ANALYSIS OF ELECTRIC UTILITY EV PROPOSALS

by

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Executive Summary

The project analyzes a sample of Electric Vehicle program proposals put forth by electric utilities across the U.S. for developing and installing electric vehicle (EV) charging infrastructure. The aim of this project was to study each of these proposals in depth and characterize trends over the past few years that might prove to be useful for any future studies on EV utility proposals.

A sample of 61 proposals filed from 2013 to 2019 by various utilities across the country were selected for this project. These proposals were filed with the respective state public utility commissions by the utilities. These proposals can be tracked through a 'docket number' on the state utility website. The primary docket list was provided by the project client ScottMadden. Various sources of data have been used to understand the depth of these proposals. Two main sources of data are: State utility commission websites and AEE Powersuite[1].

Primarily, 10-12 proposals were focused upon along with similar research papers in the field, to develop key criteria among these proposals, that could determine the scope of the project. The shortlisted criteria from these proposals were chosen based on their common occurrence among these proposals. These criteria include time-of-use rates, program costs, cost recovery plans, type of utility, type of proposal, type of charging (public, residential, commercial), charging level (Level I, Level II, DC fast charging, date on which proposal was filed, date on which proposal was approved/rejected, length of the program, and number of charging stations/ports. There are a few other criteria like communication protocols, number of EVs incentivized, among others, that were noted while gathering data. These additional criteria are unique to a few proposals and so they are detailed in specific sections of the paper in order to outline the nuances among trends and some outliers.

Understanding the trends, from the large amount of data, proved to be a difficult task. Different proposals focused on different criteria in depth. While some proposals included all the shortlisted criteria for the project analysis, some proposals were very vague. For example, one

[1] Powersuite website link. https://powersuite.aee.net/welcome

proposal would mention program costs but not the length of the program. These challenges were overcome by arranging the data into a spreadsheet and sorting the required criteria.

First, the analysis was performed on a criterion by criterion basis. In each criterion, say for example program costs, a country wide analysis was drawn and then was narrowed down to a state by state analysis. Secondly, the state-by-state analysis includes a more magnified approach on a few states that stand out from the majority sample. These state proposals detail a few unique aspects that are worth mentioning as they identify trends that were initially unexpected. Additionally, from the final analysis of the sample data, a few inferences from program criteria, like an increase in Program Costs, a decline in Commercial charging, aligned with increase in Level II and DCFC chargers over the years. Drawing on inferences of relationships between one criterion and another, like program costs on type of charging, provided more insights on the trends. Further analysis on four utility proposals was also performed, that details a few notable aspects that could give a better understanding of the trends among criteria in the proposals.

The results of the analysis show that California has the highest number of EV proposals in the country. This could be due to the encouraging clean transportation policies and goals put forth by the State of California. The program costs of the proposals have shown an increase from 2013 to 2019, which could be due to increased awareness among the state and the public that lead to more investments over time. Almost 70% of the proposals are put forth by investor-owned utilities when compared to publicly owned utilities and electric cooperatives. There has been a steady increase in investments in public charging over residential and commercial charging, further adding to growth in investments in Level II and DC Fast Chargers (DCFC) over Level I chargers. Cost recovery of these EV programs mostly rely on distribution of rate base on customers’ utility bills. Among the sample of proposals, utilities from 21 states offer time-of-use rate design for their EV customers. These results and trends are explained in detail in the paper.

Acknowledgements

Sincere thanks to our client ScottMadden for giving us the opportunity to work on this project. This research helped improve the team's knowledge not just of electric vehicle charging proposals but also of the market overview, as well as an understanding of how EV charging is implemented, the investment of time and finances that go into charging infrastructure and most of all, exposure to how different stakeholder participation plays an important role in EV charging proposal decision-making.

Special thanks to Paul Quinlan, the point-of-contact from ScottMadden for this project. Paul has been a great resource for this research and gave timely updates and feedback on this project, which was very crucial to the project outcomes. Monthly meetings and email exchanges over market analysis, utility related questions and project goals with Paul helped shape the research into the direction of the project goals.

Furthermore, thanks to the project adviser, Timothy Johnson, for his constant advice and continual support throughout the duration of this research. Tim has encouraged the team and at times pushed the team forward to achieve the project goals. Tim’s guidance is a major contributing factor to this project.

Additionally, the team is also thankful to the Nicholas School of Environment and Duke University for access to several resources which have been immensely useful in the research process. Also, thanks to all the students and professors at the Nicholas School for giving feedback on this project and helping the team reach its goals.

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Introduction

Technology and innovation bring us something new every day. One of the major trends these days is owning an electric vehicle. With sleek, futuristic designs, electric vehicles have owned an increasing share in automobile sales[2]. From budget electric vehicle models such as the Chevy Bolt to luxury models like Rimac Concept One, there are an increasing number of choices for the customer.

On the other hand, battling climate change can be difficult, but it is not impossible. One of the major causes of climate change is Greenhouse Gas Emissions (GHG) emissions[3]. Pollution from the release of GHG emissions is a major contributor to global increase in temperatures, sea level rise, ozone depletion among others that ultimately fatal to human life. There are different sources that contribute to GHG emissions. Among the different sectors in our society, transportation industry contributes to 28% of GHG emissions in the United States[4]. Emissions from tailpipe of vehicles, contribute significantly to overall GHG emissions in today's world. In order to regulate GHG emissions, the US Supreme Court in 2007 ruled that EPA could regulate GHGs under the Clean Air Act (CAA)[5].

Along with effective policies from the government and modern-day technology, our daily commute has transformed. Electric Vehicles (EVs), as the term suggests, are vehicles that run on electricity rather than combustion of fossil fuels. EVs have an in-built battery, that can be charged periodically to keep the vehicle running[6]. EVs can minimize GHG emissions in two major ways: Firstly, they do not have or release any harmful tailpipe emissions and secondly, they can be charged by the electricity generated from clean energy (renewable) sources like solar and wind energy among others.

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[2] Electric Vehicle Sales are Taking off in 2018. David Reichmuth. (Sep. 2018). https://blog.ucsusa.org/dave-reichmuth/electric-vehicle-sales-are-taking-off-in-2018

[3] Pollution and Climate Change. Greenpeace. https://www.greenpeace.org/usa/oceans/issues/pollution-climate-change/

[4] Sources of Greenhouse Gas Emissions. EPA. (2018). https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions

[5] Clean Air Act. EPA. (2007). https://www.epa.gov/nsr/clean-air-act-permitting-greenhouse-gases

[6] Electric Vehicle Basics. DOE. https://www.energy.gov/eere/electricvehicles/electric-vehicle-basics

Some of the most important factors that come into mind regarding electric vehicles for a prospective EV owner[7] are: ‘Is there a good charging infrastructure?’, ‘How do I charge my car?’, ‘How expensive are EVs’? ‘How far can I drive an EV’? In order to have an effective charging infrastructure[8], not just the federal government, but both state governments and utilities have to ensure that there are sufficient resources available to stakeholders who would develop a charging infrastructure and at the same time make it affordable for ratepayers and taxpayers to be able to afford this technology. Various states across the country have put forth effective energy policies and Renewable Portfolio Standards (RPS)[9] that require utilities to submit proposals for clean energy programs. While these programs usually focus on energy generation, the policies tend to align with incentives/rebates for electric vehicle programs too[10]. Hence, state policies in RPS should include and encourage EV programs to ensure more adoption of EV usage in the state.

This project focuses on analyzing EV charging proposals put forth by utilities across the United States. The scope of the project is to analyze the sample data and understand the depth of these proposals to project trends that could be useful for any future analysis of EV charging proposals put forth by utilities.

A sample of 61 proposals filed from 2013 to 2019 by various utilities across the country were selected for this project. These proposals were filed with the respective state public utility commissions by the utilities. These proposals can be tracked through a ‘docket number’ on the state utility website. The primary docket list was provided by the project client ScottMadden. Various sources of data have been used to understand the depth of these proposals. Two main sources of data are: State utility commission websites and AEE Powersuite[11].

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[7] 6 Burning Questions about Electric Cars. Consumer Reports. (Jul. 2014). https://www.consumerreports.org/cro/news/2014/07/six-burning-questions-about-electric-cars/index.htm

[8] Vehicle Charging. DOE. https://www.energy.gov/eere/electricvehicles/vehicle-charging

[9] Most States have Renewable Portfolio Standards. EIA. (Feb. 2012). https://www.eia.gov/todayinenergy/detail.php?id=4850#

[10] Transportation electrification should build on energy efficiency and renewable program success. Robin Lunt. (Apr. 2018). https://www.utilitydive.com/news/transportation-electrification-should-build-on-energy-efficiency-and-renewa/521008/

[11] Powersuite website link. https://powersuite.aee.net/welcome

Primarily, 10-12 proposals were focused upon along with similar research papers in the field, to develop key criteria among these proposals, that could determine the scope of the project. The shortlisted criteria from these proposals were chosen based on their common occurrence among these proposals. These criteria include time-of-use rates, program costs, cost recovery plans, type of utility, type of proposal, type of charging (public, residential, commercial), charging level (Level I, Level II, DC fast charging, date on which proposal was filed, date on which proposal was approved/rejected, length of the program, and number of charging stations/ports. There are a few other criteria like communication protocols, number of EVs incentivized, among others, that were noted while gathering data. These additional criteria are unique to a few proposals and so they are detailed in specific sections of the paper in order to outline the nuances among trends and some outliers.

Understanding the trends, from the large amount of data, proved to be a difficult task. Different proposals focused on different criteria in depth. While some proposals included all the shortlisted criteria for the project analysis, some proposals were very vague. For example, one proposal would mention program costs but not the length of the program. These challenges were overcome by arranging the data into a spreadsheet and sorting the required criteria.

First, the analysis was performed on a criterion by criterion basis. In each criterion, say for example program costs, a country wide analysis was drawn and then was narrowed down to a state by state analysis. Secondly, the state-by-state analysis includes a more magnified approach on a few states that stand out from the majority sample. These state proposals detail a few unique aspects that are worth mentioning as they identify trends that were initially unexpected. Additionally, from the final analysis of the sample data, a few inferences from program criteria, like an increase in Program Costs, a decline in Commercial charging, aligned with increase in Level II and DCFC chargers over the years. Drawing on inferences of relationships between one criterion and another, like program costs on type of charging, provided more insights on the trends. Further analysis on four utility proposals was also performed, that details a few notable aspects that could give a better understanding of the trends among criteria in the proposals.

Our Client

This project was outlined by ScottMadden. Since the inception of the research, ScottMadden has guided and helped define the project goals and deliverables. ScottMadden is a general management consulting company. ScottMadden was founded in 1983 and is based out of Raleigh, North Carolina. They provide an array of consulting services in a broad range of areas in the energy industry.

Target Audience

The research is intended for all industry professionals in EV charging and EV enthusiasts, who are looking for an analysis on recent trends in utility proposals filed for EV programs. This analysis is also useful for utilities to understand how proposals filed by utilities in other states vary from the proposals in their own states. It can also serve as a reference source for EV charging network developers to understand trends and make decisions on investments for future development. Overall, it also serves as a reference for any person interested in understanding the market trends in EV proposals over the past few years.

Similar Studies

There are a few studies that have done research on how a charging network should be designed, developed, and installed for the public to adopt it faster and use the charging network more efficiently. One of these studies has been published by the Idaho National Laboratory (INL)[12]. An elaborate research was made by the INL to understand the needs of an effective EV charging infrastructure. This research was carried out between 2011 and 2014[13]. It analyzed over 17,000 charging stations in the country along with more than 8,000 plug-in and all-electric car drivers. These studies involved data from automakers like Nissan and General Motors along with EV charging companies like ChargePoint and Blink.

This study found that it is convenient for EV owners to charge in their workplace than drive to a public charging facility, as EV charging takes a few hours based on the capacity of the battery in the car and so charging the car during work will prove to be time-saving over waiting in a public charging station. The study also concludes that, "Two things are going to affect the widespread adoption of EVs in the United States: gasoline prices and the life cycle costs of an EV versus a gasoline-powered car." This study was also part of a larger goal to support the Department of Energy's (DOE) strategic goal to increase U.S. energy security and reduce the country's dependence on foreign oil[14].

Figure 1 shows the number of electric vehicles enrolled in the project, where the study took place. We can observe that San Francisco and Washington State have the highest number of EVs from this study. Most of these vehicles were Nissan Leaf, while others included the Chevy Volt and Smart Electric Drive. If other EV vehicles such as Tesla, Ford Focus, etc. were also included then maybe the data on the map would look different. The data collected for this study is only a sample study taken over 3 years that includes 2 major EV makers and 2 electric charging companies primarily. From Figure 2, we can see the number of chargers proposed to be

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[12] Large National Studies Analyze EV Infrastructure Needs. Paul Menser. https://avt.inl.gov/project-type/technical-reports

[13] Summary of EV study by INL. Paul Menser. https://inl.gov/article/charging-behavior-revealed-large-national-studies-analyze-ev-infrastructure-needs/

[14] Trends Observed in Plug-in EV Infrastructure Demonstrations. John Smart, INL. (Jan. 2014). https://avt.inl.gov/sites/default/files/pdf/EVProj/SAEGovtIndMtgJan2014.pdf

installed by Blink across the country through September 2013. These chargers mostly include DC fast charging (DCFC) and Level II chargers (about which we will discuss in detail in further sections of this paper).

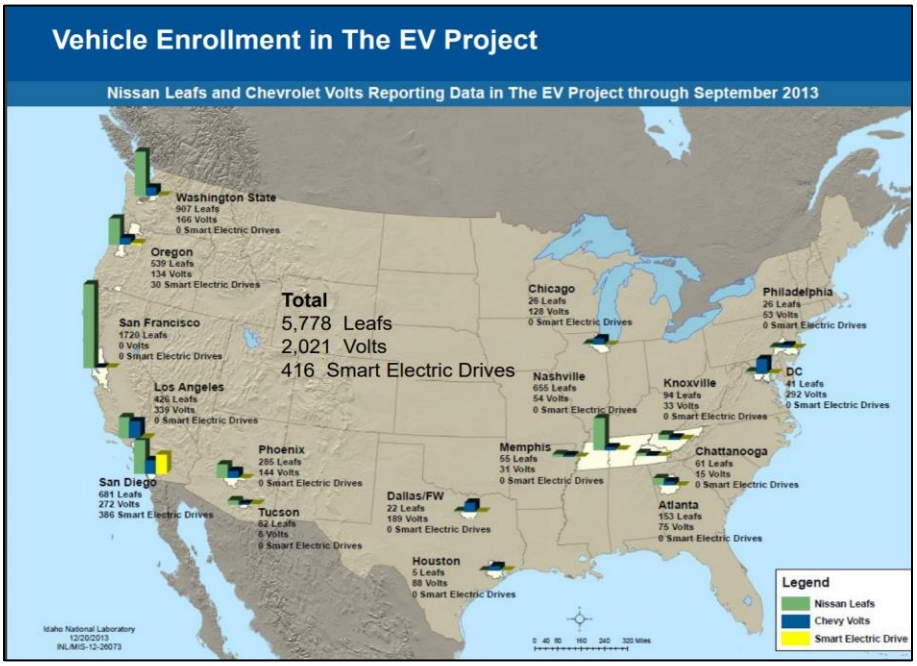

Figure 1 Vehicle enrollment in the EV project, INL Study, (2011-2014), taken from (https://avt.inl.gov/sites/default/files/pdf/EVProj/SAEGovtIndMtgJan2014.pdf)

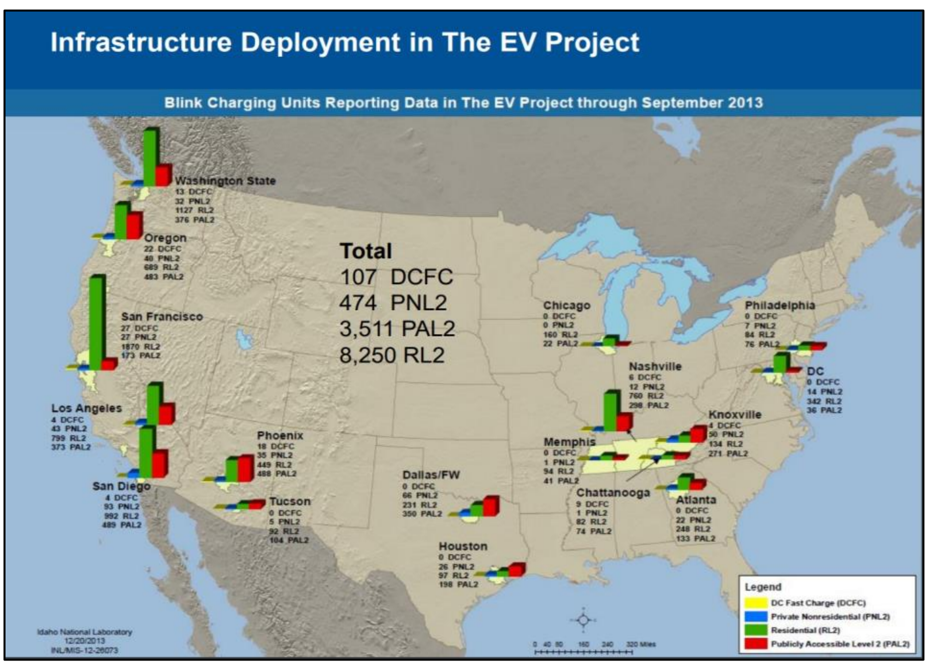

Figure 2 Infrastructure Deployment in the EV project, INL Study, (2011-2014), taken from (https://avt.inl.gov/sites/default/files/pdf/EVProj/SAEGovtIndMtgJan2014.pdf)

From Figure 3 we can see that the study by INL has also compared different types of charging. That is, the data in Figure 3 is mapped for chargers in different uses (areas) like residential, commercial, and public. From the below map we can observe that most of these chargers are either a residential charger or public charger. One other observation from this data is that most chargers are located either in the Northeast U.S. or on the West coast. This data further looked into the frequency of charging away from home and the percentage of EV owners charging their vehicles at home vs away from home. This data overall provides a useful insight into chargers installed based on different charging levels across a few states.

