

Electric Utilities and the EV Market: A Decision-Making Tool for State-Specific Strategies

by

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20 April 2020

Master's Project submitted in partial fulfillment of the requirements for the Master
of Environmental Management degree

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Executive Summary

Electricity demand has been nearly flat in the U.S. over the past decade. In parallel, growth in the electric vehicle (EV) market offers opportunities for boosting the revenue and resilience of utilities in addition to the environmental benefits that EVs have to offer through reducing the use of fossil fuels. This research project assesses how utilities can best engage to advance the EV market, address the barriers and challenges posed, and benefit from new opportunities.

Based on market research and expert interviews, the project identified 15 strategies commonly deployed across the U.S. Due to increased modeling complexity and data unavailability, the project scope was brought down to investigating 10 of these 15 EV adoption strategies for utilities: time of use (TOU) rates, private and public charging infrastructure, customer engagement, light duty fleets for utility use, shared light duty fleet partnership, light duty and commercial and industrial (C&I) fleet services, and vehicle to grid integration.

A state-specific multi-criteria decision matrix was developed to help utilities identify which of the above strategies could prove to be most promising in their region. The decision matrix relies on inputs from the user to run calculations specific to each state, market type (regulated/deregulated), utility type (investor owned/municipal), territory size, utility return on investment, project length, and estimated adoption rate. In-depth background research and data collection for each state and for each strategy were used to populate this decision matrix and simulate results. The output of this decision-making tool provides each state with a list of the best EV adoption strategies ranked according to local financial, political, and regulatory conditions.

The decision matrix can be used to provide a market overview for a variety of different users. It was used to simulate the best strategies for specific states, compare states' EV market maturity, and strategies likely to succeed across the U.S. For example, a sample investor owned utility with a territory population of two million was input into the decision matrix to identify which strategies would be the most favorable in each state.

The analyses performed identified that a majority of states are in early stages of EV adoption. Decision matrix results showed that customer engagement and TOU rates are ranked high most often due to low cost and ease of implementation of these strategies. The matrix also yielded that certain states should focus on investing in public and private charging infrastructure, electrifying their personal fleets, and offering light duty and C&I fleet services. These strategies were ranked higher as a result of successfully deployed utility programs that show promise of replication in other states, rebates and incentives, and promising rates of return on investment, as well as a history of regulatory approval or a policy drive to increase the number of EVs on the roads. The study also concludes that no state is ready for more mature strategies such as vehicle grid integration.

The results demonstrate the need for substantial action to advance EV markets and to meet state and national targets. Utilities have a crucial role in educating customers and transitioning the transportation sector to a new fuel source. Unfortunately, most advanced and proactive strategies carry investment risks and challenges, particularly considering the lack of regulatory approval or policy action. Utilities in states that are further along the EV adoption curve have successfully deployed programs for early stage strategies that carry low risk and high ease of implementation. We find merit in this approach based on our analysis and advocate that utilities in states that are in earlier stages of EV adoption could follow suit to launch their respective programs. Utilities must also engage with state regulators and policy makers. With continued public-private engagement, more aggressive mid-late strategies would become more realistic; thereby accelerating the adoption of EVs.

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Introduction

Background

The global automotive sector is undergoing an electric revolution. Automotive manufacturers have been planning the phase-out of Internal Combustion Engine Vehicles (ICEVs) world over in favor of Battery Electric Vehicles (BEV).¹ BEVs are viewed by automotive manufacturers as a sustainable revenue stream and firms have been investing significant man-hours and money into electric vehicle R&D. Automotive manufacturers in the United States are following their European counterparts' suit, with companies such as Ford Motor Company pledging upwards of \$11 billion towards electric vehicle (EV) production and R&D by 2022.² Ford also plans to introduce upwards of 40 EV models in the US market by 2022, a move that would entirely transform the U.S. transportation sector. EVs have long been a distant dream owing to the limitations in battery capacities and the resulting “range anxiety” phenomenon. In recent times, the costs of batteries have significantly dropped (50% lower today compared to 2010), power and energy densities are increasing at an annual rate of 5-8% and as a result, the interest in EVs is higher than ever before.^{1,3}

In the United States, the electric power sector accounts for a larger fraction of energy consumption (38.1%) than the transportation sector (28.8%). However, an Energy Information Administration (EIA) report from 2016 states that transportation has surpassed electricity generation as the leading greenhouse gas (GHG) emitter in the US.⁴ The IPCC report from June 2018 discusses the expected ill-effects of global warming beyond 1.5 degrees Celsius and stresses the importance of carbon mitigation pathways in preparation to escape potential calamities world-wide.⁵ All these factors - namely steadily improving EV technology, falling costs, and the pressing need for reform – has sprung several U.S. states into action. California has adopted a Zero Emission Vehicle (ZEV) continuous improvement mandate with an ambitious goal of having 5 million ZEVs on the road by 2030. Several other states are now following suit. The regulatory policy favoring EV adoption, in conjunction with the steadily receding technological barriers are expected to cause a boom in the EV market. This is evidenced by the EV sales in 2018, which came in at an 81% increase over 2017.⁶

Objective & Scope

This rapidly changing energy landscape provides ample opportunity for the investor-owned utilities (IOUs) to expand their business model and increase their revenue. This project looks into IOUs and municipal utilities and their role in increasing EV adoption for all 50 states in the U.S. Extensive market research and inputs from expert interviews were used to build a decision-making tool in the form of a decision matrix. Load serving entities can use this tool to decide which EV adoption strategies will reap the best results under their specific jurisdiction. The following strategies were selected for the tool as they were the most prevalent in the industry: TOU rates, private and public charging infrastructure, customer engagement, light duty fleets for utility use, shared light duty fleet partnership, light duty and C&I fleet services, and vehicle grid integration.

¹ Forbes. [Seven reasons why the internal combustion engine is a dead man walking](#). (2018).

² Reuters. [Ford plans \\$11 billion investment, 40 electrified vehicles by 2022](#). (2018).

³ Bloomberg New Energy Finance. [A behind the scenes take on lithium-ion battery prices](#). (2019)

⁴ EIA. [U.S. energy facts explained](#). (2019).

⁵ IPCC. [Summary for policy makers](#). (Accessed 2020).

⁶ Greentech Media. [US electric vehicle sales increase by 81% in 2018](#). (2019).

Background data collected for each state includes pilot programs for each strategy, EV sales and projections, utility avoided costs and electricity rates, energy and tax data, incentives and fees, rebate programs, infrastructure costs, and customer statistics.

To ensure that decision making is robust to changes in location and different market conditions, a state-specific decision matrix tool (“the Matrix”) uses inputs from the user regarding market type, territory size, strategy weighting, and other strategy specific details. These inputs are used to populate the matrix for the following criteria for each selected strategy: Internal Rate of Return (IRR), associated risk, state policy environment, and status of regulatory approval. The output of this decision-making tool would be to provide, for each state, a list of the best EV adoption strategies ranked according to deployment priority.

In addition, this report aims to describe challenges associated with each selected strategy and identify drivers and barriers for EV adoption.

Literature Review: Current Role of the Utility in Electric Vehicle Markets

Potential for Utility

Given the current EV market scenario, utility companies are being viewed as a silent hero – one that could have a significant impact through involvement in the EV market. The idea of utility engagement in the EV market arises from two primary issues facing the current utility business model. Firstly, electricity demand in the US has remained fairly stagnant which has limited the growth of utility companies.⁷ Secondly, the cost-of-service model of utility regulation is coming under criticism as this model is predicted to be under threat given the increasing penetration of Distributed Energy Resources (DERs) such as solar photovoltaics and EVs.⁸ EVs are an elegant solution to both the above challenges. For starters, EV adoption is expected to increase 2050 U.S. electricity consumption by 38% according to NREL estimates in 2018. Secondly, the possibility of utility regulation shifts in the U.S. dictates that utilities would benefit to engage in alternative revenue streams that leverage DERs. This makes EVs an appropriate investment choice for utilities given that the market is still young and growing rapidly.

However, EV adoption does possess certain barriers. The most common issue being the “chicken and egg dilemma” which details consumers’ reluctance to purchase EVs due to lack of charging infrastructure and investors’ hesitation to build infrastructure without clear market signals.¹ The utility’s engagement in the EV value chain can help alleviate some of these barriers for EV adoption and result in cleaner and more efficient grid operations while acting as a long-term revenue source for utilities. Some novel utility engagements in the EV market could take the form of EV charging infrastructure investments, redefining rate structures for EV consumers, rethinking non-coincident demand charges or through time of use rates to disrupt consumption patterns. Many of these engagement scenarios may possess evident economic advantages to utilities.

Barriers to Utility Entry into EV Market

Especially in the case of IOUs, EV adoption strategy planning would need the support of policies and regulations. EV regulatory filings tend to be concentrated in certain states, usually ones with higher EV adoption and ambitious ZEV adoption goals. This regulatory uncertainty is the biggest barrier to EV adoption. The lack of policies and regulatory approval for EV adoption strategies in certain states makes replicating successful utility programs in other states challenging. The following image is an overview of

⁷ Bloomberg. [U.S. power demand flatlined years ago, and it’s hurting utilities.](#) (2017).

⁸ Energy Innovation. [Going deep on performance-based regulation.](#) (2018).

the 2017 EV regulatory landscape in the US.⁹ While more EV focused dockets are more frequently introduced in 2020, this is an accurate representation to why utility EV programs are just beginning to gain traction.

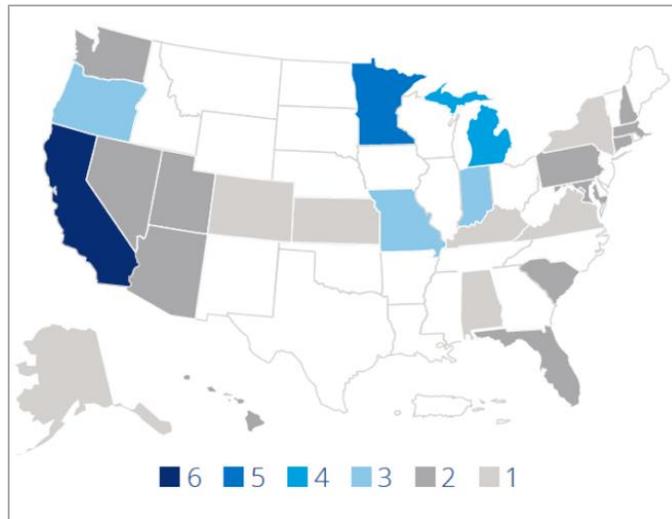


Figure 1: Total Number of EV Related Regulatory Dockets by State (SEPA, 2018)

In addition, customers need to be made aware of the benefits and incentives surrounding EVs, and increased efforts in utility marketing strategies are necessary to help ease the education process for customers.

Methodology

Interviews with Industry Experts

Aside from a thorough literature review, which provided the background for the previous sections, a key research method used throughout this project was interviewing industry experts. These were interviews with professionals actively working on new business models and utility analyses for EV markets. There were 12 interviews conducted with experts from a variety of areas across the space. This included investor owned utility employees actively working on EV pilots or programs, trade organizations, non-profits, magazine contributors, utility consulting firms, and private company employees.

Our interviews were conducted through open dialog, with the interviewees sharing their insights, knowledge, and personal opinions as advisors for the project. For this reason, their names and employers are not disclosed. All information gathered was used to help direct the research, and all specific information regarding pilots, programs, or research were all corroborated with public sources and referenced appropriately.

The interviews were all directed with a format similar to the following:

- a. How do you feel utilities are currently doing at engaging in the EV market?
- b. What do you view as the utility's role with EVs?
- c. What utilities, in your view, are doing a good job at engaging in the industry?
- d. What do you see as the main drivers for how utilities have engaged thus far?
- e. Other specific questions relevant to the interviewee's industry and role, programs involved.

Interviews were typically between 30-60 minutes depending on the availability of the interviewee.

⁹ Smart Electric Power Alliance. [Utilities and Electric Vehicles – Evolving to Unlock Grid Value](#). (2018).

Multi Criteria Decision Model

Decision making has been a robust area of study since the 1970s, yielding numerous models attempting to best simulate reality. The use of decision models occurs when there is a problem or question with no solution that fully optimizes a chosen set of criteria, and it is not obvious whether one solution is superior to another.¹⁰

This approach directly aligns with the research question regarding how a utility should view the EV market and pursue an action. There are a seemingly unlimited number of ways that a utility could engage, but utilities must make strategic decisions that optimize the outcome. To aid in these decisions, we developed a tool, the Matrix, which uses a decision matrix to produce a merit order of strategies that would be most beneficial for a utility to pursue based in a specified state. The merit order is defined as the strategies that are most attractive rank highest, and those that are less attractive rank lower.

The decision model chosen for this investigation was adapted from Pinkel, who used the model to illustrate a process decision through a number of parameters that yield a merit order, ranking processes from best to worst given a set of criteria.¹¹ This matrix was chosen for this study due to the availability of information, qualitative and quantitative criteria, and range of audiences whom this tool is developed for. For our purposes, the systems in which Pinkel was ranking correspond to utility EV strategies, and the parameters correspond to our criteria. Pinkel claims that in practice, the merit order is determined with Equation 1:

$$I^J = \frac{[\sum_{i=1}^n R_i^J W_i]}{\sum_{i=1}^n W_i}$$

(Equation 1)

Where: I^J = the rating index of J strategy
 R_i^J = J strategy rating for i criteria
 W_i = weighting for i criteria
n = number of criteria

Typically, the criteria weighting all sum to 1, but for viewing simplicity, this investigation's model sums to 100 and then yields a weighted average.

The specific criteria to evaluate each strategy were carefully selected through literature review, conversations with the client, and industry interviews. The criteria used to develop the merit order in this decision matrix are the investment potential through internal rate of return (IRR), risk assessment, regulatory history of approval, and state policy environment.

¹⁰ Munda. G, et al. "Qualitative multicriteria evaluation for environmental management." Ecological Economics. 12 July 1993. http://aoatools.aua.gr/pilotec/files/bibliography/munda_EE-3857317632/munda_EE.pdf

¹¹ Pinkel, Benjamin. "On the Decision Matrix and the Judgement Process; A Developmental Decision Example." The RAND Corporation. P-3620 June 1969. Santa Monica, California.

Evaluation Criteria

Investment Potential – IRR

A natural first criterion for any business decision is the requirement to earn an attractive financial return. This intuition was confirmed upon discussion with the client, who specified this as a key criterion they use throughout their decision-making processes. The metric chosen for the decision matrix is the internal rate of return (IRR), which calculates the growth potential of a program or project.¹²

This metric is appropriate as it is commonly used to compare the profitability between new projects or expanding projects. This fits well with the nature of the matrix which directly compares multiple EV strategies. Additionally, the IRR is appropriate for the flexibility for which the tool is built for. Since the client is not situated in one specific utility in one specific market, it is important the tool be translatable to different utilities in different markets across the United States. Other common financial metrics, such as Net-Present Value, require specific inputs, such as a discount rate, which vary between projects and regions. An IRR, however, can provide a valuable financial metric with minimal inputs from the user.

The decision matrix compares the IRRs between 10 different strategies (outlined below) to yield a merit order from highest IRR to the lowest. Each strategy requires different inputs from the user and is calculated using different assumptions, historical pilot studies, state-specific data, or other methods. Each strategy's IRR calculation is detailed individually in the strategy sections below.

Risk – Probability of Success and the Impact of Failure

The second criterion chosen through client discussion and interviews is an assessment of the risk associated with each strategy. A commonly used method for measuring risk is through using a risk matrix. This method uses the probability of success along with the potential impact of the failure.¹³

Assessing the risk in this decision model is limited in precision due to the logistical differences between strategies, varying consumer behaviors and preferences, and infancy of EV strategies without a significant amount of data to use for estimates. This lack of precision yields to difficulty in defining the probability of each individual strategy's success. While the precise probability of success is difficult to address, it can be approximated through using the regulatory history of a strategy. A prominent question for an IOU when undertaking a new project is the ability to include its costs in their rates to recover costs or earn a return. For this reason, the probability of success was defined as 0, 0.5, or 1 using the regulatory history of a strategy. These designations are defined in Table 1.

Probability Score	Regulatory Meaning
0	No history of an approval of a similar program found
0.5	Pending or Partial Approval
1	Full program has been approved

Table 1: Scoring Metric for Risk

¹² Investopedia. [Internal rate of return – IRR](#). (2019).

¹³ Julian Talbot. [What's right with risk matrices](#). (2018).

The lack of regulatory approval, or only having partial approval increases the risk, as all costs are not guaranteed recovery. An example of a partial approval would be in Iowa, where a full commercial and industrial EV program is not in place, but there is approval for forklifts and other off-road equipment.¹⁴

The negative impact potential is the costs that a utility would incur but may not have the ability to recover or earn a return. For all strategies, this is the capital costs calculated in the manners outlined in the IRR calculations below.

The risk criterion is therefore calculated as Equation 2 below:

$$Risk = (1 - Probability) \times Impact$$

(Equation 2)

The merit order between strategies is then determined from lowest risk to highest risk.

Regulatory History

The importance of regulatory approval cannot be overstated, resulting in a criterion specifically dedicated to the regulatory history of a strategy in a specific state. For an IOU to move through the regulatory process, the lack of precedent will have many impacts. These could include opening debate with stakeholders, significant delays in the implementation of a new program, and uncertainty in a request approval. However, if a PUC has previously approved a program that fits with the proposed strategy, that greatly increases the certainty of future cash flows through allowing the utility to recover costs or earn a return on their investment.

