Taking First Steps: Insights for States Preparing for Electric Transportation

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APRIL 2020

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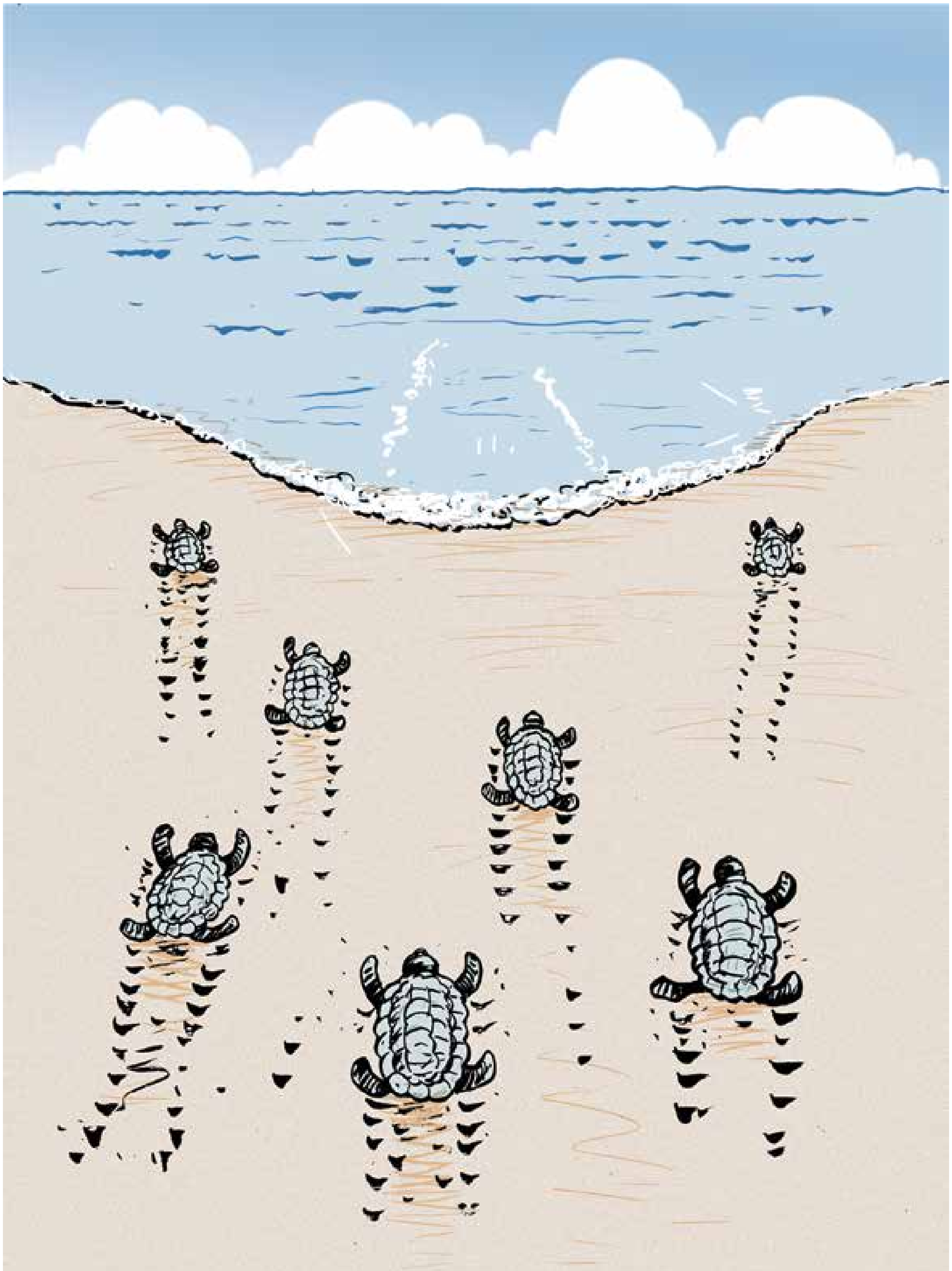
Cover photos: Dennis Schroeder/National Renewable Energy Laboratory
Illustration: Tim Newcomb

Suggested citation

Farnsworth, D., Shipley, J., Sliger, J., LeBel, M., and O'Reilly, M. (2020). *Taking first steps: Insights for states preparing for electric transportation.* Montpelier, VT: Regulatory Assistance Project

Many states are taking their first steps toward electric transportation, with clear goals in mind including securing the public good.



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Acknowledgments

Editorial assistance was provided by Donna Brutkoski and Ruth Hare.

The authors would like to express their appreciation to the following people who provided helpful insights into an early draft of this paper:

Anne Blair, Southeast Energy Efficiency Alliance
Erin Boyd, Karen Glitman, Larry Goldenhersh and Rebecca Wheeler, Center for Sustainable Energy
Ashley Lynn Chrzaszcz, Kevin Dillon, Jim Ferris and Michael Hornsby, New Jersey Board of Public Utilities
Angela L. Conroy, Virginia Department of Environmental Quality
Annie Gilleo, Greenlots
Emily K. Green, Conservation Law Foundation
Alleyn Harned and Matthew Wade, Virginia Clean Cities
Miles Muller, Natural Resources Defense Council
Chris Nelder, Rocky Mountain Institute
Andrew Twite, Fresh Energy

Abbreviations

C&I . . . . commercial and industrial
CPUC . . . . . . California Public Utilities Commission
DCFC . . . . . . direct current fast charger
EV . . . . electric vehicle
EVSE. . . . . . . electric vehicle supply equipment
kW. . . . . kilowatt
kWh . . . . kilowatt-hour
MUD . . . . multi-unit dwelling
PG&E . . . . . . Pacific Gas & Electric
PSC. . . . . Public Service Commission
PUC . . . . Public Utilities/Utility Commission
SDG&E. . . . . San Diego Gas & Electric Co.
TOU . . . . time-of-use
VER. . . . . variable energy resource
VGI . . . . vehicle-grid integration
ZEV. . . . . zero-emission vehicle

Figures

Executive Summary

As the market for electric vehicles (EVs) in the United States continues to grow, states are beginning to pay more attention to EV-related issues. While no one state agency has clear responsibility, utility commissions are taking their first steps toward determining how best to prepare for, accommodate and promote this transition.

Regulators are meeting with sister state agencies to learn what the others are thinking about these changes. They are meeting with and learning from stakeholders about transportation electrification and the various issues that will need to be addressed to promote beneficial outcomes and avoid unnecessary challenges. And they are reviewing utility proposals to support electrified transportation.

This paper looks at these efforts and identifies insights and lessons learned by utility commissions across the country that are taking their first steps.

Highlights

- Public utility commissions are emerging leaders in states exploring the development of electric transportation.
- Many states recognize the importance of managing EV charging; using rate design as a key management tool; understanding the needs of specific charging market segments; and collecting data to evaluate and improve programs.
- Because programs are what customers see, it is critical that they are designed to ensure that customers of all types are informed and can take advantage of electric transportation opportunities.
- Pilot programs are transitional arrangements that allow utilities and states to experiment and educate themselves under certain time and budget limitations, and to develop pathways for the adoption of better developed proposals for more permanent programs.