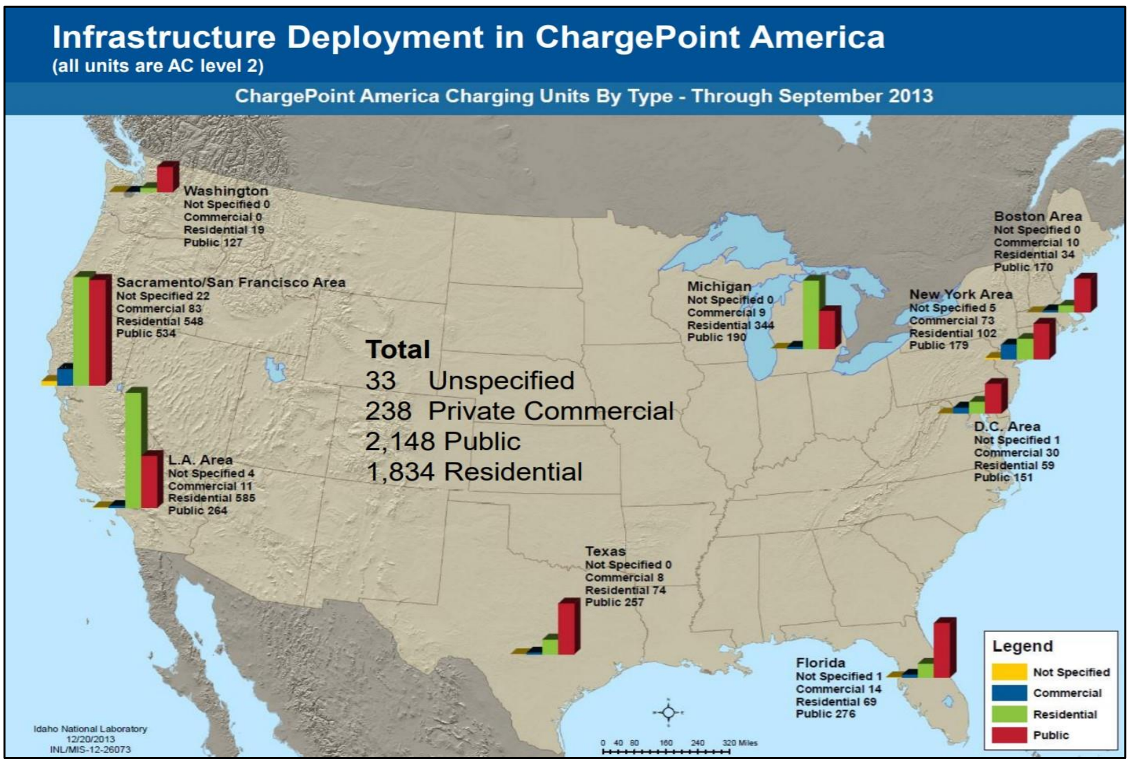

Figure 3 EV Charging Infrastructure Deployment by ChargePoint America, INL Study, (2011-2014), taken from (https://avt.inl.gov/sites/default/files/pdf/EVProj/SAEGovtIndMtgJan2014.pdf)

Another study by McKinsey & Company in 2018 outlines the demand of EV charging infrastructure[15]. This study not only looks at data from the United States but also looks at data from other countries like the European Union (EU) and China. This data also includes a recent

[15] Charging Ahead: EV Infrastructure Demand. Hauke Engel, Russell Hensley, Stefan Knupfer, and Shivika Sahdev. (Aug. 2018). https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/charging-ahead-electric-vehicle-infrastructure-demand

survey conducted by McKinsey in 2016[16] on EV buyers in China, Germany, and the U.S. The 2018 study suggests that "the base-case scenario for EV adoption suggests approximately 120 million EVs could be on the road by 2030 in China, the European Union, and the United States." The study also projects the growth in energy demand due to EV charging in the four regions.

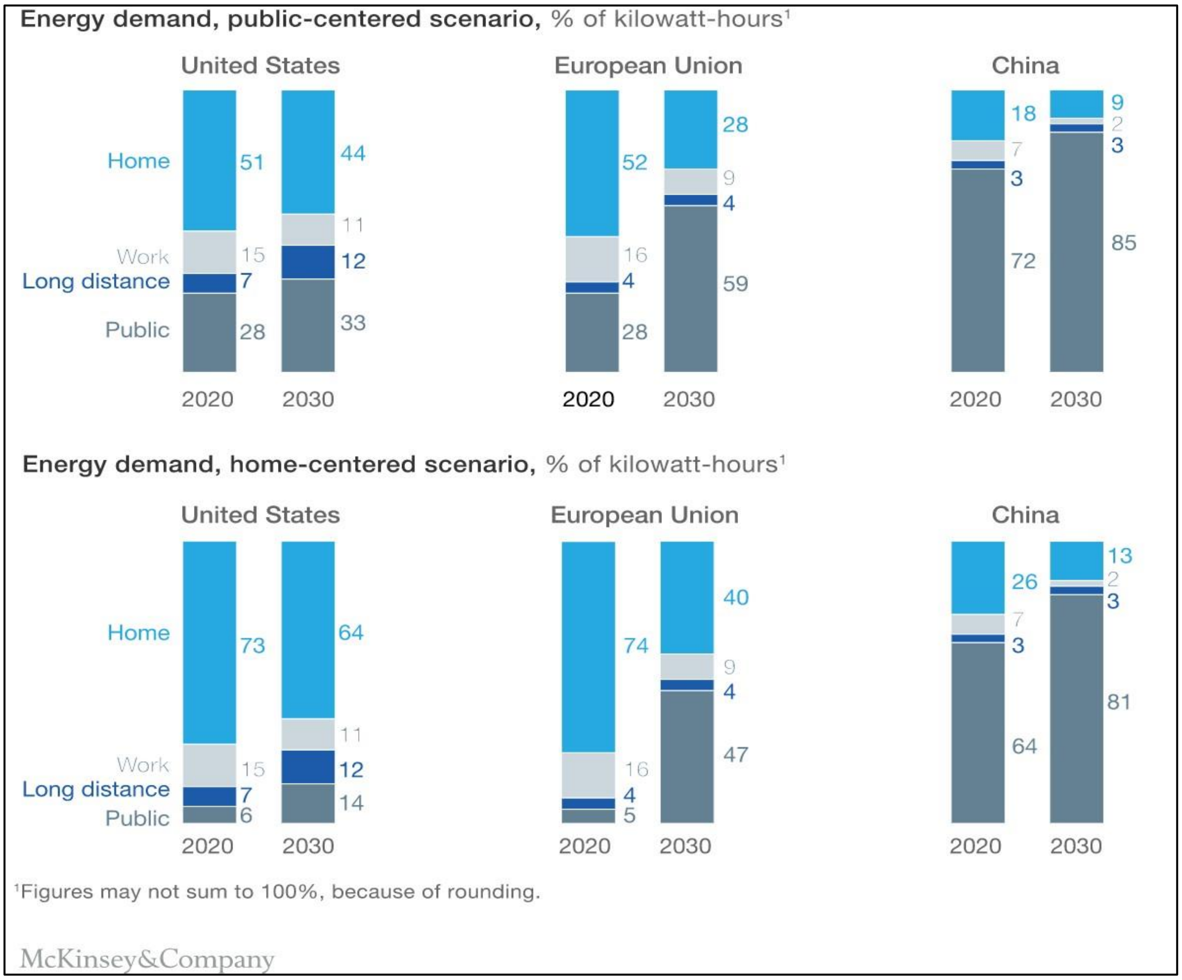

Figure 4 Energy demand for public and home-based charging scenarios by Mckinsey & Company taken from (https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/charging-ahead-electric-vehicle-infrastructure-demand)

Over the past five years, utilities in the U.S. have been urged by the State utility commissions to invest more in electric vehicle infrastructure programs. Some utilities proposed programs voluntarily while other utility programs were based on orders issued by the public utility

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16 Electrifying Insights: How Automakers Can Drive Electrified Vehicle Sales and Profitability. Stefan M. Knupfer, Russell Hensley, Patrick Hertzke, Patrick Schaufuss. (Jan. 2017). https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/electrifying-insights-how-automakers-can-drive-electrified-vehicle-sales-and-profitability

commissions to install more charging stations. For example, in October 2017, Utility Dive (a news site) reported[17] that, one of the biggest electricity providers in the Northeast, Eversource Energy, installed charging stations, although it was initiated by the commission and quoted: "Massachusetts Department of Public Utilities issued an order in Eversource's rate case that approves the company's proposal to install more than 4,000 new make-ready electric vehicle (EV) charging stations over the next five years, representing an investment of approximately $45 million."[18] The Sierra Club comments on the action that "this is the first major EV-utility program approved in the Northeast, but there are many others coming down the pike in the region.[19] In Missouri, with years of holding back from their commission, Ameren Missouri is finally "moving ahead with incentives to help business install more than 1,000 electric vehicle charging stations throughout its service territory"[20] with the approval of Missouri Public Service Commission.

In California, the widely recognized EV practice leading state in the U.S., approval of EV charging programs was not uncommon since as early as 2016. In March 2016, "the California Public Utilities Commission unanimously voted to approve Charge Smart and Save, a program initiated by Pacific Gas & Electric to deploy 7,500 electric vehicle charging stations across Northern California."[21] Similarly, in Southern California, emerging discount programs for electric vehicle service was seen. In July 2019, the Southern California Public Power Authority (SCPPA), representing its member utilities, proposed EV and EV service equipment purchasing

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[17] Why utilities need to respond now to the EV boom, UtilityDive, Oct. 2017 https://www.utilitydive.com/news/why-utilities-need-to-respond-now-to-the-ev-boom/506761/

[18] Sierra Club Applauds DPU Approval of Eversource Proposal to Advance EV Adoption: Acknowledges Concerning Aspects of DPU Order, Sierra Club, Dec. 2017 https://www.sierraclub.org/press-releases/2017/12/sierra-club-applauds-dpu-approval-eversource-proposal-advance-ev-adoption

[19] Approval of Electric Vehicle Utility Proposal in Massachusetts A Sign of What's Coming Down the Pike in Northeast & Mid-Atlantic, Sierra Club, Dec. 2017 https://www.sierraclub.org/compass/2017/12/approval-electric-vehicle-utility-proposal-massachusetts-sign-what-s-coming-down

[20] Missouri regulators approve Ameren plan for 1,000-plus EV charging stations, Power Engineering, Oct. 2019https://www.power-eng.com/2019/10/18/missouri-regulators-approve-ameren-plan-for-1000-plus-ev-charging-stations/#gref

[21] Diverse Coalition Backs Plan for Deployment of Electric-Vehicle Charging Stations in Northern California, Sierra Club, Apr.2016 https://content.sierraclub.org/press-releases/2016/04/diverse-coalition-backs-plan-deployment-electric-vehicle-charging-stations

discount programs involving Level I (120V) charging stations, Level II (240V) charging stations, and DC fast charging stations.[22]

Another study by Black & Veatch[23] in 2017, looks at the stakeholder role for driving electric vehicle charging. From Figure 5 we can see that the study shows about 69% of utilities are considering EV programs. This could increase EV adoption among new and existing customers.

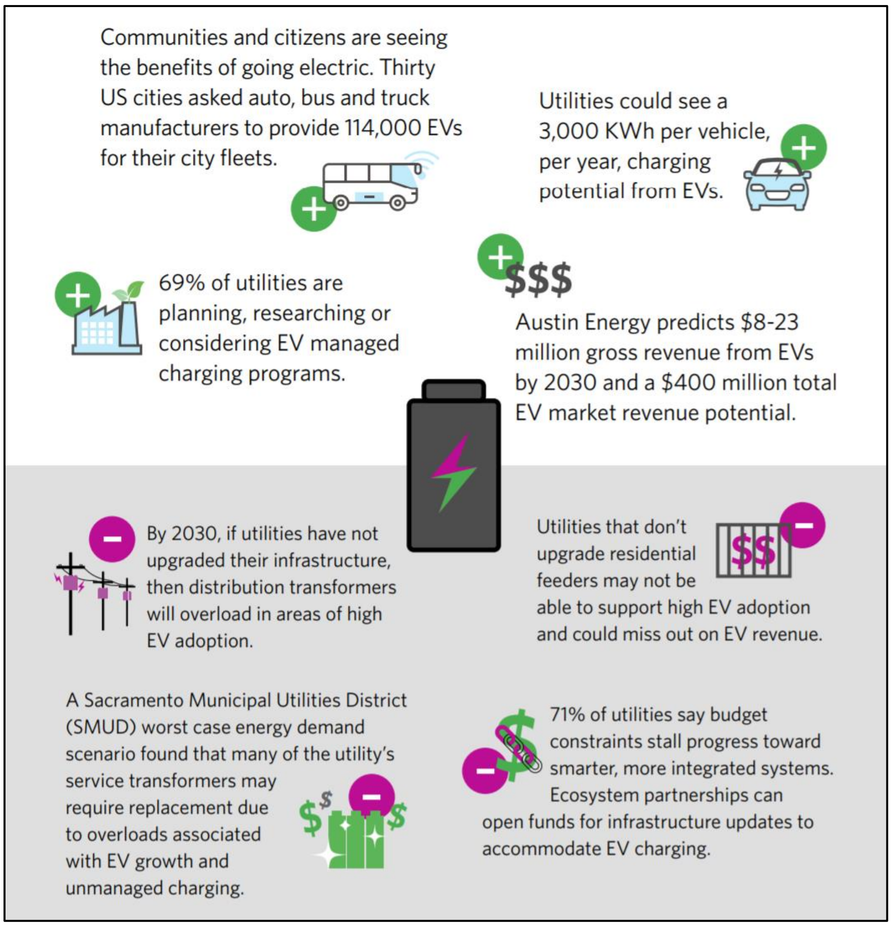

Figure 5 Utilities Make the Case for Electric Vehicle Integration[24]

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[22] Request for Proposals for Electric Vehicle and Electric Vehicle Service Equipment Purchasing Discount Programs, SCPPA, July, 2019 http://scppa.org/file.axd?file=/2019/07/RFP_Electric%20Vehicle%20and%20Electric%20Vehicle%20Service%20Equipment%20Purchasing%20Discount%20Programs_07-03-2019%20to%2007-24-2019%20FINAL.pdf

[23] Who's Driving Electric Vehicle Charging? Black & Veatch. 2017. https://www.bv.com/sites/default/files/2019-10/17%20BV%20Electric%20Vehicle%20Report_0_0.pdf

[24] Who's Driving Electric Vehicle Charging? Black & Veatch. 2017. https://www.bv.com/sites/default/files/2019-10/17%20BV%20Electric%20Vehicle%20Report_0_0.pdf

A study performed by MJB&A along with the Georgetown Climate Center, discusses the role of utilities and regulators to accelerate EV market penetration along with growth in charging infrastructure[25]. Utilities' action on EV charging infrastructure investment is comprehensively discussed under multiple models. Essentially, utilities can cover different components of the charging infrastructure ranging from utility distribution network, utility pad mounted transformers, to panel and meters, charging devices. Some utilities would have host sites or third parties to invest and install the actual electric vehicle chargers. MJB&A's project examines the proposals including these different models and help understand utility's investment on EV infrastructure.

Overall, the papers studied and cited in the above pages show the role of electric utilities and regulators in the growth of EV market. Some studies also show and suggest the investments required for certain types of charging like residential or public charging. This paper and the research focus is on the utility proposals for EV programs and the trends among them from 2013 to 2019.

[25] Utility investment in electric vehicle charging infrastructure: key regulatory considerations. MJB&A, Georgetown Climate Center. (Nov. 2017). https://www.georgetownclimate.org/files/report/GCC-MJBA_Utility-Investment-in-EV-Charging-Infrastructure.pdf

Methods

This analysis will discuss electric vehicle programs proposed by utilities across the U.S. by examining existing proposals on a series of criteria. The main approach of this analysis relies on utility proposal filings with public utility commissions along with market intelligence reports like AEE Powersuite website. AEE Powersuite[26], is a platform that collects data on energy policy and related information, from which additional data on these proposals was gathered.

Specifically, the data collection system was adopted after a full examination of existing research and understanding the requirements in the electric vehicles market. Initially, a set of about 90+ proposals was provided by our client, ScottMadden. These proposals were then categorized and examined across multiple criteria. Most of the criteria these proposals were categorized on were based on the information found in these proposals. For example, after examining 10 proposals, a set of primary and secondary criteria for the analysis was determined. While primary and secondary criteria like program costs, type of utility and more, were found in majority of the proposals, additional criteria like communication protocols were not commonly found. Proposals were grouped into different categories based on the information they had. The reason to have categorized these proposals is to better understand the diversity of the proposals.

After reading these proposals and discussing the details with the client, a spreadsheet model was adopted to collect and organize data. Data was sorted into different categories based on criteria that were common in most of these proposals. Data was collected from two major sources among others: Public Utility Commission (PUC) websites and AEE Powersuite. The data provided by ScottMadden, that is the information regarding a set of proposals to be analyzed, contained specific docket numbers. Using these docket numbers, the proposal documents filed by the respective utility to its PUC along with other documents that contain comments by involved parties could be found on the PUC portals.

The information from these two sources was further expanded upon by looking at information from other sources, including energy related media, journals, and utility websites.

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[26] Powersuite by AEE. https://powersuite.aee.net/welcome

Data like dates of proposals filed, the status of these documents and the executive summary of the proposal was taken from AEE Powersuite. Other data like program costs and program length were taken from the documents filed to the commission of the respective states. Furthermore, data like information on time-of-use (TOU) rates, type of utility, cost recovery and more, were taken from the utility websites or other official sources.

