell Energy		Covers cost of hardware, network service, management service & warranties		
Duke Energy		Free Level-2 or DCFC		
Jacksonville Electric Authority			\$500	\$1,000
Kissimmee Utility Authority	\$100			\$100
Orlando Utility Commission				\$200

Source: AFDC 2019

It is worth noting that EV market conditions are often different for different utilities and continue to evolve. While it is useful to study different EV incentive programs, the experience from different geographic markets and political environments may not always be applied somewhere else without adjustment for local realities. Building a successful EV incentive program often involves trial-and-error approach. Utilities looking to establish EV incentives or specialized EV rate programs may consider implementing a small-scale pilot program that can be adjusted and/or expanded as more data on program utilization and customer response is collected.

3.4. Incremental costs and benefit of EVs

There are multiple studies quantifying potential benefits that managed EV charging can provide to utilities. A number of pilot projects or simulation studies attempt to identify the most effective electric rate structure to ensure that EVs can bring the most benefits to the grid managers. The general consensus in all of these studies is that, widespread EV adoption can benefit all electricity customers that may face lower electric costs, regardless of the type of vehicles they own. Regulated utilities may use these findings to justify rate-basing the costs of providing some of the EV incentives.

For example, a 2015 analysis of electricity rate models, encouraging EVs to charge during off-peak in the state of New York, found that, if half of EVs in the state charged during off-peak, this would result in an average daily statewide load reduction of 276 MW during summer peak hours in 2030. This translates to savings of over $600 per EV that will be realized by New York utilities as a result of reduced generation and infrastructure expenditures (MJB&A, 2015).

A 2019 Duke Energy study estimated the costs and benefits of increased adoption of electric vehicles in Florida through 2050 under different electric vehicle adoption scenarios. The study forecasts, that under moderate EV growth scenario (currently assumed by the U.S. Energy Information Administration), by 2050, electric utility customers in Florida will receive a total cumulative benefit of $2.2 billion in the form of reduced electric bills directly resulting from greater electric vehicle use. Additionally, Florida EV drivers are expected to realize cumulative savings of $9.5 billion by 2050 in the form of reduced vehicle operating costs, or approximately $925 per vehicle per year.

Assuming ten-year life of EV, the average electric vehicle in Florida is projected to increase utility net revenue (net of additional costs incurred to secure additional generating capacity and upgrade distribution system to accommodate growth in EV fleet) by $1,068 in 2030 and by $607 in 2050 over the life of the vehicles, provided that charging is managed (MJB&A, 2019).

Given the forecasted net benefit to the utilities in terms of additional electricity sales from EV charging, the amount of rebate the utility companies can potentially provide in the future to buyers of new EVs can range from $600 to $1,000. Managing EV charging will be critical for the utilities to realize the above benefits from additional EVs in their service territory, and, in turn, to be able to provide a rebate to customers. Therefore, implementing and EV rebate will require some form of charging management, either directly controlled by the utility or implemented through time-of-use rates, or other dynamic price signals, ensuring that EVs are charged during off-peak periods as much as possible.

Conclusions

Electric utilities can realize significant benefits from increased number of EV/PHEV in their service territory, including possible reduction in GHG emissions, additional electricity sales, balancing the grid through off-peak charging, more efficient use of existing generating capacity, avoiding expensive grid upgrades through potential load control, building grid resilience through vehicle-to-grid (V2G) technologies, integrating renewable power sources, and other potential benefits.

While EV market growth presents certain challenges, in general, the case can be made that, combined with managed charging, larger number of EVs can ultimately benefit all utility customers by allowing more efficient utilization of existing utility generating capacity and, thus, lowering electric rates to all customers. This argument is used by some utilities across the country to rate-base the costs of utility-provided incentives for EVs and charging infrastructure.

At least two utilities in the U.S. have been successful in receiving an approval from their state utility commissions to recover the cost of EV incentive programs through electric rates paid by all customers. A utility from Washington state estimated that an EV would generate a net benefit of $770 to the utility through additional electricity sales during the life of the vehicle.

Forty three utility companies operating in 25 states currently offer various rebates for EVSE installation. The average utility-provided rebate amount is $471 for residential Level-2 EVSE, $4,069 for commercial Level-2 charger, and $43,286 for commercial DCFC. Sixteen utility companies operating in 10 U.S. states offer rebates to their customers for purchasing or leasing plug-in electric vehicles. The average utility-provided EV rebate across the country is $383 for PHEV and $954 for EV.

There are currently no state-funded financial incentives for EV or EV charging infrastructure in Florida. Three Florida utilities provide incentives for purchasing or leasing EVs that range from $100 to $1,000. Jacksonville Electric Authority offers, by far, the most generous incentive to EV owners, compared to other Florida utilities, providing customers with $500 rebate for purchasing or leasing PHEV and $1,000 rebate for purchasing or leasing EV.

To maximize the potential benefit of increased EV adoption, utilities may consider combining EV incentives with effective time-of-use electric rates to ensure that additional load from EV charging is shifted to the periods when utility generating capacity is under-utilized.

Finally, since market conditions are different in different markets and continue to evolve, the experience of other utilities with incentive programs may not always be applicable in other areas without adjustment. Instead of attempting to design a perfect program from the start, utilities may consider implementing pilot incentive programs that can be adjusted and expanded as more data is collected on local EV market conditions and customer acceptance.

References

Alexander, M., Knipping, E., Young, D., Duvall, M., Tonachel, L. and Hwang, R., Environmental Assessment of Full Electric Transportation Portfolio, Volume 2: Greenhouse Gas Emissions. Electric Power Research Institute (EPRI) and Natural Resources Defense Council (NRDC), September 2015. [Online]. Available: https://www.epri.com/#/pages/product/3002006876/?lang=en-US [Accessed: Dec 17, 2018].

Alternative Fuel Data Center (AFDC), Alternative Fueling Station Locator, 2019a. [Online]. Available: https://afdc.energy.gov/stations/#/analyze [Accessed: Sep 18, 2019].

Alternative Fuel Data Center (AFDC), State Laws and Incentives, 2019b. [Online]. Available: https://afdc.energy.gov/laws/state [Accessed: Oct 8, 2019].

Alternative Fuel Life-Cycle Environmental and Economic Transportation (AFLEET) Tool, Argonne National Laboratory, 2018. [Online]. Available: https://afleet-web.es.anl.gov/afleet/ [Accessed: Nov 27, 2018].

Andwari, A.M., Pesiridis, A., Rajoo, S., Martinez-Botas, R. and V. Esfahanian, "A review of battery electric vehicle technology and readiness levels," Renewable and Sustainable Energy Reviews 78, (2017): 414-430 [Online]. Available: https://doi.org/10.1016/j.rser.2017.03.138 [Accessed: Sep. 28, 2018].

Atlas Public Policy, Atlas EV Hub, Washington, D.C., 2018 [Online]. Available: https://www.atlasevhub.com/ [Accessed: Sep. 19, 2018].

Auto Alliance, Advanced Technology Vehilce Sales Dashboard, 2018. [Online]. Available: https://autoalliance.org/energy-environment/advanced-technology-vehicle-sales-dashboard/ [Accessed: Jan 28, 2019].

Bloomberg New Energy Finance (BNEF), EV Sales Forecast in the U.S. 2010-2040, May 2016.

Bonitz, J., H. Brutz, S. Buster, A. Carr, B. Lips and A. Proudlove, 50 States of Electric Vehicles: 2017 Policy Review, NC Clean Energy Technology Center, Raleigh, N.C., 2017, 74 pp. [Online]. Available: https://nccleantech.ncsu.edu/wp-content/uploads/2017_EVs_Final2-1.pdf [Accessed Nov 20, 2018].

Brown, M.H. and L. Breckenridge. State Alternative Fuel Vehicle Incentives: A Decade and More of Lessons Learned. National Conference of State Legislatures, February 2001. [Online]. Available: https://pdfs.semanticscholar.org/769d/43fa923bf4a55386dcaf2bdb69b35ca44964.pdf [Accessed: April 15, 2014].

Burke, A., Jungers, B., Yang, C. and J. Ogden, "Battery electric vehicles: an assessment of the technology and factors influencing market readiness," Public Interest Energy Program, California Energy Commission, (2007): 1 – 24 [Online]. Available: http://samersanaat.com/en/wp-content/uploads/2012/07/AEP_Tech_AssessmentBEVs.pdf [Accessed: Aug. 16, 2018].

California Air Resources Board (CARB), 8 state alliance releases plan to put 3.3 million zero-emission vehicles on the road, May 29, 2014. [Online]. Available: https://ww2.arb.ca.gov/news/8-state-alliance-releases-plan-put-33-million-zero-emission-vehicles-road [Accessed: Aug 21, 2019].

California Electric Transportation Coalition (CalETC), 2016. Evaluating Methods to Encourage Plug-in Electric Vehicle Adoption, October 2016. [Online]. Available: https://pluginamerica.org/wp-content/uploads/2016/11/PEV-Incentive-Review-October-2016.pdf [Accessed: Dec 10, 2018].

Center for Climate and Energy Solutions (C2ES), U.S. State Clean Vehicle Policies and Incentives, January, 2019. [Online]. Available: https://www.c2es.org/document/us-state-clean-vehicle-policies-and-incentives/ [Accessed: May 25, 2019].

Dubin, J., Barney, R., Csontos, A., Um, J. and Wu, N. Realizing the Potential of Los Angeles Electric Vehicle Market, University of California, Los Angeles (UCLA), May 2011. [Online]. Available: https://luskin.ucla.edu/sites/default/files/LA%20EV%20Final%20Report%20-%20Formatted%20-%20Final%20-%20High%20Quality%20for%20printing.pdf [Accessed: Nov 5, 2019].

Electrify America, Cycle 2 National ZEV Investment Plan, Miami Overview, Sep 19, 2019. [Online]. Available: https://southeastfloridaclimatecompact.org/wp-content/uploads/2019/09/Electrify-America-Cycle-2-National-ZEV-Investment-Plan.pdf [Accessed: Nov 11, 2019].

Evarts, E.C., "VW plans 27 electric cars by 2022 on new platform," Green Car Reports, September 19, 2018 [Online]. Available: https://www.greencarreports.com/news/1118857_vw-plans-27-electric-cars-by-2022-on-new-platform [Accessed: Oct. 3, 218].

Farley, R., Vervair, M., Czerniak, J. "Electric Vehicle Supply Equipment Pilot", Avista Corporation, October 18, 2019. https://www.myavista.com/-/media/myavista/content-documents/energy-savings/electricvehiclesupplyequipmentpilotfinalreport.pdf?la=en

Farrell, J., Utilities Cry "Fowl" Over Duck Chart and Distributed Solar Power, CleanTechnica, Jul 21, 2014. [Online]. Available: https://cleantechnica.com/2014/07/21/utilities-cry-fowl-over-duck-chart-and-distributed-solar-powercrying-fowl-or-crying-wolf-open-season-on-the-utilitys-solar-duck-chart/ [Accessed: Dec 19, 2018].