Key Findings

Unmanaged EV charging loads could increase the level of stress on the grid unless they are managed effectively. In fact, their flexibility means that EV loads can be deployed as an energy resource, providing benefits such as increased reliability from reducing peak demand and environmental emissions, deferring the need for grid investment, increasing capability to accommodate variable energy resources, and creating conditions favorable to lower-cost EV charging.

Reasonably designed rates are a key to utilities managing EV load and maximizing public benefits from transportation electrification. Regardless of the type of charging — for example, residential, fleet, public DC fast charging or multi-unit dwelling — customers need meaningful price signals to encourage them to charge their vehicles during off-peak periods when the system is less stressed. Rates and related charges also can be designed in a way that will help promote the charging needs of various market segments.

Because electric vehicle supply equipment availability, or its perceived scarcity, is considered a major barrier to transportation electrification, states need to examine and resolve issues around the role of utilities and utility ownership of EV charging infrastructure. In most cases, commissions find themselves in a balancing act. On one side is the desire to promote an EV market and improve the delivery of electric transportation services. On the other is the need to make sure that utility investments neither carry too high a price tag nor eliminate opportunities for competition among market entrants who could provide charging services and benefit the overall power system.

Well-designed electric transportation programs should focus on customers, helping them gain control over their transportation energy bills and empowering them to manage their energy usage. Regulators need to understand the role of utility programs and the effectiveness with which they deliver services to consumers. Utilities should be expected to report meaningful data to regulators that, in turn, demonstrate the effectiveness of EV programs.

Pilot programs can be helpful before the adoption of larger, more permanent programs. They are transitional arrangements that allow for useful experimentation under time and budget limitations, providing opportunities for learning. Pilots should incorporate clear and measurable goals — identifying what success looks like. They may require more extensive and frequent data reporting to enable monitoring and eventual scaling. Customer education is a key pilot program element, helping the public understand the benefits of transportation electrification and educating potential owners about the benefits of an EV.

Introduction

The U.S. market for electric vehicles (EVs) continues to grow. 2018 saw over 360,000 EVs delivered to U.S. car owners, an 81% jump from 2017.[1] By the end of October 2019, over 236,000 more EVs were delivered, an increase of more than 2% over the same three quarters in 2018.[2] EVs are becoming more commonplace; electricity is more and more becoming a transportation fuel, and states are paying attention.[3]

States are taking their first steps toward determining how best to prepare for, accommodate and promote this transition. Specifically, individual state agencies are meeting with each other to learn what others think about these changes. They are also meeting with and learning from stakeholders to educate themselves about transportation electrification and the various issues that will need to be addressed to promote beneficial outcomes and avoid unnecessary challenges.

In this paper, we look at a number of key commonalities shared by states that are taking first steps. They include, for example:

- The near-universal recognition of the value of managing EV charging load.
- The use of rate design as a management tool.
- The need to differentiate between market segments for both program and rate design.
- The importance of collecting relevant and timely data to improve the way these early programs and pilots deliver services to consumers and promote the public good.

States are taking first steps in the transition to EVs

We focus on the role of state utility commissions and the particular elements that they have determined are important to include as they consider these new programs.[4] The discussion is organized around the following topics.

- State processes and stakeholders.
- Early-stage topics to consider, including:
    - EV load as a grid resource
    - Rate design
    - EV charging
    - The consumer perspective and why programs are important
- Key elements of utility EV pilots.

State Processes: Coordination, Stakeholders and Focus

Summary

- State agencies are meeting and coordinating their efforts around electric transportation.
- They are hosting educational and policy discussions with stakeholders.
- They also work with stakeholders to identify key early-stage topics to address, including:
  - EV charging
  - Rate design
  - Education and outreach
  - Reporting requirements

State agencies are meeting and coordinating their efforts around electric transportation. Some agencies are acting at the direction of state legislatures (e.g., California), while others are coordinating and planning this market transformation as part of their existing authority and role in promoting the public interest.

Public utilities commissions (PUCs) are first coordinating with sister agencies.

A typical starting point for state utility commissions is to meet with other agencies to explore different views on the topic of transportation electrification and its relation to their respective subject-matter expertise and jurisdiction.[5] For example, the Texas Public Utility Commission recently convened such a meeting with other state agencies as part of Project 49125, its review of issues related to EVs (see text box at right). The meeting was an opportunity for agencies to share their views regarding their respective responsibilities and to get up to speed on other EV-related work underway across their state government. The opportunity to exchange notes also gave agencies a sense of goals, schedules and the scope of efforts being adopted by sister organizations.

Building on other informal EV-related discussions, the Vermont Public Utility Commission recently conducted a set of workshops and then, in a report to the Legislature, created a list of state agencies that it expects will have a role as electric transportation develops in that state (see text box on the next page).[6]

Initial participants in Texas review of EV issues

- Commission on Environmental Quality
- Department of Licensing and Regulation
- Public Utility Commission of Texas
- Office of Public Utility Counsel
- Department of Transportation
- Department of Motor Vehicles
- Department of Public Safety

These initial steps by Texas and Vermont commissions illustrate how state agencies can coordinate in supporting electric transportation growth and meeting state goals, as they bring into focus their state's role in a growing market for electric transportation.[7]

PUCs are also meeting with external stakeholders.

State agencies have typically followed up these initial internal meetings by convening interested parties to gather various viewpoints on appropriate goals, costs, benefits and

Vermont agencies deemed relevant to electric transportation

- Department of Public Service (the public advocate and energy office)
- Department of Transportation (transportation planner and program manager)
- Agency of Natural Resources (implementer of state and federal environmental laws and overseer of Volkswagen settlement monies)
- Office of Attorney General (consumer protection)
- Agency of Agriculture, Food and Markets (authority over weights and measures and potentially over consumer price disclosure and related information)
- Department of Buildings and General Services (manager of state properties)

other related issues. For example, building on prior in-state efforts,[8] in developing its 2018 *Virginia Energy Plan,* the Virginia Department of Mines, Minerals and Energy conducted significant outreach on various topics, including several facilitated sessions focusing on EVs.[9] Each of the department's EV sessions attracted members of various nongovernmental organizations, municipal governments, planning commissions and other interested citizens.[10]

As another example, the Arizona Corporation Commission recently worked with a similarly broad group of stakeholders composed of various academic institutions, businesses including those related to transportation, nongovernmental organizations and representatives of local government (see the list in Appendix 1). Meeting with external stakeholders allows the discussion to move beyond government to recognize others who will participate in this new market — including auto dealers, charging companies and equipment manufacturers — and can expand the discussion to include experiences from other states.