The cash flow certainty comes from the Public Utility Commission (PUC) approving a program to be included in the rate base, allowing the utility to profit from the investment, or at a minimum allowing the recovery of the costs. In general, the rates an IOU charges its consumers balance the financial integrity of the utility with the public interest.¹⁵ State PUC's often make decisions about whether a utility's action is necessary and for the public benefit based off their own state's values. One state's decision does not predict other states' actions.

This can be seen when looking at the instance of utility subsidized private chargers. There are different opinions across the country to how this type of EV program serves the public. In Wisconsin, a 2019 rate case yielded a denial of funding for utility incentives to install in-home charging stations for a two-year pilot program.¹⁶ The Wisconsin Public Service Commission ruled that it is the responsibility of the EV buyers to purchase their charging system, not the rate payers. Conversely, in California, the California Public Utilities Commission (CPUC) approved a variety of home charging incentive programs offered through the three IOUs under the rationale that it is instrumental in the overall state climate goals.¹⁷

The regulatory approval criterion in the decision matrix is determined through finding relevant programs within each state. The strategy is then assigned a score as defined in Table 2 below.

¹⁴Alliant Energy. [Electric vehicle market infrastructure](#). (2019).

¹⁵ Eisen, Joel. Hammond, Emily. Rossi, Jim. Spence, David. Weaver, Jacqueline. Wiseman, Hannah. [Energy, Economics and the Environment \(4th ed. 2015\)](#). Pgs 455-500.

¹⁶ Wisconsin State Journal. [Regulators deny EV charging subsidies, allow pollution control cost overruns for WEC utilities](#). (2019).

¹⁷ "Summary of Approved SB 350 Transportation Electrification Priority Review Projects for SDG&E, SCE, and PG&E." Web.

Score	Regulatory Meaning
1	No history of an approval of a similar program found
2	Pending or Partial Approval
3	Full program has been approved

Table 2: Scoring Metric for Regulatory History

These values are directly entered into the decision matrix yielding a merit order for this criterion.

State Policy Environment

The final Matrix criterion, state policy and incentives, represents an important component to any utility’s ultimate strategy goal. All utilities operate in a highly regulated environment, and the ability to implement new pilot programs for innovative services and offerings is highly dependent on the state in which the program is imposed. For this reason, it is important for the utility to align with state policy goals.¹⁸ These policies range from goals to incentivize increased light-duty EV ownership, heavy-duty fleet adoption, and greenhouse gas emission reduction programs. Some states, however, have a very clear absence of policy that support vehicle electrification, which has implications to a utility in their ability to act.

The U.S. Conference of Mayors and the Center for Climate and Energy Solutions (C2ES) performed a study in 2018 to determine how the policy environment effects the adoption of alternative fuel vehicles, including BEV and hybrid EVs. This has shown that across the different vehicle classes, the existence of green policy goals has an increasing effect on the percentage of cars of a specific fuel type (Figures 2 - 4).¹⁹ These figures show a clear trend that states having some degree of green vehicle policies are more likely to have a higher number of green vehicles on the road. To add context, as of 2017, North Dakota, South Dakota, Alaska, and Kansas had no policies effecting the purchase of EVs or construction of EV charging equipment. In terms of 2017 EV sales, they ranked 1st, 3rd, 4th, and 18th lowest in the nation.^{20,21}

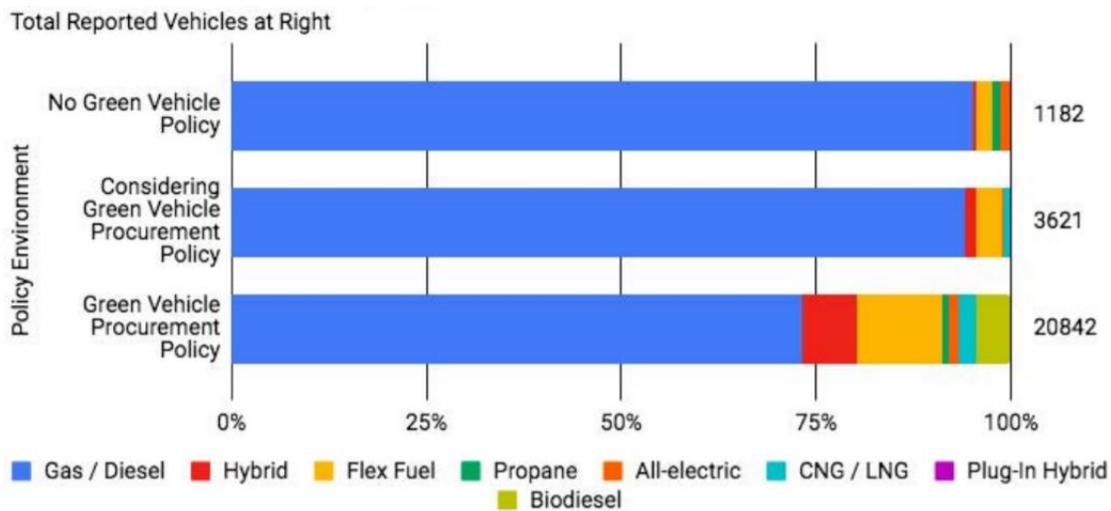


Figure 2: Light Duty Vehicles (U.S. Conference of Mayors & C2ES, 2018)

¹⁸ Boston Consulting Group. [Electric Vehicles are a Multibillion-Dollar Opportunity for Utilities](#). (2019).

¹⁹ Alliance for a Sustainable Future. [Mayors Leading the Way on Climate Change](#). (2018).

²⁰ Florida Public Service Commission. [Electric Vehicle Charging Update](#). (2018).

²¹ EVAdoption. [EV Market Share by State](#). (2019).

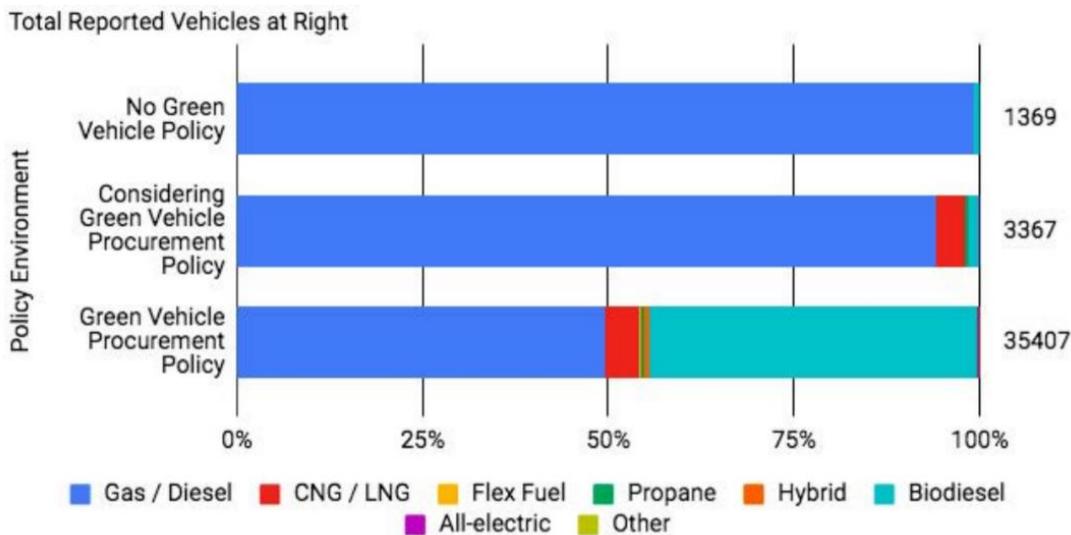


Figure 3: Medium and Heavy-Duty Vehicles (U.S. Conference of Mayors & C2ES, 2018)

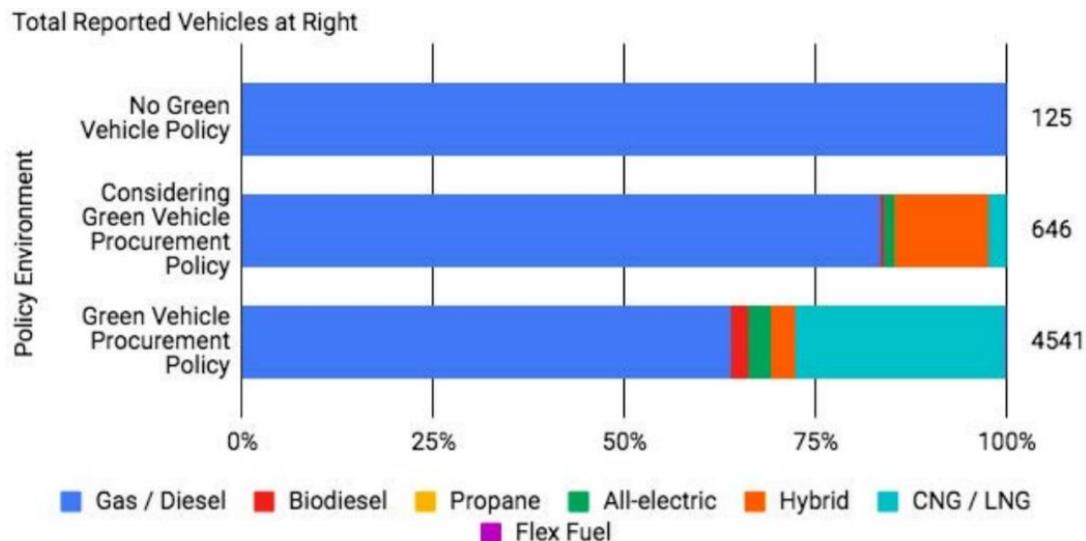


Figure 4: Bus Fleets (U.S. Conference of Mayors & C2ES, 2018)¹⁹

It is important to distinguish that the decision matrix uses only state policy goals and not any federal or local policies. Federal law and policy preempt all state policy, so any federal law or policy created is applicable to every utility in the United States. For the purposes of this tool, an important assumption made is that for any federal law or policy regarding electric vehicles, each utility is aware and compliant. Similarly, 40 of the 50 states in the US operate using some form of Dillion Rule limiting local government jurisdiction.²² Therefore, state law most often preempts any local jurisdiction in many aspects of laws and goal making. It is important for a utility to understand the local communities in which it operates, but that is far too granular for this high-level strategy overview. For these reasons, federal and local municipal laws are not included in this investigation. However, it is prudent for any utility to align any strategy or program at this granular level.

²² National Association of Counties. [Dillion Rule or Not?](#) (2004).

To determine how the chosen strategies to be evaluated in the decision matrix align with state policies and incentive programs, the Department of Energy’s Alternative Fuels Data Center (AFDC) was used.²³ The database is frequently updated with the ever-changing policy environment, and the policies are accurate as of 11/15/2019.

The policies included in the AFDC database were categorized to their relevance to each of the chosen strategies. These categories included fleet, charging infrastructure, consumer benefit, heavy-duty fleet, taxes, and fees. Through these categories, it was possible to use a count of how many policies directly address a specific strategy. The merit order is then determined with a strategy having a higher count of relevant policies given a higher rank.

EV Strategy Selection Process

Some utilities have begun using many innovative programs and models to promote and profit off the EV trend. This tool was developed using publicly available information for programs and utilities across the U.S. The selection of the modeled strategies was a process through the use of three criteria – impact, relevance, and ability to model with publicly available data within the scope of the project (Figure 5). This section will discuss the strategies which are included in the decision matrix and those which are not, but a utility should take under consideration when considering their role in the EV space.

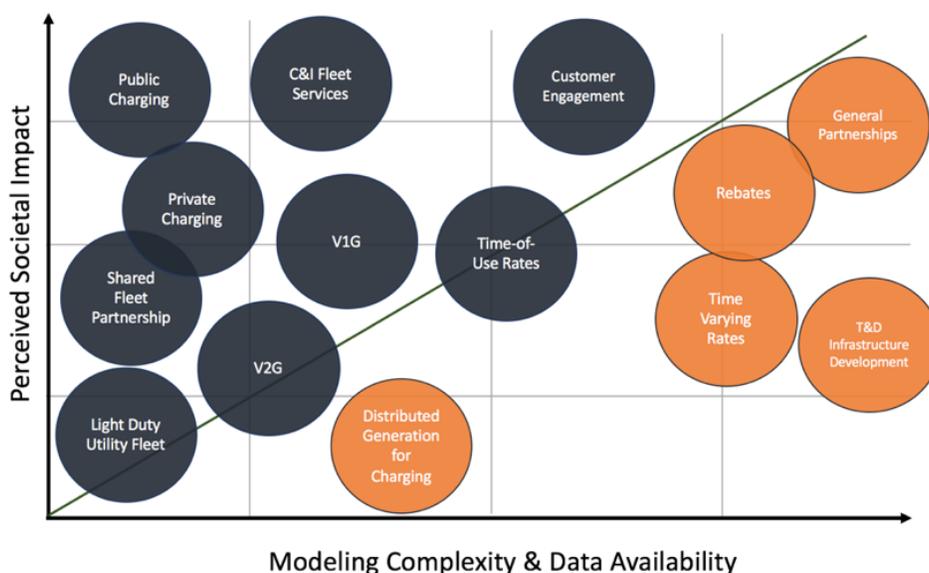


Figure 5: Strategy Selection Process Criteria

Overview of Common Utility Strategies

In recent years, several utilities have made major EV charging infrastructure investments. Georgia Power in Atlanta announced a pilot program worth \$12 million to increase electric charging stations in its territory of service in October 2014. Apart from offering incentives to customers to install charging stations, they aim to install 50 EV charging islands in public areas.²⁴ In January 2015, Kansas City Power & Light announced the installation of 1,001 public electric charges in its service territories of Missouri and Kansas.

²³ Alternative Fuels Data Center. [State Laws and Incentives](#). (Accessed 2019).

²⁴ Atlanta Business Chronicle. [Georgia Power motors into transportation business with \\$12M pilot](#). (2014).

The investment for this project is about \$20 million dollars, which will be recovered partly by increased demand and partly by increased electricity rates – around \$1 to \$2 a year paid by residential customers.²⁵

In February 2015, Pacific Gas and Electric proposed a \$653 million investment to install 25,000 EV charging stations in northern and central California. To cover the expense, residents would have to pay an additional charge of about 70 cents a month on their electricity bills.²⁶ Southern California Edison and San Diego Gas & Electric (SDG&E) have also made pilot charging infrastructure investment plans of \$553.8 million and \$225.9 million respectively. Most recently, in 2018 NV Energy created an Electric Vehicle Infrastructure Demonstration Program to invest \$15 million to develop charging stations in Nevada.²⁷

Utilities have also recently started owning and operating electric vehicle fleets. As of 2018, Florida Power and Light's clean vehicle fleet includes 493 electric and hybrid-electric vehicles. Austin Energy's commitment is to own over 300 fleet vehicles and 30 electric buses by 2020. In 2018, SDG&E received regulatory approval to partner with UPS and other delivery companies for an EV delivery fleet project. In addition, the utility had programs approved for the electrification of medium-heavy duty vehicles and forklifts for a marine port project, a green shuttle bus project, an airport ground transport project, and a park and ride public charging project.⁹

Two utilities in New York – New York State Electric & Gas (NYSEG) and Rochester Gas & Electric (RG&E) – are proposing electric vehicle-related battery storage projects to encourage distributed energy resources (DERs). According to the New York Public Service Commission, NYSEG has proposed plans to aggregate up to eight batteries having 1.1 megawatt and 4.2 megawatt-hours of storage. RG&E is planning to combine two DC fast chargers and five level 2 chargers with a 150-kilowatt, 600-kilowatt-hour battery with a battery management system. This system would be accessible to the public at utility facilities. RG&E aims to use this set-up to reduce the facility's peak electricity demand.²⁸

The largest involvement shown by utilities towards EV adoption has been through rate designs and rebates. Fifty-nine utility companies in 40 states offer incentives for EV consumers ranging in the form of discounted rates, time of use rates, and rebates.²⁹

Strategies Included in the Decision Matrix

Time of Use Rates

What is it?

Increasing EV adoption results in substantial load addition to the distribution grid. Additionally, if customers charge their EVs during hours of peak electricity demand, it would lead to grid congestion and increased system costs. During peak hours, the power system dispatches peaking power plants to generate electricity and meet demand, which are costlier and more polluting than base load plants. Utilities define special rate structures to change customer charging behavior in order to reduce peak demand on the grid and resulting system costs. Time varying rates, or TOU rates, is one such rate structure.

TOU electricity pricing charges different prices per unit of electricity, as a function of the time of the day the electricity is consumed. Prices increase during hours of peak demand and reduce during hours of low demand, reflecting the cost of electricity generation and supply at these hours. This incentivizes consumers

²⁵ Kansas City Star. [KCP&L plans to install 1,001 more chargers for electric cars](#). (2015).

²⁶ The Mercury news. [PG&E floats \\$654 million plan to increase electricity bills to finance electric vehicle charging stations](#). (2015).

²⁷ Utility Dive. [Nevada regulators allow utilities to own EV charging stations](#). (2018).

²⁸ American Public Power Association. [N.Y. utilities plan aggregated and EV storage projects](#). (2018).

²⁹ Fleetcarma. [Electric Utility led EV incentive programs help grid stability, reduce emissions, manage costs, and provide greater efficiency](#). (2017).

to shift their charging hours from peak to off-peak periods. TOU pricing can play a crucial role for utilities that are trying to manage the additional load that electric vehicles bring to the grid. By shifting load from peak hours (late afternoon to evening) to non-peak hours (late night or early morning), the use of peaking plants will reduce, which results in an overall reduction in electricity costs and makes grid operation cleaner and more efficient. Additionally, customers benefit from reduced electricity bills.