Fitzgerald, G., Nelder, C. and Newcomb, J. Electric Vehicles As Distributed Energy Resources. Rocky Mountain Institute, 2016. [Online]. Available: https://rmi.org/wp-content/uploads/2017/04/RMI_Electric_Vehicles_as_DERs_Final_V2.pdf [Accessed: Nov 19, 2018].

FleetCarma (2020), "The Geography of EV Charging: Understanding how regional climates impact charging and driving behavior", May 2020. https://www.fleetcarma.com/geography-of-ev-charging/

Florida Department of Environmental Protection (FDEP), State of Florida Beneficiary Mitigation Plan, October 2019. [Online]. Available: https://floridadep.gov/sites/default/files/Florida%27s%20Beneficiary%20Mitigation%20Plan.pdf [Accessed: October 27, 2018]

Florida Department of Highway Safety and Motor Vehicles (FLHSMV), Electric Vehcile Registrations by County, 2018.

Frades, M. A Guide to Lessons Learned from the Clean Cities Community Electric Vehicle Readiness Projects, 2014. [Online]. Available: https://www.c2es.org/site/assets/uploads/2014/02/pev-guide-lessons-clean-cities-readiness-project.pdf [Accessed: Nov 15, 2019].

Francfort, J., Salisbury, S., Smart, J., Garetson, T., Karner, D. "Considerations for Corridor and Community DC Fast Charging Complex System Design", Idaho National Laboratory, March 2017. https://avt.inl.gov/sites/default/files/pdf/reports/DCFCChargingComplexSystemDesign.pdf

Galeon, D., "Carmaker sees ultrafast charging for 2022 electric vehicles," Mach, November 28, 2017 [Online]. Available: https://www.nbcnews.com/mach/science/carmaker-sees-ultrafast-charging-2022-electric-vehicles-ncna824576 [Accessed: Oct. 21, 2018].

Gallagher, K. and Muehlegger, E. Giving Green to get Green? Incentives and Consumer Adoption of Hybrid Vehicle Technology, Journal of Environmental Economics and Management, Volume 61, Issue 1, January 2011, pp 1-15. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S0095069610000768 [Accessed: Nov 20, 2019].

Hledik, R., Higham, J. and Faruqui, A. Emerging Landscape of Residential Rates for EVs, Public Utilities Fortnightly, May 2019. [Online]. Available: https://www.fortnightly.com/fortnightly/2019/05/emerging-landscape-residential-rates-evs?authkey=a156bf22c30ce08fdd0ccbd32b88b6445671698e2ca1b51abea38a7fa0488378 [Accessed: Oct 10, 2019].

Howell, D., Boyd, S., Cunningham, B., Gillard, S. and Slezak, L. Enabling Fast Charging: A Technology Gap Assessment, October 2017. [Online]. Available: https://www.energy.gov/sites/prod/files/2017/10/f38/XFC%20Technology%20Gap%20Assessment%20Report_FINAL_10202017.pdf [Accessed: Aug 30, 2019].

Idaho National Laboratory (INL), 2015 (a). Residential Charging Behavior in Response to Utility Experimental Rates in San Diego, EV Project, April 2015. [Online]. Available: https://avt.inl.gov/sites/default/files/pdf/EVProj/ResChargingBehaviorInResponseToExperimentalRates.pdf [Accessed: Dec 20, 2018].

Idaho National Laboratory (INL), 2015 (b). What Residential Clustering Effects Have been Experienced in the San Diego Region? April 2015. [Online]. Available: https://avt.inl.gov/sites/default/files/pdf/EVProj/ClusteringInSanDiego.pdf [Accessed: Mar 1, 2019].

Idaho National Laboratory (INL) 2015 (c). "What is the Impact of Utility Demand Charges on a DCFC Host?" INL/EXT-15-35706. June, 2015. [Online]. Available: http://avt.inl.gov/pdf/EVProj/EffectOfDemandChargesOnDCFCHosts.pdf [Accessed: Sep 19, 2019].

International Council on Clean Transportation (ICCT), 2013. Electric Vehicle Grid Integration in the U.S., Europe, and China, July 2013. [Online]. Available: https://theicct.org/sites/default/files/publications/EVpolicies_final_July11.pdf [Accessed: Nov 15, 2019].

Kiser, J. and M. Essery, Is There a Target Market for Electric Vehicles?, Ipsos, 2017, 8 pp.

Kolpakov, A., A.M. Sipiora, and B.R. Sneath. Task 4 - Technical Report: A Review of Alternative Fuel Vehicle Market Penetration and Projected VMT Penetration Rate Analysis for Florida, in Autonomous Vehicle (AV) and Alternative Fuel Vehicle (AFV) Florida Market Penetration Rate and VMT Assessment Study, October 2018, Florida Department of Transportation, Office of Policy Planning: Tallahassee, FL.

Kwan, I., Lutsey, N., Slowik, P., & Jin, L. Identifying the Leading Regional Electric Vehicle Markets in the United States. International Council on Clean Transportation, November,

2016. [Online]. Available: www.theicct.org/regional-us-city-electric-vehicle [Accessed: Nov 15, 2018].

Lawrence, M. California Electric Transportation Return on Investment Assessment, California Electric Transportation Coalition (CalETC), June 2015. [Online]. Available: https://www.caletc.com/wp-content/uploads/2016/08/New-Study-Shows-State-Investment-in-Zero-Emission-Vehicle-Incentives-Pays-Off.pdf [Accessed: Nov 27, 2019].

M. J. Bradley and Associates (MJB&A), Electricity Pricing Strategies to Reduce Grid Impacts from Plug-in Electric Vehicle Charging in New York State, June 2015. [Online]. Available: https://www.mjbradley.com/sites/default/files/NYSERDA-EV-Pricing.pdf [Accessed: Dec 3, 2019].

M. J. Bradley and Associates (MJB&A), Utility Investment in Electric Vehicle Charging Infrastructure: Key Regulatory Considerations, November 2017. [Online]. Available: https://www.georgetownclimate.org/files/report/GCC-MJBA_Utility-Investment-in-EV-Charging-Infrastructure.pdf [Accessed: May 15, 2019].

M. J. Bradley and Associates (MJB&A), Electric Vehcile Cost-Benefit Analysis, January 2019. [Online]. Available: https://www.mjbradley.com/sites/default/files/FLPEVCBAnalysis07jan19.pdf [Accessed: May 10, 2019].

Mohamed, M., Ferguson, M.R., Higgins, C. and P. Kanaroglou, "Identifying and characterizing potential electric vehicle adopters in Canada: A two-stage modelling approach," Transportation Policy 52, (2016): 100-112 [Online]. Available: DOI: 10.1016/j.tranpol.2016.07.006 [Accessed: Oct. 30, 2018].

Myers, E., Utilities and Electric Vehicles, The Case for Managed Charging. Smart Electric Power Alliance, April 2017. [Online]. Available: file:///C:/Users/Kolpakov/Documents/Projects/TECO/Benefits%20of%20EV/Resources/SEPA091_Managed_EV_Report_print__1.pdf [Accessed: Dec 10, 2018].

NV Energy, Standard Residential Electric Vehilce Rates, 2019. [Online]. Available: https://www.nvenergy.com/account-services/energy-pricing-plans/electric-vehicle/standard-rates-residential [Accessed: Dec 2, 2019].

Ryan, N. and Lavin, L. Engaging Utilities and Regulators on Transportation Electrification, The Electricity Journal, Volume 28, Issue 4, May 2015, pp. 78-91. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S1040619015000755 [Accessed: Nov 4, 2019].

Salisbury, M. and Toor, W., How leading Utilities are Embracing Electric Vehicles, Southwest Energy Efficiency Project, February 2016. [Online]. Available: https://www.swenergy.org/data/sites/1/media/documents/publications/documents/How_Leading_Utilities_Are_Embracing_EVs_Feb-2016.pdf [Accessed: Dec 10, 2018].

Saunders, E., Butler, T., Quiros-Tortos, J., Ochoa, L. and Hartshorn, R. Direct Control of EV Charging on Feeders with EV Clusters, 23-rd International Conference, on Electricity Distribution, Lyon, France, June 15-18, 2015. [Online]. Available: https://pdfs.semanticscholar.org/7642/33b30d24d33cb0f14f859628a44787af8e4b.pdf?_ga=2.242276674.1993026712.1575325423-733549407.1575325423 [Accessed: Nov 20, 2019].

Schey, S., Scoffield, D. and Smart, J., A First Look at the Impact of Electric Vehicle Charging on the Electric Grid in the EV Project, EVS26 International Battery, Hybrid and Fuel Cell Electric Vehicle Symposium, Los Angeles, CA, May 6-9, 2012. [Online]. Available:

https://www.energy.gov/sites/prod/files/2014/02/f8/evs26_charging_demand_manuscript.pdf [Accessed: Dec 19, 2018].

Schmidt, E., The Benefits of Electric Vehicle Adoption For Electric Power Utilities and Distributors, Fleetcarma, February 26, 2018. [Online]. Available: https://www.fleetcarma.com/benefits-electric-vehicle-adoption-electric-power-utilities-distributors/ [Accessed: Nov 20, 2018].

Stainken, K. Colorado makes a move to adopt the ZEV mandate, Plug-in America, August 21, 2018. [Online]. Available: https://pluginamerica.org/colorado-makes-a-move-to-adopt-the-zev-mandate/ [Accessed: Sep 24, 2019].

Teter, J., Cazzola, P. and T. Gul, The Future of Trucks: Implications for Energy and the Environment, International Energy Agency (IEA), IEA Publications, France, 2017 [Online]. Available: https://www.iea.org/publications/freepublications/publication/TheFutureofTrucksImplicationsforEnergyandtheEnvironment.pdf [Accessed: Oct. 1, 2018].

Trabish, H. Why Utilities Need to Respond Now to the EV Boom, Utility Drive, Oct 9, 2017. [Online]. Available: https://www.utilitydive.com/news/why-utilities-need-to-respond-now-to-the-ev-boom/506761/ [Accessed: Nov 20, 2018].

U.S. Census Bureau, Population Division, "Annual Estimates of the Resident Population: April 1, 2010 to July 1, 2017," 2018 Population Estimates, 2018 [Online.] Available: https://factfinder.census.gov/faces/nav/jsf/pages/community_facts.xhtml [Accessed September 2, 2019].

U.S. Department of Energy (DOE), Costs Associated with Non-Residential Electric Vehicle Supply Equipment, 2015. [Online]. Available: https://afdc.energy.gov/files/u/publication/evse_cost_report_2015.pdf [Accessed: Oct 16, 2019].

U.S. Department of Energy (DOE), Funding Opportunity Anouncement DE-FOA-0001808, October 2017. [Online]. Available: https://eere-exchange.energy.gov/Default.aspx?Search=DE-FOA-0001808&SearchType [Accessed: Nov 11, 2017].

U.S. Department of Energy (DOE), All-Electric Vehicles, 2018. [Online]. Available: https://www.fueleconomy.gov/feg/evtech.shtml [Accessed: Dec 4, 2018].