To ensure that stakeholder processes are broadly representative and promote equity, states will need to explicitly consider the degree to which all consumers have access to electric transportation and the ability to share in its benefits, regardless of consumers' specific economic and geographic circumstances.[11] With respect to organizing convenings, we recommend that states consider consulting the Jemez Principles for Democratic Organizing as a starting point for their efforts to respectfully and cooperatively encourage inclusive stakeholder processes.[12]

To the extent that state public policy and related stakeholder processes recognize equity as part of the broader public interest,[13] one can expect the benefits of electric transportation to be more equally shared. For example, the goal of the Transportation and Climate Initiative — a regional collaboration of 12 Northeast and mid-Atlantic states and the District of Columbia — is to improve transportation, develop the clean energy economy and reduce carbon emissions from the transportation sector.[14] The initiative's Framework for a Draft Regional Policy Proposal adopts equity as its first program design element.[15] The recent joint statement supporting electric transportation that was adopted by the National Consumer Law Center, Natural Resources Defense Council, Illinois Citizens Utility Board and Sierra Club also sets out principles to ensure that low-income consumers will share in the benefits of the transition to electric transportation.

PUCs are relying on stakeholders to dig deeper into relevant issues.

Another typical feature of state agency efforts involves setting out an agenda and list of specific topics for in-depth consideration. For example, the Arizona Corporation Commission's EV policy statement directed staff to develop a list of EV-related topics to explore (see text box on the next page).[16]

The Public Service Commission (PSC) of Maryland, in its effort to transform its electricity grid (Public Conference 44), identified EVs as one of the seven topics of interest.[17] Later, the PSC supported the formation of an EV Working Group, which it charged with looking into the following topics:

- Considering additional rate structures for customers with EVs, including EV-only time-varying rates in all utility territories.
- Planning a limited utility investment in charging infrastructure, or electric vehicle supply equipment (EVSE),

Arizona EV topic list

- Pilot programs
- Rate design
- Cost recovery
- Education and outreach
- Best practices and consumer protections
- Location of EV charging stations and make-ready infrastructure
- Reporting requirements

working with private industry and identifying locations where it is difficult to attract private capital for EVSE investment.

- Developing a strategy in partnership with other state agencies and in consultation with utilities to address grid-related costs associated with vehicle fleet electrification.
- Considering unique tariffs for corporate fleets and workplace and commercial charging.
- Partnering with the Maryland Department of Transportation and the auto industry to promote the cost savings and other benefits of EV rate structures.[18]

These examples illustrate that processes to promote and explore electric transportation can develop cooperatively across state government. They can be set up to address the full suite of issues associated with designing, implementing, monitoring and improving EV programs, as well as adapting them to changing conditions. They also illustrate how stakeholders can be integral to state efforts to develop EV policy by providing useful data and perspectives from other states that have already taken many of these steps. Stakeholder processes are a flexible structure for working through policy questions and resolving conflicts as part of or completely outside a typical quasi-judicial PUC setting. As states take their first steps and explore the many questions that will arise in this context, they can expect to benefit by working across state agencies, convening interested parties and drawing upon their combined expertise.

Questions for PUCs to Consider

1. What agencies in your state are involved in transportation?
2. Has your legislature provided your utility commission or other state agency directions regarding transportation electrification?
3. How is Volkswagen settlement[19] money being used in your state?
4. Has your state convened any discussions about electric transportation?
5. Have stakeholder groups been convened in your state to explore transportation electrification?
6. Have stakeholder convenings in your state encouraged and enabled the participation of environmental and social justice groups?
7. What have the utilities done for transportation electrification?
8. How are utilities engaging with state agencies, fleets, automakers or other stakeholders to advance transportation electrification?
9. What transportation electrification-related industries exist in the state?

Suggested Resources

Vermont Public Utility Commission. (2019). *Promoting the ownership and use of electric vehicles in the state of Vermont.* Montpelier, VT: Author. Retrieved from https://puc.vermont.gov/sites/psbnew/files/doc_library/Electric%20vehicles%20report.pdf

Arizona Corporation Commission Utilities Division, Docket No. RU-00000A-18-0284, memorandum on December 12, 2018 (Arizona Corporation Commission Staff Policy Statement for Electric Vehicles, Electric Vehicle Infrastructure, and the Electrification of the Transportation Sector in Arizona). Retrieved from http://docket.images.azcc.gov/0000194370.pdf

Public Service Commission of Maryland, Case No. 9478, Order No. 88997 on January 14, 2019. Retrieved from https://webapp.psc.state.md.us/newIntranet/Casenum/NewIndex3_VOpenFile.cfm?FilePath=//Coldfusion/Casenum/9400-9499/9478/\109.pdf

Early-Stage Topics

Managing Electric Vehicle Load

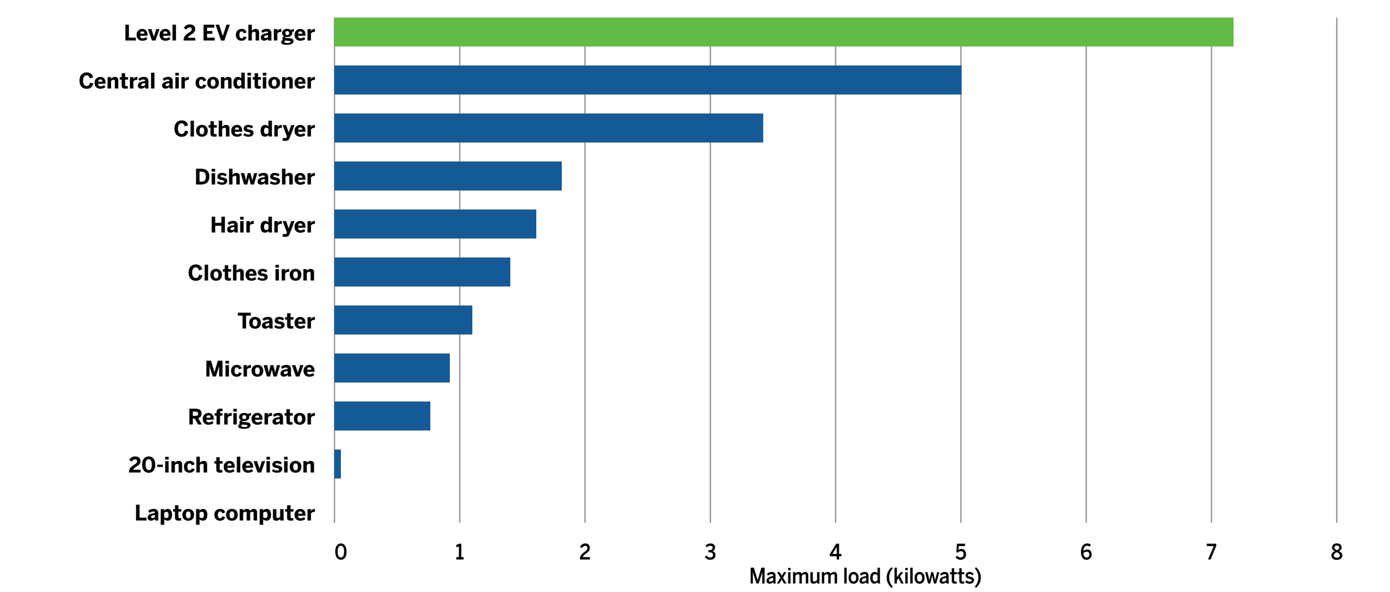
Summary

- Unmanaged EV charging loads could increase the level of stress on the grid, but simple policies and rate designs can drastically reduce grid impacts.
- Because of its flexibility, EV charging load can be managed to provide benefits to the power grid that include:
  - Increased reliability and lower costs from reducing peak demand and, as a related benefit, deferred need for investment in generation, transmission and distribution resources.
  - Increased capabilities to accommodate variable energy resources (VERs), including reducing uneconomic VER curtailments.
  - Reduced environmental emissions due to more efficient use of existing generation resources and increasing utilization of renewable energy.
  - Favorable conditions for lower-cost EV charging, and — coupled with smart management of EV charging load — the opportunity for lower charging rates.
- These attributes mean that rather than simply being a draw on the system, EV load can be deployed like an energy resource on par with traditional, supply-side options.