Resource Adequacy (RA) is a regulatory construct put forth by state PUCs to enforce the availability of a minimum reserve margin above peak load. For example, California Public Utilities Commission (CPUC) mandates that all load serving entities (LSE) in California purchase capacity commitments with a reserve margin of no less than 15%.³⁰ This would mean that the LSE would need to invest in enough generation to be able to produce 115% of the peak demand in their jurisdiction. As peak demand increases due to EVs, cost of purchasing capacity to meet minimum reserve margins would increase subsequently. Therefore, use of time varying rates to reduce peak demand would serve to be beneficial to reduce overall power system costs and improve operating efficiency. Ultimately, such rate structures help in deferring or even avoiding investments in capacity and infrastructure expansion.

Implementing time varying rates would involve the installation of a smart meter or residential Advance Metering Infrastructure (AMI) that is capable of billing these dynamic rates at different hours of the day. Smart meter costs are upfront costs for the consumer. However, utilities are increasingly incentivizing smart meters to promote customers to opt into TOU rates. This is explored further in the following sections.

Time varying rates have been offered by utilities for almost a decade now. However, with recently increasing EV adoption rates, utilities have started to offer electric vehicle specific time of use rates. Only EV owners are allowed to opt in for these rate structures. This project focuses on EV specific electric vehicle time of use rates.

Overview in the US

As of September 2019, 58 active residential EV TOU rates were offered by 50 utilities in the country, according to Smart Electric Power Alliance and The Brattle Group.³¹ The following figure shows the adoption pattern of residential EV time varying rates in the US.

³⁰ Power. [What is resource adequacy?](#) (2007).

³¹ Smart Electric Power Alliance. [Residential Electric Vehicle Time-Varying Rates That Work: Attributes that Increase Enrollment.](#) (2019).

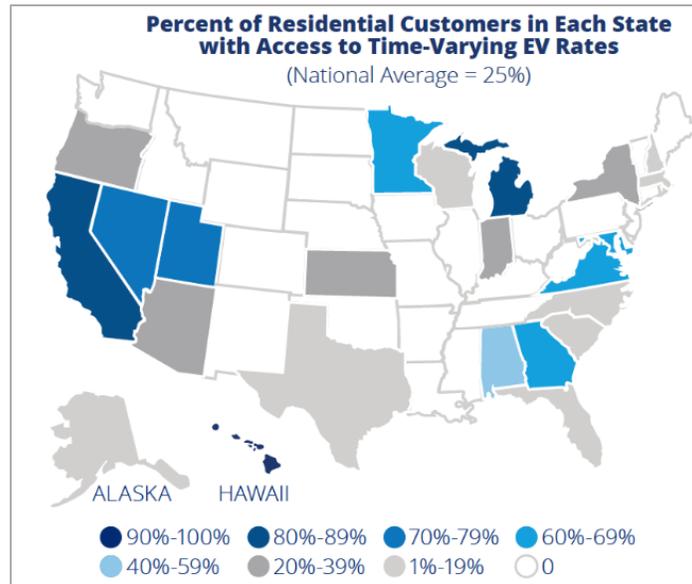


Figure 6: Percent of Residential Customers with Access to Time-Varying Rates (SEPA & The Brattle Group, 2019)

It is observed that in California, Hawaii, and Michigan, customers have the highest access to TOU rates, followed closely by Utah and Nevada. One of the first ever EV TOU rate structures was offered in Michigan by Indiana Michigan Power which defined an off peak BEV charging rate as low as 3.9 cents/kWh. The TOU rate structure landscape is flourishing rapidly in recent years as an increasing number of utilities and states realize the benefits offered.

The structuring of these TOU rates vary significantly from one state to another. The costs and time of the day defined as peak and off-peak hours depend on local geographical and weather conditions, customer behavior, regional load curves, population, EV adoption rates, and proximity to clean energy resources.

As discussed above, most utilities define rates for two time periods, on-peak and off-peak. However, some define a third time period, mid-peak (daytime hours) and super-off peak (early morning or late-night hours, with lowest rates). Each of these periods are defined differently for summer and winter/non-summer months. On conducting thorough research from data gathered from all EV TOU programs from PUC dockets, it was found that on-peak rates can be as high as 56.7 cents/kWh consumed and off-peak rates can be as low as 1.4 cents/kWh consumed (depending on state) to incentivize this load shift.

Some utilities offer whole house EV TOU rates in which the rate structure can be applied to any household appliances in addition to electric vehicles. This enables customers to perform various activities such as laundry, dishwashing, etc. at lower costs. However, some utilities define their EV-TOU rates to apply only to electric vehicles and not for household use. Alternatively, some utilities provide the consumer with an option to choose between electric vehicle only TOU rates and whole household TOU rates.

Xcel Energy Minnesota Residential EV Service Pilot³²

In 2018, Xcel Energy launched a residential EV TOU Rate pilot that incentivizes customers by using the telemetry properties of electric vehicle supply equipment (EVSE) to avoid the installation and costs of a second meter. This was intended for customers installing new EVSE in their homes. The pilot was capped at 100 participants and up-front meter cost savings were as high as \$2,196 per customer. The pilot was highly successful, resulting in 96% of the EV load to be during off-peak hours. Customers saved an average of \$117 annually on the EV-TOU rate.⁹

³² Xcel Energy MN Compliance Filing, [Docket No. E002/M-15-111 and E002/M-17-817](#). (2019).

Georgia Power

Georgia Power was granted regulatory approval for a residential BEV TOU rate, which involved the installation of a second smart meter. The utility priced peak rates at \$0.203/kWh for hours between 2pm and 7pm on weekdays from June to September, off peak rates at \$0.066/kWh for the remaining daytime hours and a third super off-peak rate of \$0.014/kWh between 11 pm and 7 am, year-round.³³ The rate structure was reported to be successful in shifting load to off-peak hours. In addition, customers saved \$180 on average one their annual electricity bills.

Challenges

One of the biggest reasons for the failure of some TOU pilots is the lack of awareness among residential customers that alternative rate plans exist. According to a survey conducted by the Smart Energy Consumer Collaborative, even though 62% of the customers said that they would prefer time varying rates over standard rates, only 5% actually participate in them.

PECO, a subsidiary of Exelon, was mandated by Pennsylvania regulation to perform a TOU pilot program.³⁴ The program defined an on-peak rate of \$0.1595/kWh between 2pm to 6pm on weekdays and an off-peak rate of \$0.0685/kWh during the remaining hours of the year. Even with 121,000 people eligible to opt in for these TOU rates, only 4% of customers signed up. The program also guaranteed that if the customer's electricity bill had not reduced when compared to a flat rate structure, PECO would refund the difference. PECO ended up with more than \$1,300 in refund costs and 5% of those enrolled dropped out of the pilot before the end of the year. PECO recognizes the lack of customer awareness and finding the right marketing and customer engagement strategies that could have turned the pilot into a success.

American Electric Power (AEP) has recognized that there is an issue with offering whole house TOU rates, without an option of EV only TOU rates. Having whole house TOU rates forces customers to plan their EV charging schedule along with behavioral changes related to household heating, cooling, etc. This was found as a barrier among customers towards adopting EV-TOU Rates. Having separate EV only TOU rates instead helped eliminate the customer's anxiety towards whole house rates.

Additionally, residential TOU rates are often criticized for being disadvantageous for low and moderate income (LMI) communities.³⁵ As a result of their reduced overall energy consumption, LMI communities fall under a lower bracket where customers are already paying reduced rates. If subjected to mandatory TOU rates, due to escalated peak pricing, LMI customers experience an overall increase in electricity bills. Therefore, utilities need to meticulously design their rate plans to pay special attention to such communities and make calculated decisions between having mandated time varying rates versus optional ones.

Decision Matrix IRR Calculation

For decision matrix calculations, an assumption was made that target customers who are looking to adopt TOU rates already possess the EVSE required for charging purposes. The utility provides customers with the smart charger required for metering TOU rates as an incentive. To estimate smart meter costs, average annual smart meter costs from TOU programs across the country were collected from PUC filings and utility websites and calculated and found to be \$146.4/meter. Revenue calculations were made from avoided energy costs from deferring EV charging from peak to non-peak hours. These avoided energy costs for each state were obtained from utility websites or locational marginal price (LMP) information from ISO websites. The user can enter a strategy adoption percentage for their service territory. The avoided costs

³³ National Association of Regulatory Utility Commissioners. [State Commission Staff Surge Call: Electric Vehicles](#). (2018).

³⁴ Utility Dive. [Inside the surprising lessons from PECO's time-of-use rate pilot](#). (2015).

³⁵ Utility Dive. [An emerging push for time-of-use rates sparks new debates about customer and grid impacts](#). (2019).

(\$/kWh) were multiplied with the energy required to charge a BMW i3 for a year to obtain annual revenue. These cash flows were then used to calculate the IRR for each state.

Public Charging Infrastructure

What is it?

Public charging stations are those that are available for pay and use in common places outside of residences such as parking lots, workplaces, destination centers, etc. A strong public charging network is essential to sustain a city's EV growth rate and address barriers such as range anxiety among EV owners. With expected on road EV growth rates in the country, existing public charging infrastructure will not suffice. Even in California, the state that has been at the forefront of all EV related trends with state plans to build 26,000 new charging stations by 2025, an analysis by The International Council on Clean transportation shows that the state may be 41,500 chargers short in the future.³⁶

Electric utilities are excellently positioned to play an important role in public charging infrastructure investments. The two primary utility investment models for charging infrastructure are: the "Owner and Operator" model and the "Make-Ready" model.³⁷ As the name suggests, under the "Owner and Operator" model, utilities invest in both grid infrastructure that leads up to the charging stations and the EVSE itself. This method allows utility to manage program components such as host site management, pricing, operation and maintenance, etc., it gives the utility an unfair monopolistic market advantage, which may result in increased costs and slower development.

The "Make-Ready" model addresses the disadvantages of the "Owner and Operator" model. Make-ready refers to all necessary electrical infrastructure between the utility grid interconnection and the chargers, including stepdown transformers, electric service panels, conduit, conductors (wire), switchgear and power conditioning units (for DCFC), mounting pads or brackets, and other such elements.³⁸ This model limits the utility's investments to only make-ready costs and lowers utility side costs by eliminating EVSE investments. The utility can then make a case to recover the infrastructure costs through ratepayers. A few states have pilots with make-ready infrastructure costs approved by the PUC to be a part of the rate base, some of which are described below. The EVSE is owned and operated by third party companies that specialize in manufacturing chargers, such as ChargePoint, introducing competition in the marketplace and increasing flexibility of pricing structures and other options that third-party companies may have to offer. Additionally, this model takes advantage of a utility's biggest strengths: access to capital and experience with infrastructure. For this project, we have incorporated the make-ready model in our calculations, considering its benefits over the own and operate model.

Apart from infrastructure investments, utilities have been aiding in lowering total cost of ownership by providing rebates for charger costs as well.

Overview in US

The network of public chargers in the United States has grown from about 6,900 chargers in 2012 to approximately 61,000 by the end of 2017. Seventy-four percent of all these chargers were in the 100 most populous metropolitan areas.³⁹ These public chargers are of types Level 2, DCFC, or Tesla Superchargers (Described in Figure 9 below). The following figure shows the top five US states with the highest number of public chargers, according to the Alternative Fuels Data Center.⁴⁰

³⁶ The International Council on Clean Transportation. [Quantifying the electric vehicle charging infrastructure gap across the U.S. markets](#). (2019).

³⁷ MJB&A. [Accelerating the Electric Vehicle Market](#). (2017).

³⁸ Rocky Mountain Institute. [Reducing EV Charging Infrastructure Costs](#). (2020).

³⁹ The International Council on Clean Transportation. [Whitepaper – Quantifying the electric vehicle charging infrastructure gap across U.S. markets](#). (2019)

⁴⁰ Alternative Fuels Data Center (AFDC). [Data](#). (Access 2020).

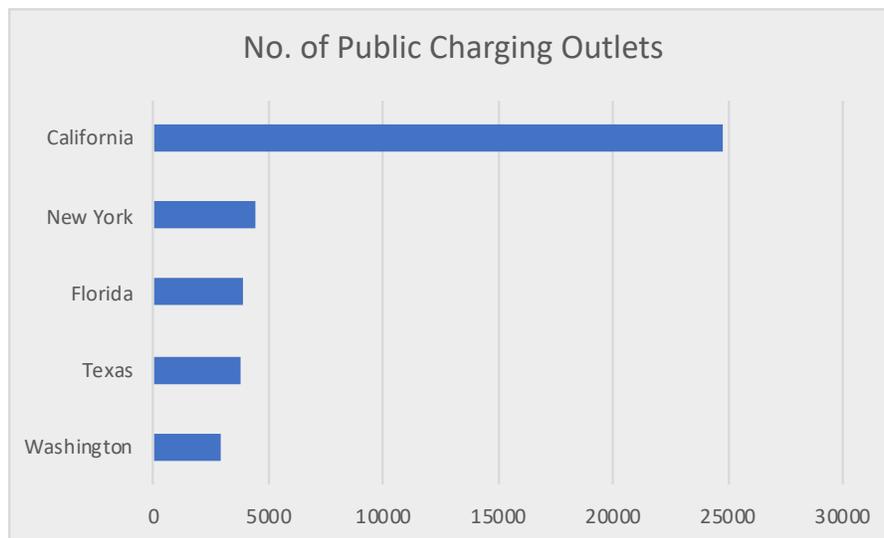


Figure 7: Top 5 States with Highest Public Charger Numbers (AFDC, 2020)

Southern California Edison

Southern California Edison’s (SCE) \$22 million “Charge Ready Pilot” made use of the make-ready model to rate-base infrastructure and installation costs.⁴¹ In addition, SCE also provided rebates for EVSE costs. After the success of this pilot, and post installation of the 1,000th Charge Ready charger, SCE launched Charge Ready 2 for 48,000 more charging ports and the Charge Ready Transport program for medium and heavy-duty charging stations at 870 commercial sites within a 500,000 square mile service area.^{41, 42}

Kansas City Power & Light

Kansas City Power & Light Company’s (KCP&L) Clean Charge Network is the largest electric utility charging station installation in the country with 1,200+ public charging stations. The EVSE for this program were manufactured by ChargePoint.⁴³

EV Charging Corridors

Apart from intrastate public chargers, investments are also being made in interstate EV charging corridors. BMW, Volkswagen, and ChargePoint have together completed a corridor of EV express chargers (DCFC) along the East and West coasts.⁴⁴ Figure 8 shows the mapping of these corridors:

⁴¹ Green Car Congress. [Southern California Edison proposes \\$760M Charge Ready 2 program to expand electric vehicle infrastructure.](#) (2018).

⁴² Green Car Congress. [SoCal Edison launches Charge Ready Transport program for trucks and industrial vehicles.](#) (2019).

⁴³ ChargePoint. [KCP&L Becomes Electric Vehicle Infrastructure Leader with Groundbreaking Announcement.](#) (Accessed 2020).

⁴⁴ ChargePoint. [BMW, Volkswagen, and ChargePoint Announce Completion of Electric Vehicle Express Charging Corridors on the East and West Coasts.](#) (Accessed 2020).



Figure 8: ChargePoint EV Corridor (ChargePoint, 2020)

The New York government announced in 2018 that NYPA (New York Power Authority) will work towards installing up to 200 DCFCs along important interstate corridors, making them available every 30 miles.⁴⁵

The map below shows Tesla’s North American Supercharger network, which provides 1,870 Supercharger stations and 16,585 Superchargers.⁴⁶

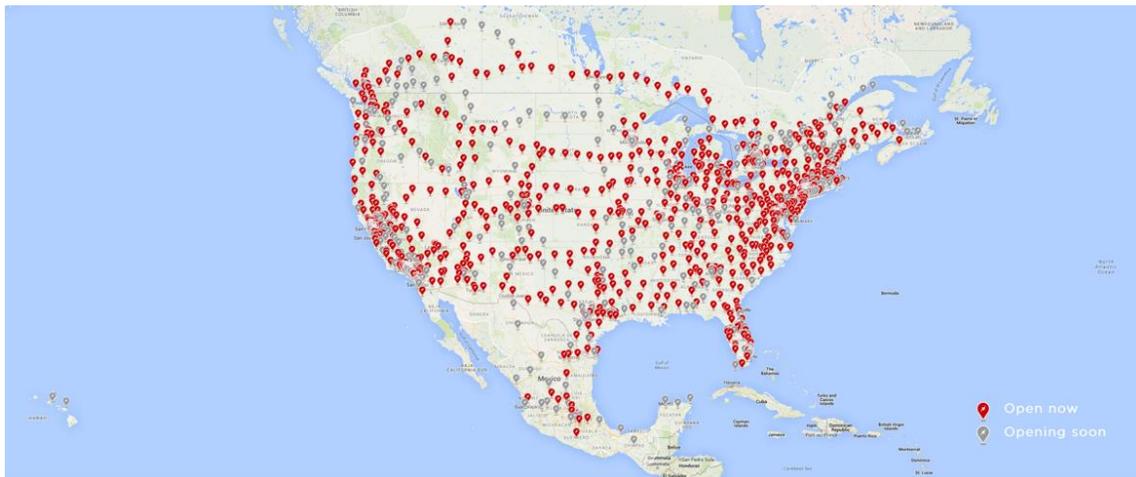


Figure 9: Tesla's North American Corridor (Tesla, 2020)

Due to the state specific focus of this study, the decision matrix includes intrastate public charging infrastructure only.

Challenges

The electrification of transportation is partly being held back by the slow pace of EV charging infrastructure deployment.⁴⁷ States have set ambitious EV adoption goals for the next decade, which would require extensive expansions of public charging infrastructure. To achieve this, states like California, New York,

⁴⁵ The Verge. [Three US states will spend \\$1.3 billion to build more electric vehicle charging](#). (2018).