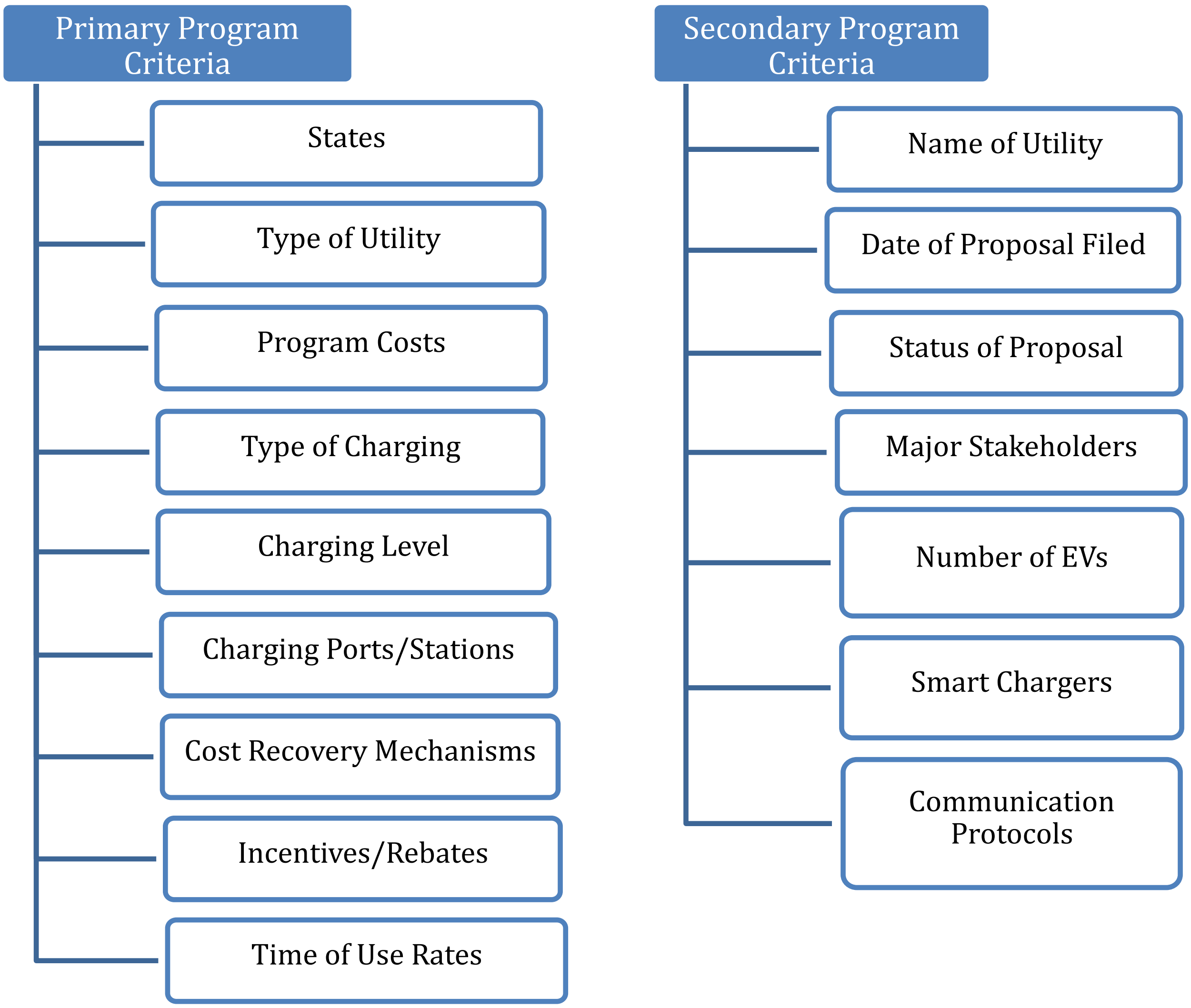

Figure 6 Categorization of EV program criteria

The final list of criteria was consolidated after analyzing 15 proposals. This was done to check for common criteria among these proposals that will help in mapping out trends. About 25 columns were put on the spreadsheet after finalizing all the criteria. These criteria were grouped as primary and secondary criteria to understand which criteria had the most weight to perform a quantitative/qualitative analysis. From Figure 6, the categorization of program criteria includes primary criteria like state, utility, type of utility, type of charging, charging level, time-of-use (TOU) rates, and number of ports/charging stations and secondary criteria like name of utility and date of proposal filed.

Each of the primary criteria were studied in depth. The data filled into these columns from various proposals was carefully analyzed. Among the 90+ proposal dockets provided by the client, the shortlisted proposals after sorting for EV specific proposals came to 61 proposals. While analyzing data for each criterion individually (as discussed later in other sections of the paper), some criteria were not included in some proposals, based on the information available in that proposal document. After analyzing each of the criteria, further analysis was performed with respect to trends in time and the data was then summarized in charts and figures. For example, some criteria like program cost, charging type, etc. were projected with respect to the year of the proposals filed. This way a time analysis was done to understand the trends in these criteria. Additionally, a more qualitative analysis was also performed on a few criteria to better understand the data in depth.

Analysis of Proposals

In this section of the paper, the sample data of proposals are explained in terms of a few criteria that will better outline the trends and help explain the analysis of the market for EV proposals filed by utilities in the United States.

Utility Proposals in the U.S. by State

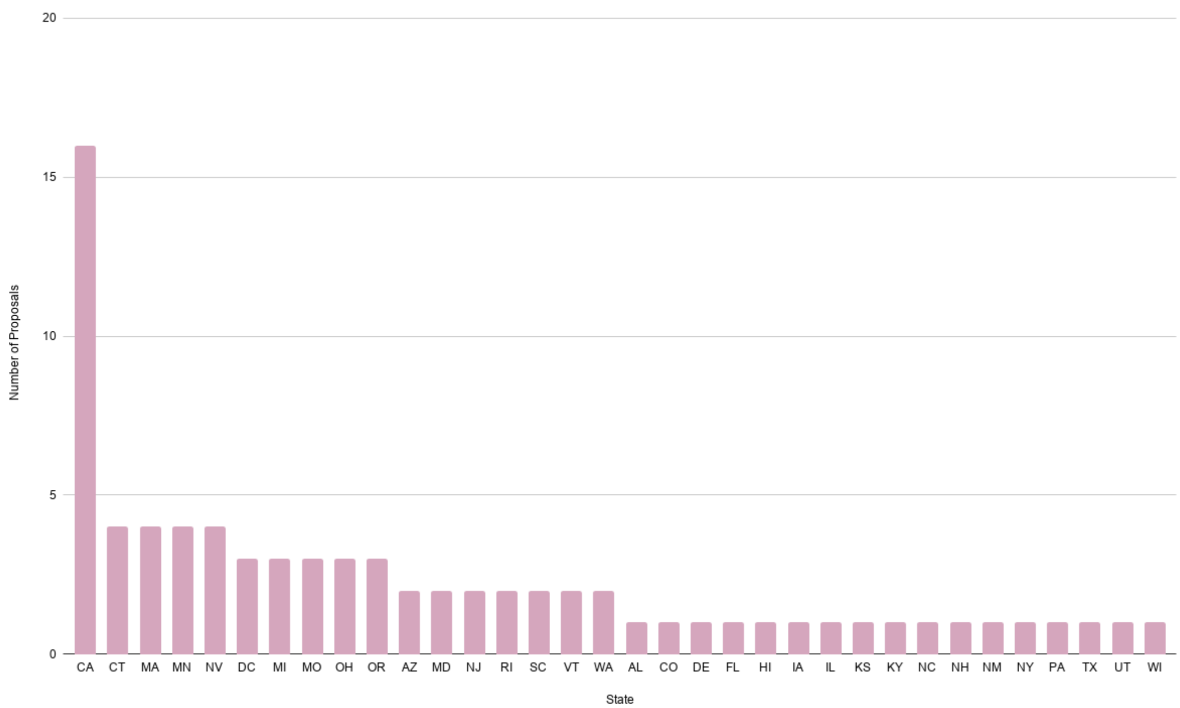

Figure 7 Figure: Bar chart showing the number of proposals filed by utilities from each state

The sample data that was analyzed was taken from multiple states across the United States. While some states had more proposals these past few years, other states had very few. Figure 7 gives a glimpse into the distribution of proposals from each state. These proposals are the ones that are filed by the utilities to the state utility commission. California has the highest number of EV proposals in the country from 2013-2019 (in the project data sample). Connecticut, Massachusetts, Minnesota, and Nevada stand second to California in the number of proposals put forth my electric utilities for EV programs.

The number of proposals from each state could also depend on the policies put forth by their respective states. California has the highest number of proposals in the country and is one of the leading examples to look at[27]. The California Energy Commission (CEC) has been making tremendous investments in EV charging infrastructure[28]. Just last year, the CEC approved $95 million for developing EV charging infrastructure[29]. Other states have also developed policies that have encouraged utilities and EV charging companies to work on effective charging networks. Massachusetts (MA) is one state that has a number of policies in place to increase EV adoption. One of the programs in MA called 'MOR-EV' offers up to $2,500 in incentives and rebates for new EV owners,[30] encouraging more EV adoption.

EV charging infrastructure and development involves many stakeholders. From State commissions to Utilities, and EV charging companies, the process of filing proposals is a long process. Some of the proposals in the sample data of this project have received approval within 2 years while other proposals are still under review. Many EV companies are also part of the discussions in the committee meetings for these proposals. Many states are increasingly adopting various policies to encourage residents in using EVs. Many of these policies include incentives, rebates, free parking, and HOV lane access. Plug-in America, a nonprofit organization that is working on increasing the EV footprint has launched a map that shows various policies and incentives put forth by various states in the country[31]. Further sections in this paper will provide details on the incentives and rebates policies of each utility EV program, which will further build on the correlation of the count of proposals and incentives/rebates. The paper will also look into other primary criteria like program costs among others, to understand the market trends along with possible correlations among the criteria.

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[27] SDG&E Final 2019 RPS Plan. Laura M. Earl. (Jul. 2019). https://www.sdge.com/sites/default/files/regulatory/2019_Final%20RPS%20Plan%20Public%20Version.pdf

[28] CEC Approves $95 million for Clean Transportation. California Energy Commission (CEC). (Sep. 2019).https://www.energy.ca.gov/news/2019-09/cec-approves-95-million-plan-critical-clean-transportation-investments

[29] CEC approves $95 million for Critical Clean Transportation Investments. CEC. (Sep. 2019). https://www.energy.ca.gov/news/2019-09/cec-approves-95-million-plan-critical-clean-transportation-investments

[30] Massachusetts EV rebate program. https://mor-ev.org/

[31] State and Federal Incentives. Plug-in America. https://pluginamerica.org/why-go-plug-in/state-federal-incentives/?location=tx

Type of Utility

This section looks at the types of electric utilities that have filed EV proposals. Figure 8 illustrates the number of proposals put forth by utilities, based on the type of utility. This analysis categorizes utilities into 3 groups: investor-owned utilities, publicly owned utilities, and cooperatives. The main difference among these utilities is that publicly owned utilities are utilities controlled by the public, investor-owned utilities (which are publicly traded) are the utilities which are controlled by a group of shareholders, and cooperatives are owned by the customers where profits are reinvested or distributed among customers. While IOUs are lesser in number than cooperatives in the U.S., they serve a larger number of customers compared to other utility types[32].

The PUC initiated orders were also taken for reference during our analysis, to better understand the data and also because, in the sample data, it was observed that there were about 15-20 orders/proposals put forth by the state commissions for encouraging investments in EV charging infrastructure or as part of their larger electrification process. One of these examples is an electrification process put forth by the Maryland Public Service Commission (PSC)[33]. The PUC proposals, like the one by Maryland PSC usually involve an order or a case that allocates a specific budget and design proposal, for EV charging infrastructure and the investment that is required for it. During this process, electric utilities in the state along with EV manufacturers, EV charging companies and nonprofits comment on the various aspects of the document for revision or approval. Once the discussion and public/stakeholder involvement process is done, the commission approves the budget and allocates it to stakeholders like utilities to invest in charging infrastructure.

[32] Investor-owned utilities served 72% of U.S. electricity customers in 2017. EIA. (Aug. 2019). https://www.eia.gov/todayinenergy/detail.php?id=40913

[33] Maryland EV Charging. Maryland Public Service Commission. (Mar. 2011). http://webapp.psc.state.md.us/newIntranet/Casenum/CaseAction_new.cfm?CaseNumber=9261

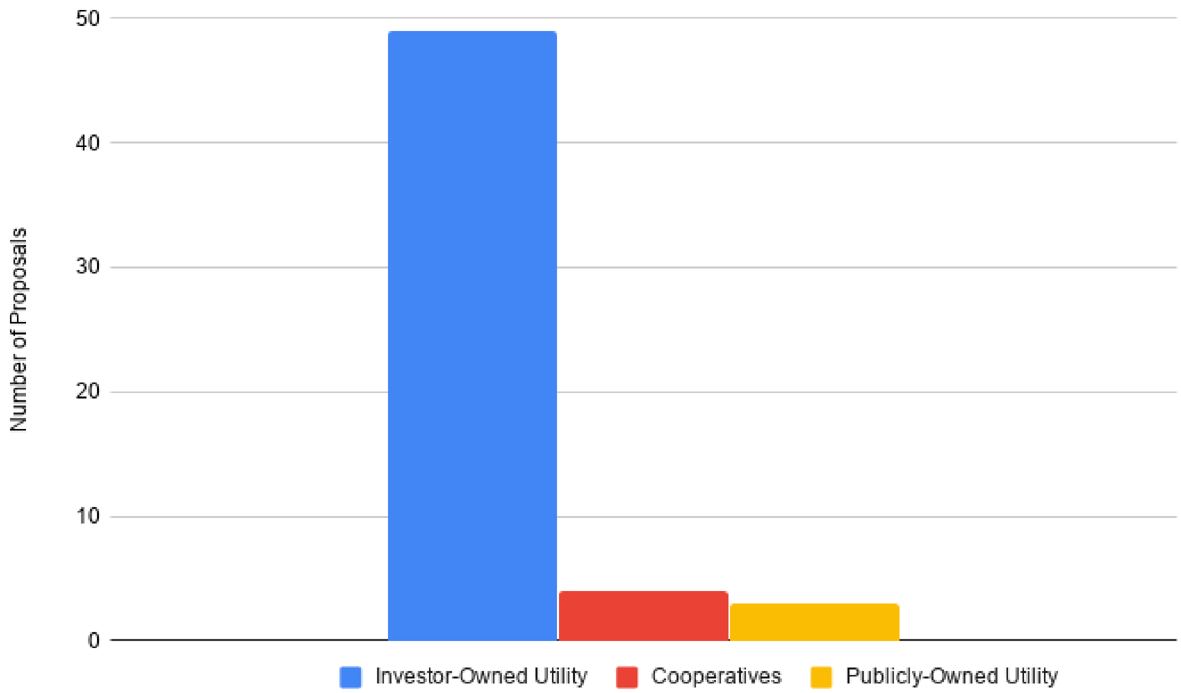

Figure 8 Number of proposals filed categorized by the type of utility

Figure 8 above illustrates that most of the proposals have been filed by investor-owned utilities (IOUs). While a majority of these proposals show that they have been filed by IOUs, most of these utilities are subsidiaries of Holding Companies. Some of these examples include, Pacific Power[34] (subsidiary of PacifiCorp), NSTAR[35] (subsidiary of Eversource Energy), and Nantucket Electric Company[36] (subsidiary of National Grid). Most IOUs (or subsidiaries of them) file proposals to the commission separately for approval of EV charging proposals. IOUs serve a large number of customers and so have big networks of transmission and distribution lines in the state and country, which makes installing EV charging networks a more streamlined process. Most publicly owned utilities and cooperative utilities are smaller companies in terms of size (customers), network infrastructure, and so the number of proposals and the size of the proposed budget also seems to be smaller in scale when compared to IOUs. From Figure 8, it can be observed that while IOUs constitute almost 70% of the EV proposals, publicly owned utilities and cooperatives make only about 30% of the total proposals in the sample data. Also, from the

[34] Pacific Power. https://www.pacificpower.net/
[35] NSTAR. http://www.nstar.com/
[36] Nantucket Electric Company. https://nantucketenergy.com/

program costs analysis as seen in Figure 9, it can be observed that SCE which is an IOU has a program cost of $760.1 million in 2018, which is the highest proposed EV program cost in the sample data. One other reason that there are a greater number of proposals from IOUs could also be that, cooperatives and municipalities are often less subjective to PUC oversight.

Program Costs

Various proposals have different program costs. While some proposals have specific program costs exclusively for EV charging infrastructure, other proposals have a proposed budget that is part of a bigger electrification program that includes smart grid investments and net metering, along with EV charging infrastructure.

Figure 10 shows the proposed program costs by different utilities from the sample data. These program costs along with the number of proposals from each state have been analyzed over time (from 2014-2019). These proposals are also categorized based on geographic location of the utilities. From the figure, it can be seen that almost 40% of the proposals from the sample data were filed in 2018. An increasing trend in proposed program costs can be observed in some of these proposals.

Figure 9 shows the trends in program costs for utilities in California and Oregon from 2014-2019. California and Oregon have been chosen for understanding program costs trends with a closer look, as utilities from these states, have filed multiple proposals from 2013-2019. It can be inferred from this plot that while some program costs for utilities like Southern California Edison (SC&E) and Portland General Electric have increased, program costs for other utilities like Pacific Gas & Electric (PG&E) and San Diego Gas & Electric (SDG&E) have fluctuated over time.

Multiple proposals from each state, within a time period of 5 years is very interesting to study for several reasons. Utilities file for different kinds of programs. While some proposals are only for residential and public charging, some proposals are exclusively for EV programs that include pilot programs or a specific number of charging stations/ports or commercial charging, among others. There are also proposals that are part of a wider electrification program that entails clean energy investments, EV roll-out programs, among others.