As regulators convene stakeholders, certain topics of interest are bound to arise. One of them is EV load as a grid resource; others that we discuss in this section are rate design, EV charging and the role of programs.

Due to charging patterns, location, speed and other charging behaviors, large numbers of EVs could either pose problems for the power grid or, properly managed, support the grid and provide substantial benefits. EVs can draw substantial amounts of electricity compared with other household loads. A Level 2 charger,[20] for example, as illustrated in Figure 1,[21] can draw several kilowatts (kWs) more than the typical central air conditioner.

Figure 1. Level 2 charger load compared with other household loads



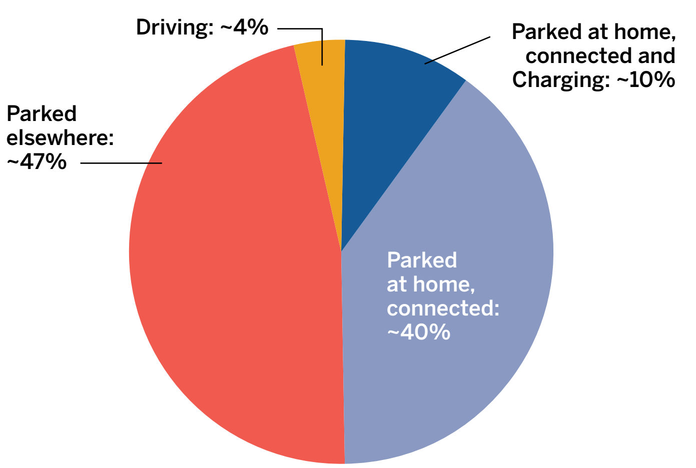
Source: Allison, A., and Whited, M. (2017, March 2). *A Plug for Effective EV Rates*.

The Maryland PSC, in a recent review of EV program proposals, recognized both the challenge and opportunity of increasing EV load. The PSC noted that incremental EV demand could present a technological and economic challenge:

> As the number of EVs in Maryland is projected to grow rapidly in the near term, the deployment of charging infrastructure to support that growth will only increase the level of stress on the distribution grid, especially during peak system hours, which further implicates issues concerning grid reliability and resiliency. Therefore, EV load must be managed effectively, otherwise all ratepayers will share in the expensive costs of upgrading and maintaining the distribution system to accommodate increased load on the system.[22]

Because EVs can charge efficiently over short periods of time and then sit idle for the majority of the day, they are both geographically and temporally flexible load.[23] This charging flexibility is the central reason EV load can be utilized as a resource that can provide potential benefits to the power grid — another technological and economic point not lost on the Maryland PSC. The commission noted that "pairing EV adoption and EV charging with intelligent rate design can improve electric distribution system utilization and create downward pressure on rates through load management and system peak reduction."[24] Figure 2 illustrates that EVs are stationary and available for charging over 95 percent of the day.[25]

Figure 2. Electric vehicles' low capacity utilization makes them potential grid resource



Source: Langton, A., and Crisostomo, N. (2013, October). *Vehicle-Grid Integration: A Vision for Zero-Emission Transportation Interconnected Throughout California's Electricity System.*

EV charging

A **Level 1** is a 120-volt charger (2 kW) that usually comes as standard equipment with an EV and requires an extended time to charge. For example, a Level 1 charger would take approximately 12 hours to charge the 16-kWh battery in a Chevrolet Volt.

A **Level 2** is a 240-volt charger (4 kW) that is controllable and remotely readable and, for example, can charge a 16-kWh battery in approximately four hours.

DC fast chargers (DCFCs) primarily provide direct current at up to 500 volts (20 to 90 kW). DCFCs can charge the majority of EVs to 80% in around 30 to 60 minutes, depending on battery capacity.

Just as EV load can be shifted away from more expensive system peaks to cheaper hours of the day, it can also be moved to times when VERs are more available.[26] The 2018 Virginia Energy Plan notes that "[g]iven its flexibility, EV charging can be used by utilities to make the grid itself more flexible."[27] The growing amount of VERs like solar and wind generation on the grid means that system operators increasingly need this flexibility to focus on meeting net load — the difference between forecast load and the amount of load met by VERs.[28]

The flexibility of EV charging is a key factor in determining its value to the grid.[29] For example, if midday is a peak time for a power grid, the increased EV demand could result in stress and greater expense, as noted by the Maryland PSC in the quote above. Conversely, midday charging could be very desirable if, for example, the grid is rich with solar resources.

As penetration of solar on the grid increases, smart charging will provide the opportunity to take advantage of low-cost, low-emissions power during daytime hours.[30] For example, the California Independent System Operator "duck curve," which shows the significant drop in net load during the daytime hours on its system due to increased solar resource deployment, illustrates how much excess solar power could be usefully employed to charge vehicles with cheap, clean power.[31] So, flexible EV load can not only help reduce peak demand and, as a result, the need for investment in incremental generation, transmission and distribution resources,[32] it could also improve the grid's ability to accommodate greater amounts of VERs if properly incentivized and managed.[33] Consequently, this resource and its flexibility benefits are critical considerations for regulators as they articulate goals of EVSE charging programs and review EV charging proposals.

Smart charging "provide[s] enhanced capabilities that allow for data acquisition, network communication, and demand response, which will allow the Company to determine baseline charging profiles and to ultimately enable demand response programs."

Washington Utilities and Transportation Commission, Docket UE-160082, Order on April 28, 2016

Questions for PUCs to Consider

1. Do utility proposals include load management as part of their plans? Examples of this could include:
    - Reducing peak demand and, as a result, deferring the need for investment in incremental generation, transmission and distribution resources.
    - Managing charging into low-cost hours of the day, thereby enabling lower-cost EV charging.
    - Accommodating increased levels of variable energy resources.

Suggested Resources

Colburn, K. (2017, January 24). Beneficial electrification: A key to better grid management [Blog post]. Regulatory Assistance Project. Retrieved from https://www.raponline.org/blog/beneficial-electrification-a-key-to-better-grid-management/

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Avi, A., and Whited, M. (2017, November). *Electric vehicles are not crashing the grid: Lessons from California.* Cambridge, MA: Synapse Energy Economics. Retrieved from https://www.synapse-energy.com/sites/default/files/EVs-Not-Crashing-Grid-17-025_0.pdf

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Alternative Fuels Data Center, https://afdc.energy.gov/vehicles/electric.html

Rate Design

Summary

- Regardless of the type of charging — for example, residential, fleet or multi-unit dwellings (MUDs) — it is critical for utilities to manage EV load in order for all ratepayers and states to receive the most benefit.
- Reasonably designed rates can avoid circuit overloads and the need to invest in system upgrades by sending price signals to customers that encourage them to charge their vehicles during off-peak periods when there is less stress on the system.
- Effective rate designs can also protect non-EV customers (and EV customers who charge off-peak) from subsidizing the system costs imposed by an EV customer who charges during peak periods.