U.S. Energy Information Administration (EIA), Energy Use for Transportation, Washington, D.C., 2017 [Online]. Available: https://www.eia.gov/energyexplained/index.cfm?page=us_energy_transportation [accessed Nov. 20, 2018].

U.S. Energy Information Administration (EIA), Interactive Electricity Data, Retail Sales of Electricity to Ultimate Customers, by State and Utility, 2018a. [Online]. Available: https://www.eia.gov/electricity/data.php [Accessed: Dec 18, 2018].

U.S. Energy Information Administration (EIA), 2017 Average Monthly Bill – Residential, October 12, 2018b. [Online]. Available: https://www.eia.gov/electricity/sales_revenue_price/pdf/table5_a.pdf [Accessed: Dec 19, 2018].

U.S. Environmental Protection Agency (EPA), Source of Greenhouse Gas Emissions, 2016. [Online]. Available: https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions#transportation [Accessed: Dec 5, 2018].

U.S. Environmental Protection Agency (EPA), Light-duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: 1975 through 2017, January 2018. [Online]. Available: https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100TGDW.pdf [Accessed: Dec 13, 2018].

Vermont Energy Investment Corporation (VEIC) and National Association of State Energy Officials (NASEO), Review of Utility Integrated Resource Plans and Electric Vehicle Load Forecasting, September 2013. [Onoline]. Available: https://www.naseo.org/data/sites/1/documents/publications/NASEO-Review-of-Utility-Integrated-Resource-Plans-and-Electric-Vehicle-Load-Forecasting.pdf [Accessed: Nov 20, 2019].

Walton, R., "Duke to install 530 EV chargers in Florida, study grid integration," Utility Dive, October 4, 2018 [Online]. Available: https://www.utilitydive.com/news/duke-to-install-530-ev-chargers-in-florida-study-grid-integration/538813/ [Accessed: Oct 20, 2018].

Whitwam, R. BMW, Porsche Demo Super-Fast Electric Car Charger, ExtremeTech, December 17, 2018. [Online]. Available: https://www.extremetech.com/extreme/282364-bmw-porsche-demo-super-fast-electric-car-charger [Accessed: Oct 10, 2019].

World Economic Forum (WEF), Electric Vehicles for Smarter Cities: The Future of Energy and Mobility, Switzerland, January 2018, 13 pp. [Online]. Available: http://www3.weforum.org/docs/WEF_2018_%20Electric_For_Smarter_Cities.pdf [Accessed: Dec 3, 2018].

Appendix

Table A-1 - Utilities Offering Special Rates to EV Owners

Utility	State	Type of Utility (ownership)	Special EV Rates	TOU for all Customers	Pay for Smart Meter	Separate Meter Required for EV Rate
Alabama Power	AL	IOU	Peak/off-peak rates for EV fleets; 1.7 c/kwh discount for residential for off-peak			Yes
Salt River Project	AZ	Cooperative	Yes			
Tucson Electric Power	AZ	IOU	5% off TOU	Yes		
Sacramento Municipal Utility District	CA	Cooperative	1.5 c/kwh discount for EVs (midnight - 6 am)	Yes		
Los Angeles Department of Water and Power	CA	Municipal	2.5 c/kwh discount for EVs	Yes		Yes
Pacific Gas & Electric	CA	IOU	Off-peak TOU			
San Diego Gas & Electric	CA	IOU	Off-peak TOU			
Southern California Edison	CA	IOU	Off-peak TOU			
Azusa Light & Water	CA	Municipal	5 c/kwh discount for EVs off-peak			Yes
Burbank Water & Power	CA	Cooperative	Off-peak TOU			
Georgia Power	GA	IOU	Off-peak TOU			
Hawaiian Electric Company	HI	IOU	Off-peak TOU	Yes		Yes (for commercial EVSE)
Illinois Electric Cooperative	IL	Cooperative	Off-peak TOU			Yes
Indianapolis Power & Light	IN	IOU	Off-peak TOU			Yes
Indiana Michigan Power	IN	IOU	Off-peak TOU			
Baltimore Gas & Electric	MD	IOU	Off peak TOU for entire residence			
Pepco	MD	IOU	Off-peak TOU		Yes	Yes
DTE Energy	MI	IOU	Off-peak TOU	Yes	Yes	Yes

Consumers Energy	MI	IOU	Off-peak TOU			
Lansing Board of Water & Light	MI	Municipal	Off-peak TOU			
Connexus Energy	MN	Cooperative	Off-peak TOU			
Dakota Electric	MN	Cooperative	Off-peak TOU			Yes
Xcel Energy	MN	IOU	Off-peak TOU			Yes
Cape Hatteras Electric Cooperative	NC	Cooperative	Off-peak TOU			
New Hampshire Electric Co-Op	NH	Cooperative	Off-peak TOU			Yes
Con Edison	NY	IOU	Off-peak TOU with guarantee to pay no more than standard electric rate			
Nevada Energy	NV	IOU	Off-peak TOU			
Randolph Electric Membership Cooperative	NC	Cooperative	Off-peak TOU			
Rocky Mountain Power	UT	IOU	Off-peak TOU for entire residence			
Madison Gas & Electric	WI	IOU	Off-peak TOU for entire residence			

Source: Alternative Fuel Data Center (AFDC), 2019

Table A-2 – Utility EV/EVSE Incentives

Utility	State	Incentive Description
Entergy	AR, LA, MS, TX	Qualified Entergy customers are eligible to receive $250 cash incentive for residential Level 2 EVSE. https://entergyetech.com/
Salt River Project	AZ	SRP offers a rebate to business customers who purchase and install Level 2 EVSE for use by their employees. The rebate is $500 per Level 2 EVSE installed. Rebates are available on a first-come, first-served basis. https://savewithsrpbiz.com/rebates/evcharger.aspx
Alameda Municipal Power	CA	AMP provides rebates of up to $800 to residential customers toward the purchase of Level 2 EVSE. Customers may apply for multiple rebates at a time. https://alameda.dsmtracker.com/shop/residential-rebates/level-2-electric-vehicle-charger.html
Anaheim Public Utilities	CA	Anaheim Public Utilities provides rebates of up to $500 for residential, commercial, and industrial customers that install EVSE at their home or business. Eligible expenses include the cost of the charger and installation. Anaheim Public Utilities will also pay for any associated permit fees. http://www.anaheim.net/593/Personal-EV-Charger-Rebate
Burbank Water and Power	CA	BWP provides rebates to commercial and residential customers toward the purchase of Level 2 EVSE. Commercial customers who purchase and install EVSE can receive up to $2,000 for each charger and up to four rebates per fiscal year. Residential customers who install a charger can receive up to $500 and will be placed on BWP's time-of-use electric rate. Applications must be submitted no later than four months from the date of purchase. Rebates are available on a first-come, first-served basis until funds are exhausted. https://www.burbankwaterandpower.com/conservation/electric-vehicles-rebate
Glendale Water and Power	CA	GWP provides rebates to commercial and residential customers toward the purchase of Level 2 EVSE. Commercial customers who purchase and install EVSE can receive up to $2,000 for each charger and up to four rebates. Residential customers who install a charger can receive up to $500. https://www.glendaleca.gov/government/departments/glendale-water-and-power/electric-vehicles
Los Angeles Department of Water and Power (LADWP)	CA	The Los Angeles Department of Water and Power (LADWP) provides rebates to commercial and residential customers toward the purchase of Level 2 EVSE. Commercial customers who purchase and install EVSE for employee and public use can receive up to $5,000 for each charger, with up to $750 in additional rebate funds per extra charge port. Rebates do not cover the cost of installation. Eligible customers may qualify for up to 40 rebate awards depending on the number of parking spaces at the installation site. Residential customers who install wall-mounted chargers can receive up to $500. EVSE must be installed within the LADWP service area. Rebates are available on a first-come, first-served basis through June 30, 2021, or until funds are exhausted. https://www.ladwp.com/ladwp/faces/ladwp/residential/r-gogreen/r-gg-driveelectric?_adf.ctrl-state=gqempvenj_4&_afrLoop=243722027642889
Pacific Gas and Electric	CA	Pacific Gas and Electric (PG&E) provides rebates of $800 to residential customers who purchase or lease an eligible PEV. Residential account holders may apply on behalf of a PEV owner in their household or their tenant in a multifamily household with the vehicle owner's permission. https://www.pge.com/en_US/residential/solar-and-vehicles/options/clean-vehicles/electric/clean-fuel-rebate-for-electric-vehicles.page?WT.mc_id=Vanity_cleanfuelrebate-ev

Pasadena Water and Power	CA	PWP residential electric customers are eligible for up to a $250 rebate when they purchase or lease a new or used plug-in electric vehicle (EV). An additional $250 is available for eligible PEVs purchased or leased from a Pasadena dealership. Customers participating in PWP's income-qualifying programs may also qualify for an additional $250 rebate, for a total of $750. https://ww5.cityofpasadena.net/water-and-power/residentialevrebate/ PWP provides rebates of $600 for residential customers toward the installation of a WiFi enabled EVSE, or $200 toward the installation of a non-WiFi enabled EVSE. PWP provides rebates of $3,000 per port for commercial, workplace, multi-unit dwelling (MUD), and fleet customers for the installation of networked Level 2 EVSE, or rebates of $1,500 per port for non-networked Level 2 EVSE. PWP also provides rebates of $6,000 for the installation of direct-current (DC) fast EVSE or Level 2 EVSE installed at select sites. https://ww5.cityofpasadena.net/water-and-power/commercialchargerrebate/
Sacramento Municipal Utility District (SMUD)	CA	SMUD offers residential customers a $599 rebate or a free Level 2 (240 volt) EVSE. Rebates or chargers are available to SMUD residential customers with the purchase or lease of a new plug-in electric vehicle (PEV). To be eligible for the rebate or charger, completed applications must be postmarked within 180 days of the date of purchase or lease of the PEV. https://www.smud.org/en/Going-Green/Electric-Vehicles/Residential SMUD offers rebates for commercial customers to purchase and install Level 2 EVSE and direct current (DC) fast chargers at their business. Eligible applicants may receive up to $120,000 per project for public access DC fast chargers and up to $1,500 per Level 2 EVSE installed at multi-unit dwellings or workplaces. Up to 20 Level 2 EVSE may be installed per business location. https://www.smud.org/en/Going-Green/Electric-Vehicles/Business
Sonoma Clean Power	CA	Qualified Sonoma Clean Power (SCP) customers are eligible to receive a free EVSE that can be connected to Wi-Fi and communicate with the SCP GridSavvy Community. Customers are responsible for shipping and installation costs. Customers may also receive $5 per month for connecting the EVSE to the GridSavvy Community. https://sonomacleanpower.org/programs/gridsavvy
Southern California Edison	CA	Southern California Edison's (SCE) Clean Fuel Reward Program provides rebates of up to $1,000 to residential customers who purchase or lease an eligible new or used PEV. Residential account holders may apply on behalf of a PEV owner in their household. https://evrebates.sce.com/
Gunnison County Electric Association	CO	GCEA provides rebates to residential customers toward the purchase of Level 2 EVSE. Eligible customers who purchase and install EVSE can receive a rebate of 70% of the cost of the EVSE, up to $500. Customers who purchase the EVSE directly through GCEA may receive a 5% discount on the equipment. https://gcea.coop/ev-rebates
Holy Cross Energy	CO	HCE offers free or discounted Level-2 EVSE for residential and commercial customers, respectively. https://www.holycross.com/charge-at-home/
Groton Utilities	CT	Groton Utilities offers a limited number of $2,000 rebates for the purchase of a new PEV and $1,000 rebates for the lease of a new PEV. The rebate is available to the first 20 applicants. Customers may also be eligible for a $600 rebate for the installation of a qualifying Level 2 electric vehicle supply equipment (EVSE). http://grotonutilities.com/electric-vehicle-rebate-program/