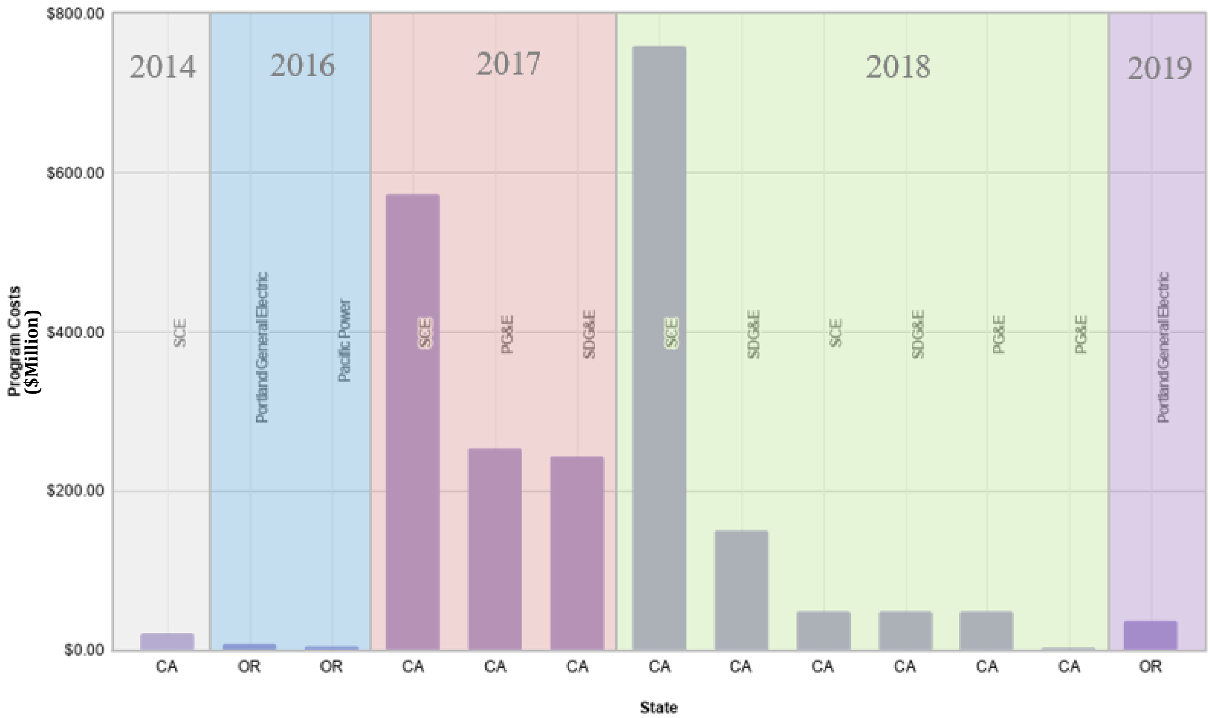

Figure 9 Proposed program costs by utilities in California and Oregon

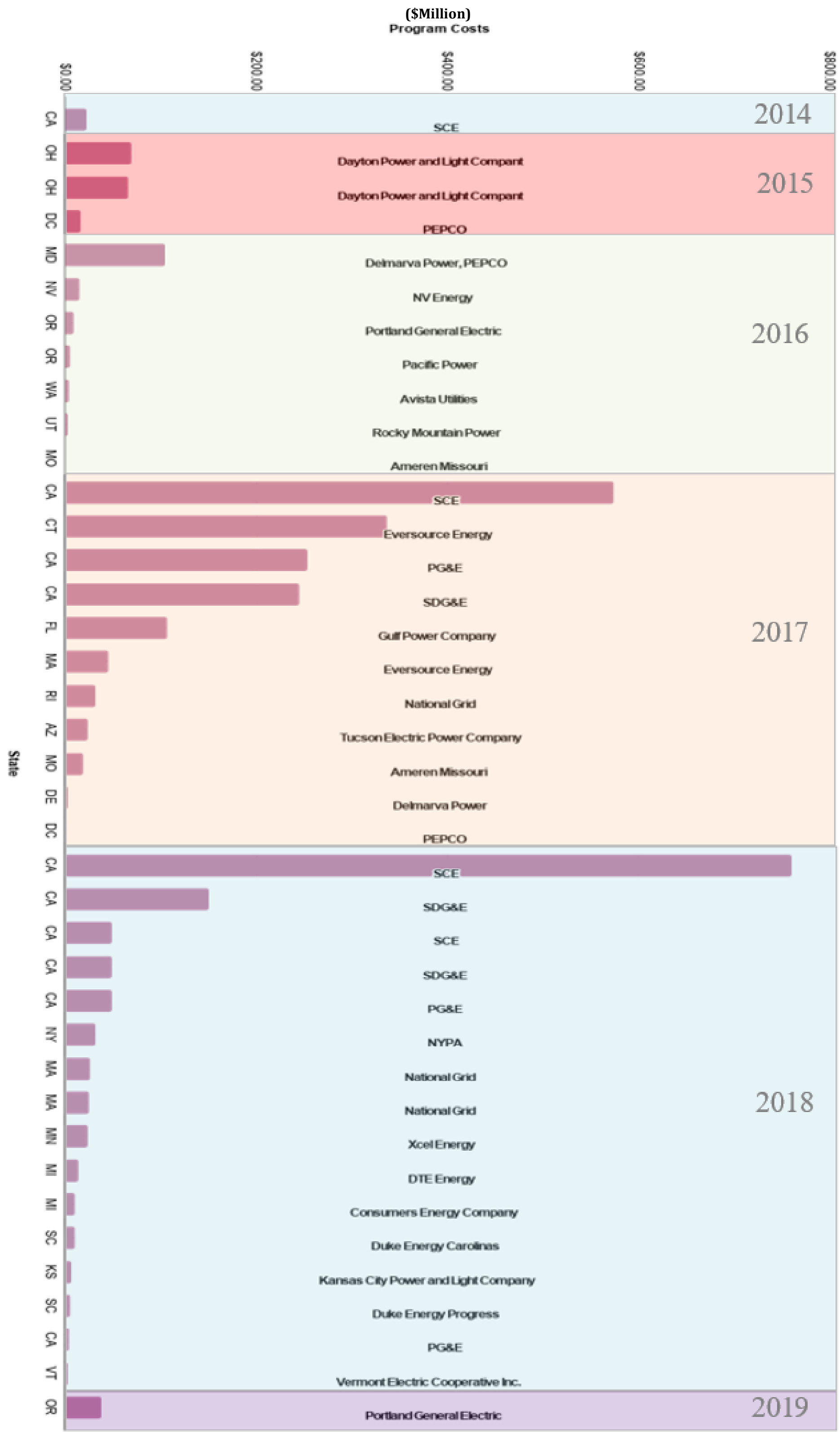

Figure 10 Program Costs proposed by utilities from 2014-2019

Type of Charging

Most proposals list three main types of charging. These types are categorized as: public, residential, and commercial. Some proposals also include other categories like Multi-Unit Dwellings (MUDs) and Workplace charging. The MUDs were categorized as residential charging, and workplace charging was categorized as commercial charging in this paper, for a more simplified analysis.

Public charging is charging that is available to the public, situated along highways and off roads in cities. These are convenient for frequent travelers and long-distance commuters. They are like gas stations which can be used to charge EVs while commuting. Residential charging is a type of charging that is situated in an apartment complex or a house to charge while at home. And, commercial charging, including workplace charging, is a network built for specific workplaces like a company or organization or a retail establishment, which is mainly useful for employees working in that organization to charge their vehicles during work.

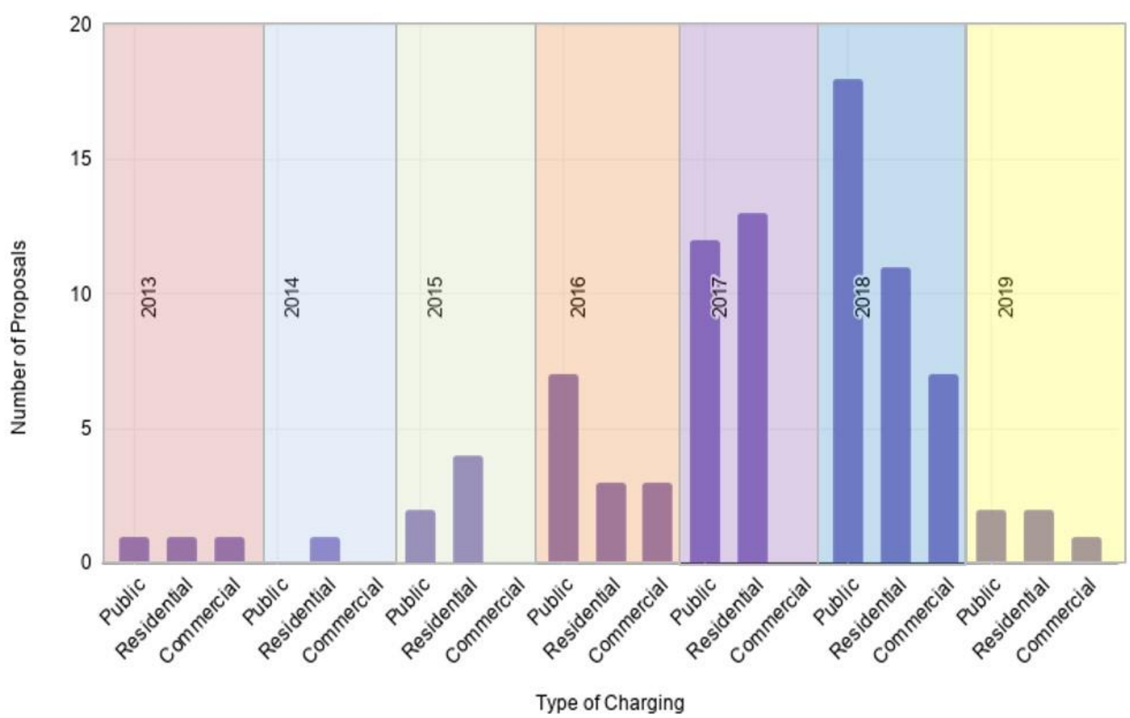

Figure 11 Types of charging proposed by utilities from 2013-2019

The trends in Figure 11 show the change in the number of proposals for different charging types over the years. It can be observed that there have been very few changes in the number of proposals that have included commercial charging. There is a steady growth in public charging when compared to residential and commercial charging. Additionally, there has been a fluctuation in residential charging over the years. It should also be noted that the data acquired from the year 2019, in this project sample data is partial. Furthermore, utilities in these proposals have focused more on public and commercial charging when compared to residential charging.

From the 'program costs' analysis in the previous section, the highest number of proposals were in the year 2018. This reflects a spike in the number of proposals for charging type in 2018 too, especially for public charging. More public charging will reduce range anxiety for EV owners who travel long distances. A study by EnelX (an energy solutions company), details that, 'the ratio of EV chargers to EV vehicles in comparison to gas stations[37] is: ratio for public charging stations is 1 to 74 while it is 1 to 1600 for gas stations.' This shows that there is good access to public charging which is continuing to grow with time. But, the fact that the ratio of EV chargers is better than gas stations, should also account for the amount of time each vehicle requires for charging. While it only takes a couple of minutes to fill a car with gas, it could take hours for an EV to charge, depending on the type of charger and make of the car.

Charging Level

There are three types of charging levels in the market broadly: Level I, Level II and DC Fast Charging (DCFC). Most EVs can charge on different levels provided the relevant plugs are available. These charging levels provide different voltages, current ratings, and power ratings, which can charge the battery in the car in different durations[38]. Most Level I chargers provide charging through a 120-volt AC plug. This can be done at an electric outlet at home. To charge a battery of 100kWh for a Tesla Model S, that is completely drained, it would take about 50 hours to be charged fully using a Level I charger. On the other hand, Level II charger uses a 240V AC

[37] EV Public Charging. EnelX. (Nov. 2019). https://evcharging.enelx.com/news/blog/579-the-ultimate-guide-to-electric-vehicle-public-charging-pricing

[38] Levels of Charging. EV Town. http://www.evtown.org/about-ev-town/ev-charging/charging-levels.html

plug. This charger usually requires some additional equipment for installation and can charge a vehicle in 4-6 hours. This kind of system is usually found in residential areas like apartment complexes and in workplaces. The DCFC charger uses a 480V DC plug and can charge a vehicle in about 20-30 minutes. This is used in public and commercial charging.

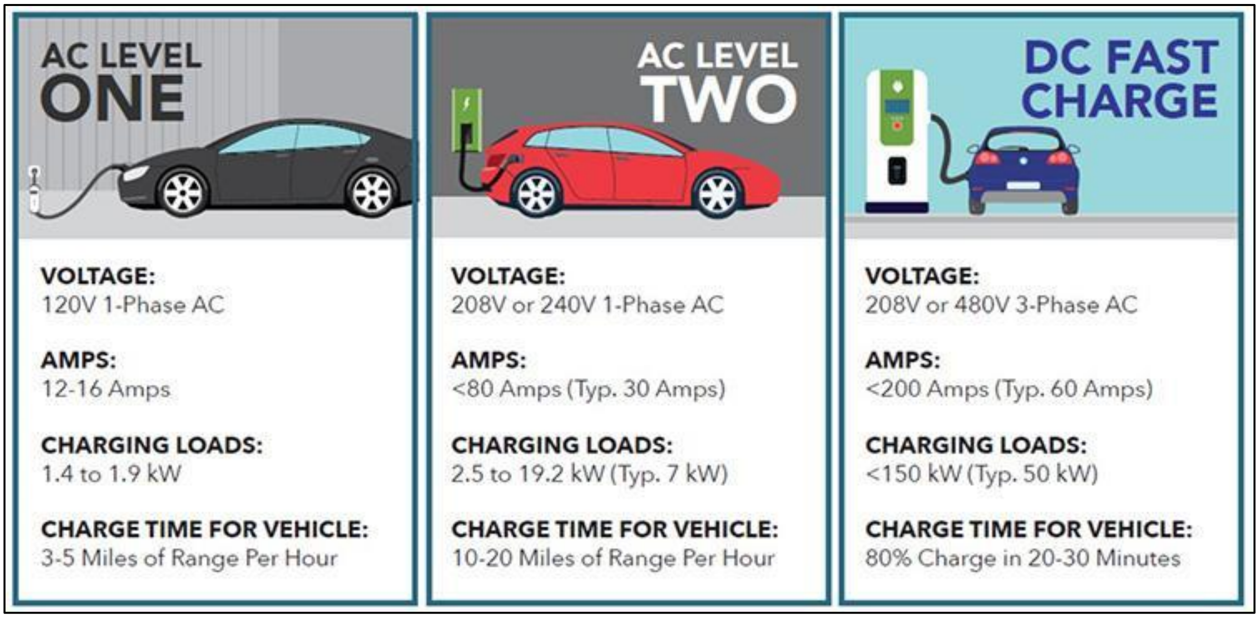

Figure 12 Different charging levels taken from Energy United (Source: http://www.evtown.org/about-ev-town/ev-charging/charging-levels.html)

Figure 12 shows the specifications for different EV charging levels. These chargers can be differentiated based on size and plugs as shown in the image. In order to understand the importance of charging levels in building an EV charging infrastructure from the proposals put forth by utilities, the data that pertains to charging levels from the sample of proposals was taken and mapped with the timeline and number of proposals in order to understand the trend among the charging levels in the proposals.

Figure 13 shows trends among the three different charging levels from 2013-2018 for the sample data in this research. The chart shows that there has been a gradual increase in the trend of the number of proposals put forth for Level II chargers. As most Level II chargers are used in commercial and residential areas, it can be beneficial to people to charge their vehicles conveniently and balance the load of electricity consumed by charging overnight. Also, a majority percentage of charging vehicles happens residentially and most utility EV proposals do not take in to account for Level I chargers at home. There has been a decrease in Level I chargers over the years. The number of DCFC chargers have increased gradually. And, Level II chargers seem to have acquired more investments when compared to Level I and DCFC, as Level II chargers have consistently had higher number of proposals in this sample data.

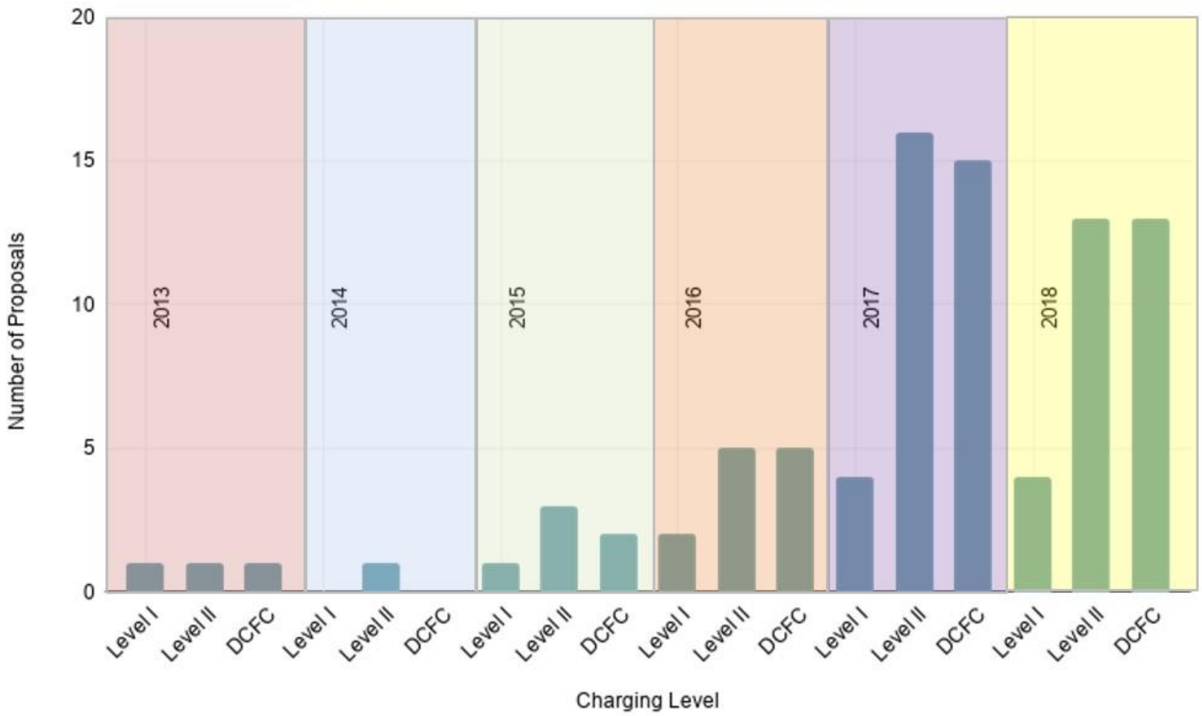

Figure 13 Trends in types of charging levels from 2013-2018

Charging Ports and Stations

In the sample data of proposals, utilities across various states included a specific number of charging ports/stations in their requests. While some of these were even more specific as to whether these ports are Level I, Level II or DCFC, other proposals only included the number of charging ports/stations. Planning for the number of charging ports/stations will help determine the costs of the program as a whole, along with the equipment needed for specific charging levels.