⁴⁶ Tesla. [Charge on the Road](#). (Accessed 2020).

⁴⁷ GreenBiz. [The great EV infrastructure challenge](#). (2019).

Kansas, and Washington have granted regulatory approval for charging infrastructure costs to be included in utility rate base. This nascent trend would need to gain popularity among other states to be able to achieve EV sales goals. Additionally, rate base inclusion, price design, and charger locations need to be well thought out to avoid utility stranded assets and disadvantages to LMI communities.

Closing the public charging infrastructure gap is still lagging in the multi family dwelling scenario. Utility programs tend to focus largely on workplaces, parking lots, and entertainment centers. SCE’s Charge Ready pilot had only 4% of chargers placed in multi- unit homes.³⁵

Decision Matrix IRR Calculation

EV projections for 2030, along with driver/charger ratios from the Xcel Energy and HOURCAR shared fleet pilot were used to estimate the number of public charging ports needed for each state. SCE’s Charge Ready pilot was used to obtain utility side costs for public charging ports: \$2,129/port. These infrastructure costs were corrected to obtain state-specific costs using state-wise highway infrastructure costs as an index (infrastructure cost correction factor). Once total capital cost for all chargers needed was obtained, the utility’s required rate of return was applied to this capital cost value to calculate annual revenue. These cash flows were then used to calculate state specific IRRs.

Private Charging Infrastructure

What is it?

In the United States, most BEV owners do 80% of their charging at home.⁴⁸ Most cars sit idle for 95% of the day and drivers find it convenient to make use of reduced prices and charge their EVs in their own homes.⁴⁹

The Electric Vehicle Supply Equipment (EVSE) needed for at-home charging are either of Level 1 or Level 2 types. Level 1 EVSE is simpler and charges through a 120-volt AC outlet. For one hour of charging, Level 1 EVSE adds about 2-5 miles of driving range. Level 2 EVSE charges through a 240V AC plug and adds about 10 to 60 miles of range in an hour of charging. Level 1 chargers are more suited for plug-in hybrid EVs, whereas Level 2 chargers are more suitable for all EVs. Details on different charger types are described in Figure 10 below.⁵⁰

Charging Level	Voltage	Estimated charging time to provide 80 miles of range	Typical Locations	Vehicle Restrictions
Level 1	120V	16 hours	Home	All vehicles can use
Level 2	240V (residential) 208V (commercial)	3.5 hours	Home, workplace, and public	All vehicles can use
Direct Current Fast Charger	480V	30 minutes	Public	Plug-in hybrid EVs cannot typically use; charging connections vary
Tesla Supercharger	480V	15 minutes	Public	Only Tesla can use

Figure 10: Characteristics of Different EV Charger Types (Office of Energy Efficiency & Renewable Energy, 2020)

A utility’s role in private charger investments have largely been through offering rebates to lower up-front costs, this is highlighted further under the ‘Strategies Not Selected for the Decision Matrix’ section. Similar to public charging investments, private charging infrastructure also involves make-ready costs. For a simple

⁴⁸ Office of Energy Efficiency & Renewable Energy. [Charging at Home](#). (Accessed 2020).

⁴⁹ General Motors. [Fact or Fiction? General Motors Offers an Easy Way to Connect with At-Home Charging Electricians](#). (Accessed 2020).

⁵⁰ Office of Energy Efficiency & Renewable Energy. [Vehicle Charging](#). (Accessed 2020).

wall-mounted residential installation of a Level 2 charger, the make-ready often consists of no more than a breaker in the service panel, some conduit and wire, and an outlet, costing less than \$1,000.⁵¹ According to AEP, many EV owners either receive charging hardware with their vehicle or purchase directly from a retailer, and therefore may not need or want utility program-specific charging hardware.⁹ Therefore, the make-ready approach is adopted in this project for private charging infrastructure as well.

Overview in US

Utility involvement in private charging infrastructure development has a large focus on rebates for residential customers on EVSE and marketing for customer engagement. Not unlike public charging infrastructure, residential EV charger numbers are higher for urban and metropolitan cities. The following figure shows the top 5 states with the highest number of private chargers.

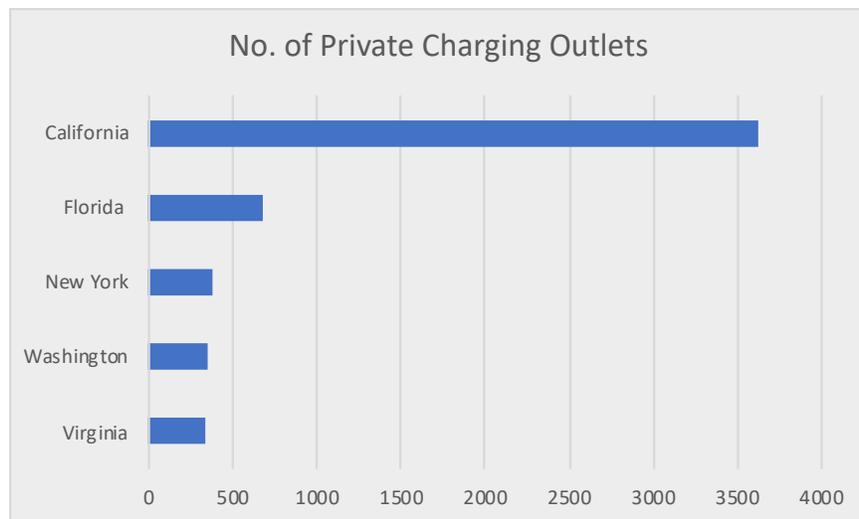


Figure 11: Top 5 States with Highest Number of Private Charging Outlets (AFDC, 2020)

To support New York’s goal of deploying 850,000 ZEVs by the end of 2025, the New York Public Service Commission has issued a state-wide utility supported make-ready program. NYSERDA has performed a benefit to cost analysis on infrastructure costs and calculates residential make-ready costs to be \$700.⁵²

Under a new rule in Seattle put forth in 2019, all new homes with off-street parking are required to be constructed with the necessary wiring for EV charging. In the same year, regulators in Washington DC rejected Pepco’s application for the own and operate model and approved the make-ready model for investing in charging infrastructure.⁵³ In Florida, Duke Energy has planned to invest \$8 million toward 500 charging locations, with 10% of chargers located in low income communities.⁵⁴

Challenges

As described above, states like California, Washington, New York, and Florida have successful charging infrastructure programs and EV adoption rates largely due to aid from state regulators and utilities. However, this may not be the case with all states.

For example, the Wisconsin PUC ruled that utilities cannot use ratepayer money to subsidize residential electric vehicle charging stations.¹⁶ With up-front charger costs being the largest barrier from the customer’s

⁵¹ Rocky Mountain Institute. [Electric Vehicles as Distributed Energy Resources](#). (2016).

⁵² NYSERDA. [Benefit Cost Analysis of Electric Vehicle Deployment in United States](#). (2019).

⁵³ Utility Dive. [What’s the best role for utilities as EVs proliferate? With Pepco, DC aims to find the right balance](#). (2019).

⁵⁴ Fleetcarma. [Electric Vehicle Infrastructure in Florida](#). (2018).

perspective, there needs to be a further push from state regulations, especially in states with ambitious EV deployment goals.

The current status of both public and private charging infrastructure is far behind compared to what is required for the next decade. The following graph by ICCT depicts this infrastructure gap.⁵⁹

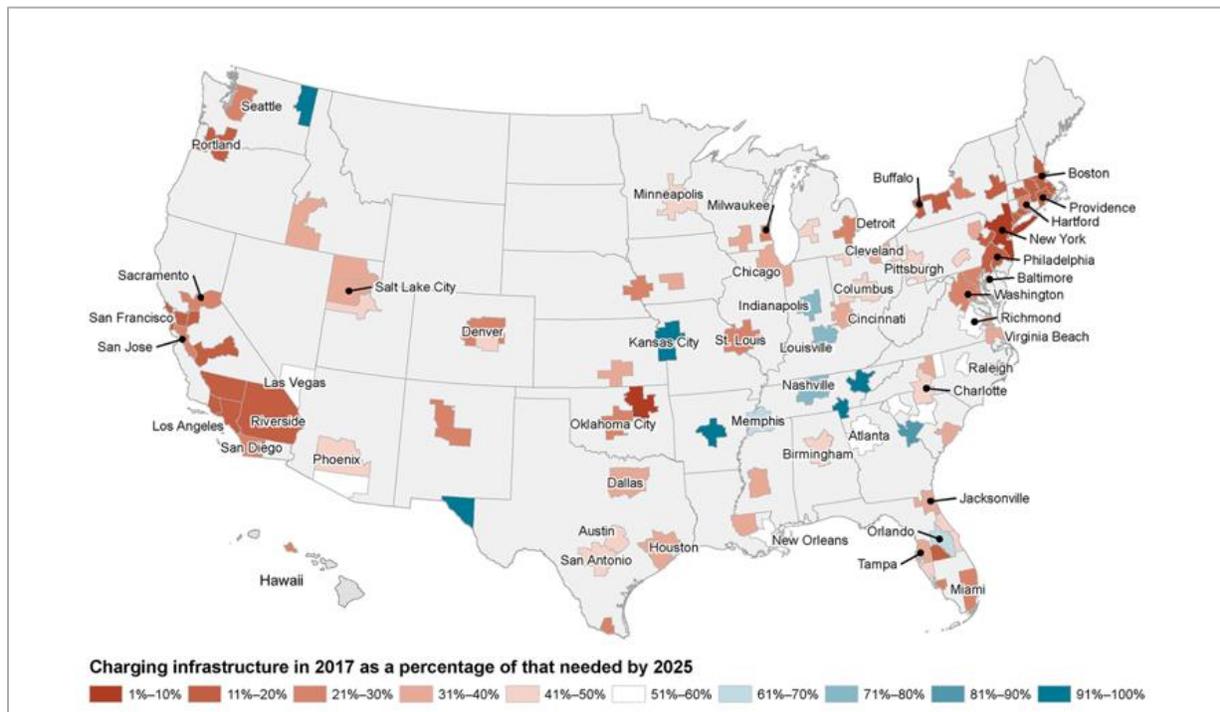


Figure 12: Current Charging Infrastructure as a Percentage of 2025 Target Requirements (ICCT, 2019)

Decision Matrix IRR Calculations

To estimate the number of private chargers required to power the expectation of 73% of households having access to private charging, state-level housing data was obtained.⁵⁵ Then, NYSERDA’s estimate for residential make-ready costs (\$700/charger) was used. Finally, the state infrastructure cost correction factor was applied to find total costs.

Two revenue streams were considered to calculate IRR:

1. Revenue to utility from increased EV demand
2. The utility’s rate of return.

The increased demand was calculated for a BMW i3 and used state-specific residential electricity costs to obtain revenue for utilities. Lastly, the rate of return is obtained from the user and applied to total costs. This is then added to revenue from increased demand to find annual revenue.

⁵⁵ McKinsey & Company. [Charging ahead: Electric-vehicle infrastructure demand](#). (2018).

Customer Engagement

What is it?

One of the most often cited barriers to the adoption of EVs is consumers' general lack of understanding of the technology and the market.^{56,57,58} There are perceptions around EVs that prevent car shoppers from purchasing EVs which include range anxiety, perceived high cost of EVs compared to ICEVs, or just general misunderstanding of using electrons verses petroleum as a fuel source. The utility sits in a unique position of directly communicating with customers regularly and this provides ample opportunity for education and outreach. SmartGrid Consumer Collaborative also found that utilities are trusted advisors for energy related decisions.⁵⁹

Overview in the United States

There are infinite ways to engage with a customer. SEPA has outlined some specific methods that have been successful in the U.S. specific to utilities and EVs (Figure 13).⁶⁰ One method is through developing an informative website that includes information about EVs, products and offerings, and even a comparison tool that can be used when looking to purchase a new EV or ICEV. PG&E is an example of a powerful website that was developed under budget and received 10,000 unique visitors in its first two months.⁶¹



Figure 13: EV Adoption Through Customer Centric Programs (SEPA, 2019)

Another method of engaging with the consumer is providing them with direct interactions with an EV through driving or riding in it. This can occur through the utility itself or using a model similar to Sacramento Municipal Utility District (SMUD). SMUD worked closely with dealers to ensure informed EV interactions. SMUD worked with 13 dealers, and within six months, 255 EVs were sold.⁶²

Challenges

Utilities have traditionally operated in a highly regulated space where they are guaranteed territory and a customer base, providing little incentive to develop a thorough education and outreach program. Similarly, consumers had little opinion on their electricity service and their interaction with their utility was to just pay their bill. This is a changing landscape, with information more readily available to make a more informed consumer and consumers gaining more control over their energy choices.⁶³ Utilities are working to rise to the challenge of developing a strong marketing and consumer engagement strategy that was not

⁵⁶ Seattle Office of Sustainability & Environment. [Removing Barriers to Electric Vehicle Adoption by Increasing Access to Charging Infrastructure](#). (2014).

⁵⁷ MIT Sloan School of Management. [The real barriers to electric vehicle adoption](#). (2017).

⁵⁸ Forbes. [The 4 Lingerin Obstacles To Electric Vehicle Adoption \(And What Might Overcome Them\)](#). (2019).

⁵⁹ SmartGrid Consumer Collaborative. [Consumer Driven Technologies](#). (2016).

⁶⁰ Smart Electric Power Alliance. [Switching lanes: How utilities can encourage EV adoption through customer-centric programs](#). (2019).

⁶¹ PG&E. [Welcome to the EV Savings Calculator](#). (Accessed 2020).

⁶² Sacramento Municipal Utility District. [Apply for your electric vehicle incentive](#). (Accessed 2020).

⁶³ Digitalist. [Why Customer Service Is The New Utilities Battleground](#). (2018).

necessarily needed in the past. This requires significant investment in customer surveys and other methods to gauge consumer preferences in ways which the utility did not before.

Decision Matrix IRR Calculation

An organization may choose to engage with customers in a variety of ways with varying degrees of detail and engagement. This results in more of a spectrum than a rule of which methods are most effective to accomplish the most desired effects. For utilities, this has included a website, smartphone apps, media advertisements, owning test cars for EVs, and a range of other activities.

Along with this spectrum of activities, there is also a variable cost structure to each, based on where in the country a utility is located. For this reason, the IRR calculation for Customer Engagement was based off of Xcel Energy’s published budget for “EV awareness, education, and outreach activities” for 2018 and for the period of 2019-2021 (Table 3). This budget includes a range of actions and line items and was approved by the Minnesota Public Utilities Commission in 2019.⁶⁴

Communication Method	2018 Estimates	2019-2021 Estimated Budgets
Events & Outreach	\$43,000	\$143,000
Advertising Brand & Media	\$76,000	\$381,000
Collateral & Promotional Items	\$7,000	\$38,000
Auto Dealers & Electricians	\$37,000	\$191,000
EV Advisor Online Tool	\$70,000	\$580,000
Total	\$233,000	\$1,333,000

Table 3: Customer Engagement IRR Calculation

These costs are held consistent in the calculation despite where the utility resides or the size of their territory. The reasoning for this is that, while there may be fewer people in the territory, that does not mean that an EV advisor tool or promotional materials should be any less emphatic and educational.

Similarly, the cost values for the other categories (Events & Outreach, Advertising, Promotional items, and auto dealers) were relatively low for a 3-year budget. For all categories, a scale down could result in lower quality and a less effective campaign. Xcel Energy’s reputation as a first mover when it comes to various EV programs, lend credibility to this budget. We chose to keep it as is to have a conservative, fully formed budget that a utility should consider if deciding to undergo a new customer engagement strategy.

The revenue calculations were conservative for this strategy. There is little public information available to the exactly quantify the direct impact a utility’s consumer engagement methods on the EV market. For this reason, the revenue was calculated using projected EV electricity consumption for the maximum estimated EV growth in the territory.

Light Duty Fleet for Utility Use

What is it?

A strategy for a utility to showcase their commitment to EVs is through the adoption of them within their own vehicle fleets. This is a common thread that exists throughout utility types. For example, CPS Energy in San Antonio, Texas has begun using 59 hybrid Ford trucks, and will deploy 14 fully electric sedans.⁶⁵

Utilities investing in EVs for their business provide numerous benefits. Some of these benefits are the same as those achieved by the residential consumer – lower costs from fuel, lower costs from operations and maintenance (O&M), the extended lifetime of the asset, and a reduction in emissions. Other benefits

⁶⁴Xcel Energy MN Petition for Approval. [Docket No. E002/M-18-_____](#). (2018).

⁶⁵ Utility Fleet Professional. [CPS Energy Makes a Big Push into Truck Electrification](#). (2018).

specific to the utility include vehicle noise reduction which can extend working hours in certain communities, improve employee safety due to communication ease with the lower noise, improve their brand image, and increase customer confidence in their role as an expert in EVs.⁶⁶ Additionally, utilities can use their vehicles to benefit their grid in a V1G or V2G aspect through controlling their charging behavior and access to provide ancillary services, peak shifting, or as a distributed battery during times of peak load.

The way in which a utility can translate their fleet to electric differs from an IOU to a municipal utility, as both entities have different financial goals. A municipal utility is looking to recover costs while an IOU is looking for a return. They both also have different financial mechanisms in which to transition and can take advantage of different policies and incentives. The federal government provides a substantial tax credit for \$7,500 per EV. A municipal utility cannot use federal tax credits while an IOU can. However, different states have special tax credits and rebates that exist specifically for government entities and the public sector which an IOU cannot access, but a municipal utility can.⁶⁷

Overview in the United States

Utilities across the US have been building up their electrified fleets. Approximately 630 vehicles of Southern California Edison's fleet are electrified, Public Service Electric and Gas Co. in New Jersey has some degree of electrification in 327 of their vehicles, and CPS Energy has plans to deploy 14 electric sedans along-side its fleet of hybrid Ford F-150s.⁶⁸

City governments are leading the charge in fleet electrification, with approximately 60% passing green vehicle policies.¹⁷ This provides an avenue for municipal utilities to work closely with their government to quickly procure the new vehicles as opposed to working within a regulatory framework like an IOU.