Norwich Public Utilities	CT	Norwich Utilities offers electric vehicle rebates: $500 for purchasing new PHEV, $1,000 for purchasing a new EV, $250 for purchasing used PHEV, $500 for purchasing used EV. Charging equipment rebates: $500 for purchasing a residential use Level 2 EVSE, $1,500 for purchasing a commercial use Level 2 EVSE for workplace charging or multifamily (4+ units) use, $2,000 for purchasing a commercial use Level 2 EVSE available to the general public at a commercial or public location. https://norwichpublicutilities.com/residential/electric-vehicle-charging-rebate-program/
Brickell Energy	FL	Brickell Energy's aFLoat Program offers two different incentives to facilitate the installation of EVSE in Florida. Through the aFLoat Host Agreement, Brickell Energy will cover the cost of hardware, network service plans, management service, and warranties. Eligible hosts include commercial real estate property owners and managers. Hosts must cover the cost of installation. The aFLoat Rental Plan offers public and commercial locations the EVSE hardware, network service plan, management service, and warranties at a reduced fee. https://brickellenergy.com/afloat-program/
Duke Energy	FL	Duke Energy offers free Level 2 and direct current (DC) fast EVSE, installation, warranty, and network connection services to its customers through the Park & Plug pilot program. Eligible entities include multi-unit dwellings, workplaces, businesses, and areas along high-traffic corridors. Site hosts are responsible for electricity costs and must agree to participate in the pilot program through December 2022. https://www.duke-energy.com/our-company/florida-future/park-and-plug
Jacksonville Electric Authority	FL	Jacksonville Electric Authority (JEA) offers rebates for the purchase or lease of new PEVs. PEVs with a battery less than 15 kilowatt-hours (kWh) in capacity receive $500, and PEVs with larger battery capacity are eligible for $1,000. A copy of a valid Florida vehicle registration, proof of sale, and a recent JEA Electric bill are required. https://www.jea.com/Ways_to_Save/Go_Green/Plug-in_Electric_Vehicles/Electric_Vehicle_Incentives//
Kissimmee Utility Authority (KUA)	FL	KUA provides rebates of $100 to residential customers for the purchase of a new EV and $100 for the purchase and installation of a home EVSE. The EV must be registered to the customer's address and a proof of purchase is required. The EVSE must be installed by a licensed electrical contractor and must meet all state and local codes. Rebates are limited to one rebate per vehicle and one EVSE rebate per household. https://kua.com/energy-conservation-and-renewables/kua-rebates-and-participating-contractors/
Orlando Utility Commission	FL	Orlando Utilities Commission (OUC) provides rebates of $200 to residential customers who purchase or lease an eligible new or preowned PEV. Applicants must apply within six months of the purchase or lease of the PEV. https://www.ouc.com/residential/save-energy-water-money/electric-vehicles-at-home
Georgia Power	GA	Georgia Power offers a rebate to residential customers, businesses, and builders who install Level 2 EVSE. Customers are eligible for a $250, $500, and $100 rebate, respectively, for each dedicated circuit installed through December 31, 2019. https://www.georgiapower.com/residential/save-money-and-energy/products-programs/electric-vehicles/buying-an-ev.html
Aliant Energy	IA, WI	Alliant Energy offers rebates to residential customers who purchase and install Level 2 EVSE. The rebate is $250 for non-networked EVSE and $500 for networked EVSE. The EVSE must be purchased and installed between January 1, 2019, and December 31, 2019. https://www.alliantenergy.com/InnovativeEnergySolutions/SmartEnergyProducts/-ElectricVehicles/EVHomeChargersandRebates

		A rebate is also available to commercial and industrial customers who purchase and install Level 2 EVSE for use by employees, tenants, or the public. The rebate is $500 for the purchase of a single port EVSE, $1,000 for a dual port EVSE, and $1,500 for a dual port networked EVSE. Rebates are available on a first-come, first-served basis.
MidAmerican Energy	IA	MidAmerican Energy provides $500 rebates to residential customers who buy or lease a new electric vehicle. The company also offers $1,500 rebates to businesses that purchase and install Level 2 charging station. https://www.midamericanenergy.com/electric-vehicles
Braintree Electric Light Department	MA	BELD offers customers a discount of $250 for the purchase of a qualified Level 2 EVSE. To qualify, customers must enroll in the Smart Charging Program. https://braintree-ev.ene.org/charging-guide/rebates-and-incentives-charging/
Baltimore Gas and Electric	MD	Baltimore Gas and Electric (BGE) provides rebates to residential and multifamily customers toward the purchase of qualified Level 2 and direct current (DC) fast charging EVSE. BGE offers residential customers a $300 rebate for a Level 2 smart EVSE. BGE offers customers that own or operate multifamily properties a rebate of 50% of the purchase and installation cost of Level 2 smart EVSE, up to $5,000 per port, and 50% of the purchase and installation cost of eligible DC fast charging EVSE, up to $15,000 per port. There is a maximum rebate of $25,000 per multifamily site. https://www.bge.com/SmartEnergy/InnovationTechnology/Pages/ElectricVehicles.aspx
Delmarva Power	MD	Delmarva Power provides rebates to residential and multifamily customers toward the purchase of qualified Level 2 EVSE. Delmarva Power offers residential customers a $300 rebate for a Level 2 smart EVSE and offers customers that own or operate multifamily properties a 50% discount on the purchase of eligible Level 2 smart EVSE and a 100% discount on the accompanying installation. https://www.delmarva.com/SmartEnergy/InnovationTechnology/Pages/Electric-VehicleProgramMD.aspx
Pepco	MD	Pepco provides rebates to residential and multifamily customers toward the purchase of qualified Level 2 EVSE. Pepco offers residential customers a $300 rebate for a Level 2 smart EVSE. Only chargers purchased and installed after July 1, 2019, are eligible. Pepco offers customers that own or operate multifamily properties a 50% discount on the purchase of eligible Level 2 smart EVSE and a 100% discount on the accompanying installation. https://www.pepco.com/SmartEnergy/InnovationTechnology/Pages/ElectricVehicle-ProgramMD.aspx
Consumers Energy	MI	The Consumers Energy PowerMIDrive program offers rebates to residential and commercial customers who install Level 2 or direct current fast charging (DCFC) EVSE. Residential customers are eligible for a $500 rebate to install a qualified Level 2 EVSE. Commercial customers installing qualified, publicly accessible EVSE are eligible for rebates up to $5,000 per Level 2 and up to $70,000 per DCFC EVSE installed. https://www.consumersenergy.com/residential/programs-and-services/electric-vehicles/powermidrive?utm_campaign=powermidrive&utm_source=powermidrive&utm_-medium=vanity-url&utm_content=powermidrive
DTE Energy	MI	DTE Energy offers a $500 rebate for the installation of a Level 2 EVSE for qualified residential customers that purchase or lease a plug-in electric vehicle (PEV) and enroll in the PEV Charging Rates. https://newlook.dteenergy.com/wps/wcm/connect/dte-web/home/service-request/residential/electric/pev/pev-res-charge-frwd

Indiana Michigan Power	MI	Indiana Michigan Power also provides rebates of up to $2,500 to residential customers who purchase or lease a new PEV and install a Level 2 EVSE with a separate meter. Customers must also sign up for the Indiana Michigan Power PEV time-of-use rate. The rebate is available to the first 250 qualified customers who submit a completed application. https://www.indianamichiganpower.com/info/ElectricCars/MichiganIncentives.aspx
Lansing Board of Water & Light	MI	BWL offers a reimbursement of up to $1,000 for the purchase and installation of EVSE for customers that have enrolled in the PEV charging rate. The program is limited to the first 10 qualified residential customers. https://www.lbwl.com/customers/save-money-energy/plug-electric-vehicles-pev
Connexus Energy	MN	Connexus Energy provides $500 rebate for installing Level 2 EV charger. Must be enrolled in TOU or off-peak rate programs. https://www.connexusenergy.com/save-money-and-energy/programs-rebates/electric-vehicle
Dakota Electric Association	MN	Dakota Electric offers a rebate of up to $500 for the installation of Level 1 or Level 2 electric vehicle supply equipment (EVSE). https://www.dakotaelectric.com/wp-content/uploads/2016/09/EV_Programs.pdf
Lake Region Electric Cooperative	MN	LREC also offers a rebate of up to $500 for the installation of Level 1 or Level 2 electric vehicle supply equipment (EVSE). https://www.lrec.coop/products-service/chargewise
Otter Tail Power	MN	Otter Tail Power Company also offers a $400 rebate for the installation of a Level 2 EVSE. https://www.otpco.com/ways-to-save/electric-vehicles/
Cape Hatteras Electric Co-Op	NC	CHEC offers a bill credit of $100 to residential customers who install a Level 2 EVSE. https://www.chec.coop/electricvehicles
Randolph Electric Membership Corporation	NC	Randolph EMC's Electric Vehicle Utility Program (REVUP) offers rebates for residential customers of $500 towards the purchase of residential Level 2 electric vehicle supply equipment (EVSE). To qualify, residents must be a registered owner of an electric vehicle (EV), purchase and install a Wi-Fi connected Level 2 EVSE, and agree to share the data collected by the EVSE. Rebates are available to the first 25 applicants. https://www.randolphemc.com/content/revup
Omaha Public Power District	NE	Omaha Public Power District (OPPD) offers residential customers rebates of $2,500 toward the purchase of a new EV and qualified Level 2 EVSE, $500 toward the purchase of qualified Level 2 EVSE, and $100 toward residential installation. Participants must purchase the EVSE through OPPD. https://www.oppd.com/residential/products-services/electric-vehicle-ev-rebate-program/
New Hampshire Electric Co-Op	NH	NHEC offers rebates of $1,000 for the purchase or lease of a new or used electric vehicle (EV), and $600 for the purchase or lease of a new or used plug-in hybrid electric vehicle. The PEV must be purchased or leased between January 1, 2019, and December 31, 2019. https://www.nhec.com/drive-electric/#/find/nearest NHEC offers rebates for residential customers to install EVSE. Customers may receive a rebate of up to $300 to install EVSE and a separate electric meter.
Nevada Energy	NV	Nevada Energy (NV Energy) provides rebates for the purchase and installation of Level 2 EVSE and direct current (DC) fast charger stations. Eligible projects include charging for fleet, workplace, and multi-unit dwellings. NV Energy offers rebates of 75% of project costs, up to $3,000 per connector, whichever is less, for Level 2 EVSE. NV Energy offers