There were a few other proposals that mentioned charging ports/stations in their proposals but did not include a specific number that would help compare the number of charging ports/stations with other utility proposals. The number of charging ports/stations can also affect the total program costs. For example, after California and Connecticut, Maryland has the highest program costs (shown in Figure 10 from Program Costs section), and utilities from these states have proposed a significant number of charging ports/stations. Utilities in California are leading in the number of proposed charging ports/stations. Figure 14 and Figure 15 represent the specific number of charging ports and charging stations proposed by utilities. These figures are created with the assumption that a charging station can have multiple chargers which in turn have a few ports each. Some of the utilities in the figures below occur repetitively as these proposals put forth more than one proposal from 2013-2019.

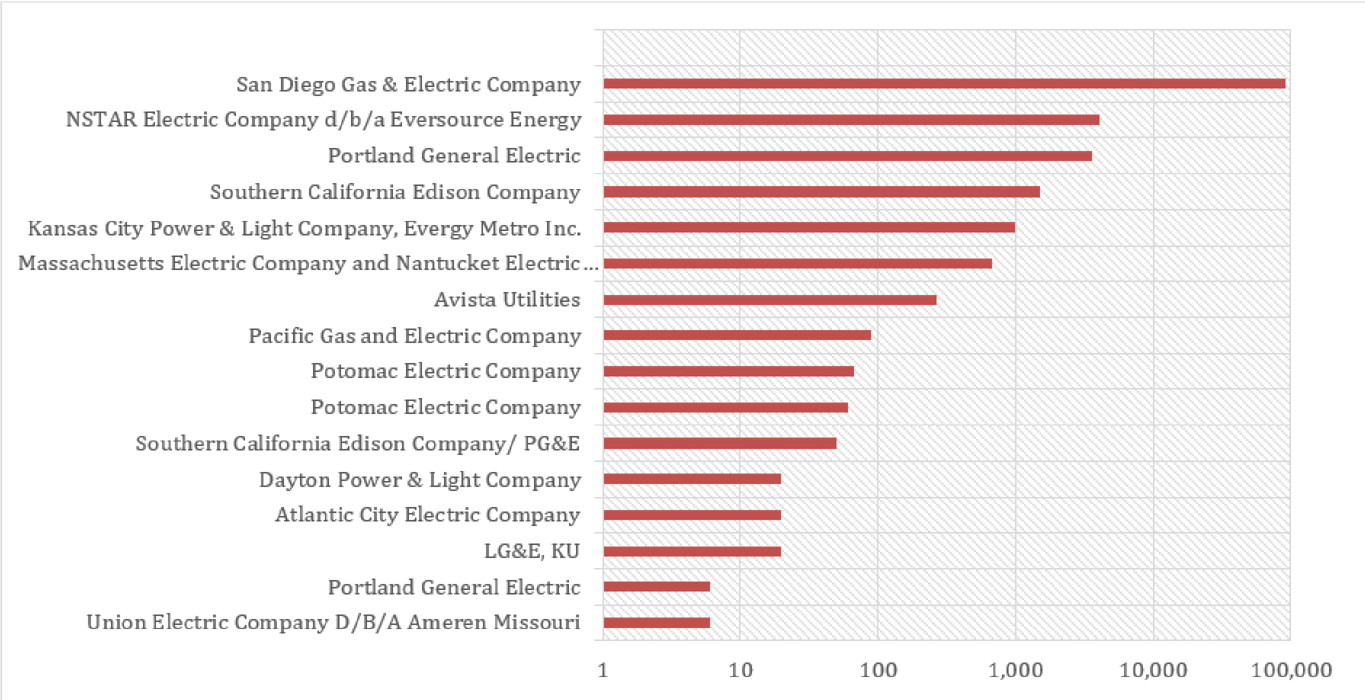

Figure 14 Number of charging stations proposed by utilities

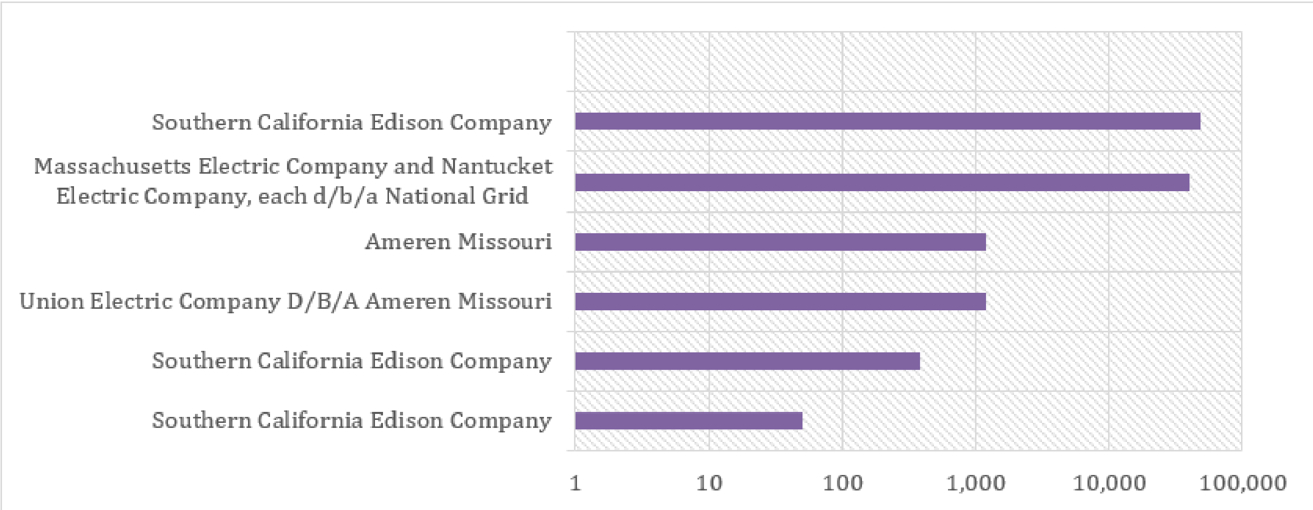

Figure 15 Number of charging ports proposed by utilities

Cost Recovery

A way for utilities to recuperate their cost is through cost recovery mechanisms. Looking at the expense of installations and manufacturing costs upfront in EV charging programs, cost recovery plays a significant role for electric utilities in terms of enabling electric vehicle integration into the existing transportation sector. Essentially, cost recovery refers to the method of recovering an expenditure on electric vehicle charging infrastructure when electric utilities take on EV programs.[39] For example in California, state clean energy advocacy clearly supports the investment on electrification of transportation along with the cost recovery mechanism. The mechanism has to comply with the market rules to be implemented.[40] In Missouri, during Ameren Missouri's Charge Ahead (electric vehicles program), public advocates expressed their support stating, "only if Ameren's ability to recover the cost of running the program is tied to meeting EV adoption goals.[41]" This indicates the importance and weight of cost recovery mechanisms in an EV proposal and that it can directly determine the support of public advocates. Specifically, in the position statement of the Office of the Public Counsel (OPC), the program is

[39] The Strategic CFO, https://strategiccfo.com/cost-recovery/

[40] The Wheels Are In Motion on Electric Vehicle Cost Recovery Efforts In California, Dan Lowrey, Nov. 2018, https://www.spglobal.com/marketintelligence/en/news-insights/research/the-wheels-are-in-motion-on-electric-vehicle-cost-recovery-efforts-in-california

[41] Ameren EV charger cost recovery should be tied to EV adoption rates: Missouri public advocate, Robert Walton, Dec. 2018, https://www.utilitydive.com/news/ameren-ev-charger-cost-recovery-should-be-tied-to-ev-adoption-rates-missou/543372/

supported and suggests the commission's approval on the proposal as well. These examples indicate the importance and significance a utility would attach to cost recovery in EV charging program design.

In this paper, based on the proposals that are being passed by the commissions or the EV programs that are on-going in the U.S., different cost recovery mechanisms were found across the country. Understanding the proposals being passed by the commission, or the proposals successfully proceeding to program implementation, different cost recovery mechanisms can be witnessed across the states. While there are four different types of cost recovery mechanisms in this sample data: DCRF, regulatory asset, shareholders and deferred accounting, there were proposals that did not mention the type of cost recovery mechanism but rather just mentioned that there was some cost recovery method involved. In order to account for the proposals that do not have a definite mechanism, these proposals were categorized based on the status of their proposal: awaited and disallow status. Overall, six different cost recovery mechanisms are summarized in Table 1.

Table 1 Summary of cost recovery status

Status/Type of Cost Recovery	Explanation
DCRF	Distribution Cost Recovery Factor/Formula
Awaited	Approved in proposal but no action
Regulatory asset	Rely heavily on commission grants
Shareholders	Cost recovered borne by shareholders
Deferred accounting	Delay recognizing expenses for later proceeding
Disallow	Disallow cost recovery or deny DCRF

DCRF refers to distribution cost recovery factor or formula. Utilities recover their cost through attaching increased rate to customers, which incorporates a cost recovery factor in their rate structuring process. Awaited status refers to utility proposals that have been approved by a PUC or PSC, however the cost recovery part of the proposal have not been implemented with exact follow up execution order or plans. This might be due to the case being closed for some utilities. Regulatory asset cost recovery method refers to where utility relies heavily on the commission to recover the EV infrastructure cost. Essentially, for the parts of charging infrastructure cost that is financially difficult for utility companies to recover, the state public commission would help utilities to recuperate the cost for the program to kick off smoothly. Some utilities also allow their shareholders to bear the cost of certain charging infrastructure, depending on different models of investment for utilities. The deferred accounting method indicates that the utility would prefer delaying recognizing expenses for later proceeding. And finally, some commissions directly reject the cost recovery method that the utility proposed. Table 2 below shows a spectrum of more specific cost recovery information proposed by a few utilities.

Table 2 State level cost recovery mechanisms summary on EV charging proposals

State	Utilities	Cost Recovery Mechanism	Contexts
Arizona	Tucson Electric Power, Arizona Public Service, UNS Electric	DCRF	ACC[42] permits utilities to recover costs of deploying EV infrastructure in low utilization areas in the rate base[43]
California	Pacific Gas and Electric, Southern California Edison, San Diego Gas & Electric	DCRF	Distribution cost recovery factor/formula was created in all three major IOUs and rebates for customers to offset equipment and installation costs
Colorado	Colorado Public Utilities Commission (PUC)	Awaited	S.B. 77 allows electric utilities to build EV charging stations as regulated services and recover

[42] Arizona Corporation Commission

[43] Low utilization areas: Where low utilization is directly caused by the high cost of make-ready infrastructure, it may be appropriate for PSCs to bear the cost of the make-ready infrastructure, while non-regulated entities will bear any additional costs. -- ACC Draft Implementation Plan, basis for discussion at the March 26, 2019 EV Stakeholder meeting, https://docket.images.azcc.gov/0000196918.pdf

			costs for EV support facilities[44]. However, the case remains inactive from May 2019[45]
The District of Columbia	The Potomac Electric Power Company	Regulatory assets	Pepco proposes that the Commission preapprove the prudency of the program costs and their full recovery and permit the establishment of a regulatory asset to recover costs associated with this EV program[46]
Florida	Gulf Power Company	DCRF and Regulatory assets	Fuel and purchased power cost recovery clause with generating performance incentive factor[47]
Oregon	Portland General Electric	DCRF and Regulatory assets	PGE said increased electricity sales and other benefits, cashing in the value of Clean Fuels Program credits that businesses accrue, for instance, would return $34.7 million, trimming the net cost to $2.4 million[48]
Massachusetts	Nantucket Electric Company	Awaited	The department determined that it would establish a cost recovery mechanism for eligible EV infrastructure program costs[49]
Maryland	Potomac Edison	DCRF and Regulatory assets	PE is proposing to recover the costs associated with this proposal through a surcharge rider[50]
Missouri	Union Electric, Consumers Energy, Ameren Corporation	Shareholders; Deferred accounting; Disallowed	Ameren Missouri claimed that a majority of the costs for the pilot project would not be recovered by the rate base. Instead, they

44 Electric Motor Vehicles Public Utility Services, Colorado General Assembly, SB19-077, https://leg.colorado.gov/bills/sb19-077
45 PUC CO: 17I-0692E, https://powersuite.aee.net/dockets/co-17i-0692e
46 PSC DC: FC1143 (later transferred to 1130), https://powersuite.aee.net/dockets/dc-fc1143
47 PSC FL: 20160186, https://powersuite.aee.net/dockets/fl-20160186
48 PUC OR: UM2003, https://powersuite.aee.net/dockets/or-um-2003
49 DPU MA: 17-13, https://powersuite.aee.net/dockets/ma-17-13
50 PSC MD: 9261, https://powersuite.aee.net/dockets/md-9261

			would be borne by shareholders[51]
Minnesota	Otter Tail Power, Xcel Energy	DCRF; Deferred accounting	OTP implements 1.336 c/kWh EV tariff for cost recovery; for Xcel Energy adopts later proceeding strategy[52]
Wisconsin	We Energies, Wisconsin Public Service of Green Bay	Disallowed	Public Service Commission of Wisconsin disallowed utility to subsidize home charging stations for electric vehicles from their customers' money.[53]

Among multiple cost recovery mechanisms passed by the commissions shown in Figure 16, distribution cost recovery rates come in as the most common practice in utility EV program proposals, followed by regulatory assets from commissions and deferred accounting along with shareholders assistance. Also, 23% of the proposals involving cost recovery have received passive treatment from the commission where they got rejected or held under status quo, which are mostly proposals coming from Colorado, Oregon, and Massachusetts, based on the data. Additionally, a significant percentage of them received direct denial from commission, disallowing general or specific cost recovery attempts. For example, Missouri Public Service Commission denied Ameren's proposal to implement cost recovery through rate increase in 2017, although the PUC approved incentives offsets costs of EV charging stations at the beginning of this year (2020). In Wisconsin, WEC utilities[54] also received direct denial of rate base increase mechanism from public service commission and commented that "the company should be able to recover its investment, but not be allowed to earn $36 million in profits on the overrun amount"[55]. This indicates that the commissions, in some cases, have allowed utilities to

[51] PSC MO: ET-2016-0246, https://powersuite.aee.net/dockets/mo-et-2016-0246

[52] PUC MN: 15-111, https://powersuite.aee.net/dockets/mn-15-111

[53] Regulators deny EV charging subsidies, allow pollution control cost overruns for WEC utilities, Wisconsin State Journal, Chris Hubbuch, https://madison.com/wsj/news/local/govt-and-politics/regulators-deny-ev-charging-subsidies-allow-pollution-control-cost-overruns/article_5739f2dd-2239-5df8-8fb5-9b484ebc799a.html

[54] WEC Energy Group, one of the nation's largest electric generation and distribution and natural gas delivery holding companies. They provide energy services to customers in Wisconsin, Illinois, Michigan and Minnesota. https://www.wecenergygroup.com/about/aboutus.htm

[55] Regulators deny EV charging subsidies, allow pollution control cost overruns for WEC utilities, Wisconsin State Journal, Chris Hubbuch, https://madison.com/wsj/news/local/govt-and-politics/regulators-deny-ev-charging-subsidies-allow-pollution-control-cost-overruns/article_5739f2dd-2239-5df8-8fb5-9b484ebc799a.html

recover their investment but not solely rely on rate increase, with a potential risk of rate increase mechanism becoming a lucrative mechanism for utilities. In Minnesota, the cost recovery actions are in the picture but mildly under discussion, “MP [Minnesota Power] did state that it would request cost recovery in the future if it does incur significant advertising costs.” Thus, MP’s cost recovery mechanism is to monitor its promotional costs for now and, if necessary, to pursue cost recovery in a future rate base.

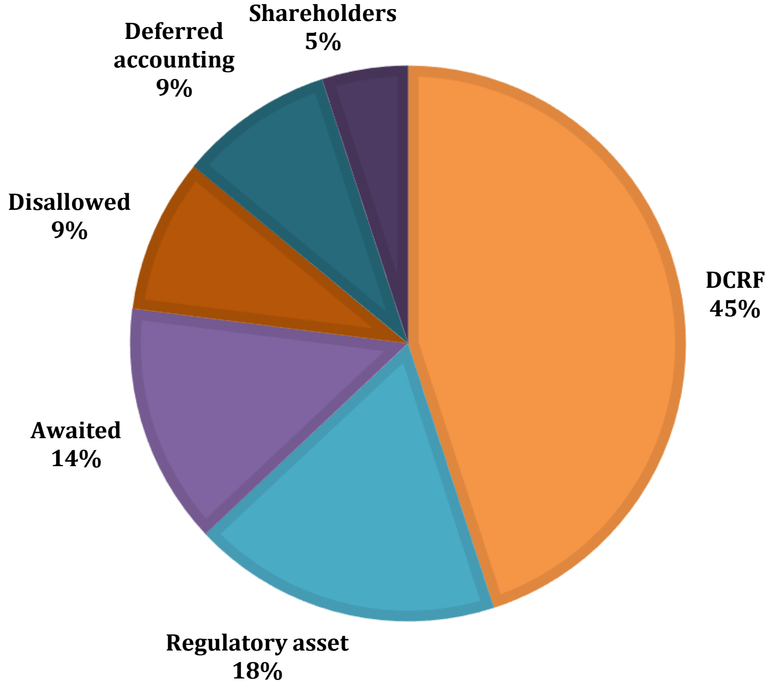

Figure 16 Cost Recovery Mechanism

For distribution cost recovery rate practice, often a complicated formula depending on states’ financial risks, system-wide rates, and filing requirements among many other, seem to be influential factors in determining the formula[56]. For example, the formula can involve invested capital, depreciation expense, current federal income tax, other taxes, distribution revenues by rate class, rate class allocation factor, and rate class billing determinants. Often, the cost recovery rates are defined through application of ‘DCRF’ (distribution cost recovery factor) and determined with an effect and expiration date set by the commission.