Challenges

One challenge with converting the utility fleet to EVs is that while it is acceptable in the rate base, the conversion must be sensible and fit into a budget already marked for their fleet. This can cause delays when implementing this strategy or the utility would cause rates to increase unsustainably.

Another challenge with converting an EV fleet is that a utility's fleet is primarily composed of light duty trucks and bucket trucks. While these types of electrified trucks as exist in the market, they are not very cost effective, nor are there many options. CPS Energy, who has invested in new plug-in hybrid trucks, confirmed that it was not a financial decision to translate these vehicles, it was an ethical one. While electric truck prices are falling, they are still high limiting the extent a utility could reasonably transition their fleet.

Decision Matrix IRR Calculation

In the decision matrix, the IRR was calculated using the total cost of ownership (TCO) of a new EV sedan (2018 Ford Focus EV) and the savings incurred over a five- year lifespan compared to that of the total cost of ownership of an ICE (2018 Ford Focus).⁶⁹ While a significant amount of a utility's fleet is made up of medium-duty trucks for work purposes, many of these are being converted to a hybrid or being purchased as hybrid – not fully electric. For this reason, the decision matrix focuses on the use of fully electric sedans for utility purposes.

The TCO for both an EV and ICE include the upfront vehicle cost, O&M and insurance, and fuel costs. The EV also includes additional EV fees included in some states, alternative fuel taxes based on a per kWh, and

⁶⁶ Edison Electric Institute. [Transportation Electrification: Utility Fleets Leading the Charge](#). (2014).

⁶⁷ Utility Dive. [Electric revolution: As EV demand increases, can utilities and cities keep up?](#) (2019).

⁶⁸ Utility Fleet Professional. [Fleet Profiles](#). (2020).

⁶⁹ Edmunds. [Cost of Car Ownership](#). (Accessed 2020).

federal or state financial incentives such as tax credits, rebates, or removal of sales tax. The revenues are modeled as the savings incurred through not using an ICEV for the duration of the car lifetime.

Shared Light Duty Fleet Partnership

What is it?

The transportation sector is not only seeing a revolution in alternative fuel sources, it is also seeing a revolution in how consumers view personal ownership of vehicles leading the increased use of car or ride sharing. The market potential has been reported to have revenues of \$11 billion by 2030 with a CAGR of 20%.⁷⁰ McKinsey published their projections for the future of mobility, with shared mobility growing drastically with or without the introduction of autonomous vehicles, as can be seen in Figure 12.⁷¹

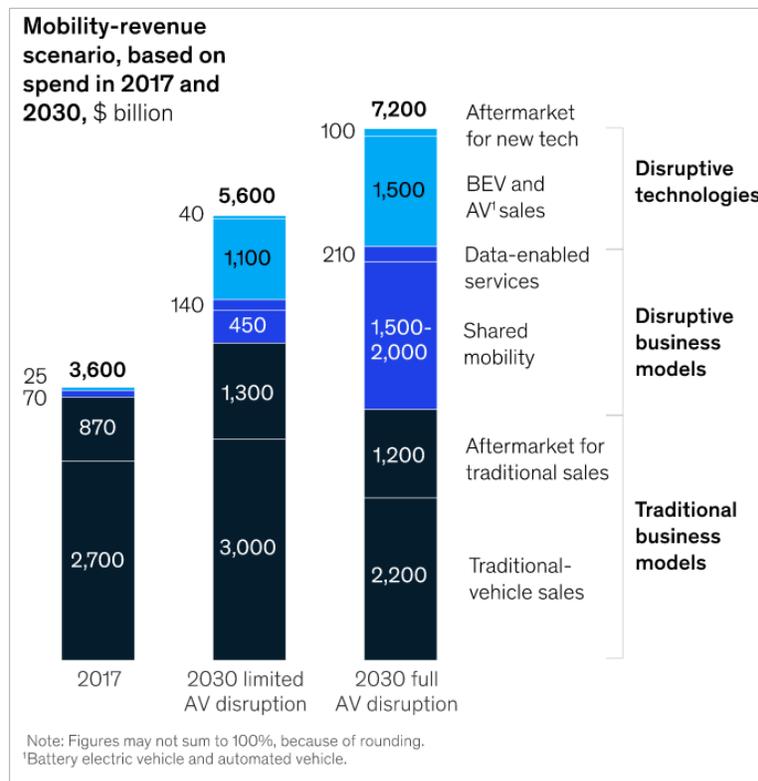


Figure 14: Mobility Revenue Projections (McKinsey & Company, 2019)

Within this trend, there are EV specific car share programs popping up across the country. Lyft has introduced a “Green Mode” allowing users to choose an EV for their commute.⁷² States are also looking into how to promote these sorts of programs within their borders. Utilities are in the position to capitalize on this growth and changing mobility landscape as they provide expertise in the new fuel source and required infrastructure. Most commonly, utilities are partnering with mobility companies and/or municipalities to provide charging infrastructure and services for new shared vehicle programs.

Overview in the United States

One-way car sharing companies in the US are typically ICE, with few focusing solely on electric vehicles. The services offered provide an alternative to car rentals or ride sharing, where a user can rent a car, is

⁷⁰ MarketWatch. [Car Sharing Market Size is expected to surpass USD 11 billion by 2024](#). (2019).

⁷¹ McKinsey & Company. [How sharing the road is likely to transform American mobility](#). (2019).

⁷² Lyft. [Making Cities More Livable with Electric Vehicles](#). (2019).

charged by the hour, and can return it to any predetermined place within a territory. There are currently eight states with public or private programs operating and five states with future pilots or discussions regarding the implementation of such a program. These programs exist primarily in varying levels of public and private partnerships.

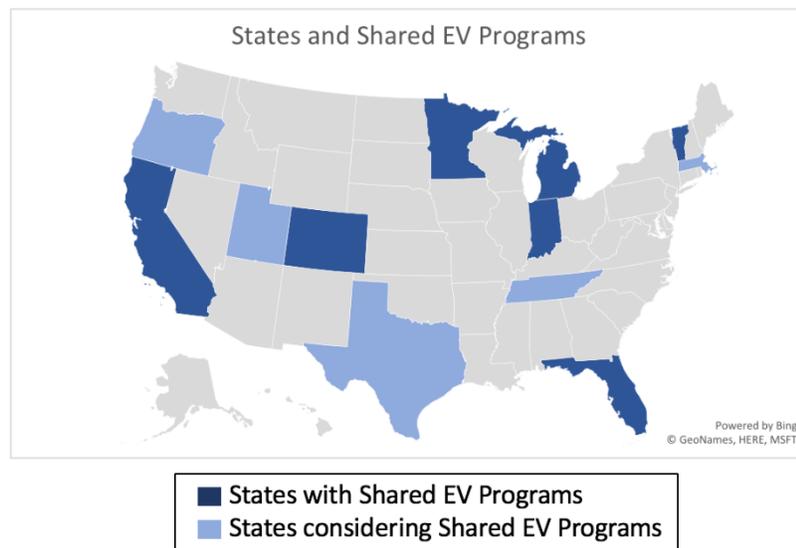


Figure 15: Overview of Shared EV Programs in the US

BlueLA

BlueLA began in 2015 with a grant from the California Air Resources Board for electric car sharing in low income communities in Los Angeles, California. BlueLA is operated by Bolloré Group, a French company that has experience with electric car sharing programs in Singapore and London. The program, which has 100 EVs and 200 chargers, was made possible with over seven partners, including the municipal utility, Los Angeles Department of Water and Power (LADWP).⁷³

BlueLA was launched in 2017, and experienced positive linear growth to have 920 drivers and almost 160,000 vehicle miles traveled by December 2018. This initial success led to the 2019 approval of Phase 2, which expands the program to new areas.

LADWP is described as a “core partner to the project.” They provided services for charging station design and funding for 200 charge points. Their effectiveness was partially attributed to LADWP existing as a municipal utility and not as an IOU. This project was situated through the Mayor’s office and relied heavily on other city agencies, and LADWPs access, experience, and flexibility helped them provide as much support as possible.

BlueLA was developed with \$10 million total investment, with LADWP contributing \$880,000 from charger rebates and waivers. The project is not expected to be profitable for 10 years, but its creative method of using electric car sharing to help meet city climate goals and increasing access to low income communities, create incentive in itself for this long break-even point.

The Shared Use Mobility Center (SUMC) provides various key lessons gained through Phase 1 of this pilot. One was to emphasize the benefit of public-private partnerships to increase the speed and flexibility for the

⁷³ BlueLA. [BlueLA](#). (Accessed 2020).

introduction of a new program of this complexity into the market. However, the SUMC warns that the partnership contract needs to be clear. Another key lesson was to consider a wide range of customer classes to increase profitability and have a wider impact. The initial goal of this project was to increase access to low income communities, but they eventually expanded it to higher income areas to supplement the profitability. This required price balancing to be both affordable to all customer classes and profitable to BlueLA. Finally, the importance of outreach was highlighted, with the need to have a substantial funding in the budget. This is one area where BlueLA is expanding in their next phase, as they did not foresee the importance and cost for Phase 1.⁷⁴

BlueIndy

BlueIndy is a similar program as BlueLA, as can probably be gleaned from the name. It is an EV car sharing program in Indianapolis, IN that was launched in September 2015 as a key contributor to the city's transportation plan.⁷⁵ It is owned and operated by Bolloré Group, with significant contributions from Indianapolis Power & Light (IPL), the IOU. By 2019, BlueIndy had 11,000 members who took 180,000 trips. This number, however, is below the initial projection of 15,000 members by 2020.

Unlike its counterpart in Los Angeles, BlueIndy is ceasing its operations in May 2020 due to this underperformance. Bolloré Group originally claimed that BlueIndy would be profitable by 2020, and once profitable, the company would pay back the investment from the city and IPL. IPL provided \$3.7 million to the project. It had initially asked for \$16 million from the Indiana Utility Regulatory Commission for distribution system upgrades and charging station deployment. The PUC only approved the distribution upgrade funding, and the remainder for charging infrastructure was paid for by the city and Bolloré Group.⁷⁶

Many of the lessons learned through this project echo the lessons learned through BlueLA. The need for a strong private-public partnership is instrumental, along with a range in customer classes, and the importance of outreach. The largest difference between BlueIndy and BlueLA is the function of the customer classes. While in BlueLA expanding the customer base was necessary to improve the profitability in the program, in BlueIndy it would have been crucial for technology acceptance. Indiana has high car ownership and low EV sales. This has been a main contributor to the failure of the project.⁷⁷

Xcel Energy & HOURCAR

Xcel Energy received approval from the Minnesota Public Utilities Commission in April 2019 for a pilot program in partnership with the cities of Minneapolis and Saint Paul using the company HOURCAR.⁷⁸ HOURCAR is a regional, non-profit, car sharing service in the Twin Cities. This Public-Shared Partnership Pilot in Minnesota came to fruition with the help of the SUMC and their 2017 report recommending a car sharing program to improve the regions mobility options and competitive edge with a new work force.⁷⁹ Additionally, Saint Paul is highly motivated through its own goal of 90% of residents being within 10 minutes walking distance to a clean transportation mobility hub.⁸⁰

Through this partnership, Xcel Energy will provide \$4.8 million in capital investment of make-ready chargers and will only own the supply infrastructure as shown in Figure 13. Additionally, the cities have applied to use funds from the Federal Congestion Mitigation Air Quality funding to pay for their end of the partnership.

⁷⁴ Shared-Use Mobility Center. [Electric and Equitable: Learning form the BlueLA Carsharing Pilot](#). (2019).

⁷⁵ BlueIndy. [BlueIndy](#). (Accessed 2020).

⁷⁶ Atlas Public Policy. [Lessons Learned from BlueIndy: An EV Shared-Use Mobility Case Study](#). (2017).

⁷⁷ Indianapolis Business Journal. [Electric car service Blue Indy ceasing operations](#). (2019).

⁷⁸ Minnesota Public Utilities Commission. [Electric Vehicles](#). (2020).

⁷⁹ Shared-Use Mobility Center. [Twin Cities Shared Mobility Action Plan](#). (2017).

⁸⁰ Twin Cities Pioneer Press. [These 2 key initiatives in St. Pau will help address climate change](#). (2019).

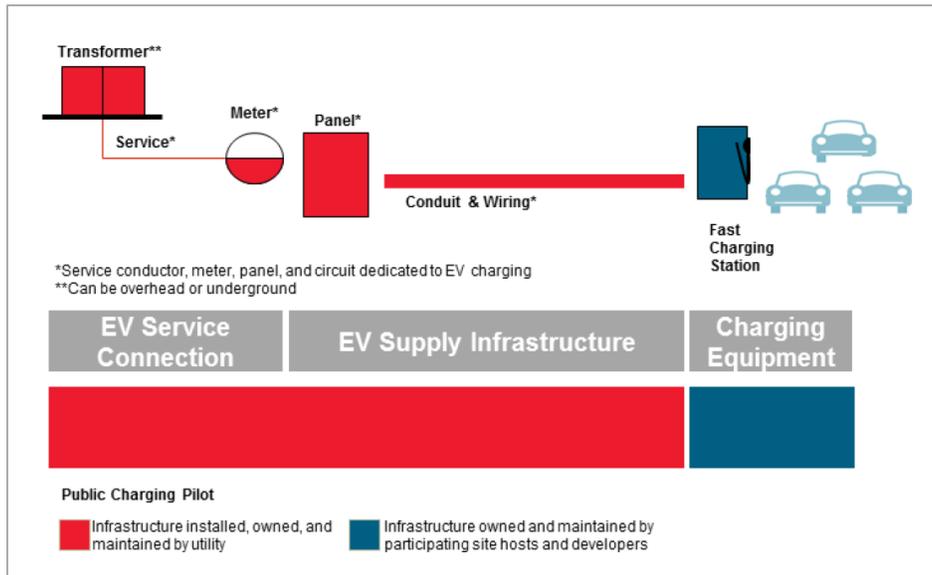


Figure 16: Shared Pilot Charging Infrastructure Ownership (Xcel Energy, 2018)

These chargers will be primarily owned by HOURCAR as the anchor tenant while allowing use to anyone driving around and needing a charge. Xcel Energy has also proposed a dedicated TOU tariff for the public chargers and the anchor tenants or developers will need to pay a monthly service fee. This pilot is not yet in service but is expected to be a future model for other programs across the U.S.⁸¹

Challenges

The challenges with this business model became apparent with the failure of BlueIndy. The program's ridership was significantly below predictions. As was also referenced with BlueLA, it is necessary to devote a significant amount of funding and effort to outreach and engagement. This is instrumental in overcoming customer barriers to understanding EV and increasing ridership.

An additional challenge is the complexity of these projects. BlueLA has almost 10 partners to make the pilot successful – including city agencies, non-profits, and the municipal utility. The number of stakeholders can cause delays and conflicting opinions and ideals, though is necessary for a project of this type to be successful. BlueLA offers some guidance on how to navigate this challenge through contract development and engagement practices.

Another challenge worth highlighting is the sheer cost of a project of this type. The failure of the BlueIndy pilot and its inability to recoup costs make this risk ever more apparent. A public-private partnership does help mitigate this risk through sharing the cost. For example, Xcel Energy has reduced some of the risks in its pilot program by partnering with Saint Paul, Minneapolis, and opening up the possibility for other tenants to cover any other costs.⁶⁴ Even with these partnerships and shared goals, funding for such projects is difficult to procure. Xcel Energy has confirmed that if the cities are unable to reach their funding requirements, despite receiving approval for \$4 million from the PUC, they will pull the pilot program which as of this publication, has not yet begun.

Decision Matrix IRR Calculation

Xcel Energy's partnership with HOURCAR has been widely praised for its design with commentators suggesting it as a new national model. For this reason, the budget and contract format were adapted from this program to apply across the U.S. An additional reason this program was chosen was due to its pilot size. While BlueLA has been proven successful, it was contained to a 10-mile radius in downtown Los

⁸¹ Energy News Network. [Xcel program will work to electrify car-sharing and government fleets](#). (2019).

Angeles. This would not be applicable for extrapolating to other areas – whereas Minneapolis/Saint Paul has a broader appeal, both in project size and in city type. The budget for this program was pulled from the approval docket.

Cost Item	Capital	5 year O&M	Total
EV Service Connection	\$2,019,000	\$29,000	\$2,048,000
EV Supply Infrastructure	\$5,781,000	\$87,000	\$586,000
Construction Management, Design engineering, legal agreement review	\$0	\$575,000	\$575,000
Marketing & Outreach	\$0	\$60,000	\$60,000
Program Management	\$0	\$555,000	\$555,000
IT	\$0	\$95,000	\$95,000
Total	\$7,800,000	\$1,401,000	\$9,201,000

Table 4: Shared LD Fleet Partnership IRR Calculation

This pilot was for the development of 70 “community mobility hubs,” evenly split between Minneapolis and Saint Paul with about four charging points each. Using each cities’ respective populations, the number of people per charging point was found to be 2,191 people/charger in Saint Paul, and 3,016 people/charger in Minneapolis. These charger metrics are used in the model to estimate the number of charging points a utility would need to install within the user-defined territory population.