		rebates of 50% of project costs, up to $400 per kilowatt or $40,000 per station, whichever is less, for DC fast chargers. https://www.nvenergy.com/publish/content/dam/nvenergy/brochures_arch/cleanenergy-/handbooks/2018-2019-electric-vehicle-charging-station-incentives-programs-handbook.pdf
American Electric Power	OH	American Electric Power (AEP) Ohio offers financial incentives for the hardware, network services, and installation of EVSE for up to 300 Level 2 and 75 direct current (DC) fast charging stations. Incentives in varying amounts are available to all non-residential customers that have a valid AEP Ohio account. EVSE must be installed at a workplace, government facility, multi-family complex, or other publicly available charging location served by AEO Ohio. https://www.aepohio.com/save/business/ElectricVehicles/
Central Lincoln	OR	Central Lincoln offers residential and commercial customers a one-time rebate of $250 to purchase a Level 2 EVSE. https://clpud.org/energy-efficiency/electric-cars/level-2-station-rebate/
Emerald People's Utility District (EPUD)	OR	EPUD customers are eligible for a $100 incentive to register their new or used EV with the Oregon Department of Motor Vehicles. New or used neighborhood electric vehicles and new or used plug-in electric vehicles and plug-in hybrid electric vehicles with at least 2 kilowatt-hours of on-board battery capacity qualify. https://www.epud.org/register-your-ev/
Eugene Water & Electric Board	OR	EWEB offers rebates for residential and commercial customers to install Level 2 EVSE. Eligible residential customers may receive up to $500, and eligible commercial customers may receive up to $1,000. http://www.eweb.org/residential-customers/going-green/electric-vehicles/ev-incentives
Duquesne Light Company	PA	DLC offers rebates to commercial customers for the installation of publicly available Level 2 EVSE. Rebates are available for 100% of make-ready installation costs, up to $32,000 per site. Eligible projects must include a minimum of four dual-port Level 2 networked EVSE. https://www.duquesnelight.com/energy-money-savings/electric-vehicles DLC also offers a one-time bill credit of $60 to residential customers who purchase or lease a PEV.
Pepco	PA, DE	PECO provides rebates of $50 to residential customers who purchase a new, qualified PEV. https://pecorebateportal.com/electric-vehicles/smart-driver-rebate.html
Austin Energy	TX	Plug-in electric vehicle owners in the Austin Energy service area may be eligible for a rebate of 50% of the cost to purchase and install a qualified Level 2 EVSE, up to $1,200. https://austinenergy.com/ae/green-power/plug-in-austin/home-charging/home-charging Austin Energy offers a rebate for commercial customers to install approved EVSE at workplaces. Austin Energy provides a rebate of 50% of the cost to install approved Level 1 or Level 2 EVSE, up to $4,000 depending on the equipment, and provides rebates up to $10,000 to workplaces that install a DC fast charger. https://austinenergy.com/ae/green-power/plug-in-austin/workplace-charging
Rocky Mountain Power	UT	Rocky Mountain Power provides rebates to non-residential and multi-family customers toward the purchase of Level 2 and direct current (DC) fast EVSE. Customers installing Level 2 EVSE may receive a rebate of 75% of equipment cost, up to $2,500 for single port stations and $3,500 for multi-port stations. Customers installing DC fast charging EVSE may receive a rebate of 75% of equipment and installation cost, up to $30,000 for single port stations and $42,000 for multi-port stations. To receive a rebate, customers installing Level

		2 EVSE must submit an application within 90 days of the station installation; customers installing DC fast charging EVSE must submit an application for utility approval before purchasing and installing equipment. Customers may also complete an application for a custom grant project; applications must be submitted by April 1, 2019. Rebates and grant funding is available on a first-come, first-served basis. https://www.rockymountainpower.net/savings-energy-choices/electric-vehicles/utah-incentives.html
Burlington Electric Department	VT	BED customers are eligible for a $1,200 rebate on the purchase or lease of a new qualifying all-electric vehicle (EV) or plug-in hybrid electric vehicle (PHEV). Moderate income customers are eligible for an additional $600 rebate for an EV or an additional $300 rebate for a PHEV. Vehicles must have a manufacturer's suggested retail price of less than $50,000 and be registered in Burlington, VT. Rebates are available through December 31, 2019. https://www.burlingtonelectric.com/ev#rebate BED also offers a rebate of $400 for the purchase and installation of a qualifying Wifi enabled EVSE for customers that have enrolled in BED's Residential EV Rate.
Green Mountain Power	VT	GMP residential customers are eligible for a free Level 2 EVSE when they purchase a new all-electric vehicle. GMP provides $1,500 rebate on a new all-electric vehicles and $1,000 for new PHEVs. Low and moderate income customers (50K or less for 1-person household or $85K or less for 2-person households) can qualify for additional $1,000 rebate. https://greenmountainpower.com/product/ev-rebate/

Source: Alternative Fuel Data Center (AFDC), 2019

Table A-3 – Utility-provided EVSE Incentives Summary

Utility	State	Type of EVSE	Rebate Amount ($)	
			Residential	Commercial
Entergy	AR, LA, MS, TX	Level -2	$250	
Salt River Project	AZ	Level -2	$500	
Alameda Municipal Power	CA	Level -2	$800	
Anaheim Public Utilities	CA	Level -2	$500	$500
Burbank Water & Power	CA	Level -2	$500	$2,000
Glendale Water & Power	CA	Level -2	$500	$2,000
Los Angeles Department of Water & Power	CA	Level -2	$500	$5,000
Pasadena Water & Power	CA	Networked L2 DCFC	$600	$3,000 $6,000
Sacramento Municipal Utility District	CA	Level -2 DCFC	$599	$1,500 $120,000
Sonoma Clean Power	CA	Networked L2	Free EVSE	
Gunnison County Electric Association	CO	Level -2	$500	
Holy Cross Energy	CO	Level -2	Free EVSE	Free EVSE
Groton Utilities	CT	Level -2	$600	
Norwich Public Utilities	CT	Level -2	$500	$2,000
Duke Energy	FL	Level -2 DCFC		Free EVSE Free EVSE
Kissimmee Utility Authority	FL	Level -2	$100	
Georgia Power	GA	Level -2	$250	$500
Aliant Energy	IA, WI	Networked L2	$500	$1,500
MidAmerican Energy	IA	Level -2		$1,500
Braintree Electric Light Department	MA	Level -2	$250	
Baltimore Gas & Electric	MD	Level -2 DCFC	$300	$5,000 $15,000
Delmarva Power	MD	Level -2	$300	50% off
Pepco	MD	Level -2	$300	50% off
Consumers Energy	MI	Level -2 DCFC	$500	$5,000 $70,000
DTE Energy	MI	Level -2	$500	
Lansing Board of Water & Light	MI	Level -2	$1,000	
Connexus Energy	MN	Level -2	$500	
Dakota Electric Association	MN	L1 or L2	$500	
Lake Region Electric Cooperative	MN	L1 or L2	$500	
Otter Tail Power	MN	Level -2	$400	

Cape Hatteras Electric Co-Op	NC	Level -2	$100	
Randolph Electric Membership Cooperation	NC	Level -2	$500	
Omaha Public Power District	NE	Level -2	$500	
New Hampshire Electric Co-Op	NH	Level -2	$300	
Nevada Energy	NV	Level -2 DCFC		$3,000 $40,000
American Electric Power	OH	Level -2 DCFC		Varies Varies
Central Lincoln	OR	Level -2	$250	$250
Eugene Water & Electric Board	OR	Level -2	$500	$1,000
Duquesne Light Company	PA	4 dual port L2		$32,000
Austin Energy	TX	Level -2 DCFC	$1,200	$4,000 $10,000
Rocky Mountain Power	UT	L2, multi-port DCFC, multi-port		$3,500 $42,000
Burlington Electric Department	VT	Networked L2	$400	
Green Mountain Power	VT	Level -2	Free EVSE	

Source: Alternative Fuel Data Center (AFDC), 2019

Table A-4 – Utility-provided PHEV/EV Incentives Summary

Utility	State	Rebate Amount ($) PHEV	Rebate Amount ($) EV
Pacific Gas & Electric	CA		$800
Pasadena Water & Power	CA	$250	$250
Southern California Edison	CA		$1,000
Groton Utilities	CT		$2,000
Norwich Public Utilities	CT	$500	$1,000
Jacksonville Electric Authority	FL	$500	$1,000
Kissimmee Utility Authority	FL		$100
Orlando Utility Commission	FL		$200
Indiana Michigan Power	MI		$2,500
Omaha Public Power District	NE		$2,500
New Hampshire Electric Co-Op	NH	$600	$1,000
Emerald People's Utility District	OR	$100	$100
Duquesne Light Company	PA	$60	$60
Pepco	PA, DE	$50	$50
Burlington Electric Department	VT		$1,200
Green Mountain Power	VT	$1,000	$1,500

Source: Alternative Fuel Data Center (AFDC), 2019

3. Please answer the following regarding TECO's Low Income Programs:

A. Describe the conservation efforts TECO used in 2020 to ensure low-income customers are aware of, and have access to, conservation programs. Address in your response whether any of these efforts were changed or modified in 2020, compared to prior years.

B. Identify TECO's partnerships with government and non-profit agencies in 2020 designed to help identify low-income neighborhoods and educate customers on conservation opportunities.

A. A. Tampa Electric has several communication avenues to assist existing customers ensuring low-income customers are aware of, and have access to, the company's conservation programs. These communications include social media Facebook and Twitter posts from Tampa Electric's Corporate Communications Department to all Tampa Electric customers, including low-income customers. These social media posts include announcing when, where and what neighborhoods the company will be installing the Neighborhood Weatherization Program. In addition, these social media posts will provide information announcements on any upcoming community energy education and awareness events where the company will be promoting the Education, Awareness and Agency Outreach program. When customers attend an energy education and awareness event in the community, it affords the company the opportunity to engage the customer with an energy expert from Tampa Electric the ability to present valuable energy-saving tips and program information. Tampa Electric continues to grow its customer attendance over the past year by focusing on increasing the number of energy education and awareness events the company participates in. These events are free to customers who attend and may be eligible to receive a free energy-savings kits.

Due to the COVID Pandemic in 2020, Tampa Electric proactively communicated with customers since the suspension of non-essential conservation operations. The company continued to promote non-customer contact programs via paid advertising channels including television, radio and online. The company also leveraged social owned channels including social media platforms, bill communications, website, direct mail and email to promote the company's DSM programs during these challenging times. In addition, while directed at all residential customers, including low-income customers, Tampa Electric recognized that the increased number of customers working from home would need additional energy education to assist them in controlling their electrical usage during these challenging times.