With increased EV demand on the electric distribution system, it is important that utilities have the ability to manage it, and that regulators are comfortable with their approach. The Michigan PSC has observed that the adoption of EVs "could have an impact on customers' rates and electric distribution systems. This will depend on the nature, timing, and location of charging, as well as consumer adoption rates. The uncertainties in EV adoption rates require utilities to be proactive in understanding and mitigating potential impacts to the grid and related infrastructure costs."[34]

In analyzing the benefits and costs of electric vehicles in five states, M.J. Bradley & Associates has found that off-peak charging can provide net benefits to all utility customers by shifting charging to hours when the grid is underutilized and the cost of electricity is low.[35]

The Washington Utilities and Transportation Commission has also recognized that EV charging services are capable of providing "significant benefits to the overall utility transmission and distribution network if they are properly deployed," but noted that "without a price signal, drivers will generally plug in and charge immediately upon arriving home after work, exacerbating evening peak demand."[36]

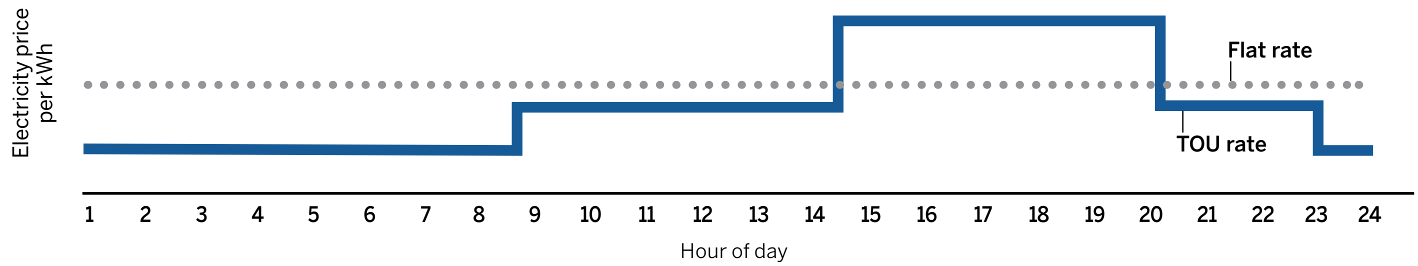
Providing EV customers with clear price signals through rate design is one key to achieving the benefits of EVs. Well-designed rate structures will lead to EV charging that is aligned with grid needs, help increase utilization of existing resources, and reduce costs for all ratepayers. By contrast, poorly designed rates may lead to increased system costs, which can result in higher rates. This section discusses how rate design for residential, commercial and public charging customers can maximize the grid management benefits of EVs and avoid potential pitfalls that could slow the transition to electric transportation.

Using Residential Rates to Send Price Signals

Typical residential rates in the United States consist of a fixed monthly charge and an energy charge, which is a price per kilowatt-hour (kWh) of consumption. Most residential rates apply a flat energy charge — that is, one that does not vary over the course of the day or year.[37] This pricing gives EV drivers no signal to charge in a way that reflects grid conditions. With a flat rate, customers will likely charge whenever it is easiest for them because the cost is the same during all hours. It does not communicate that at some times of the day, power is much cheaper to produce and deliver. Nor does it communicate that at certain times EV charging would benefit grid management because it would increase utilization of existing assets during otherwise low-usage hours. Flat rates also do little to encourage EV adoption, because they don't give drivers the opportunity to obtain very low-cost transportation fuel.

Time-varying energy charges are better able to accomplish these objectives. Standard time-of-use (TOU) rates typically consist of two or more pricing levels based on predetermined time periods. By choosing to charge less during system peak hours and more during off-peak times, EV drivers can benefit the grid and reduce their own costs. TOU rates also have the advantage of being relatively simple for customers to respond to because they know the time periods in advance and can

Figure 3. Illustrative time-of-use pricing



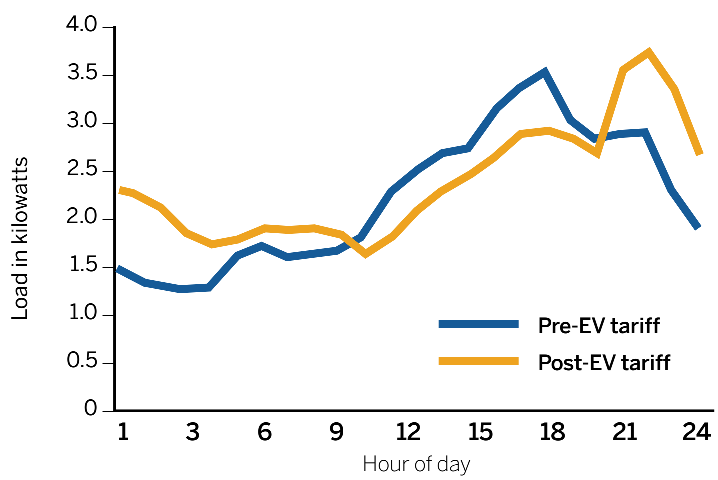
Source: Whited, M., Allison, A., and Wilson, R. (2018, June 25). *Driving Transportation Electrification Forward in New York: Considerations for Effective Transportation Electrification Rate Design.*

use smart chargers and other "set it and forget it" technology to easily respond. For example, 96% of Xcel Energy customers participating in the "Residential EV Service Pilot" tariff are charging during off-peak times with TOU rates, suggesting the effectiveness of this approach.[38] Xcel estimates that participants who primarily charge off-peak will save nearly $10 per month by comparison to the basic rate, assuming usage of at least 350 kWh.[39]

Typically, the wider the divergence between on-peak and off-peak rates, the greater the likelihood that customers will respond to a TOU price signal.[40] This is because the potential savings from aligning usage with prices — as well as the financial consequences for not doing so — are greater than if the differential between on-peak and off-peak rates were much smaller. This is illustrated, for example, by Nevada Energy's TOU EV rate which includes a large differential between on- and off-peak power. Its summertime rate for northern Nevada varies from 40.7 cents/kWh for on-peak power (from 1 to 6 p.m.) to 5.53 cents/kWh for off-peak power (from 10 p.m. to 6 a.m.).[41] A pilot study in San Diego concluded that TOU rates are very effective at encouraging customers to charge during low-cost times, with up to 90% of customers choosing to charge during "super off-peak" periods.[42] Figure 3 shows how a three-tiered TOU rate, with off-peak, midpeak and peak prices, might look compared with a flat rate.[43]