The total cost of the program for any utility is equal to the total number of required chargers multiplied by the price per charger. Using the total program cost in Xcel Energy with the 280 chargers, the cost/charger is \$32,861. This final program cost is then subjected to the state infrastructure cost correction factor.

Finally, the revenues modeled are the electricity sales the utility will gain from the program combined from monthly tenant fees. The electricity sales use the number of vehicle miles traveled (VMT) reported in the BlueLA case study and assumes a Ford Focus EV’s electricity consumption. The tenant fees are modeled off the Xcel Energy program which is dependent on the number of chargers installed. The same fee structure is replicated in the Matrix’s revenue calculation and added to the electricity sales.

Light Duty Fleet Services

What is it?

Businesses and municipalities across the U.S. are working towards transitioning their fleet to electric. These transitions are prompted by numerous different reasons. Some businesses are working to lower their carbon footprint, while some municipalities are under state mandates to procure a certain percentage of fleet vehicles that are alternative fuel sources. This is a natural opportunity for a utility to offer services to design and build charging infrastructure.

Overview in the United States

Xcel Energy’s Fleet Services Pilot

Xcel Energy was approved in 2019 for an EV Fleet Service Pilot aimed to install 700 charging points with a proposed budget of \$14.4 million. They currently have support from city agencies they have been working with to provide advisory services and charging infrastructure. This pilot allows flexibility to the customer in the charging equipment. The customer can either install, own, and maintain the behind-the-meter charger, or they can choose for the utility to own it. If the customer chooses for the utility to own and maintain the

charging equipment, the customer has the option to pay a one-time up-front fee or pay a recurring monthly fee.

A key component of the pilot is the offering of advisory services – which Xcel Energy had implemented prior to filing and approval. In this service, Xcel Energy provides the customer with EV fleet and charging information and technical assistance. Xcel Energy also partnered with FleetCarma to monitor the usage of vehicles within a fleet to identify which would be the best candidates the EV transition.⁸²

This filing received regulatory approval and is beginning its 3-year pilot. Xcel Energy is planning to use the pilot to better understand EV fleets and their needs.

Challenges

The challenges with electrifying light duty fleets are similar to those that face residential and commercial customers. The upfront cost of an EV compared to an ICE are oft stated as a barrier to adoption. State mandates and funding have played a key role in increasing EVs in the public sector. Additionally, businesses are catalyzed into electrifying their fleets to achieve their sustainability goals and meet customers’ expectations.⁸³ Another challenge has been the siting of charging infrastructure. Fleet managers have stated that the availability of charging infrastructure and the siting cause challenges for a fleet transition. This is a natural fit for utilities to offer their services to help these charging concerns.⁸⁴

A challenge specific to the utility is to determine how far their services extend. Xcel Energy is piloting a very active program where they not only build and advise on charging infrastructure, but also work with the clients to determine the best method to electrify fleets. Other programs, such as Southern California Edison, focus solely on the charging infrastructure and recommend other partners for the actual fleet management and conversion.

Decision Matrix IRR Calculation

Xcel Energy’s Fleet Services pilot was used as the base for the IRR calculations in the Matrix. The budget was obtained from the 2018 PUC filing. This program was chosen because it is a full program that includes both advisory services, outreach, and EV charging infrastructure deployment.

Cost Item	Capital	O&M	Total
EV Service Connection	\$1,864,000	\$30,000	\$1,894,000
EV Supply Infrastructure and Charging Equipment	\$9,396,000	\$457,000	\$9,853,000
Construction management, design engineering, and legal agreement review	\$0	\$575,000	\$575,000
Advisory Services and Outreach, including Analytics Services	\$0	\$1,163,000	\$1,163,000
Program Management	\$0	\$735,000	\$735,000
IT	\$0	\$175,000	\$175,000
Total	\$11,260,000	\$3,135,000	\$14,395,000

Table 5: Light Duty Fleet Services IRR Calculation (From Xcel Filing)

⁸² Xcel Energy Petition for Approval. [Docket No. E002/M-18-_____](#). (2018).

⁸³ Green Matters. [Thanks to Consumer Demand, Companies Are Greener Than Ever](#). (2019).

⁸⁴ Asset Works. [5 Benefits & Challenges of Implementing an Electric Fleet](#). (Accessed 2020).

This pilot is designed for the deployment of 700 charging ports. The user-defined territory population is used with the collective population of Minneapolis and Saint Paul to create a population factor. This population factor is applied to the 700 chargers in the pilot to estimate the number of chargers a new strategy should budget.

Using the program budget, the capital cost per charger is \$16,086. This capital cost is multiplied by the state infrastructure cost correction factor to account for variations in construction costs across states. The operations and maintenance costs are kept constant at the per charger cost of \$4,479. The total program cost is the total cost per charger and the number of chargers per program.

The revenues are modeled using the electricity withdrawal payments of the fleet combined with customer charging fees. The electricity payments were estimated using the VMT for light-duty fleet vehicles as reported by the AFDC.⁸⁵ The light duty vehicle represented in the model was a Ford Focus EV to determine exact electricity consumption. Finally, within the Xcel Energy business model, customers are charged a fee per charger. This fee is adapted based on the number of chargers calculated for the size of the utility.

Commercial and Industrial Fleet Services

What is it?

Medium- and heavy-duty vehicles made up 23% of US emission in 2017, making them an attractive candidate for electrification.⁸⁶ Adoption has been slow due to few vehicle models and range requirements. While electric long-distance freight trucks are not yet common, cities and companies have been focusing on electrification of other medium- and heavy-duty vehicles that operate intracity. Instrumental in many city carbon reduction initiatives is a public bus transit system. Proterra, a well-known electric bus manufacturer, currently services 100 customers in 43 states and Canadian provinces.⁸⁷

This electrification of these vehicles is additionally attractive for the local utility, as buses and other commercial and industrial (C&I) vehicles require significant energy that can significantly boost electricity sales.

Overview in the United States

Across the U.S., utilities are stepping in to aid in the electrification of C&I vehicles. The programs exist from full support of all vehicle types to specific vehicle classes and targeted approaches.

Charge Ready Transport: Southern California Edison, CA

Charge Ready Transport is a program which supports medium- and heavy-duty electric fleets' charging infrastructure.⁸⁸ It was approved through the CPUC in 2018 for \$343 million for make-ready installations. The program is meant to serve 870 sites and at least 8,490 vehicles.⁸⁹ This program includes a requirement to serve disadvantaged communities, transit agencies, school buses, and fleets at ports or warehouses.

The structure of the program is that SCE will provide no cost make-ready charging infrastructure and advisory services to help with the transition from petroleum to electric. In providing these services, SCE is

⁸⁵ Alternative Fuels Data Center. [Average Annual Miles Traveled by Major Vehicle Categories](#). (2017).

⁸⁶ Environmental Protection Agency. [Fast Facts on Transportation Greenhouse Gas Emissions](#). (2018).

⁸⁷ Proterra. [Our Customers](#). (Accessed 2020).

⁸⁸ Southern California Edison. [Charge Ready Transport](#). (Accessed 2020).

⁸⁹ California Public Utilities Commission. Summary of Decision on Transportation Electrification Program Proposals from the Investor-Owned Utilities. (2018).

responsible for installing the infrastructure both in front of and behind the meter. The customer is responsible for installation, ownership, and maintenance of the EV charging equipment.⁹⁰

As this program is in its infancy, there is not much documentation at the time of this publication as to the success and progress of this program.

Electric School Buses: Dominion Energy, VA

Dominion Energy is in the process of deploying 50 electric school buses across Virginia by the end of 2020. The ultimate goal of this program, however, is to deploy over 1,000 by 2025. This is currently the largest electric school bus program in the US.⁹¹ The cost of this initial deployment is \$13.5 million and was approved by the Virginia SCC to be included in the rate base.

While the goal of 1,500 electric buses has large implications on climate change mitigation and electricity withdrawals, this project is most notable because of its second phase. Dominion Energy plans to use these school buses as grid resources with V2G, particularly in the summer months. School buses are some of the best candidates for V2G due to their highly predictable schedule and routes, and more importantly, their being parked in designated lots during summer peak hours.⁹² Dominion Energy estimates that once all 1,000 buses are on the road, they can provide energy to 10,000 homes.

Dominion Energy plans to cover much of the costs associated with the transition of the diesel fleet with the approved \$13.5 million. They will cover any extra costs an electric bus would have over a diesel and pay for the charging infrastructure.⁹³

Challenges

As with most customer classes, the challenges around electrifying a commercial fleet are the costs. Fleet managers have sited the upfront cost of an electric vehicle as the primary barrier to transition a fleet to electric.⁹⁴ One method of circumventing this issue is Dominion Energy's method in Virginia. Here, Dominion Energy is paying the excess vehicle cost as well as infrastructure for electric school buses. This method, however, is dependent on state policy and goals as these costs are ultimately passed on to the rate payers.

Another challenge is the fundamental difference between using electrons versus petroleum as a fuel source and cost item for the business. Complicating this issue further is the use of demand charges for C&I customers. This difference in fuel procurement is a barrier for fleet owners in fully understanding and taking advantage of the cost structures. This has led some utilities, such as PG&E, to propose dropping demand charges in favor of a subscription-based service.⁹⁵ In SCE's Charge Ready Transport, demand charges are waived for the first five years, then slowly reintroduced in for customers to get more well acquainted with the idea and remove the barrier to purchases.

Decision Matrix IRR Calculation

The IRR for a C&I program strategy is modeled off the budget for SCE's Charge Ready Transport Program. This program was chosen because it is already modeled off SCE's Charge Ready pilot which was a successful pilot. This indicates a successful model and realistic costs. Additionally, this is a full program,

⁹⁰ "Charge Ready Transport Program Handbook: Clean Energy to Fuel Southern California's Medium-and Heavy-Duty Fleets." Southern California Edison. 10 July 2019.

⁹¹ Dominion Energy. [Dominion Energy Moves Forward with Electric School Bus Program](#). (2020).

⁹² Inside Lines. [V2G Hits the Big Time with Dominion Electric School Bus Project](#). (2019).

⁹³ Pv magazine. [Electric company pushing electric school buses in Virginia, high speed car sharing network in Iowa](#). (2019).

⁹⁴ Material Handling & Logistics. [Fleet Owners Going Electric Due to Sustainability, Lower Costs](#). (2018).

⁹⁵ Greentech Media. [PG&E Proposes Ditching Demand Charges for Commercial EV Charging](#). (2018).

verses a pilot, which encompasses a full range of vehicles, not just forklifts or school buses. The base budget used can be seen in Table 4.⁸⁷

Cost Item	# Sites	# Vehicles	Capital Budget	Expense Budget	Total Budget
Forklifts	100	1919	\$13,189,700	\$71,600	\$13,261,300
TSE	8	160	\$790,168	\$2,136	\$792,304
TRU	156	2964	\$28,849,080	\$95,004	\$28,944,084
Port Cargo Trucks	12	136	\$4,007,664	\$7,116	\$4,014,780
Transit Bus	140	1680	\$47,691,140	\$58,660	\$47,749,800
School Bus	54	648	\$7,896,258	\$27,108	\$7,923,366
Airport GSE	30	600	\$4,002,810	\$14,610	\$4,017,420
Medium-Duty	400	4800	\$59,064,400	\$174,000	\$59,238,400
Other Heavy-Duty	105	4084	\$35,768,355	\$43,995	\$35,812,350
Program Management			\$20,175,419		\$20,175,419
Contingency			\$20,175,419		\$20,175,419
Education (PG&E)				\$5,941,858	\$5,941,858
Transit & School Bus Rebates				\$64,620,000	\$64,620,000
Program Total			\$241,610,553	\$101,045,670	\$312,666,881

Table 6: C&I Fleet Services IRR Calculation

A change that was made to the SCE budget was to remove the Disadvantaged Community Rebate and replace it with education, which was provided in the PG&E budget for a similar program. The research conducted throughout this project has been clear that education and outreach should be budgetary items when working with customers to purchase and effectively use new EVs. The Disadvantaged Community Rebate was removed because this is a specific goal and motivator for programs in California, and the value and inclusion are likely to differ greatly across states.

The IRR calculation requires multiple user inputs.

- Territory size: This is used as a factor compared to the territory population of SCE and PG&E for vehicle number and education scaling.
- Whether or not the utility serves an airport or a cargo port. The input will determine the inclusion of these vehicles in the program cost.

The final factor to determine the total program cost is a state infrastructure correction factor.

The revenue is determined through estimates of electricity sales for each vehicle. Various databases created by the California and Massachusetts state governments and the University of Michigan (See the Matrix for full citations) were used to estimate each vehicle type’s annual electricity consumption. Since SCE is not using demand charges at this point, with PG&E also discussing similar tariff changes, these were omitted for this study. The revenues are solely the electricity consumption of the consumer.

Managed Charging (VIG)

What is it?

Electric vehicles are a largely growing load on the grid. The fact that this load is flexible and charging times can be managed is used as an advantage for smooth grid functioning. VIG is a method by which an electric

vehicle can be programmed to charge during off-peak hours or hours of high renewable generation, while avoiding charging during hours of peak demand. This results in a smoother demand curve through the peak shifting not relying on customer behavior changes. This avoids the purchase of expensive electricity from peaking power plants and infrastructure upgrades.

Overview in US

SEPA’s study reported 38 utility run managed charging pilots across the United States. The utility’s involvement in managed charging is shown in the image below.⁹⁶ It is observed that a majority of utilities realize the magnitude of cost savings achievable through managed charging and are spending efforts in research and pilot design. Sacramento Municipal Utility District (SMUD) conducted a study that around 12,000 (17%) of their transformers need to be replaced to increased loads from EVs, at around \$7,400 per transformer.⁹⁷

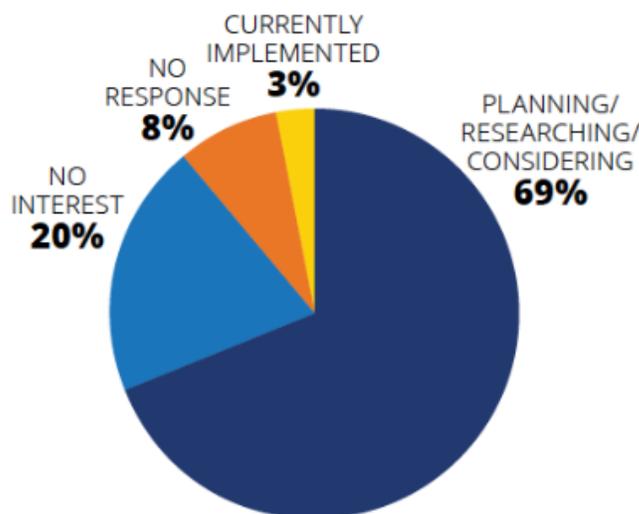


Figure 17: Utility Interest in VIG (SEPA, 2017)

BMW and PG&E

PG&E’s ChargeForward Pilot, in partnership with BMW is one of the most successful VIG pilots in the country. The first phase of this pilot involved 96 BMW i3 drivers.⁹⁵ Enrolled drivers were provided with a \$1,000 incentive for participation. Through BMW’s proprietary software and app, PG&E was able to send signals to the vehicles whenever demand response was necessary. A second life EV battery was used as stationary storage for when the drivers were not able to contribute to demand response (DR) events. PG&E’s day ahead prediction of renewable energy overgeneration was used to optimize EV charging.

The pilot was successful in that BMW was able to meet 90% of load requirements for DR events. Customers were highly satisfied, as 93% of them were willing to recommend it to other drivers. However, 80% of load requirements were met by the stationary battery and the 20% contribution from drivers were skewed towards weekends.

The second phase of the program saw 350 enrolled participants and focused on increasing renewable energy use and accounted for residential and public charging.

⁹⁶ Smart Electric Power Alliance. [EV Managed Charging: Lessons from Utility Pilot Programs](#). (2019)

⁹⁷ Utility Dive. [Electric vehicles can be grid assets or liabilities. How utilities plan will decide](#). (2017).

Challenges

The development of technology to ensure smooth network to charger communication is an essential element for a managed charging program to be successful. This would need EV manufacturers, utilities, and EVSE suppliers to collaborate to come up with a tested protocol for managed charging, which is yet to happen.

The V1G landscape has not moved passed pilot programs as of this publication. However, with increased adoption of EVs, these programs are expected to grow, and the resulting bulk load shift would save utilities from heavy investments on expanding grid infrastructure, making these V1G programs more and more economical.

Decision Matrix IRR Calculation

IRR calculations were performed for a program size of 100 EVs. The following table shows the various costs associated with a typical V1G program, using the BMW ChargeForward pilot as a template.

Cost Item	Value
Customer Incentives (\$)	1,000
Aggregator Costs (\$/kW)	10.40
Stationary Storage Costs (\$/kW)	82
Battery O&M Costs (\$/kW)	6

Table 7: V1G IRR Calculation

Similar to TOU rates, the revenue stream was calculated using peak avoided energy cost values for a BMW i3 vehicle.

An important caveat to the cost calculation is that aggregator costs were included only for deregulated markets. IOUs in vertically integrated markets are assumed to not need aggregator services.

Vehicle to Grid (V2G)

What is it?

The battery of an idle electric vehicle can be thought of as an asset to the electric grid, as it has the ability to perform ancillary services. Under V2G programs, the grid would tap into the energy potential of EV batteries, pulling power from the vehicle to the grid during peak hours. This strategy can be used for managed charging purposes as well as for delivering power to the grid. Like V1G, V2G can help reduce infrastructure expansion costs and use of highly polluting peaking plants.

Overview in US

Currently in the US, there are 16 V2G pilots that have been fully deployed.⁹⁸ Most of them have been in California, with a few pilots in Massachusetts, New York, Oregon, Colorado, and Hawaii.