Tampa Electric Residential Energy Analysts created seven energy conservation videos to promote energy savings tips and promotion of programs on social media platforms (Facebook, Twitter, etc.). These videos included the following topics:

- The benefits of an online energy audit
- Water heating energy conservation tips
- HVAC maintenance and changing air filters monthly
- The benefits of a phone energy audit
- Energy efficiency tips for Summer (Spanish)
- The benefits of Weatherization kits/program and who qualifies
- Energy efficiency tips for the summer - closing blinds, adjusting thermostat settings and other methods to reduce HVAC runtime

The Residential Energy Management Team also worked with Tampa Electric's Marketing and Communications to provide energy-efficient press releases which offered tips and guidance on the following energy related topics:

- Working from home
- Costs to run appliances
- Standby (Vampire) loads
- Holiday lighting
- Cooking
- Safety

B. Tampa Electric continued partnerships with Hillsborough County Neighborhood Service Centers and Tampa Hillsborough Action Plan during COVID Pandemic. The pandemic has brought economic hardships to many of the company's customers. The company continued to respond in significant ways to help customers in need working closely to receive federal funding, both Low Income Home

Energy Assistance Program (“LIHEAP”) and the Emergency Home Energy Assistance for the Elderly Program (“EHEAP”) funds as well as assisting over 3,000 customers with the company’s internal SHARE Program that assists qualified customers with the payment of their basic electric and/or natural gas utility bill(s). Additional efforts included continuous media avenues to provide energy education with informative videos and webinars as well as providing energy education efficiency kits and the delivery of weatherization kits to low income customers living in multifamily dwellings.

4. In 2020, what was the Company's System Average Line Loss percentage?

A. In 2020, the company used the following values for the Company's Line Loss Percentages:

	Line Loss Percentage
Residential kW	7.30%
Residential kWh	5.60%
Commercial kW	7.00%
Commercial kWh	5.20%

5. On Bates Stamp Page 1 of the report, the Company acknowledged that it was unable to achieve the annual residential Summer and Winter Demand reduction goals in 2020, yet all of the goals in the Commercial/Industrial (C/I) sector were achieved by wide margins. Please describe the Company's assessment for why the program results in the C/I sector achieved all goals by wide margins in 2020, compared to shortfall experienced in the residential sector. Address in your response what the Company is doing to improve its performance in order to achieve its 2021 goals in the residential customer class.

A. In 2020, the chart below shows the four commercial/industrial DSM programs which had excellent customer participation which contributed to the achievement of exceeding the annual commercial/industrial ("C/I") goals by a wide margin:

	Commercial/Industrial DSM Goal					
Commercial/Industrial Program	Summer MW	% of Goal	Winter MW	% of Goal	Annual Energy GWh	% of Goal
	3.5		1.7		10.3	
GSLM 2&3	1.605	45.9%	1.605	94.4%	0.379	3.7%
Standby Generator	3.651	104.3%	3.651	214.8%	0.359	3.5%
Lighting Conditioned Space	4.808	137.4%	3.744	220.2%	17.465	169.6%
Lighting Unconditioned	1.327	37.9%	1.327	78.1%	6.522	63.3%
	Summer MW	% of Total	Winter MW	% of Total	Annual Energy GWh	% of Total
Total 2020 C/I Programs Achievements	11.8		10.4		26.1	
Total of 4 C/I Programs Above	11.391	96.5%	10.327	99.3%	24.725	94.7%

Tampa Electric for 2021, is still implementing the conservation related efforts toward the COVID Pandemic as was provided in the company's 2020 Annual DSM Report in Appendix "A" that was filed on March 1, 2021 in efforts to achieve both the 2021 annual DSM Goals for the residential and commercial/industrial sectors and to improve the participation in the company residential portfolio of DSM programs. The company is optimistic that it will be able to return to assisting customers in those DSM Programs which require face-to-face programs in 2021 which will improve the contributions in both sectors and should enable the company to achieve all of the Commission's annual DSM goals.

6. On Bates Stamp Page 3 of the report, the Company provided information on its residential walk-thru audit program. The report indicates 1,514 audits of this type were conducted in 2020, down from 6,786 conducted in 2019.

A. Identify the reasons why this program did not achieve the projected participation levels for 2020.

B. What, if any, program modifications is the Company considering or researching to ensure that this program will be able to more closely achieve projected participation levels? Please explain.

C. Please provide a full list of the annual demand and energy savings measures that were offered in 2020 under this program. Specify in the list the amount of annual demand and energy savings for each measure.

D. If a kit is provided to participants in this program, please list the full contents of the kit. Identify from the list which components contribute to annual demand and energy savings, and which are considered behavioral in nature, and do not contribute to savings.

E. When kits are provided to customers, what follow-up actions by the Company, if any, are done to assess whether self-install items from the kit have, in fact, been installed? Please explain your response.

F. What is TECO’s estimate of the number of self install kit items which were distributed in 2020 by type?

G. Are the kits distributed as part of this program homogeneous in their contents, or are the self install items that are included in the kits dependent upon audit results? Please explain.

H. For each type of item included in the kit, what is TECO’s estimate of the proportion actually installed of all such items distributed in 2020? How does TECO measure this?

I. Please show the calculations to support the Combined Summer kW Reduction (at the generator) of 3,583.

J. Please show the calculations to support the Combined Winter kW Reduction (at the generator) of 4,241.

K. Please show the calculations to support the Combined Annual kWh Reduction (at the generator) of 20,327,984.

L. Describe why the Company believes the practice of not counting the annual demand and energy savings reductions in achievements is appropriate.

A. A. The reason why the Residential Walk-Through Energy Audit did not achieve the projected participation levels for 2020 was the COVID Pandemic. On March 16, 2020, Tampa Electric suspended non-essential operations with customers that require face-to-face interactions (on-site). The Residential Walk-Through Energy Audit not only requires face-to-face interactions but requires the company's Energy Analyst to fully walk through participating customer's homes which would contradict guidance for trying to control the spread of the COVID Pandemic. Although the company was able to achieve 1,514 participants between January 1, 2020 and March 15, 2020, this participation trend would have projected to complete a year end amount which would have exceeded the projection amount of 5,000 that was included in the company's projection filing that was filed on August 7, 2020.

B. Tampa Electric is not proposing any further modifications to the Residential Walk-Through Energy Audit at this time due to the COVID Pandemic. In the company's 2020 Commission approved DSM Plan, Tampa Electric included the performance of a walk-through energy audit as part of the company's Neighborhood Weatherization program. This change was initiated after researching that approximately 50 percent of all recent Residential Walk-Through Energy Audits were performed on homes that qualified for participation in the Neighborhood Weatherization program. Tampa Electric is confident that when the ability to perform face-to-face interactions with customers at their residences has returned, the company will achieve the projected numbers of participants in both DSM programs. Tampa Electric is still implementing the conservation related efforts toward the COVID Pandemic as was provided in the company's 2020 Annual DSM Report in Appendix "A" that was filed on March 1, 2021

C. Tampa Electric does not offer or provide any demand or energy savings measures under this program.

D. Tampa Electric does not offer or provide any energy efficiency kits under this program.

E. Tampa Electric does not offer or provide any energy efficiency kits under this program.

F. Tampa Electric does not offer or provide any energy efficiency kits under this program.

G. Tampa Electric does not offer or provide any energy efficiency kits under this program.

H. Tampa Electric does not offer or provide any energy efficiency kits under this program.

I. The value that is reflected in the Data Request is asking about the company's Residential Customer Assisted Energy Audit (Online) and not the Residential Walk-Through Energy Audit as outlined in the Data Request No. 6 above. The company is providing this response which will answer both questions as they are interrelated.

Prior to a DSM Goals Setting Process, Tampa Electric will have the company's internal Load Forecasting Department conduct an analysis to determine the actual energy and demand savings that were being achieved by the performance of recent Residential Walk-Through Energy Audits. For the 2015-2024 DSM Goals Setting process, the empirical analysis revealed that a typical recent customer participating in this program would have the following savings as compared to a customer that had not participated in the program:

Summer kW savings:	0.070 kW
Winter kW savings:	0.081 kW
Annual energy kWh savings:	395 kWh

These values were included in the company's 2015-2024 DSM Plan that was filed with the Commission on March 16, 2015. The energy and demand savings for the Residential Customer Assisted Energy Audit have historically been estimated to be 25 percent less than the Residential Walk-Through Energy Audit. From the 2015-2024 DSM Plan, the following savings would be realized from a customer participating in the Residential Customer Assisted Energy Audit:

Summer kW savings:	0.053 kW

Winter kW savings:	0.061 kW
Annual energy kWh savings:	296 kWh

A copy of the analysis that was performed in 2014 to support the 2015-2024 DSM Goals Setting Process is included further below.

From the Residential Walk-Through Energy Audit analysis that was performed in 2019 to support the 2020-2029 DSM Goals Setting Process, the empirical analysis revealed that a typical recent customer participating in this program would have the following savings as compared to a customer that had not participated in the program:

Summer kW savings:	0.096 kW
Winter kW savings:	0.127 kW
Annual energy kWh savings:	625 kWh

These values were included in the company's 2020-2029 DSM Plan that was filed with the Commission on February 19, 2020. The energy and demand savings for the Residential Customer Assisted Energy Audit was estimated to be 25 percent less than the Residential Walk-Through Energy Audit. From the 2020-2029 DSM Plan, the following savings would be realized from a customer participating in the Residential Customer Assisted Energy Audit:

Summer kW savings:	0.072 kW
Winter kW savings:	0.095 kW
Annual energy kWh savings:	469 kWh

A copy of the analysis that was performed in 2019 to support the 2020-2029 DSM Goals Setting Process is included further below.

To perform the calculations to determine the Combined Summer kW, Winter kW and Annual kWh reductions at the generator for the Residential Customer Assisted Energy Audit. The company took the participants in each DSM Plan, recognizing that the company transitioned to the 2020-2029 DSM Plan in November 2020. Then the company, multiplied the participant count during each period by the appropriate Summer kW, Winter kW and Annual Energy kWh savings amount for that period. The amounts were then adjusted by the appropriate line loss factor to adjust the meter savings to the generator and then the amounts were totaled to obtain the combined amounts of:

Summer kW savings:	3.582 MW

Winter kW savings:	4.241 MW
Annual energy kWh savings:	20.328 GWh

The company is including the excel worksheet "(BS_87) DR 6i - Rev 10, 1-19-21 2020 Report wo links.xls" with formulas intact as part of this response to show the calculations to support the amounts achieved. See Tabs labeled "R Free" and "R Assisted".