"Whole house" TOU rates apply to all of a customer's load, and EV-only rates apply just to the EV charging portion of the load. Both are effective at encouraging customers to charge EVs off-peak. Baltimore Gas and Electric tested how EV-driving customers would respond to a whole-house TOU rate and found that customer peak load shifted to later evening hours

Figure 4. Customers on time-of-use rates shift their EV charging away from peak periods



Source: Murach, J. (2017). *BGE Electric Vehicle Off Peak Charging Pilot.*

and away from the system peak time of 6 p.m. (see Figure 4).[44] Pacific Gas & Electric (PG&E) customers who have enrolled in EV-only rates charge off-peak 93% of the time; on Southern California Edison's EV-only rate, 88% of charging is off-peak.[45]

Barriers to EV Charging in Commercial and Industrial Rate Design

Time-varying rates are more commonly used in standard tariffs for larger commercial and industrial (C&I) customers. For the same reasons as articulated above, time-varying energy charges in C&I rates that reflect shared system costs will effectively communicate the times at which EV charging will benefit the grid.[46] In addition to time-varying rates, large-customer rates historically have included a demand charge that is measured in kWs and reflects how much power a customer uses at a given time. Utilities apply demand charges based on the maximum amount of power that a customer uses in any interval (typically 15 minutes) during the billing cycle.

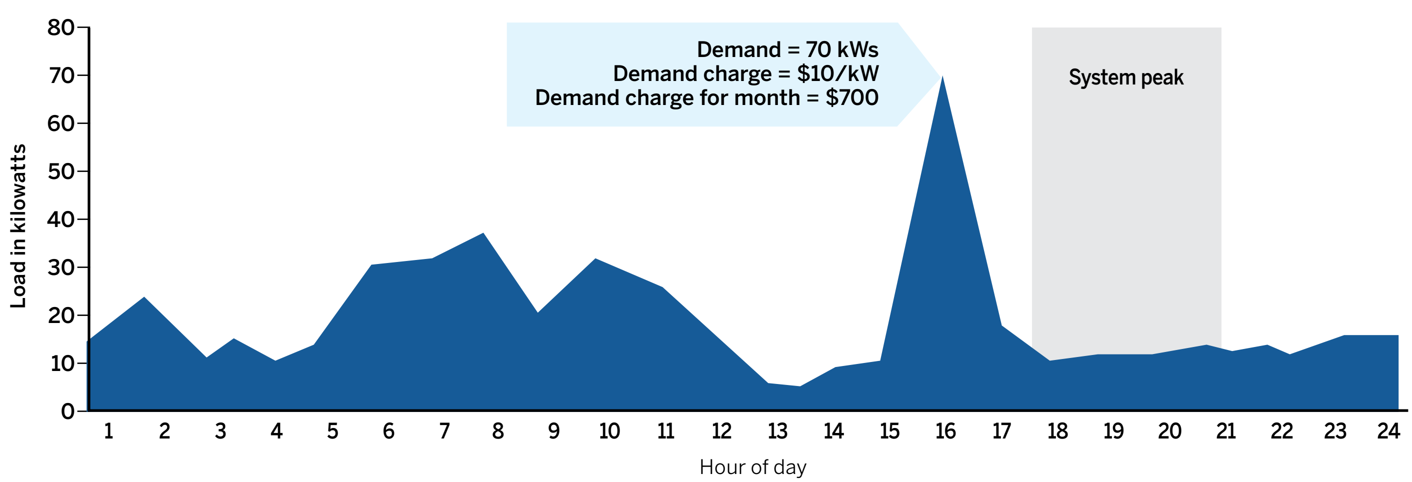
Customer demand is sometimes measured at the same time as the system's peak period (to calculate what are called coincident peak demand charges), but often is measured whenever the customer's individual peak demand occurs, regardless of time. Charges calculated based on the highest instantaneous usage at a given location are called non-coincident peak demand charges. Figure 5 provides an illustration.[47] These so-called demand rates traditionally found in C&I tariff structures were designed for large manufacturing facilities, which use electricity much more constantly than EV charging. As a result, they do not account well for the flexible nature of, nor the actual costs to serve, EV charging.

Demand charges should also be reconsidered in light of their impacts on the economics of EV charging. Vehicle charging can cause spikes in demand, triggering a high demand charge. Demand charges can effectively become a fixed charge that cannot be avoided by better managing EV charging into lower-cost times of day. For businesses subject to a demand charge in their tariff, installing vehicle charging can greatly increase their monthly utility bills, discouraging them from providing charging to employees or patrons. And for potential owners and operators of electric transportation technologies — including fleet operators, trucking companies and individual drivers — demand charge rates can lead to fuel costs that are greater than the costs of gasoline or diesel, which eliminates the potential economic benefit of electrified transportation.

In October 2019, the California Public Utilities Commission (CPUC) approved a modified proposal from PG&E that is designed to address some of the challenges with demand charges we describe.[48] The new rates apply to smaller workplaces and multifamily dwellings, as well as larger installations such as those for public fast chargers. With this rate design, the company is replacing demand charges with "subscription pricing," a monthly fee that allows customers to choose the amount of power based on their charging needs. For example, a customer will pay a certain price for a 50-kW connection. If that demand is exceeded during the month, the customer could pay an overage after a three-month grace period, but the subscription price does not change. In other words, the overage does not establish a new demand level (as would be typical of demand charges) that could automatically ratchet up a demand charge. Energy usage will be based on TOU pricing with peak, partial-peak and off-peak rates. PG&E expects[49] this design to result in significant savings over existing C&I rates, particularly for fast charging and workplace charging. Importantly, these new rates are not "subsidized" by other customers, meaning that the rates are designed to recover the costs to serve the EV customers.

Southern California Edison recently gained approval from the CPUC for a new tariff design for commercial customers that eliminates demand charges for the first five years of the program.[50] The charge will be phased back in over the following five years, as EV adoption is expected to grow. With higher utilization rates, the per-kWh costs at individual

Figure 5. Illustrative non-coincident peak demand charge



chargers will decline, making the impact of demand charges more manageable from the perspective of an individual driver or commercial business that wishes to offer EV charging.

EV Barriers in Public Charging Rate Design

Public charging and fleet charging (see text box) via DC fast charging stations faces similar challenges with respect to rate design as described above for larger customers.[51] In fact, many DCFC stations are billed on a commercial rate, and the difficulties that demand charges pose for charging economics are much more pronounced for these stations. Most DCFC stations have low overall usage (in total kWhs) but have significant spikes in demand due to the high-power delivery nature of the chargers. This means demand charges can be significant portions of the overall bill for public chargers — accounting for more than 90% of costs at some chargers in California.[52] This can make the economics of charging at these stations very difficult. The new Pacific Gas & Electric rates described above are expected to generate significant bill savings for customers using DCFC.

In conclusion, rate design can ensure that the price signals sent to customers reflect power system needs, and help utilities manage EV loads. Through lower costs, rate design can encourage customers to help with integrating variable energy resources and contributing to grid reliability. Time-varying rates can be designed to help utilities and customers take advantage of these opportunities to shift and control load when it benefits the system. And time-varying rates can refine and direct price signals, helping grid managers while saving consumers money. Unless they adopt these kinds of rates, states are less likely to see investment in EVs and more likely to require distribution system investment to accommodate unnecessary costs associated with increasing system peaks.