JumpSmartMaui, Hawaii

Hawaii has taken great strides towards EV adoption as an effort to reduce high costs associated with fossil fuel imported from the mainland. This pilot was funded by a Japanese company, New Energy and Industrial Technology Development Organization (NEDO), and conducted by Hitachi.⁹⁹ The project provided V2G services through vehicle to home (V2H). This was aimed at reducing load on the grid by reducing household electricity consumption.

⁹⁸ Everoze. [V2G Global Roadtrip: Around the World in 50 Projects](#). (2018).

⁹⁹ NEDO Smart Community. [Japan – U.S. Collaborative Smart Grid Demonstration Project in Maui Island of Hawaii State: A Case Study](#). (2017).

The pilot deployed 80 V2H chargers to demonstrate response to signals over the peak period (6pm to 9pm). The project utilized 6kW DC Hitachi chargers and 80 Nissan Leaf vehicles. Each driver was required to install an EV Power Control System, which was provided to them for free as an incentive to participate. Energy was controlled via Hitachi’s Demand Management System (DMS). EVs charging utilized the DMS to create a charging schedule to fill up the gap between the intermittency of renewable generation and the next day’s load. Then, it calculates each EV’s charge time by accounting for the EV’s connection status and desired charge end time. The following image shows a typical charge and discharge cycle of a Nissan Leaf under the JumpSmartMaui program.

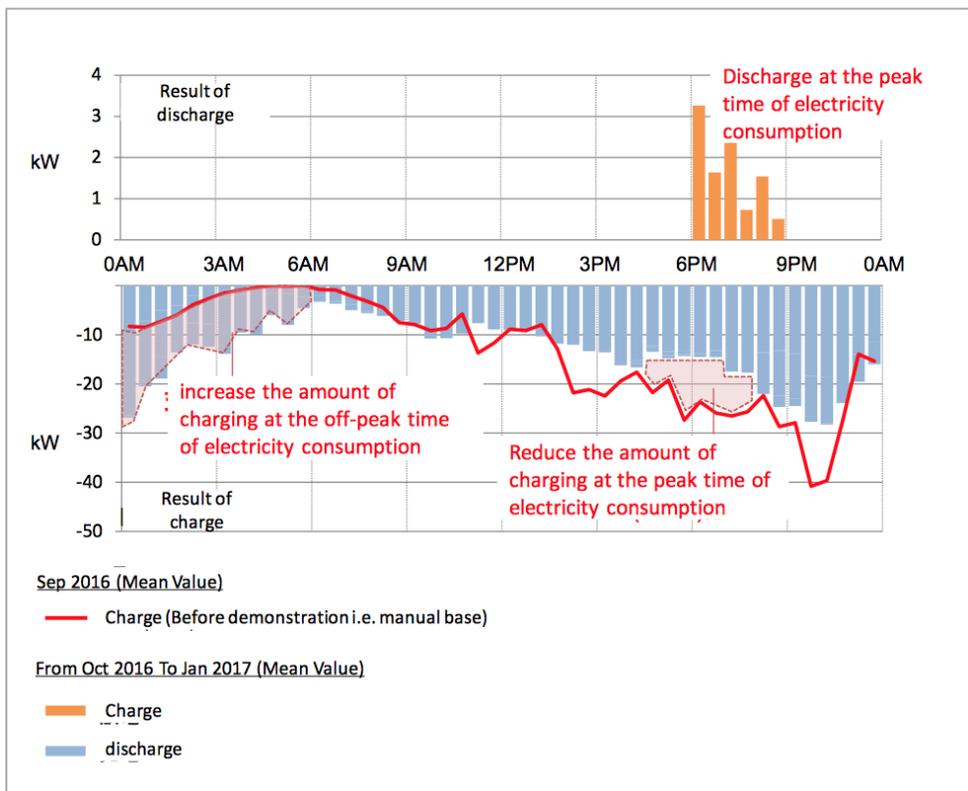


Figure 18: JumpSmartMaui Charging Schedule (Everoze, 2018)

Blue Bird School Buses (Sacramento, CA)

California’s state government invested around \$500 million tax money on school buses since 2001. Even though California has a great opportunity to reduce ownership costs through electrification, converting the entire school bus fleet to EVs would cost about \$5 billion. The CAISO frequency regulation market provides great revenue potential, and an opportunity to drive down payback period which makes EV school buses a feasible investment.¹⁰⁰

Hosted by Rialto Unified School District, the pilot utilized 8 electric school buses, with a power capacity of 200 KW per bus. All 8 of them participated in wholesale ancillary services market through frequency regulation, for both upward (frequency increase) and downward (frequency reduction) regulation. The revenue from this market participation drove down the payback period from over 20 years to 14 years.

Challenges

As seen in the Blue Bird school bus example, EV fleets have higher revenue potential from V2G. However, this revenue is dependent on wholesale ancillary services markets, which do not exist in all states. As

¹⁰⁰ Department of Energy. [Blue Bird V2G Electric School Bus Commercialization Project](#). (2018).

renewable integration increases and the issue of intermittency is more prevalent, frequency response services may start being valued at much higher prices around the country, and the revenue potential for V2G programs would improve.

Additionally, bi-directional power flow to and from the EV battery results in a reduction in battery life. For this reason, automakers are not fully on board with V2G technology. This also causes additional costs for utilities. Utility experts have expressed that the current standard is for utilities to compensate drivers for this reduced battery life since they are looking for more V2G participants. Finally, customer participation has been a barrier at the residential level, so more incentives, education, and outreach are necessary.

Decision Matrix IRR Calculation

Cost calculations for a V2G pilot followed the same procedure as V1G except that V2G programs include bi-directional charger costs. From the Hitachi pilot, charger costs were assumed as \$2,400 per charger, to be provided by the utility as an additional incentive to participate. As for V1G, aggregator costs were applied to deregulated markets only. Annual revenue was calculated using avoided energy costs both from not charging at peak hours and providing electricity to the grid during peak hours.

Strategies Not Included in the Decision Matrix

Transmission and Distribution Infrastructure Development

What is it?

The ability for a utility to provide electricity to meet the growing demand of the projected EV numbers is an oft discussed concern. Similarly, the ability for the distribution grid to be able to handle the future potential of V2G, along with other bi-directional distributed energy resources, has been a source of concern for grid operators. MISO has published documents and workshop minutes that strongly ring in this sentiment, and they feel they will not be ready for these types of resources for several years due to extensive distribution grid upgrades.¹⁰¹

Overview in the United States

Throughout the research, various utility professionals showed they were unconcerned with the ability to provide the generation.¹⁰² For example, Lang Reynolds of Duke Energy shared that while significant upgrades have been needed for individual customers, it was “not anything outside the normal course of operations.”¹⁰³

Where significant upgrades have been required, such as in Indianapolis with the introduction of the BlueIndy car-share program, the PUC did approve \$3.4 million for these distribution upgrades, though not approving charging infrastructure costs. This suggests that regulatory bodies may be amenable to approving distribution level upgrades to ensure reliable service.

Why was it not selected?

It is instrumental that individual utilities address specific infrastructure needs along with their costs and territory specific demand projections. This type of projection is outside the scope and capability of this study. This type of analysis requires very territory specific information including current distribution capabilities, future capacity needs aside from EVs, generation mix, impact from other distributed generation and energy efficiency, among other inputs. Additionally, utility and state specific clean energy goals could cause drastic shifts in the adoption rate of clean energy technologies which differ across regions and

¹⁰¹ MISO. [MISO and DER: Framing and Discussion Document](#). (2019).

¹⁰² “Preparing for the Arrival of Heavy-Duty Battery Electric Trucks.” *Advanced Clean Tech*. Webinar. 6 December 2019.

¹⁰³ Utility Dive. [Electric revolution: As EV demand increase, can utilities and cities keep up?](#) 2019.

territories. For these reasons, it was not possible to do this type of an analysis using publicly available data for this tool.

Utility Sponsored Incentive Programs for EV Leases and Purchases

What is it?

A fundamental economic principle is that incentives are a method to influence a consumer's behavior. This is especially effective with EVs, as a common barrier to a consumer is the upfront cost. Numerous agents within the EV market space are offering incentives to consumers. This includes the federal incentive of up to \$7,500 for certain models of EVs or state tax credits.¹⁰⁴

Overview in the United States

Various utilities are also providing incentives for the purchase of EVs and particularly for the installation of the charging equipment. These include Duke Energy in North Carolina offering up to \$5,000 for a charging port and Gulf Power in Florida offering \$750 for either the purchase of an EV or charging infrastructure. These incentives are varied in magnitude and rules.²⁰

These types of rebates do not exist in all states. In 2019, Wisconsin ruled that private charger rebates were not for the benefit of the greater consumer class, so the petitioning utility was unable to offer these incentives.¹⁴

Why was it not selected?

While incentives are an incredibly common and effective mechanism in the EV market, they are too varied to predict and recommend. This is a useful strategy for a utility to employ to promote EVs in their territory, but it requires additional research to understand the consumer, the likelihood of gaining regulatory approval, and to what magnitude a rebate is feasible.

Partnerships

What is it?

A common strategy that has proven successful across the space is the utility forging partnerships with other organizations – such as vehicle manufacturers, non-profit community organizations, fleet owners, etc. These partnerships range in location, magnitude, function, goals, and outcome.

Overview in the United States

There are numerous partnerships that have proven successful for the adoption of EVs. Within this report, shared EV fleet partnerships, partnerships to improve customer education and awareness to EVs, and partnerships to study the impacts of vehicle-to-grid integration have been discussed and modeled for the decision matrix. However, there are other partnerships that aim to achieve the overarching goal of increased EV penetration.

Volvo LIGHTS

Volvo LIGHTS is a program that began with a \$44.8 million investment from the California Air Resources Board and is led by Volvo for the purpose of increasing the number of EV freight trucks. The website lists 15 partners that range across the supply chain from Volvo as the original equipment manufacturer, to NGOs who are working on the community engagement, to SCE, who is advising on charging infrastructure, and dealerships who will help sell these vehicles and further educate heavy-duty fleet managers.¹⁰⁵

¹⁰⁴ Department of Energy. [Federal Tax Credits for New All-Electric and Plug-in Hybrid Vehicles](#). (Accessed 2020).

¹⁰⁵ Volvo LIGHTS. [About Volvo LIGHTS](#). (Accessed 2020).

Kansas City Power & Light's (KCP&L) Clean Charge Network

KCP&L has been celebrated for their innovative public charging program, Clean Charge Network. There have been over 1,000 chargers installed across Kansas City greatly increasing access for EV owners. This program, however, was not done solely by KCP&L, but through many local partners, and a partnership with Nissan Motor Company and ChargePoint. This partnership allows these chargers to be included in the greater ChargePoint network, the largest charging network in the U.S., and also allows for free charging for two years.

Why was it not selected?

This investigation explored a number of different partnerships that work in the EV space in different ways. Many of the successful pilots and programs have seen their level of success due to their respective partnerships. This is not so much the absence of a strategy but a section to bring awareness that beyond the partnerships that were modeled, there are dozens of other methods and partnership structures a utility could use and should explore to achieve a particular goal.

Distributed Energy Charging Stations

What is it?

EVs are considered a highly valuable solution to various climate goals and greenhouse gas emission reductions. This could be amplified further by ensuring the electrons are coming from renewable energy sources, such as a solar plus battery powered charging station. The use of distributed generation could also aid in reducing infrastructure stress by using localized charging during peak times.¹⁰⁶ Finally this would have further benefits in convincing a consumer of the reliability of an EV in the event of a power outage – as the charging station could still be operational while the grid is down.

Overview in the United States

Thus far, the research is highly theoretical. There are companies which sell natural gas generators and batteries for this purpose, but this is not common.¹⁰⁷ The concept was openly discussed on an EV panel at the Grid Edge East Conference at Duke University in Durham, NC in April 2019, but the literature review could not find any instances of this in practice in the US at the time of publication.

Why was it not selected?

The theoretical nature of this model resulted in it not being included in the Matrix. Additionally, the utility model for charging infrastructure strongly leans toward owning everything on the utility side of the meter, not behind the meter where these assets would reside. This model would therefore be unattainable for a sizable component of the Matrix's audience, as those in deregulated markets are unable to own generation assets regardless.

Other Time-Varying Rates

What is it?

Apart from time of use rates, the following are other time-varying rate structures that utilities have designed:¹⁰⁸

- **Subscription rate:** Allows customers to pay a fixed monthly fee for electricity and other utility-provided services in exchange for unlimited charging during certain hours of the day or days of the week.

¹⁰⁶ IEEE. [Increasing EV public charging and distributed generation in the electric grid](#). (2015).

¹⁰⁷ Energy Choice. [Is Distributed Generation the Future of EV Charging?](#) (2019).

¹⁰⁸ Environmental Defense Fund. [A Primer on Time-Variant Electricity Pricing](#). (2015).

- Off-Peak Credits: A fixed or variable incentive provided as a rebate or a bill credit in exchange for restricting consumption to designated hours of the day or days of the week.
- Real Time Pricing (RTP): This is the most complex time varying rate. Variable, hourly prices are determined either by day-ahead market prices in order to allow the customer to be notified with time to alter consumption decisions, or real-time spot market prices.
- Variable Peak Pricing (VPP): A hybrid of TOU and RTP, where price intervals are constant. However, peak price rates differ day-to-day to reflect system conditions and costs.
- Critical Peak Pricing (CPP): Customers pay a higher rate at designated peak demand events (also called “critical events”) on a limited number of days during the year to reflect the higher system costs during these hours.
- Critical Peak Rebate (CPR): Utilities pay customers a rebate for each kWh of electricity they reduce during peak hours of peak demand events.

Overview in US

According to SEPA’s report on time-varying rates, there have been 68 rate structures offered by 50 load serving entities in the United States exclusively for EVs.⁹ Out of the 64, 58 of them were residential TOU rates, 1 subscription rate, and 5 off-peak credit programs. Other dynamic pricing structures have not been deployed for EV charging applications at the residential level.

Why was it not selected?

As stated above, the TOU rate structure is the most popular and successful form of time-varying rates for EV charging applications. Other dynamic rate structures have been used for household purposes and have not been tested for EV charging exclusively. Therefore, this project focuses on the application of only TOU rate structures across the country.

Results & Recommendations

Practical Applications of the Decision Matrix Tool

The Matrix should be used to perform high level strategic analyses for any IOU or municipal utility operating in the U.S. Its purpose is to gain a view into how a particular region’s political and regulatory landscape and cost structures might impact business decisions for the utility. The Matrix also provides the data and resources to find more information to better understand how successful pilots and programs have been run. Additionally, the Matrix can be used to gain an overview of the EV industry in a state and how it compares to other states in the U.S. A user can then use recommended programs or policies to progress their goals in their state.

Decision Matrix Use Cases

The Matrix was used for a sample IOU with a territory population of 2,000,000, 10-year project lengths, and an 11% utility return on investment to evaluate how the output for priority EV strategies differ across the U.S. Below we highlight three specific state use cases and implications for each strategy across the country. States at different stages of EV adoption were selected: California, Colorado and Kentucky.

California

Current EV Status

California is leaps ahead of all other states in the country when it comes to EV adoption. In 2018, California contributed to 46.8% of the country’s EV market share.¹⁰⁹ The ZEV state has over 100 policies put into action specifically to advance the adoption of EVs.

Decision Matrix Output & Inferences

The following image shows the result of the Matrix.

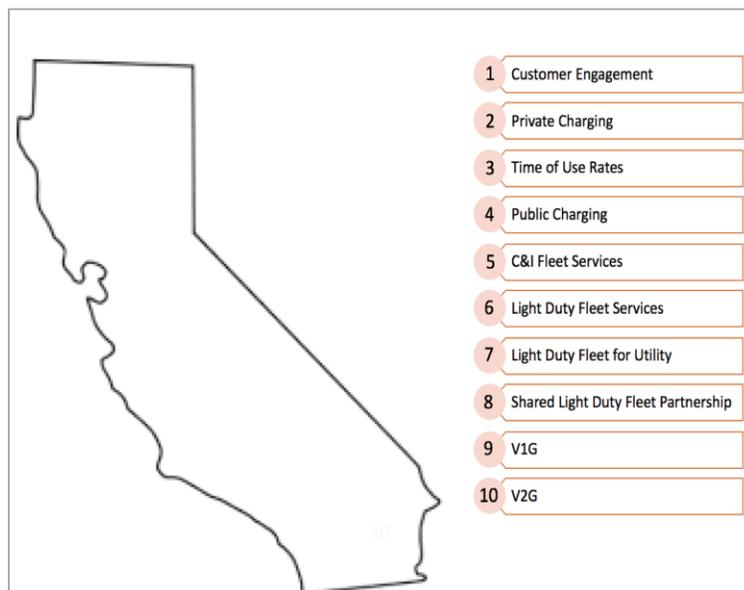


Figure 19: California Strategy Ranking Output

¹⁰⁹ EVAdoption. [EV Market Share – California](#). (2019).

It is observed that the number one strategy utilities in California should adopt is customer engagement, closely followed by private charging investments and TOU rates. On closer examination, it was found that customer engagement had the highest IRR among all other strategies. Since California is a state where charging infrastructure has been approved in the rate base and revenue potential from private charging infrastructure is high, private charging is ranked second. Additionally, there are 36 policies in place that aid charging infrastructure development.

TOU Rates had the second highest IRR value and 6 strategy related state policies. All strategies had regulatory approval from the state government. Vehicle grid integration (VGI) strategies are ranked the lowest. However, California’s landscape for VGI is much better compared to any other state, as shown in Figure 24.