J. Please see Response No. 6I directly above.

K. Please see Response No. 6I directly above.

L. There are two reasons why the practice of not counting the annual demand and energy savings reductions in achievements from the Residential Walk-Through Energy Audit and Residential Customer Assisted Energy Audit DSM Programs is appropriate. First, As approved on August 11, 2015 in Docket No. 20150081-EG, Order No. PSC2015-0323-PAA-EG, the company agreed that it would not count the energy or demand savings from these programs toward contributions toward meeting Tampa Electric's Commission approved annual energy and demand saving's goals. Second, in the most recent 2020-2029 DSM Goals setting, energy audits were considered a behavioral energy and demand savings and as such, they were excluded from the Technical Potential amount. Because of these two reasons, Tampa Electric continues at this time to support not including their contributions toward achievements toward meeting Tampa Electric's Commission approved annual energy and demand saving's goals.

TAMPA ELECTRIC

MEMORANDUM

DATE: November 7, 2014

FROM: Lori Cifuentes

TO: Mark Roche, Roxanne Gilmore

RE: Residential Free Energy Audit Analysis

The recent review of the residential Free Energy Audit conservation program shows that these participants see an energy savings over the average customer.

Test Group Assumptions:

- Customers who received free audits during 2012
- Customers have not participated in any other conservation or load management program since the free audit
- Includes rates 110 only
- Had a complete 12 months of data for 2011 and 2013
- Eliminated customers with percentage changes in year-over-year energy use that fell outside of 2 standard deviations of the mean (considered outliers)

Control Group Assumptions:

- A random sample of unaudited customers (based on Load Survey Sample)
- Customers have never participated in any conservation or load management program (including 6 years prior to 2012)
- Includes rates 110 only
- Had a complete 12 months of data for 2011-2013
- Eliminated customers with percentage changes in year-over-year energy use that fell outside of 2 standard deviations of the mean (considered outliers)

Analysis:

- In this analysis, consumption before and after the audit was compared for both sets of customers to estimate the impact associated with the audit. The study found that audit participants' year-over-year energy consumption decreased at a higher rate compared to non-participants.
- 2013 had a much milder winter, while the rest of the year was very similar. This is in line with usage being less in 2013 (vs. 2011) for both the Free Audit participants and the control group.
- It would be reasonable to assume that Free Audit participants were not as weather sensitive as the control group during the winter months of 2013, thus showing a larger reduction in usage compared to 2011.

Analysis Results

Mean Annual Usage (kwh)						
	2011	2013	Change	%Change	Avg.Annual Change	Avg.Annual %Change
Test Group	19,878	18,444	(1,434)	-7.21%	(717)	-3.7%
Control Group	18,716	17,935	(781)	-4.17%	(391)	-2.1%
					(326)	**-1.6%**

Mean Annual Usage (kwh) @ 95% confidence						
	2011	2013	Change	%Change	Avg.Annual Change	Avg.Annual %Change
Test Group	20,010	18,461	(1,549)	-7.74%	(775)	-3.9%
Control Group	19,179	18,420	(759)	-3.96%	(380)	-2.0%
					(395)	**-2.0%**

2012 Typical Residential Customer						
		kW	#RS Cust	kW/Cust	Energy %Savings	kW/cust savings
Residential	Winter	2,475,190	598,071	4.1	-2.0%	(0.08070)
Residential	Summer	2,149,200	598,825	3.6	-2.0%	(0.06999)

Degree Days			
	2011	2013	%Chg.
Heating Degree-Days	575	408	-29%
Cooling Degree-Days	3844	3780	-2%
Total	4419	4188	-5%

MEMORANDUM

DATE: August 15, 2019

FROM: Stacy Hallman

TO: Mark Roche

RE: Residential Free Energy Audit Analysis

The recent review of the residential Free Energy Audit conservation program shows that these participants see an energy savings over the average customer.

Test Group Assumptions:

- Customers who received free audits during **2017**
- Customers who have not participated in any other conservation or load management program one year prior or one year after the free audit
- Includes only single-family homes
- Had complete 12 months of data for 2016, 2017, 2018 and 6 months of data for 2019
- Eliminated customers with percentage changes in year-over-year energy use that fell outside of 2 standard deviations of the mean (removed outliers)

Control Group Assumptions:

- A random sample of unaudited customers (based on Load Survey RS Sample)
- Customers have never participated in any conservation or load management program (including 6 years prior to 2017, so no participation in DSM 2011 going forward)
- Includes only single-family homes
- Had complete 12 months of data for 2016, 2017, 2018 and 6 months of data for 2019
- Eliminated customers with percentage changes in year-over-year energy use that fell outside of 2 standard deviations of the mean (removed outliers)

Analysis:

- In this analysis, consumption in 2016 and 2018 was compared for both sets of customers to estimate the impact associated with the audit. The study found the test group's (audit participants) energy consumption decreased at a higher rate compared to the control group (non-participants). (See ***Figure 1***)
- During 2016, annual energy usage for those in the test group was 10% higher than those in the control group. This 10% gap tightened to within 2-3% during 2018 (See ***Figure 1***), despite the higher number of total degree days. (See ***Figure 2***)
- When comparing annual average usage from 2016 to 2018 in both the test and control groups, the test group saved **4.5%** more energy and **3.1%** more energy at a 95% confidence interval from the mean. (See ***Figure 2***)
- There was a steady decline in annual energy usage from the test group, years 2016 – 2018, despite the weather; while the control group showed an increase in usage from 2017 to 2018. It appears those in the test group, who had a free home energy audit during 2017, were not as weather sensitive as the control group. (See ***Figure 3***)

ANALYSIS RESULTS

Figure 1

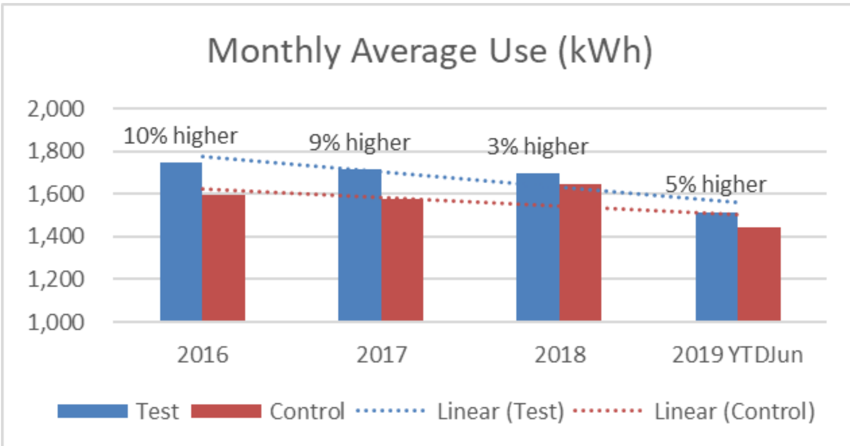


Figure 2

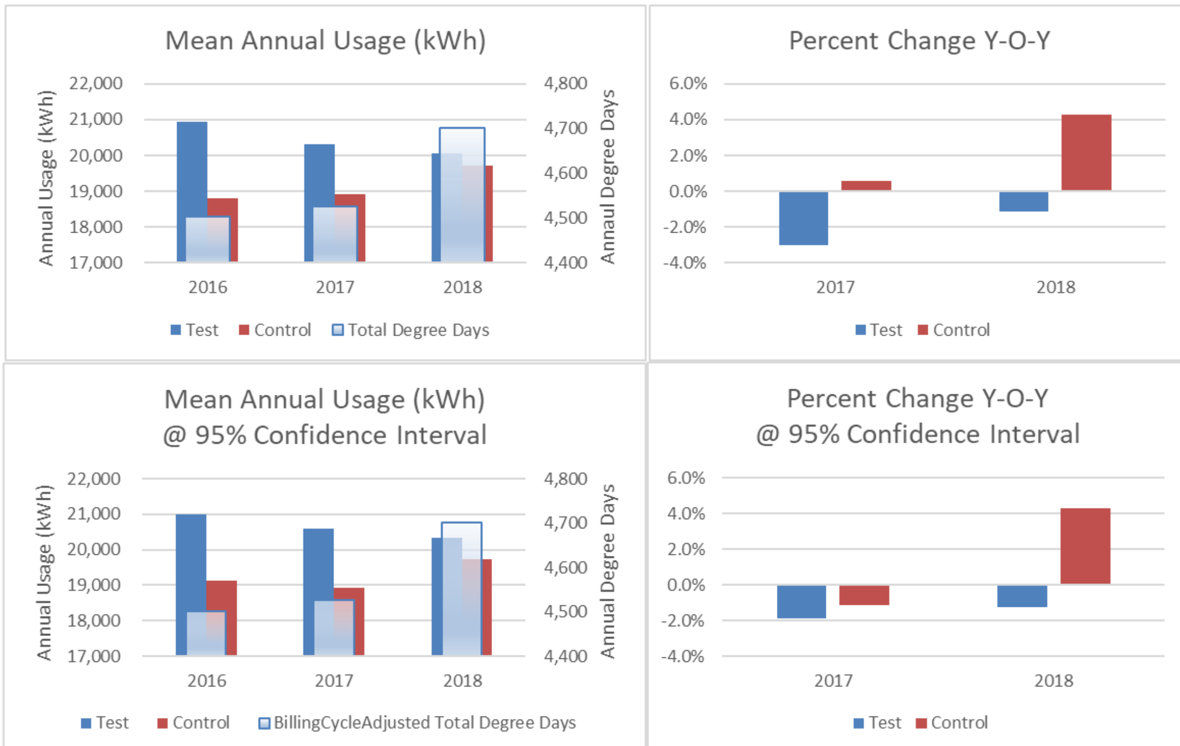
Mean Annual Usage (kWh/customer)						
	2016	2018	Change	%Change	Avg.Annual Change	Avg.Annual %Change
Test Group	20,933	20,069	(864)	-4.13%	(432)	-2.1%
Control Group	18,799	19,713	914	4.86%	457	2.4%
			kWh/customer Savings		**(889)**	**-4.5%**

Mean Annual Usage (kWh/customer) @ 95% confidence						
	2016	2018	Change	%Change	Avg.Annual Change	Avg.Annual %Change
Test Group	20,986	20,330	(656)	-3.12%	(328)	-1.6%
Control Group	19,140	19,735	595	3.11%	298	1.5%
			kWh/customer Savings		**(625)**	**-3.1%**

2017 Typical Residential Customer Demand						
		Demand kW	# of RS Customers	kW/Cust	Energy %Savings	**kW/cust savings**
Residential	Winter	2,659,050	652,773	4.1	-3.1%	**(0.127)**
Residential	Summer	2,034,310	659,313	3.1	-3.1%	**(0.096)**

Degree Days				%Chg.
	2016	2017	2018	'18 vs '16
Heating Degree-Days	350	177	409	16.9%
Cooling Degree-Days	4,152	4,349	4,292	3.4%
Total Degree-Days	**4,502**	**4,526**	**4,701**	**4.4%**

Figure 3


Mean Annual Usage (kWh)
Annual Usage (kWh)
Annaul Degree Days
22,000
21,000
20,000
19,000
18,000
17,000
4,800
4,700
4,600
4,500
4,400
2016
2017
2018
Test
Control
Total Degree Days
Percent Change Y-O-Y
6.0%
4.0%
2.0%
0.0%
-2.0%
-4.0%
2017
2018
Test
Control
Mean Annual Usage (kWh)
@ 95% Confidence Interval
Test
Control
BillingCycleAdjusted Total Degree Days
Percent Change Y-O-Y
@ 95% Confidence Interval

7. On Bates Stamp Page 4 of the report, the Company provided information on its Residential Customer Assisted audit program. The report indicates that in 2020, the actual number of participants in this program grew compared 2019, and also exceeded the Company's projected participation for 2020. Please describe the Company's assessment for why participation in this program grew compared 2019, and also exceeded projections for 2020.