Smoothing the way for electrifying public transit fleets

Where demand charges are used to recover costs not directly associated with dedicated facilities installed to meet customer demand, it poses significant challenges for the economics of electrifying public transit fleets. Public transit fleet chargers face many of the same challenges as public fast chargers: Demand spikes can be significant due to the need to charge a large vehicle quickly, but overall utilization of charging infrastructure may be low (at least in the early stages). This can make the cost per mile for going electric prohibitive.

Fleet managers will need to charge buses in a manner that meets route scheduling needs and may not be able to schedule charging over longer time periods in order to reduce demand levels. Helping public transit fleets to electrify by designing rate structures with low (or no) demand charges is one way for utilities to encourage beneficial electrification and build “good” load at the same time. PG&E’s newly approved EV commercial tariffs are an example of rate structures that will make a significant difference for transit operators, bringing the expected average fuel cost well below that of diesel.

Questions for PUCs to Consider

1. What are the underlying conditions (e.g., peaking) on your electric system throughout different times of day and across seasons?
2. How do system conditions and resource availability influence costs to serve at different times of day and across seasons?
3. Would rate design pilots be useful in your state in order to test customer responsiveness to different kinds of price signals, or is enough already known from pilots in other states?
4. Should rate designs be paired with deployment of smart charging infrastructure to assist customers in responding to price signals?
5. Are utilities proposing innovative rate designs that include time-varying energy charges and the elimination or reduction of (particularly non-coincident) demand charges for residential, commercial and industrial classes?
6. Are proposed rate designs adequate to overcome site host concerns, encourage EV adoption and achieve state objectives?

Suggested Resources

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EV Charging

Summary

- Because the lack of EVSE availability and limited private sector investment could pose a major barrier to transportation electrification, states need to examine and resolve issues around utility ownership of EVSE and cost recovery for investments that encourage the development of infrastructure in various charging market segments.
- States define the legal status of EV charging service providers through legislation or administrative action.
- The general trend has been to exempt EV charging service providers from regulatory treatment as a public utility.
- There are several models of EVSE ownership ranging from typical distribution customer service that requires greater investment by site hosts, to more extensive utility investment that is included in utility rates.
- There are various categories of charging service users, including residential; MUD; workplace and commercial; public; and transit.
- Each segment has its own characteristics, such as charging power levels, optimal charging times, and degree of commercial charging market penetration and associated need for utility involvement.

One of the major challenges to electrifying transportation is the need to ensure the availability of sufficient charging infrastructure,[53] also known as electric vehicle supply equipment, which is illustrated in Figure 6. Various planning tools are generally available that can help inform discussions about charging infrastructure. These include the National Renewable Energy Laboratory's EVI-Pro,[54] University of California, Davis' Electric Vehicle Planning Toolkit[55] and M.J. Bradley & Associates' Electric Vehicle Infrastructure Location Identification Tools.[56]

Developing an adequate charging system is sometimes characterized as one part of a chicken-and-egg problem: There are no EVs because there is no EVSE; or there is no EVSE because there are no EVs. Another viewpoint, adopted by researchers at Idaho National Laboratory, is that public charging infrastructure is not needed everywhere to enable plug-in electric vehicle adoption. Instead, charging infrastructure should be focused at homes, workplaces and public "hot spots" that serve multiple venues.[57]

As part of this policy discussion, states need to examine and resolve issues around the proper role of utility investment in EVSE. In exploring this and other EV charging-related questions, states have focused on three related topics: the legal status of charging service providers; the ownership of EVSE; and the needs of various charging market segments. We discuss each of these in turn.

Should EV charging service providers be treated the same as utilities or not subject to oversight? Should regulation be somewhere in the middle?

Licensing EV Charging Service Providers

EV charging service providers such as Greenlots or EVgo appear to sell electricity like regulated electric utilities. This prompts several questions: Should they be treated the same as utilities or not subject to oversight? Should regulation be somewhere in the middle, perhaps certifying them like competitive retail service providers? These are questions for each state to answer, because utility service requirements are established and enforced under state authority and pursuant to state goals and policies.[58]

The general trend has been to conclude that charging station owners and operators should not be regulated as public utilities solely because they charge EVs.[59] Kentucky, for example, recently reached that conclusion, noting that, in states that have exempted charging service providers, "regulatory commissions have determined either that an EVCS [electric vehicle charging station] provides service to a limited, defined class, and therefore does not provide service to or for the public, or that an EVCS provides a service where electricity is incidental to the transaction."[60] PUCs examining this question should look to the CPUC, the first state regulatory body to grapple with this question, which found (and whose language was later codified by the state Legislature): "The ownership, control, operation, or management of a facility that supplies electricity to the public only for use to charge light duty plug-in electric vehicles does not make the corporation or person a public utility within the meaning of this section solely because of that ownership, control, operation, or management."[61]

States have defined the legal status of EV charging service providers through legislation, as is the case, for example, in Hawaii.[62] They have also followed the approach adopted by the state of New York and addressed the question through administrative action.[63]

It is worth noting that the Vermont PUC's initial meetings included the Vermont Agency of Agriculture, Food and Markets because of its authority over weights and measures and potentially over consumer price disclosure and related information. When using a charger, a customer may know the difference between a Level 2 and a DCFC, but the customer may not know its capacity (kWs) or its amperage. Basic labeling requirements will help a customer know, for example, whether she is paying $10 for 30 minutes at a DCFC at 50 kWs or 150 kWs or spending $10 for 2 hours at a Level 2 at 30 amps or 40 amps.