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[56] Figure: 16 TAC §25.243(d)(1), http://txrules.elaws.us/Gateway/codepdf//TITLE16/PART2/CHAPTER25/SUBCHAPTERJ/DIVISION1/25.243/2018-11-29/PDF/201103980-1.pdf

Incentives and Rebates

In this section, the number of proposals involving incentives and rebates and network communication rebates in EV proposals are discussed based on the data from the U.S. Department of Energy and official documentations from electric utility proposals. Incentive program oftentimes refer to the scenario where a utility outsources part of the charging infrastructure to host sites or third parties for investment, installation, and management. These host sites or third-party investors could be eligible for incentive programs that a utility puts forth to support local EV charging infrastructure and EV deployment as a whole. Additionally, rebate programs are usually meant for EV drivers or customers that potentially purchase EV for rebated purchase or charging.

Utilities across the U.S. have been improving their support of EV incentive programs, which is in contrast with federal credits' cooling down for EV customers. Specifically, based on the dataset, Arizona has been moving forward with its electric vehicle expansion and specifically with a plan to develop EV infrastructure in the state. And the Arizona Corporation Commission approved the Electric Vehicle Policy Implementation Plan in July 2019[57]. In terms of the rebates policy, Tucson Electric Power Company (TEP) put forth a program where residential customers can claim a rebate covering up to 75 percent of the cost of installing EVC (Electric Vehicle Charging) infrastructure. In Figure 17, for residential EV customers after February 20, 2019, TEP offers rebate up to $500 for a qualified two-way communication EVC (electricity from grid to vehicle battery and from vehicle battery to grid) or up to $250 for a one-way, non-communicating EVC (electricity from grid to vehicle battery)[58].

[57] Arizona asks utilities to present public EV charging projects, oil lobby campaign fails, Phil Dzikiy, electrek, July.24, 2019, https://electrek.co/2019/07/24/arizona-utilities-ev-projects/
[58] ACC AZ: E-01933A-17-0250, https://powersuite.aee.net/dockets/az-e-01933a-17-0250

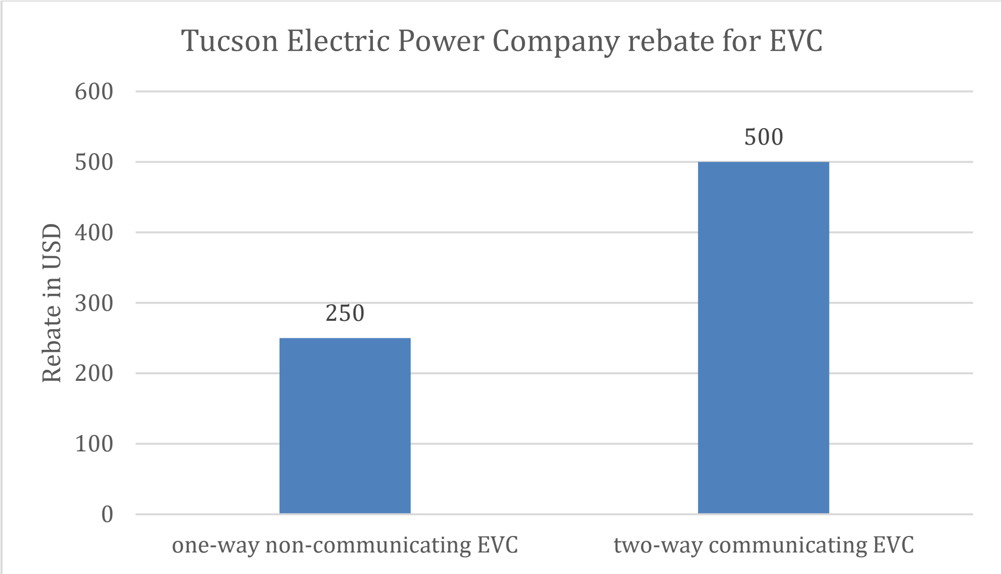

Figure 17 Tucson Electric Power Company rebate for Electric Vehicle Chargers

Network protocol indicates the protocol for communication between EVC site host and an EVC network[59]. It enables electric vehicle chargers' ability to adjust power output in response to grid demand and management software. Two-way communication EVCs (Electric Vehicle Chargers) have low service latency and more reliable system and allows reliable reservation process of charging slots within EVSEs (Electric Vehicle Supply Equipment)[60]. For TEP, the rebate for two-way communicating EVC doubles one-way communicating EVC, encouraging customers to adopt two-way communication.

In California, San Diego Gas & Electric Company (SDG&E) proposed a rebate of up to 50% of the cost of the charging station for qualified equipment and customers. Also, in order to celebrate the accomplishment and service of school district employees and first responders, SDG&E offers them a $1000 point-of-sale rebate toward the purchase or lease of an all-electric or plug-in electric hybrid vehicle. This is in addition to the $10,000 in state cash rebate and federal tax credit incentives available[61]. Pacific Gas and Electric Company (PG&E) offers 2000

[59] Electric Vehicle Charger Selection Guide. Redwood Coast Energy Authority (RCEA). https://redwoodenergy.org/wp-content/uploads/2019/02/Electric-Vehicle-Charger-Selection-Guide.pdf

[60] A two-way communication scheme for vehicles charging control in the smart grid, Jihene Rezgui, Soumaya Cherkaoui, Dhaou Said, August 2012, https://www.researchgate.net/publication/261379460_A_two-way_communication_scheme_for_vehicles_charging_control_in_the_smart_grid

[61] A1801012, https://apps.cpuc.ca.gov/apex/f?p=401:56:13816153023519::NO:RP,57,RIR:P5_PROCEEDING_SELECT:A1801012

point-of-sale incentives to LMI (low to moderate income level) customers and a $500 point-of-sale rebate for a Level II residential charging station for LMI households. Southern California Edison Company (SCE) offers 25% to 100% off base and installation price for owners. The rebate may also be endowed with a third owner depending on the contract. For example, in another proposal by PG&E[62], a third-party charging company was elected to install the 25 ports in their existing electric charging infrastructure. As a result, PG&E will not own or operate any of the infrastructure installed as part of this pilot. Albertson is responsible for the procurement, construction and maintenance of all infrastructure installed in this pilot and PG&E will provide Albertson a rebate once they have completed the design, procurement, and construction of the EVSE charging equipment. In Connecticut, Eversource Energy offers a a$150 signing rebate and then $50 at the end of the year and the next two years to customers who own an eligible EV charger. Eligible participants can enroll after installing and activating the charger and receive $300 for signing up for a three-year commitment[63]. In Colorado, funding for up to 80% of the cost for EVSE is offered by Charge Ahead Colorado program[64]. In Wyoming, a $5,000 rebate is provided by Yellowstone-Teton Clean Cities to businesses that purchase and install EVSE[65]. The funding is available on a first come, first served basis. But, nearly half of the states in the sample data examined here do not yet have an EV charging rebate policy in place.

[62] (In The Matter Of The Application Of Pacific Gas And Electric Company For Approval Of Its Senate Bill 350 Transportation Electrification Program. [Proceedings A.17-01-020, A.17-01-021, And A.17-01-022 Are Consolidated By The Scoping Memo Ruling Issued 4/13/17.]

[63] State Incentives, Plug In America, https://pluginamerica.org/why-go-plug-in/state-federal-incentives/?location=co

[64] State Incentives, Plug In America, https://pluginamerica.org/why-go-plug-in/state-federal-incentives/?location=co

[65] State Incentives, Plug In America, https://pluginamerica.org/why-go-plug-in/state-federal-incentives/?location=co

To compare the utility proposals that involve specific number of incentives and rebates design, please refer to Figure 18 for detailed information. An upper bound number of incentives

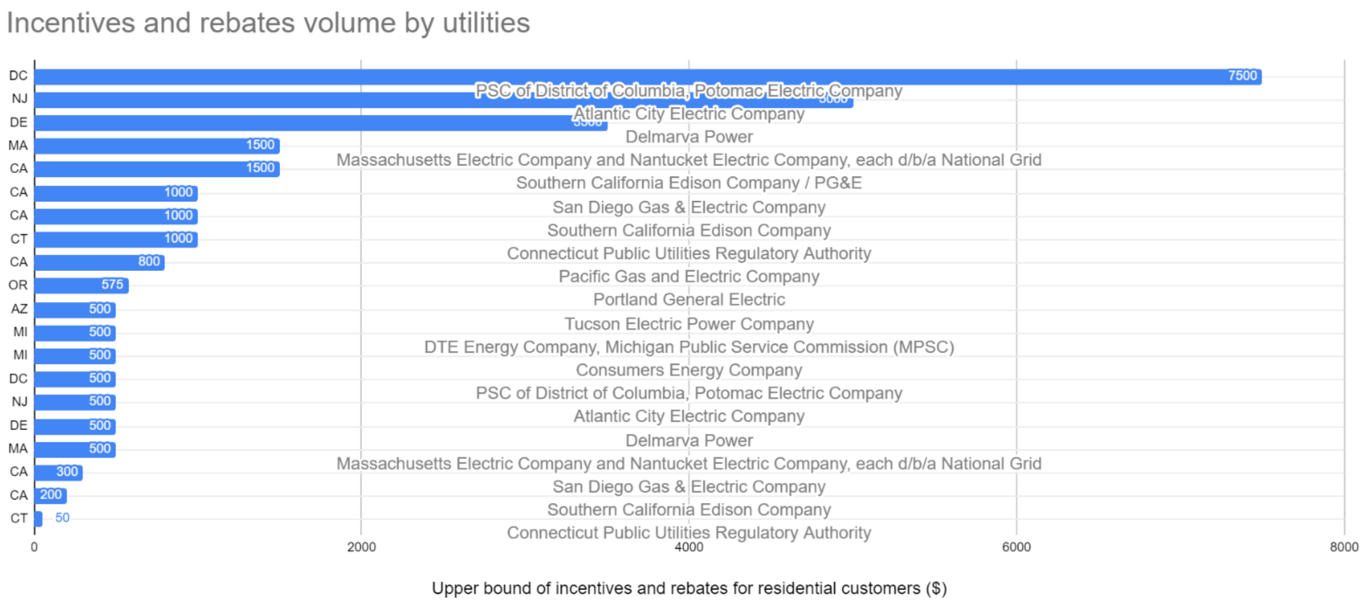

Figure 18 incentives and rebates volume by state and utilities (upper bound for residential customers)

and rebates are adopted in the graph to show the ability of the electric utility companies to support electric vehicle deployment in terms of providing incentives and rebates.

In Washington D.C., the Public Service Commission and Potomac Electric Company jointly proposed $300 rebates for Level II chargers, and up to $7500 rebates for multifamily Level II chargers, which shows as the highest rebates across the country for residential customers. New Jersey residents are eligible for a rebate of $25 per mile of electric range on the vehicle, up to $5000. The Atlantic City Electric Company subsidizes the costs associated with the purchase and installation of Smart Level II charging stations for qualified residential customers, which would be available to 100 customers at an estimated cost to the company at $415,000[66] (the proposal status is closed). Delaware, Massachusetts, California, Connecticut, and Oregon also have 4-6 proposals of rebates based on the Figure 19, while the rest of the states in the U.S. have not quite developed practical incentives or rebates programs for electric vehicle customers.

[66] BPU NJ: EO18020190, https://powersuite.aee.net/dockets/nj-eo18020190

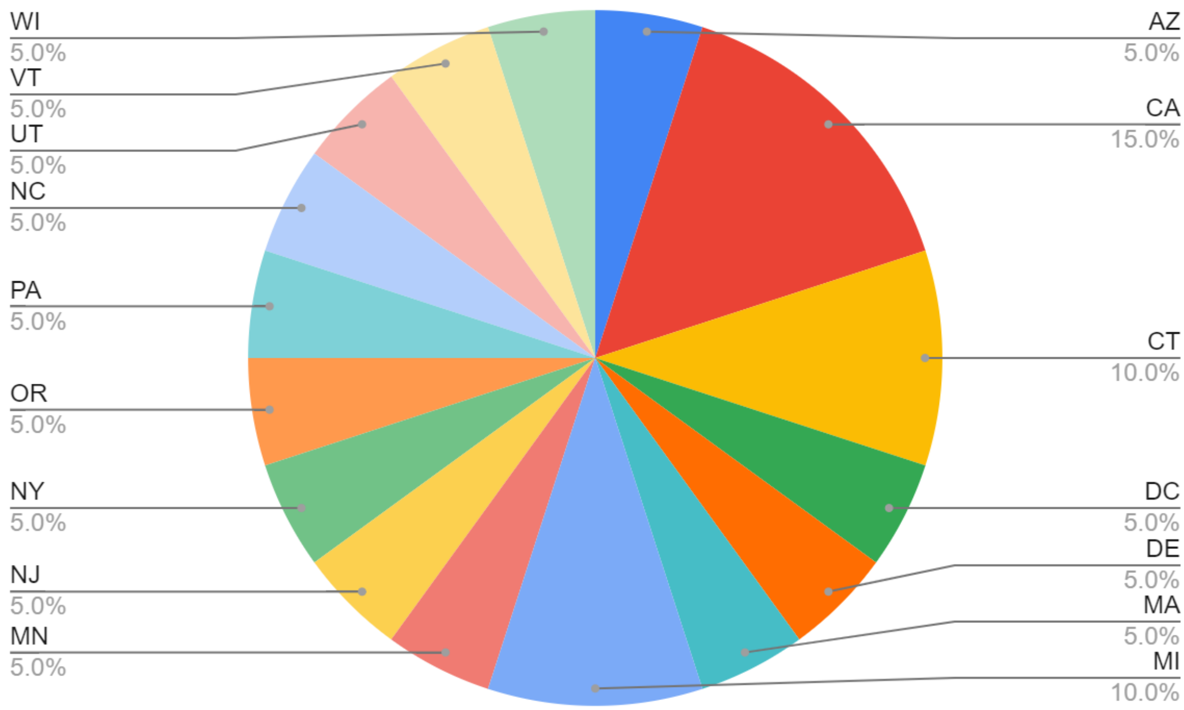

Figure 19 Percentage of state utility proposals that include incentives and rebates

Although Washington D.C. put forth the highest rebates and incentives for EV residential customers, California has the greatest number of proposals proposed by the major investor-owned utilities in the state (SCE, PG&E, and SDG&E) that include incentives and rebates design (Figure 18). Also, electric utilities in Connecticut and Michigan have 2 to 3 proposals that include a specific number of incentives or rebates.

Time of Use Rates

Time of Use rate design in the utility proposals serve as another way for utilities to support EV development. Varying rate structures are provided based on on-peak and off-peak hours. EV drivers can charge their vehicles during low electricity loads to save charging cost, for example, at nights or on weekends. Overall, there are currently 21 states in the U.S. with EV TOU rate structures in their utility proposals.

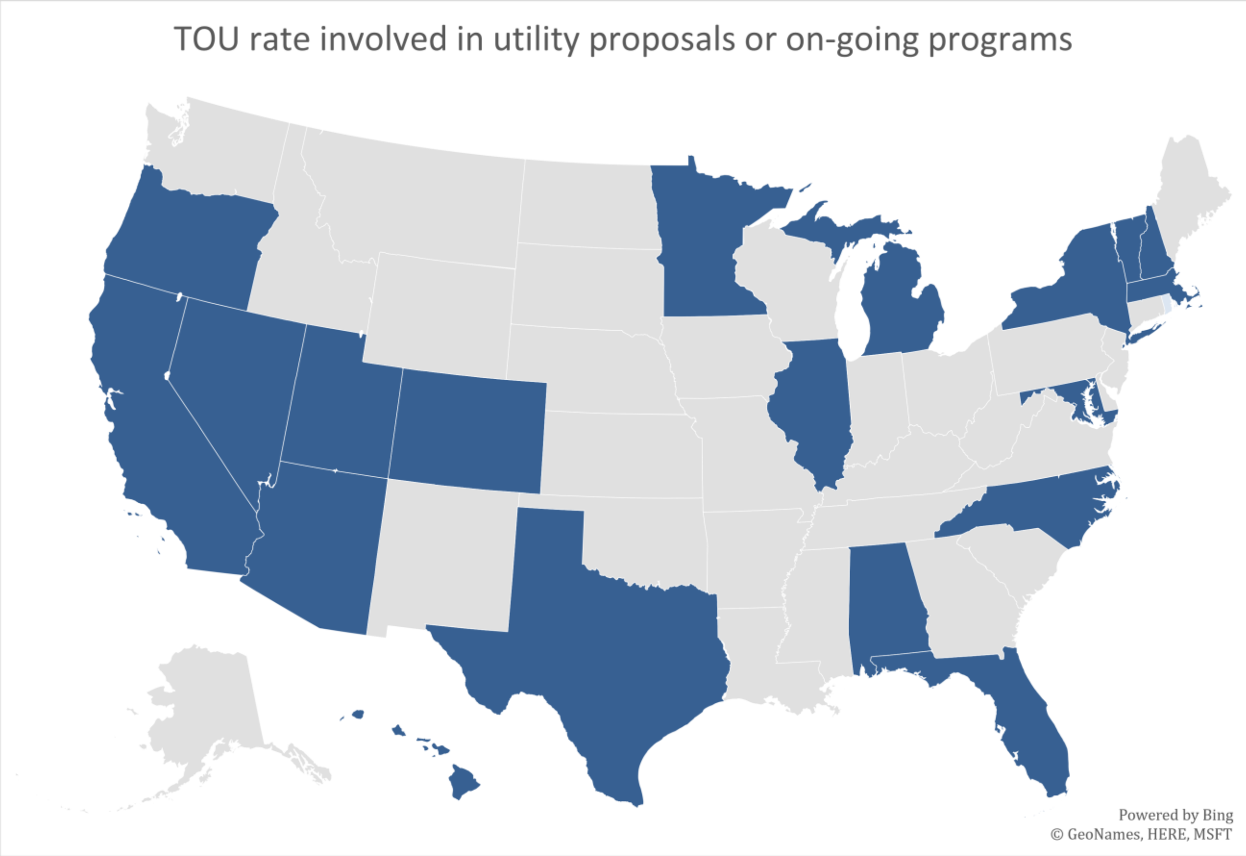

Figure 20 Time of Use Rate Adoption in the U.S.[67]

From the map (Figure 20), it can be observed that the TOU rates design have not reached majority of states in the U.S., although larger states (in geographic size), have TOU EV rates in place. Note that the map was created based on this Master Project proposals database and an updated database from Plug in America. More West Coast states offer TOU programs to EV customers when compared to utilities on the East Coast, other than Washington DC. Among the big states in the Southwest, only Arizona and Texas are currently offering EV customers a TOU rate structure. Specifically, the Salt River Project offers a TOU rate for off-peak and super-off-peak hours for customers with a qualified EV[68] (See Figure 21-23). Tucson Electric Power offers a residential TOU rate during off-peak hours to customers with an EV[69]. In Texas, Austin

[67] Dark blue means the state's one or more utilities offer TOU rate for EV customers; light blue means the states do not include TOU rate in their utility proposals based on our data; Grey area proposals are not available in the data.
[68] Electric Vehicle Price Plan, SRP, delivering water and power, https://www.srpnet.com/prices/home/electricvehicle.aspx
[69] TEP, Electric Vehicles, https://www.srpnet.com/prices/home/electricvehicle.aspx

Energy's EV360 pilot program offers EV charging with reduced off-peak rates from 7:00pm - 2:00pm on weekdays, and anytime on weekends[70]. In San Antonio, Texas CPS Energy also offers a rate program for EV drivers to access its ChargePoint network for an annual fee of $60[71]. Among all the states that do offer TOU rate for EV customers, the Figure 21 describes the adoption rate based on the number of proposals or on-going programs involving TOU rate design that utility commissions have passed.