A. The increase in participation in the Residential Customer-Assisted Audit Program is due to the following:

- For the safety of customers and employees, field activity for the Residential Walk-Through Energy Audit was suspended in March of 2020 through the end of the year due to the COVID pandemic. Because of this inability to offer the Residential Walk-Through Energy Audits, Tampa Electric increased the promotion of the Residential Customer-Assisted Audit through several marketing channels. These marketing channels included verbal communication by the company's EMS Program Support phone team, promotional videos recorded by Tampa Electric's Residential Energy Analysts, social media, e-news updates, and through bill onserts (both paper and online bills). In addition, when the suspension of face-to-face operations became clearer that it would last much longer, in June Tampa Electric added a new Residential Customer-Assisted Audit promotional pop-up message that displays to all residential customers upon logging into the Tampa Electric online portal with a call to action link, taking the customer to beginning of the online energy audit. All of these marketing channels and pop-up messages drove the number of participants to exceed the company's projected participation for 2020.

8. Regarding energy audits for commercial/industrial customers, please answer the following:

A. Does the Company offer an audit by telephone or an online option for its commercial/industrial customers? If so, please state the number of audits that were conducted by either/both methods in 2020.

B. If Company does not offer an audit by telephone or an online option for its commercial/industrial customers, has the Company examined the feasibility of expanding its audit program to include these options? If so, summarize the results of such discussions.

A. A. Tampa Electric does not have a Commissioned approved formal commercial/industrial telephone or online energy audit. Due to the suspension of face-to-face operations because of the COVID Pandemic, Tampa Electric's CEMT began offering an energy audit conducted by phone with the customer then placed on a wait list for a future walk-through energy audit that would then be counted as completion of one of Tampa Electric's Commission approved Commercial/Industrial Audits (Free). In 2020, the following commercial/industrial energy audit activities were completed:

Commercial/Industrial Energy Audits (Free):	238
Comprehensive Commercial/Industrial Audit (Paid):	0
Commercial/Industrial Phone Energy Audits:	179 (Note 1)

Note 1: These customers will be followed up with upon the reinitiating of face-to-face operations for the walk-though portion of the energy audit. The energy audit at that time would be counted as completing a Commercial/Industrial Energy Audit (Free):

B. The company has examined the potential for offering a commercial/industrial online energy audit but as explained in Response No. 2 above, due to the diverse processes, equipment, and facilities, offering a high quality online energy audit is not feasible or cost-effective at this time. Because of this diversity of processes, equipment and facilities, Tampa Electric believes that offering a phone energy audit while face-to-face interactions and facility visits are suspended provides some worthwhile value to commercial/industrial customers but cannot achieve the significant value of an energy audit that has a site visit with face-to face interactions in comparison. Because of this, Tampa Electric does not view expanding its commercial/industrial energy audit programs to add a formal Commission approved phone energy audit at this time.

9. According to Bates Stamp Page 6 of the report, the actual number of program participants in the Residential Ceiling Insulation program was lower than the number the Company projected for this program.

A. Identify the reasons why this program did not achieve the projected participation levels for 2020.

B. What, if any, program modifications is the Company considering or researching to ensure that this program will be able to more closely achieve projected participation levels? Please explain.

A. A. The reason why the Residential Ceiling Insulation program did not achieve the projected participation levels for 2020 was the COVID Pandemic. On March 16, 2020, Tampa Electric suspended non-essential operations with customers that require face-to-face interactions (on-site). The Residential Ceiling Insulation program not only requires face-to-face interactions but requires the company's Energy Analyst to go into the participating customer's homes to perform an attic inspection which would contradict guidance for trying to control the spread of the COVID Pandemic. Although the company was able to achieve 225 participants between January 1, 2020 and March 15, 2020, this participation trend would have projected to complete a year end amount which would have exceeded the projection amount of 450 that was included in the company's projection filing that was filed on August 7, 2020. In addition, due to changing some of the program processes that did not impact the program or associated standard, the company was able to attract 40 additional customers during the COVID Pandemic.

B. Tampa Electric is not proposing any modifications to the Residential Ceiling Insulation program at this time due to the COVID Pandemic. Tampa Electric is confident that when the ability to perform face-to-face interactions with customers at their residences has returned, the company will achieve the projected numbers of participants in the Residential Ceiling Insulation program. Tampa Electric is still implementing the conservation related efforts toward the COVID Pandemic as was provided in the company's 2020 Annual DSM Report in Appendix "A" that was filed on March 1, 2021.

10. According to Bates Stamp Page 7 of the report, the actual number of program participants in the Residential Duct Repair program was lower than the number the Company projected for this program.

A. Identify the reasons why this program did not achieve the projected participation levels for 2020.

B. What, if any, program modifications is the Company considering or researching to ensure that this program will be able to more closely achieve projected participation levels? Please explain.

A. A. The reason why the Residential Duct Repair program did not achieve the projected participation levels for 2020 was the COVID Pandemic. On March 16, 2020, Tampa Electric suspended non-essential operations with customers that require face-to-face interactions (on-site). The Residential Duct Repair program not only requires face-to-face interactions but requires the company's Energy Analyst to go into the participating customer's homes to perform an inspection of the duct work in the customer's attic which would contradict guidance for trying to control the spread of the COVID Pandemic. Although the company was able to achieve 148 participants between January 1, 2020 and March 15, 2020, this participation trend would have projected to be close to the year-end amount that was projected to be 500 that was included in the company's projection filing that was filed on August 7, 2020. In addition, due to changing some of the program processes that did not impact the program or associated standard, the company was able to attract 103 additional customers during the COVID Pandemic

B. Tampa Electric is not proposing any modifications to the Residential Duct Repair program at this time due to the COVID Pandemic. Tampa Electric is confident that when the ability to perform face-to-face interactions with customers at their residences has returned, the company will achieve the projected numbers of participants in the Residential Duct Repair program. Tampa Electric is still implementing the conservation related efforts toward the COVID Pandemic as was provided in the company's 2020 Annual DSM Report in Appendix "A" that was filed on March 1, 2021.

11. According to Bates Stamp Page 9 of the report, the actual number of program participants in the Energy Education, Awareness, and Agency Outreach program was lower than the number the Company projected for this program

A. Identify the reasons why this program did not achieve the projected participation levels for 2020.

B. What, if any, program modifications is the Company considering or researching to ensure that this program will be able to more closely achieve projected participation levels? Please explain.

A. A. The reason why the Energy Education, Awareness, and Agency Outreach program did not achieve the projected participation levels for 2020 was the COVID Pandemic. On March 16, 2020, Tampa Electric suspended non-essential operations with customers that require face-to-face interactions (on-site). The Energy Education, Awareness, and Agency Outreach program relies heavily on face-to-face interactions with customers at energy education events to promote the offerings of this program. Although the company was able to achieve 445 participants between January 1, 2020 and March 15, 2020, this participation trend would have projected to complete a year end amount which would have exceeded the projection amount of 750 that was included in the company’s projection filing that was filed on August 7, 2020.

B. Tampa Electric is not proposing any further modifications to the Energy and Renewable Education, Awareness, and Agency Outreach program at this time due to the COVID Pandemic. Tampa Electric is confident that when the ability to perform face-to-face interactions with customers has returned, the company will achieve the projected numbers of participants in the Energy and Renewable Education, Awareness, and Agency Outreach program. Tampa Electric is still implementing the conservation related efforts toward the COVID Pandemic as was provided in the company’s 2020 Annual DSM Report in Appendix “A” that was filed on March 1, 2021.

12. On page 16 of your FEECA filing, data is shown for the Energy Planner program. Please answer the following:

A. Please show the calculations to support the Utility Cost per Installation amount of $501.

B. Please show the calculations to support the Total Program Cost of the Utility amount of $2,477,100.

C. Please show the calculations to support the Net Benefits of Measures Installed During Reporting Period amount of $3,876,100.

D. Please show the calculations and results of cost effectiveness tests.

A. A. Please see Excel spreadsheet provided in Response No. 6 above with formula's intact. See Tab labeled "EP".

B. The $2,477,100 total program cost comes from the company's true-up filing that will be filed with the Commission on May 3, 2021. The company is providing the supporting excel worksheet, "(BS_95) DR No.12B - 3-25-21, 2020 Conservation FINAL True Up 031521.xlsm," that supports this total program cost.

C. Please see Excel spreadsheet provided in Response No. 6I above with formulas intact. See Tab labeled "EP". Also, please see the cost-effectiveness sheets that are provided in Response No. 12 D below that provides the net benefits of measures on the Rate Impact Measure Cost-Effectiveness Sheet.

D. The company is providing the Excel spreadsheet, "(BS_96) DR No. 12D - Res-Energy Planner-CE.xls," cost-effectiveness sheets with formulas intact for the Energy Planner program which was filed with the Commission on February 19, 2020 in the petition for approval of the company's 2020-2029 DSM Plan which shows the calculations and results of cost-effectiveness tests.

13. On page 32 of your FEECA filing, data is shown for the Commercial Street and Outdoor Lighting Conversion program. Please answer the following:

A. Please show the calculations to support the Utility Cost per Installation amount of $138.

B. Please show the calculations to support the Total Program Cost of the Utility amount of $3,504,400.

C. Please show the calculations to support the Net Benefits of Measures Installed During Reporting Period amount of $9,535,200.

D. Please show the calculations and results of cost effectiveness tests.

A. A. Please see Excel spreadsheet provided in Response No. 6I above with formula's intact. See Tab labeled "LED Conversion".

B. The $5,504,400 total program cost comes from the company's true-up filing that will be filed with the Commission on May 3, 2021. Please see the Excel spreadsheet that is being provided in Response No. 12B above that supports this total program cost.

C. Please see Excel spreadsheet provided in Response No. 6I above with formulas intact. See Tab labeled "LED Conversion". Also, please see the cost-effectiveness sheets that are provided in Response No. 13D below that provides the net benefits of measures on the Rate Impact Measure Cost-Effectiveness Sheet.

D. The company is providing the Excel spreadsheet, "(BS_98) DR No.13D-Comm LED Street Light and Outdoor Lighting-CE.xls," cost-effectiveness sheets with formulas intact for the Commercial Street and Outdoor Lighting Conversion program which was filed with the Commission on February 19, 2020 in the petition for approval of the company's 2020-2029 DSM Plan which shows the calculations and results of cost-effectiveness tests.