Colorado

Current EV status

Colorado became the 11th state to adopt California’s ZEV (Zero Emission Vehicle) policy. The ZEV policy requires automakers to sell a certain number of EVs within a target year. Colorado’s mandate is for 4.9% (12,876) of all new cars sold in 2023 to be EVs.¹¹⁰ The state has 32 policies dedicated towards EV adoption.

Decision Matrix Output & Inferences

The decision matrix output is represented in the figure below:

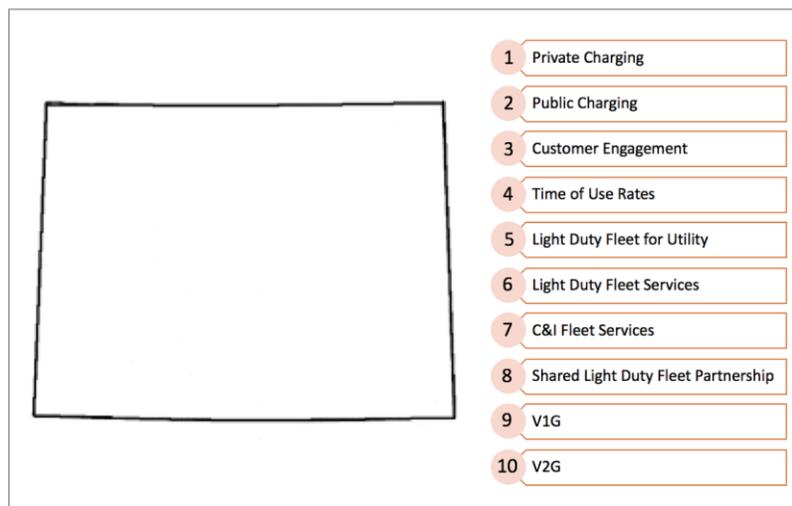


Figure 20: Colorado Strategy Ranking Output

Infrastructure costs in Colorado are considerably lower (about half of California’s costs) and the state has a history of regulatory approval for this strategy. As a result, public and private charging infrastructure are high in the deployment priority order. Colorado has 8 policies that aid charging infrastructure development, and 10 policies towards customer engagement. Additionally, having adopted the ZEV policy, managing customer charging behavior would be of significant use as EV sales numbers increase.

¹¹⁰ The Colorado Sun. [As Colorado considers an electric-vehicle mandate, here’s what to expect.](#) (2019)

Kentucky

Current EV status

In 2018, Kentucky sold 787 EVs (0.24% of total EVs sold in the country). Kentucky has only 2 policies issued in favor of EV adoption, both of them for customer engagement. However, Louisville Gas & Electric (LG&E) and Kentucky Utilities (KU) have developed plans to install EV charging stations across their service territory.¹¹¹

Decision Matrix Output & Inferences

The decision matrix output is shown in the image below:

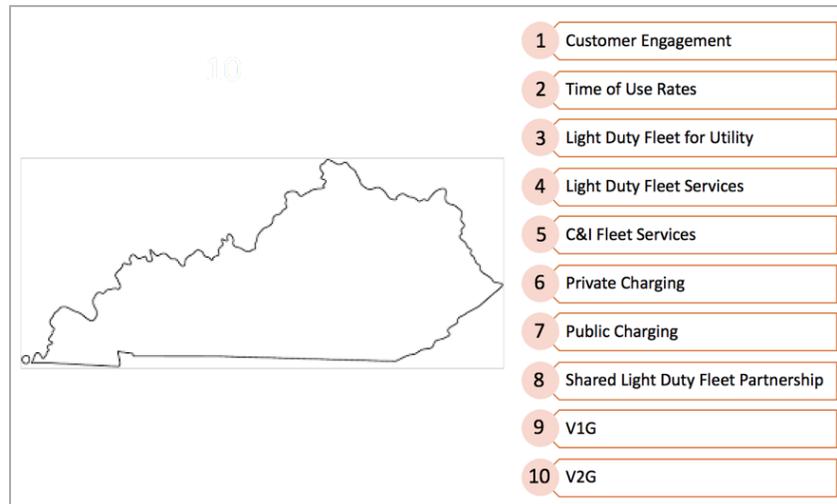


Figure 21: Kentucky Strategy Ranking Output

With both existing state EV policies being towards customer engagement, it is no surprise that the strategy has been ranked first yet again. TOU rates and light duty fleet for utility use follow closely. There have been no EV TOU rates in Kentucky in the past. The state has granted regulatory approval only for light duty fleet for utility use, and partial approval granted for fleet services and customer engagement. As suggested by the Matrix, the state first needs to spend efforts on marketing and customer engagement to increase awareness among residents on the benefits of owning an EV.

¹¹¹ Louisville Business First. [Are electric vehicles a practical option for Kentucky businesses or families?](#) (2019).

Decision Matrix Output: Mapping of Strategies for the US

The following map shows the top ranked strategy for each state:

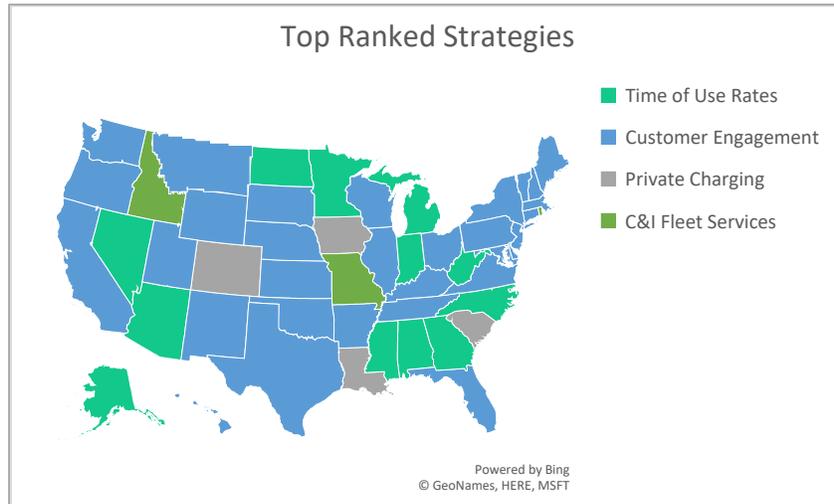


Figure 22: Top Ranked Strategies per State

The image below shows the country's EV policy landscape:

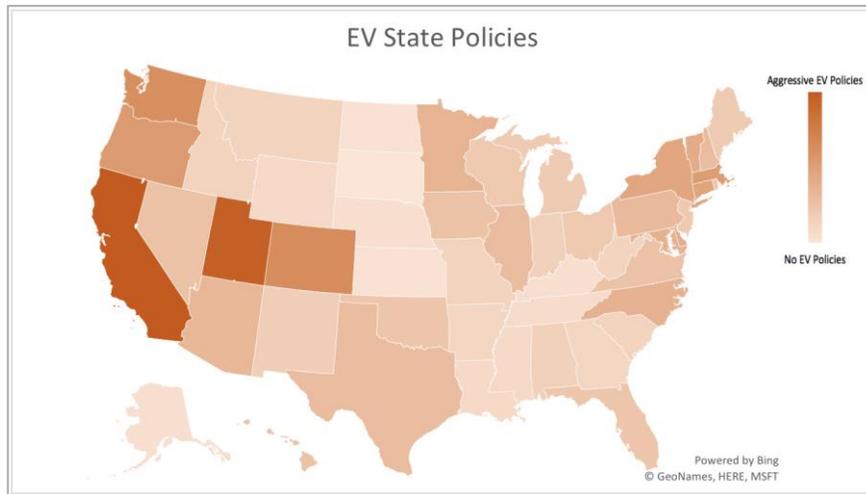


Figure 23: USA EV Policy Landscape

For each strategy, the following maps show how each state is positioned with respect to one another. The colors depict if the state is most suitable/least suitable for each strategy.

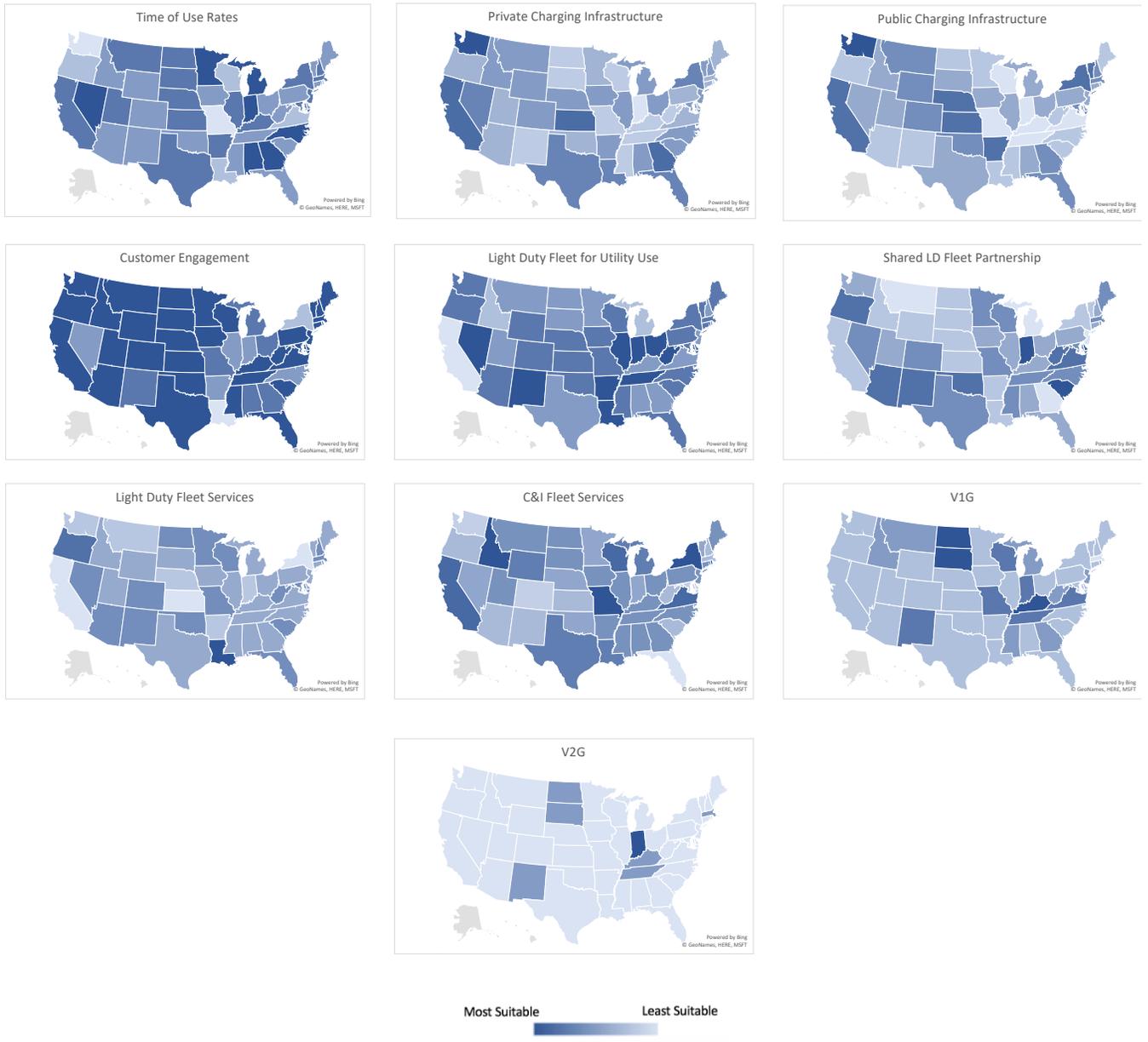


Figure 24: Strategy-wise State Suitability

Conclusion

Drivers for Utility Strategy Deployment

Consistently, all the top ranked strategies are those that have the highest number of policies and the most promising IRRs. Based on our analysis, the different stages of utility EV adoption strategies are identified to be as follows:

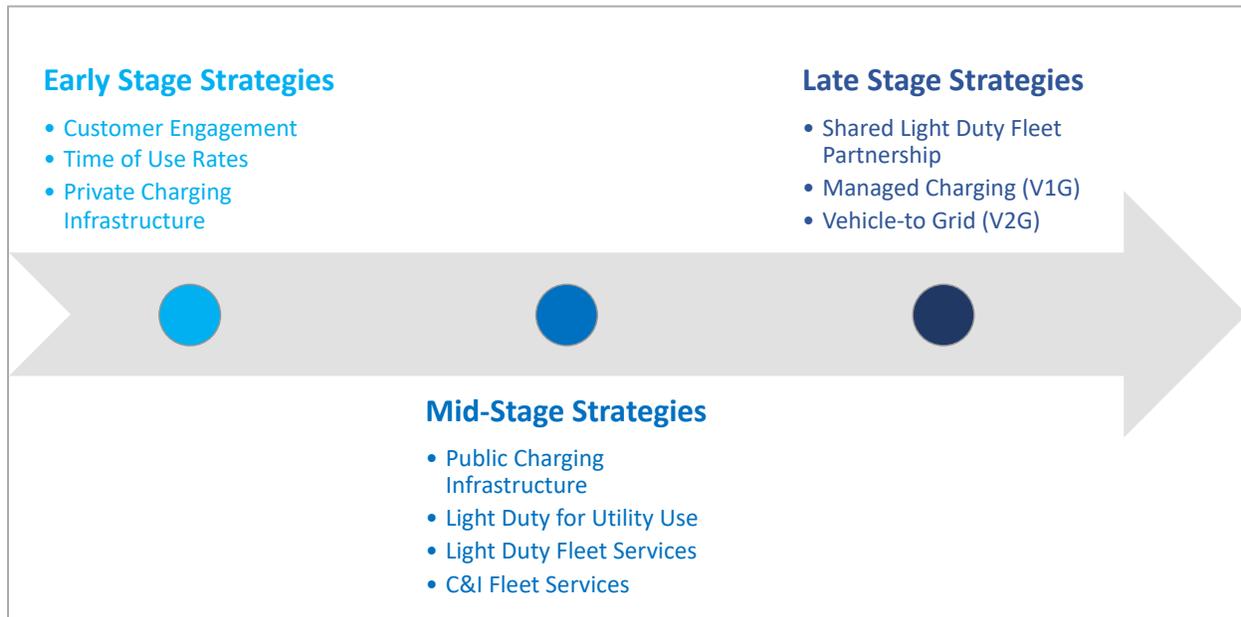


Figure 25: Utility EV Strategy Adoption Stages

Customer engagement is most frequently ranked first as it is the lowest cost approach and has the potential to reap large benefits. For instance, PG&E’s customer education website brought in over 400 rebate applications in one week and was built for less than have the initial budget.¹¹²

Customer charging behavior is another important factor to be considered to defer utility infrastructure expansion costs. The most cost-effective, low risk way to administer customer charging patterns is through time of use rates. Managed charging also achieves similar results. However, this would involve additional stationary storage and aggregator costs. The TOU rate strategy establishes a win-win situation in that customers can reduce their electricity bill while utilities save money from avoided energy costs and deferred infrastructure upgrades. As a result, this strategy is ranked high in almost all states.

Investing in private charging infrastructure, an obvious first step towards EV adoption is another commonly high ranked strategy across the country. For states that allow make-ready infrastructure costs in utility rate base, high financial returns from the utility’s PUC approved rate of return are driving this trend.

The current EV market is not yet ready for vehicle grid integration to be a top ranked strategy. Higher EV adoption, improved battery technology, projected battery cost reductions and increased renewable integration would intensify the need and economic viability of VGI strategies, which may then be ranked higher in future scenarios.

¹¹² Smart Electric Power Alliance. [Switching lanes: How utilities can encourage EV adoption through customer-centric programs](#). (2019).

Future Research

1. Impact Analysis for Selected Strategies

A key area of future research would be to further examine and quantify the direct relationship each dollar of investment in each of these 10 strategies has on electricity sales growth, EV purchases, and consumer behavior. More information is consistently being released on the current programs, with new programs being implemented. This will ultimately provide more data to understand how a utility action directly effects the market and establish a more accurate percentage increase in EV sales. Through establishing how a utility's past behaviors have affected the market, utilities can structure their future programs more precisely to maximize their impact.

2. Inclusion of Strategies not Selected

The Matrix functions only at a high level and examines just 10 of many more possible strategies. Another area future research should focus is to further evaluate the strategies not included and implement them into the Matrix. This will require greater data collection and modelling capabilities but would provide valuable insights to give a more holistic view of the industry and the options a utility can pursue.

3. Increase Granularity of Matrix Scope

In addition, any granularity that could be added would greatly improve the quality of information the Matrix provides. It currently exists at a state level, but various interviewees indicated more information is required to fully understand a strategic decision. It would be valuable to add county-level data, specific utility behavior and values toward new programs based on region, and any other more precise information.

4. Include other Load Serving Entities

The Matrix focuses primarily on IOUs with some direction toward municipal utilities. Future research should act to improve the flexibility to include other load serving entities such as cooperative utilities. Along with increasing the access to the use of the tool, it will add valuable knowledge into the full EV landscape across the country.

5. Analyze Role of Alternative Fuels and Impact on Oil and Gas Industry

As the world realizes the need to shift towards alternative fuels for transport, it is important to understand how this affects major players in the oil and gas industry. There is scope for future research to understand how this industry has been reacting to transportation electrification and also look at ways to involve their expertise into catalyzing this change. Such a study would be a valuable addition to compliment this study, along with research about other promising alternative fuels such and biofuel blends and hydrogen for long distance transport.

While the Matrix in its current form provides valuable insights for a utility looking to engage in the EV market, these recommended research areas would provide even more information for how a utility should structure their future goals to achieve the greatest impact in this growing market.

Appendix

Decision Matrix Model

A downloadable version of the decision-making tool can be found [here](#). Note, the tool must be downloaded to run.

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