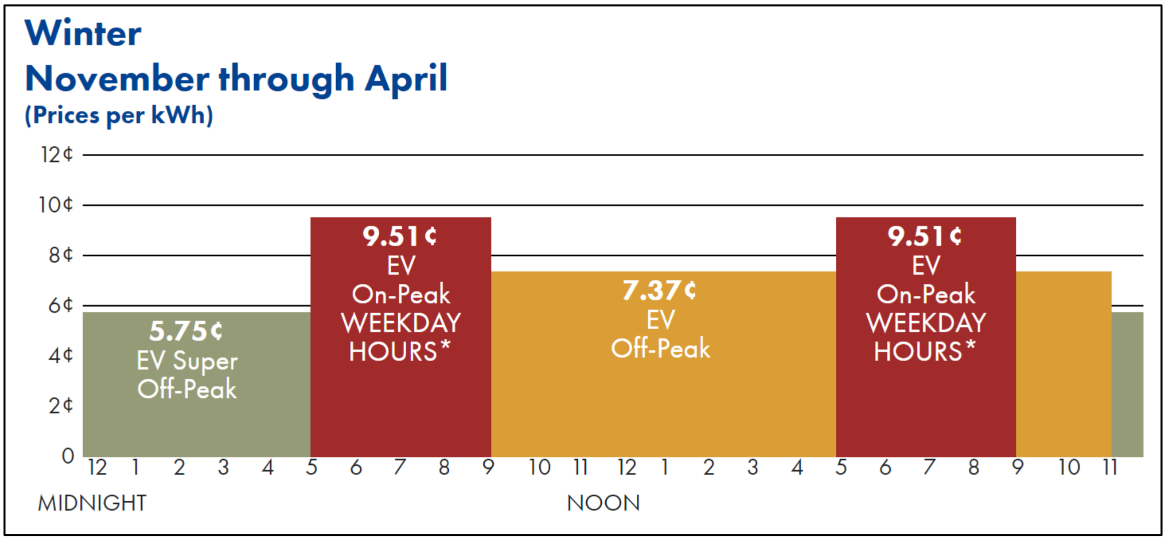

Figure 21 Salt river project wintertime Time-of-Use rate distribution graph

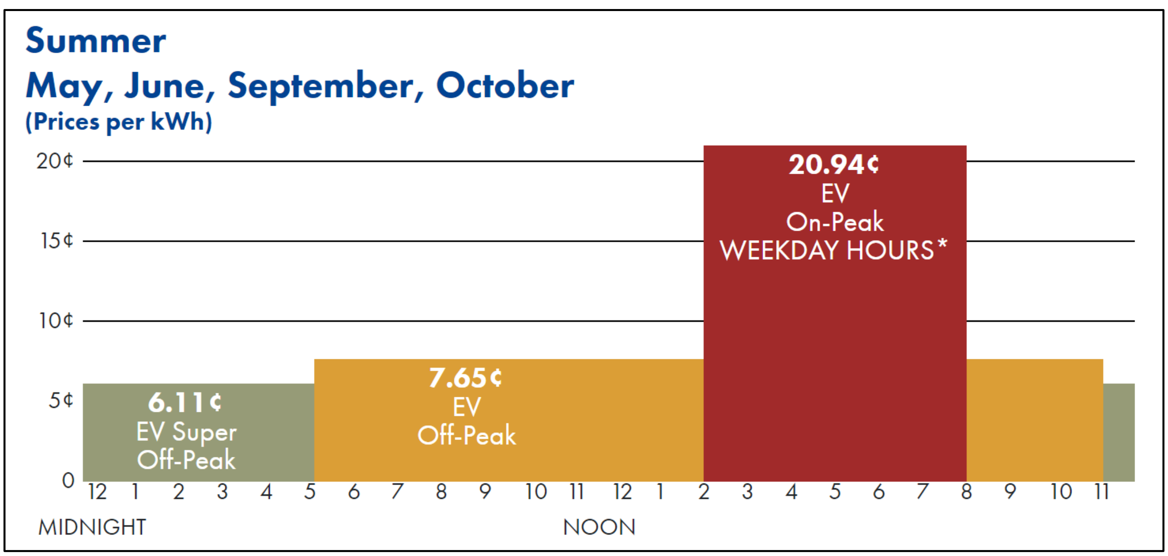

Figure 22 Salt river project summertime Time-of-Use rate distribution graph

70 Plug-in Austin Electric Vehicles, https://austinenergy.com/ae/green-power/plug-in-austin/home-charging/ev360
71 CPS Energy, https://www.cpsenergy.com/content/corporate/en/about-us/programs-services/electric-vehicles.html

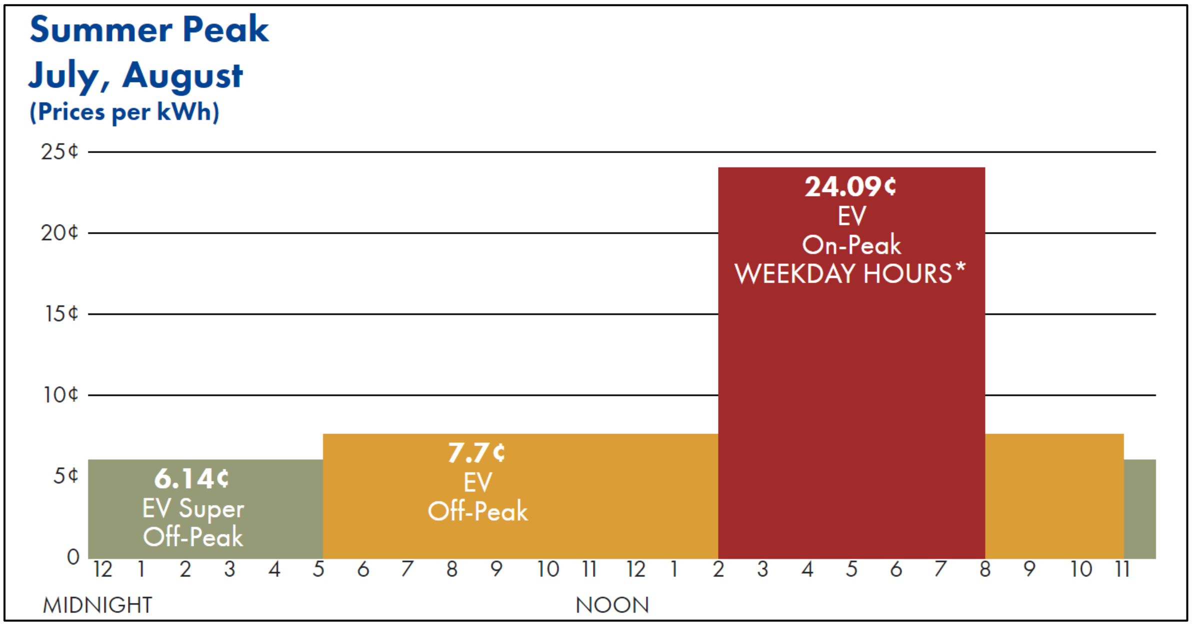

Figure 23 Salt river project summer peak time Time-of-Use rate distribution graph

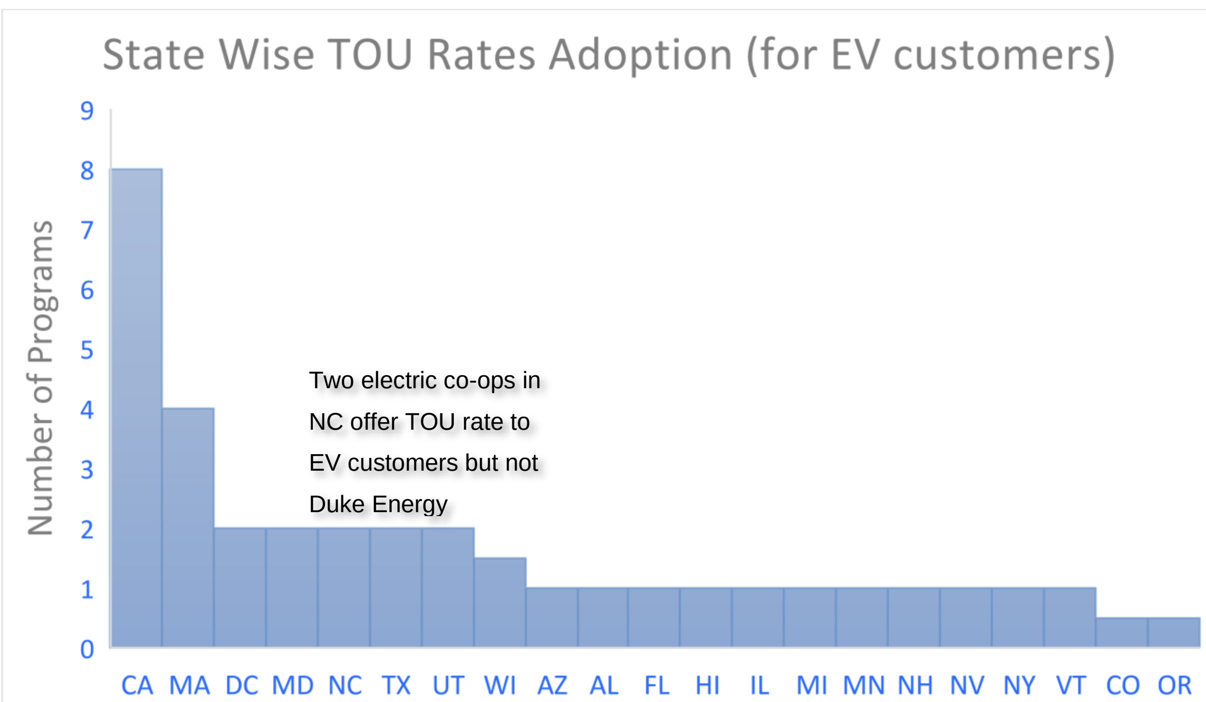

Figure 24 Number of EV TOU rates by state

Note that Colorado and Oregon do not have a practical TOU rate program, but the utility recommends a TOU rate to be adopted by EV users in general. In North Carolina, the largest electric utility Duke Energy, does not offer specific TOU rates for EV customers while Cape Hatteras Electric Cooperative (in North Carolina) does. Other similar examples include Minnesota. The electric cooperative Connexus Energy is the only electric utility that offers TOU rate for EV customers in Minnesota so far. Specifically, they have 2pm – 7pm, 7 days per week as their peak period. In summer, Connexus offers $0.2134/kWh during peak period while in winter $0.1585/kWh. All other periods have a rate of $0.0608/kWh. It is safe to say that electric cooperatives have good performance in terms of TOU rate in certain states. To compare other types of utility's performance on whether TOU rate design is adopted, Figure 25 Time-of-Use rate program adoption by different utility typesFigure 25 Time-of-Use rate program adoption by different utility types shows the distribution of the adoption on TOU rate design by investor-owned utility, electric cooperatives, and publicly owned utilities based on the proposals number.

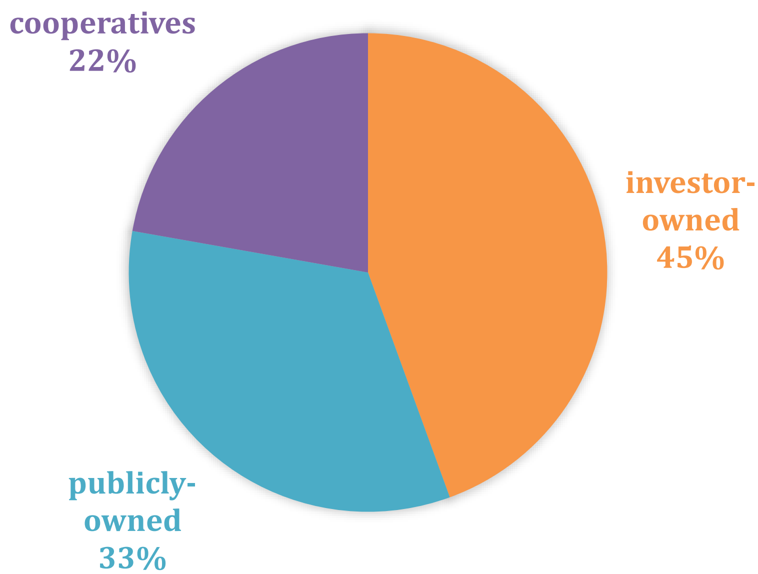

Figure 25 Time-of-Use rate program adoption by different utility types

Among all the utilities that put forth proposals with TOU rates, from the distribution pie chart, we can see that investor-owned utilities have 45% of TOU rates, which is a higher proportion when compared to electric cooperatives and publicly owned utilities. California leads the country in TOU rate adoption based on the number of proposals that were put forth and had TOU rate plans in their design. Table 3 below shows a few TOU rate design proposals approved by the CPUC.

Table 3 Time of Use rate design by electric utilities in California (Approved)

Utility	Utility Type	Time of Use Rates
San Diego Gas & Electric Company	IOU	SDG&E's dynamic "Public GIR" rate should be replaced with a TOU rate for public DC fast charging applications.
Pacific Gas and Electric Company	IOU	Participants sign up for a whole-home EV time-of-use rate that offers lower cost electricity during off-peak hours but allows customers flexibility in selecting the optimal rate for their usage.
Pacific Gas and Electric Company	IOU	The time-of-use rate is specifically designed to encourage charging during the middle of the day (with super off-peak rates offered between 9 a.m. and 2 p.m.) so that customers are taking advantage of California's surplus solar power.
Pacific Gas and Electric Company	IOU	Provide customers with the choice between three rate options (a sub-metered EV-only dynamic rate, a sub-metered EV-only TOU rate, and a whole-home TOU rate).
Southern California Edison Company	IOU	TOU-EV-1 residential rate, which requires that SCE install a new dedicated meter for charging the electric vehicle.

Southern California Edison Company	IOU	TOU price signals and load management strategies offer lower prices for EV drivers during non-peak periods of the day in order to shift EV load to hours of the day when there is excess generation on the grid, driven by increased penetration of energy from photovoltaic solar, both large-scale and distributed.

The TOU policies in California vary from utility to utility and proposal to proposal due to infrastructure limits, demand control, and peak hours shift. Different states have their own time range of peak hours and off-peak hours. In Wisconsin, the "Shift & Save " program by Madison Gas & Electric company has on peak hours from 10 am to 9 pm where Pacific Gas & Electric in California has super off-peak rates offered between 9 am and 2 pm so customers can take advantage of solar power[72].

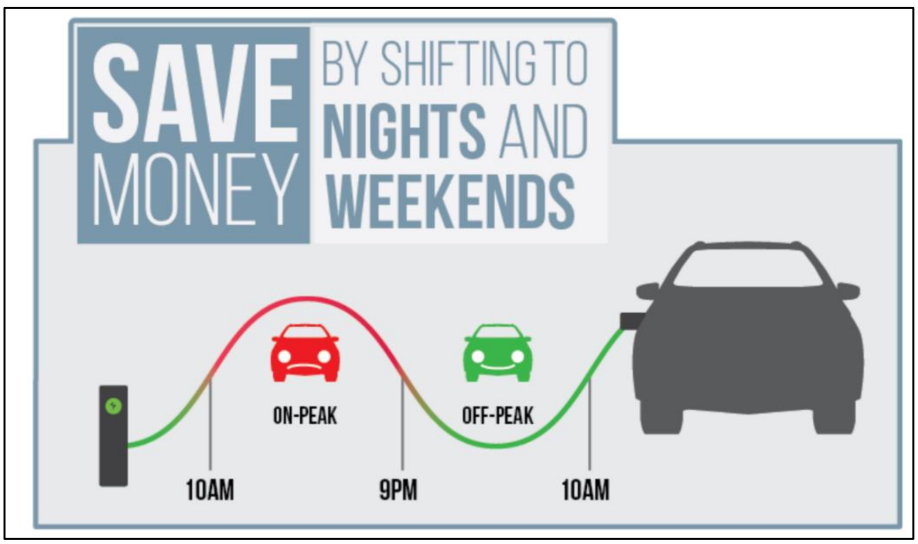

Figure 26 Madison Gas & Electric Company TOU Rate Design

Overall, the TOU rate design falls under the structural EV programs that is put forth by utilities. It is not surprising to see that certain states have not adopted time-of-use rates design for their EV users when the state is still at an early stage of developing EV infrastructure and EV

[72] MG&E, Charge your electric vehicle at night and save, https://www.mge.com/our-environment/electric-vehicles/shift-save

programs. But more requests for TOU rate design in EV programs can be expected with more policies for electrification of transportation put forth by the state utility commissions.

Case Study

This section looks at four case studies from different parts of the country to compare how trends vary across geographic locations in the United States. Key program criteria along with a few unique aspects of each of these proposals will be discussed in this section.

Table 4 Comparison between representative electric utilities on multiple criteria

State	Utility	Type of Utility	Program Costs ($ million)	Type of Charging	Charging Level	Number of Charging Ports/Stations	Program Length (years)	Cost Recovery Mechanism	Incentives and Rebates	Time of Use rates
CA	SCE	IOU	760.1	Residential, Public	Level II, DCFC	32,000	4	Distribution rates	New construction rebate	Yes
DC	PEPCO	IOU	1.6	Residential, Public	Level II, DCFC	73	7	Regulatory assets	On off peak charging	Yes
MO	Ameren	IOU	18	Residential, Commercial, Public	Level II, DCFC	1,200	7	Deferred accounting mechanism	$11 million + $7 million	No
OR	PGE	Publicly owned	37.1	Residential, Commercial, Public	Level II	3,600	14	Clean Fuels Pro credits	$575 for level 2.	Yes

From Table 6, it can be observed that there are 3 IOUs and 1 publicly owned utility. This is similar to the sample of the project data where majority of the proposals are put forth by IOUs. While most of these proposals (from the above table) mention Level II and DCFC charging, there is no mention of Level 1 charging. While Level 1 charging is a regular socket and is a more at-home charging, there are a few proposals from the sample data that included Level 1 charging too. The proposals in the case study have mostly proposed for residential and public charging, compared to commercial charging. This analysis is again similar to the sample of data. The program length among the case study proposals range from 4-14 years. There is a wide range of program length defined by various utilities. The cost recovery mechanism is different for each of the case study proposals. The majority of proposals in the sample data opt for distribution rate case method for cost recovery mechanism. All of the case study proposals offer incentives and rebates for customers to encourage EV adoption and charging. Similarly, most of the proposals from the sample data also offer some amount of incentives and rebates under their EV programs. Most of the proposals in the case study have TOU rates. Some of these proposals have specific TOU rates based on EV charging and load shifting during peak hours, while some proposals have a generic TOU rates program based on demand usage and smart metering data. Below are a few specific aspects that are unique to the proposals put forth by the utilities from the case study.

- SCE

  SCE is an example often compared to in this paper to other proposals. SCE has proposed multiple proposals from 2013- 2019. It has proposed the highest program costs and the largest number of charging stations. SCE's Charge Ready and Clean Fuels reward programs encourage EV adoption in the state. In this proposal, new solutions are put forth to address the unique challenges faced by MUDs and rebates to cover all or part of the costs of charging equipment in newly constructed MUDs.
- PEPCO

  PEPCO has smart chargers under its EV program. It also has a 'Green Rider' TOU rates program. This Green Rider program provides savings for customers who load shift during peak times. PEPCO also mentions a $1 million innovation fund, and the establishment of a $1.5 million technology demonstration program as part of its EV proposal. PEPCO proposes that the Commission pre-approved the prudency of the program costs and their full recovery and permits the establishment of a regulatory asset to recover costs associated with the EV Program, and that the EV Pilot's strong incentive to encourage off-peak charging, its inclusion of MUDs, and its investment in fast chargers would be positive steps forward in accelerating the electrification of vehicles in the District.
- Ameren:

  In Missouri, the stipulation and agreement authorize Ameren Missouri to utilize a deferral accounting mechanism, similar to the mechanism used in the Charge Ahead EV Charging Corridor, to track sub-program costs and administrative expenses. The Charge Ahead Program also provides incentives for EV buyers to adopt electric vehicles. Ameren also encourages private companies to purchase electric-powered vehicles and equipment instead of equipment with internal combustion engines.
- PGE

In Oregon, PGE said increased electricity sales and other benefits of Clean Fuels Program credits would return $34.7 million, trimming the net cost to $2.4 million. And they propose $575 rebate for Level II residential chargers (where $1840 is the total cost of installation) and an expected $1000 rebate will be granted based on income level. The proposal also mentions that the program costs will be borne by ratepayers.

Summary

The sample data has the highest cluster of proposals between 2017-2018. California has the highest number of proposals for EV programs. This could be due to encouraging clean transportation policies and goals in California. Southern California Edison proposed the highest program cost of about $760.1 million. Almost 70% of the proposals are put forth by investor-owned utilities when compared to publicly owned utilities and electric cooperatives. Furthermore, proposals with high program costs are proposed by IOUs when compared to publicly owned utilities and cooperatives. The program costs of the proposals have shown an increase from 2013 to 2019, which could be due to increased awareness among the state and the public that lead to more investments over time. There has been a steady increase in investments in public charging over residential and commercial charging, further adding to increase in investments in Level II and DC Fast Chargers (DCFC) over Level I chargers.

Cost recovery of these EV programs mostly rely on distribution of rate base on customers' utility bills. Among these, 32% of proposals have passive treatment on cost recovery including status of awaited, rejected, or disallow. Washington DC has put forth the highest amount of incentives and rebates in its proposal when compared to other proposals. Among the sample of proposals, utilities from 21 states offer time-of-use rate design for their EV customers. While some proposals have specific TOU rates, certain number of programs do not clearly mention TOU rate design in their proposals. California has been on the forefront of EV program design and investment for charging infrastructure while Arizona, Michigan, Texas among other states have followed up soon after. In the future, EV charging infrastructure is expected to develop with more commission support to EV programs and policies. Public charging plays an important role in encouraging EV adoption. Smart technology like advanced communication protocol between distribution network and EV chargers will be adopted by utilities in their proposals for charging infrastructure investment, to improve the efficiency of charging infrastructure.

Bibliography

Electric Vehicle Sales are Taking off in 2018. David Reichmuth. (Sep. 2018). https://blog.ucsusa.org/dave-reichmuth/electric-vehicle-sales-are-taking-off-in-2018

Pollution and Climate Change. Greenpeace. https://www.greenpeace.org/usa/oceans/issues/pollution-climate-change/

Sources of Greenhouse Gas Emissions. EPA. (2017). https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions

Clean Air Act. EPA. (2007). https://www.epa.gov/nsr/clean-air-act-permitting-greenhouse-gases

Electric Vehicle Basics. DOE. https://www.energy.gov/eere/electricvehicles/electric-vehicle-basics

6 Burning Questions about Electric Cars. Consumer Reports. (Jul. 2014). https://www.consumerreports.org/cro/news/2014/07/six-burning-questions-about-electric-cars/index.htm

Vehicle Charging. DOE. https://www.energy.gov/eere/electricvehicles/vehicle-charging

Most States have Renewable Portfolio Standards. EIA. (Feb. 2012). https://www.eia.gov/todayinenergy/detail.php?id=4850#

Transportation electrification should build on energy efficiency and renewable program success. Robin Lunt. (Apr. 2018). https://www.utilitydive.com/news/transportation-electrification-should-build-on-energy-efficiency-and-renewa/521008/

Large National Studies Analyze EV Infrastructure Needs. Paul Menser. https://avt.inl.gov/project-type/technical-reports

Summary of EV study by INL. Paul Menser. https://inl.gov/article/charging-behavior-revealed-large-national-studies-analyze-ev-infrastructure-needs/

Trends Observed in Plug-in EV Infrastructure Demonstrations. John Smart, INL. (Jan. 2014). https://avt.inl.gov/sites/default/files/pdf/EVProj/SAEGovtIndMtgJan2014.pdf

Charging Ahead: EV Infrastructure Demand. Hauke Engel, Russell Hensley, Stefan Knupfer, and Shivika Sahdev. (Aug. 2018). https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/charging-ahead-electric-vehicle-infrastructure-demand

Electrifying Insights: How Automakers Can Drive Electrified Vehicle Sales and Profitability. Stefan M. Knupfer, Russell Hensley, Patrick Hertzke, Patrick Schaufuss. (Jan. 2017). https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/electrifying-insights-how-automakers-can-drive-electrified-vehicle-sales-and-profitability

Why utilities need to respond now to the EV boom. UtilityDive. (Oct. 2017) https://www.utilitydive.com/news/why-utilities-need-to-respond-now-to-the-ev-boom/506761/

Sierra Club Applauds DPU Approval of Eversource Proposal to Advance EV Adoption: Acknowledges Concerning Aspects of DPU Order. Sierra Club. (Dec. 2017). https://www.sierraclub.org/press-releases/2017/12/sierra-club-applauds-dpu-approval-eversource-proposal-advance-ev-adoption

Approval of Electric Vehicle Utility Proposal in Massachusetts A Sign of What's Coming Down the Pike in Northeast & Mid-Atlantic, Sierra Club. (Dec. 2017). https://www.sierraclub.org/compass/2017/12/approval-electric-vehicle-utility-proposal-massachusetts-sign-what-s-coming-down

Missouri regulators approve Ameren plan for 1,000-plus EV charging stations, Power Engineering. (Oct. 2019) https://www.power-eng.com/2019/10/18/missouri-regulators-approve-ameren-plan-for-1000-plus-ev-charging-stations/#gref

Diverse Coalition Backs Plan for Deployment of Electric-Vehicle Charging Stations in Northern California, Sierra Club. (Apr. 2016). https://content.sierraclub.org/press-releases/2016/04/diverse-coalition-backs-plan-deployment-electric-vehicle-charging-stations

Request for Proposals for Electric Vehicle and Electric Vehicle Service Equipment Purchasing Discount Programs, SCPPA. (Jul. 2019) http://scppa.org/file.axd?file=/2019/07/RFP_Electric%20Vehicle%20and%20Electric%20Vehicle%20Service%20Equipment%20Purchasing%20Discount%20Programs_07-03-2019%20to%2007-24-2019%20FINAL.pdf

Who's Driving Electric Vehicle Charging? Black & Veatch. (2017). https://www.bv.com/sites/default/files/2019-10/17%20BV%20Electric%20Vehicle%20Report_0_0.pdf

Utility investment in electric vehicle charging infrastructure: key regulatory considerations. MJB&A, Georgetown Climate Center. (Nov. 2017). https://www.georgetownclimate.org/files/report/GCC-MJBA_Utility-Investment-in-EV-Charging-Infrastructure.pdf

State Renewable Portfolio Standards and Goals. National Conference of State Legislatures (NCSL). (Dec. 2019). https://www.ncsl.org/research/energy/renewable-portfolio-standards.aspx

SDG&E Final 2019 RPS Plan. Laura M. Earl. (Jul. 2019). https://www.sdge.com/sites/default/files/regulatory/2019_Final%20RPS%20Plan%20Public%20Version.pdf

CEC Approves $95 million for Clean Transportation. California Energy Commission (CEC). (Sep. 2019).https://www.energy.ca.gov/news/2019-09/cec-approves-95-million-plan-critical-clean-transportation-investments

CEC approves $95 million for Critical Clean Transportation Investments. CEC. (Sep. 2019). https://www.energy.ca.gov/news/2019-09/cec-approves-95-million-plan-critical-clean-transportation-investments

Massachusetts EV rebate program. https://mor-ev.org/

State and Federal Incentives. Plug-in America. https://pluginamerica.org/why-go-plug-in/state-federal-incentives/?location=tx

Investor-owned utilities served 72% of U.S. electricity customers in 2017. EIA. (Aug. 2019). https://www.eia.gov/todayinenergy/detail.php?id=40913

Maryland EV Charging. Maryland Public Service Commission. (Mar. 2011). http://webapp.psc.state.md.us/newIntranet/Casenum/CaseAction_new.cfm?CaseNumber=9261

Pacific Power. https://www.pacificpower.net/

NSTAR. http://www.nstar.com/

Nantucket Electric Company. https://nantucketenergy.com/

EV Public Charging. EnelX. (Nov. 2019). https://evcharging.enelx.com/news/blog/579-the-ultimate-guide-to-electric-vehicle-public-charging-pricing

Levels of Charging. EV Town. http://www.evtown.org/about-ev-town/ev-charging/charging-levels.html

The Strategic CFO. https://strategiccfo.com/cost-recovery/

The Wheels Are In Motion on Electric Vehicle Cost Recovery Efforts In California, Dan Lowrey. (Nov. 2018). https://www.spglobal.com/marketintelligence/en/news-insights/research/the-wheels-are-in-motion-on-electric-vehicle-cost-recovery-efforts-in-california

Ameren EV charger cost recovery should be tied to EV adoption rates. Robert Walton. (Dec. 2018). https://www.utilitydive.com/news/ameren-ev-charger-cost-recovery-should-be-tied-to-ev-adoption-rates-missou/543372/

In the Matter of the Application of Union Electric Company d/b/a Ameren Missouri for Approval of Efficient Electrification Program, Case No. ET-2018-0132, https://www.efis.psc.mo.gov/mpsc/commoncomponents/viewdocument.asp?DocId=936193667

ACC Draft Implementation Plan, basis for discussion at the March 26, 2019 EV Stakeholder meeting, https://docket.images.azcc.gov/0000196918.pdf

Electric Motor Vehicles Public Utility Services, Colorado General Assembly, SB19-077, https://leg.colorado.gov/bills/sb19-077

PUC CO: 17I-0692E, https://powersuite.aee.net/dockets/co-17i-0692e

PSC DC: FC1143 (later transferred to 1130), https://powersuite.aee.net/dockets/dc-fc1143

PSC FL: 20160186, https://powersuite.aee.net/dockets/fl-20160186

PUC OR: UM2003, https://powersuite.aee.net/dockets/or-um-2003

DPU MA: 17-13, https://powersuite.aee.net/dockets/ma-17-13

PSC MD: 9261, https://powersuite.aee.net/dockets/md-9261

PSC MO: ET-2016-0246, https://powersuite.aee.net/dockets/mo-et-2016-0246

PUC MN: 15-111, https://powersuite.aee.net/dockets/mn-15-111

Regulators deny EV charging subsidies, allow pollution control cost overruns for WEC utilities, Wisconsin State Journal, Chris Hubbuch, https://madison.com/wsj/news/local/govt-and-politics/regulators-deny-ev-charging-subsidies-allow-pollution-control-cost-overruns/article_5739f2dd-2239-5df8-8fb5-9b484ebc799a.html

Regulators deny EV charging subsidies, allow pollution control cost overruns for WEC utilities, Wisconsin State Journal, Chris Hubbuch, https://madison.com/wsj/news/local/govt-and-politics/regulators-deny-ev-charging-subsidies-allow-pollution-control-cost-overruns/article_5739f2dd-2239-5df8-8fb5-9b484ebc799a.html

Figure: 16 TAC §25.243(d)(1), http://txrules.elaws.us/Gateway/codepdf//TITLE16/PART2/CHAPTER25/SUBCHAPTERJ/DIVISION1/25.243/2018-11-29/PDF/201103980-1.pdf

Arizona asks utilities to present public EV charging projects, oil lobby campaign fails, Phil Dzikiy, electrek, July.24, 2019, https://electrek.co/2019/07/24/arizona-utilities-ev-projects/

ACC AZ: E-01933A-17-0250, https://powersuite.aee.net/dockets/az-e-01933a-17-0250

Electric Vehicle Charger Selection Guide. Redwood Coast Energy Authority (RCEA). https://redwoodenergy.org/wp-content/uploads/2019/02/Electric-Vehicle-Charger-Selection-Guide.pdf

A two-way communication scheme for vehicles charging control in the smart grid, Jihene Rezgui, Soumaya Cherkaoui, Dhaou Said, August 2012, https://www.researchgate.net/publication/261379460_A_two-way_communication_scheme_for_vehicles_charging_control_in_the_smart_grid

A1801012, https://apps.cpuc.ca.gov/apex/f?p=401:56:13816153023519::NO:RP,57,RIR:P5_PROCEEDING_SELECT:A1801012

State Incentives, Plug In America, https://pluginamerica.org/why-go-plug-in/state-federal-incentives/?location=co

BPU NJ: EO18020190, https://powersuite.aee.net/dockets/nj-eo18020190

Electric Vehicle Price Plan, SRP, delivering water and power, https://www.srpnet.com/prices/home/electricvehicle.aspx

TEP, Electric Vehicles, https://www.srpnet.com/prices/home/electricvehicle.aspx

Plug-in Austin Electric Vehicles, https://austinenergy.com/ae/green-power/plug-in-austin/home-charging/ev360

CPS Energy, https://www.cpsenergy.com/content/corporate/en/about-us/programs-services/electric-vehicles.html

MG&E, Charge your electric vehicle at night and save, https://www.mge.com/our-environment/electric-vehicles/shift-save

Acronyms

- ACC: Arizona Corporation Commission
- CEC: California Energy Commission
- CPUC: California Public Utility Commission
- DCFC: Direct Current Fast Charging
- DCRF: Distribution Cost Recovery Factor/Formula
- DOE: Department of Energy
- DPU: Department of Public Utilities
- EV: Electric Vehicle
- EVC: Electric Vehicle Charging
- EVSE: Electric Vehicle Supply Equipment
- HEV: Hybrid Electric Vehicle
- IOU: Investor-Owned Utility
- MG&E: Madison Gas and Electric
- MP: Minnesota Power
- MUDs: Multi-Unit Dwellings
- OPC: Office of the Public Counsel
- PEPCO: Potomac Electric and Power Company
- PG&E: Pacific Gas and Electric
- PGE: Portland Gas and Electric
- PHEV: Plug-in Hybrid Electric Vehicle
- PUC: Public Utility Commission
- PSC: Public Service Commission
- RPS: Renewable Portfolio Standards
- SCE: Southern California Edison
- SDG&E: San Diego Gas & Electric
- SRP: Salt River Project
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