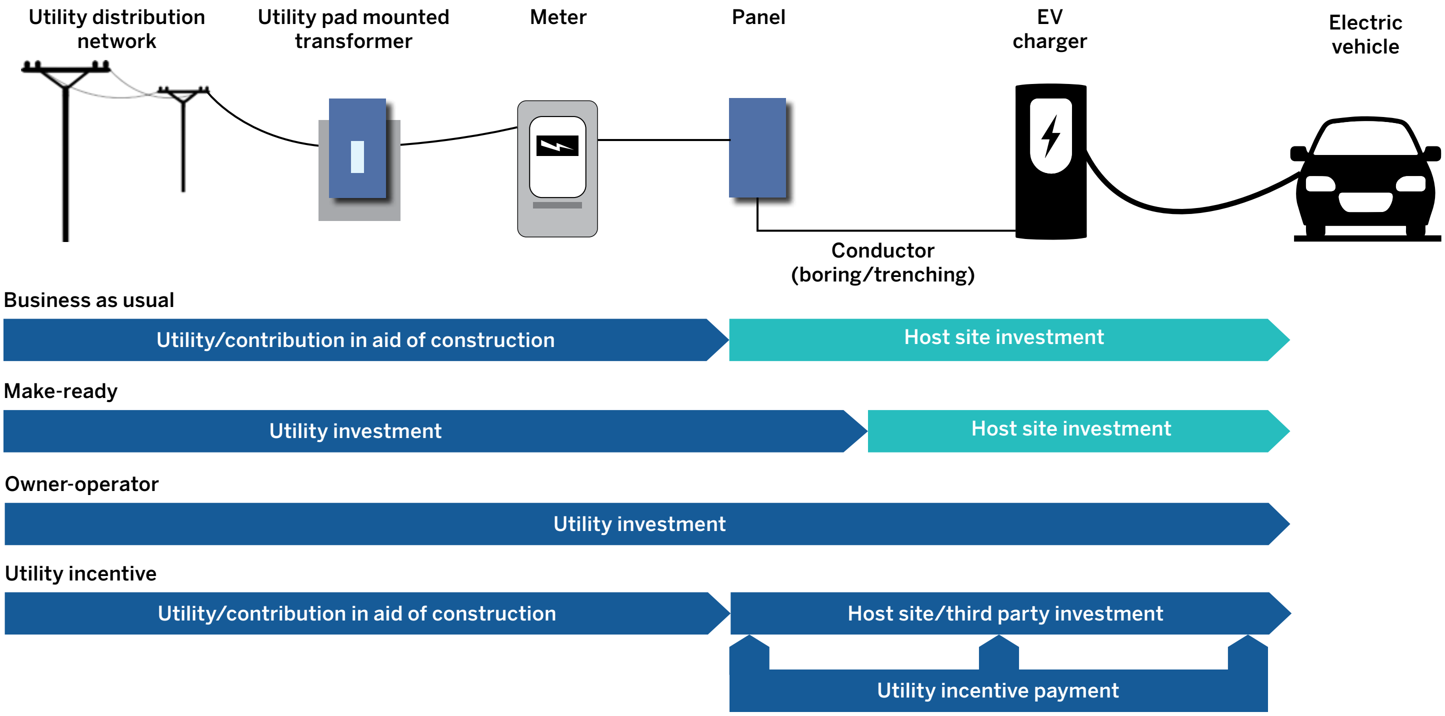
EVSE and EVSE Ownership

States have also considered the question of who should own EVSE. The diagram across the top of Figure 6[64] illustrates the basic elements of EVSE. The common elements start where a utility's distribution network connects to the property where an EV charger is located. The distribution line first goes through a separate transformer, where necessary.[65] A customer meter typically follows and connects to a service panel that joins with an EV charger. The EV charger, in turn, connects to the vehicle.

The horizontal blue lines along the bottom of Figure 6 illustrate various EVSE ownership models. The top line, business as usual, demonstrates how utilities typically connect to their customers, as well as the amount of the infrastructure that the utility would own and on which it would earn its rate of return.

The make-ready approach, the second line in Figure 6, provides some incentive to utilities to build EVSE while attempting to preserve a role for third-party EVSE providers. Make-ready builds on the business as usual model and

Figure 6. Basic elements of electric vehicle supply equipment and models of utility investment



Source: Based on Allen, P., Bradbury, J., Goetz, M., Van Horn, G., and Zyla, K. (2017, November). *Utility Investment in Electric Vehicle Charging Infrastructure: Key Regulatory Considerations.*

includes a service panel and any necessary conduit and wiring. Depending on circumstances, this additional infrastructure can be significant, e.g., require trenching and repaving.[66] Make-ready provides an incentive (including associated return on investment) to support EV buildout needs by allowing a limited, additional amount of ownership by the utility.

The way the PSC of Washington, D.C., treated Potomac Electric Power Co.'s 2018 proposal illustrates a typical approach to make-ready EVSE cost recovery.[67] The regulator allows the company to recover its costs (net of participant and external funding) through traditional cost recovery methods, rate-basing its make-ready investments and creating a regulatory asset for operations and maintenance costs to be amortized over five years.[68]

The owner-operator approach, line three in Figure 6, depicts a model where the utility invests in, owns and gets a return on all the EVSE — distribution line to charger. Finally, what is labeled the utility incentive model is an approach whereby the utility owns the same amount of EVSE that it would own under the business as usual model, but also receives a return on the incentives it pays a site host or third party to build out the remainder of the EVSE.

The Vermont PUC has taken the position that "utilities are uniquely situated to ensure that EV charging stations are deployed in underserved areas and that new load from EVs is incorporated in a safe, reliable, and efficient manner."[69] The PUC notes that, to develop an EV market, the state must overcome the fact that the "business case for investing in, owning, and operating public charging infrastructure is not attractive for private investment alone."[70] Following this rationale, if private investment is less likely, at least in the near term, utility ownership would be justified.

Other regulatory commissions acknowledged this ownership challenge and have attempted to find solutions. The Washington Utilities and Transportation Commission, for example, authorized Avista's ownership of certain EVSE in its pilot program but recognized that the topic of EVSE ownership would be revisited post-pilot.[71] The Massachusetts Department of Public Utilities has also considered this question. It articulated a test for approval of utility EVSE investments that are part of programs it has approved.[72] The test is discussed further below in the context of MUDs. Essentially, it provides that, where there is the potential for private investment in EVSE, a utility need not be the go-to source of investment and ownership. As states consider this issue, it will be an important part of commission deliberations.

Apart from the four utility EVSE approaches described above, ownership can be tied to the term of the utility pilot program. This approach is illustrated in a recent Xcel pilot that provides residential customers two options for acquiring EVSE: one where customers prepay for the smart charger and another where customers pay for it over time.[73] In both cases, Xcel owns the smart chargers during the pilot program. At the end of the pilot, customers who prepay can "take ownership" and either revert to their prior rate or move to any new tariff compatible with their charger. Alternatively, they can replace or upgrade the charger if a new tariff requires different technology. Customers who do not prepay are also able to revert to their prior rate (with Xcel removing the charger) or move to a new EV tariff and, where necessary, have the charger replaced or upgraded. Xcel also gives the customers the opportunity to purchase the charger at a cost that reflects its undepreciated balance.

It is also important to note that, despite public utilities being in a useful position to invest in EVSE, there are additional sources of funding that states should recognize. For example, Volkswagen settlement funding is being used around the country to make these investments. Washington, Hawaii, Rhode Island and Vermont were recently praised for committing "substantial amounts to accelerate electrification, including electrifying their mass transit systems."[74] In order to promote the public good, states should consider working in coordination with utilities and private industry to plan for and develop EVSE.

Charging Market Segments

In addition to understanding what EVSE is and who can own it, there are also various "use categories" for EVSE. We consider several of these market segments here and point out some of the challenges associated with each category. In most cases, review and approval of utility charging proposals requires commissions to balance the desire to promote an EV market, and to learn how to improve the delivery of electric transportation services, with the need to make sure that utility investments neither carry too high a price tag nor discourage opportunities for competition among market entrants who could provide charging services.[75]

Residential Charging

Utility residential charging programs commonly focus on helping customers install Level 2 chargers. Smart Level 2 chargers, typically 240 volts, by definition are controllable; i.e., they allow management of EV charging. While utility program approvals are based on the consideration of numerous factors, regulators naturally will be concerned about program costs compared with the benefits.

In their review of a residential charging proposal, Maryland regulators recently approved rebates for the incremental cost of smart Level 2 chargers versus chargers that aren't controllable.[76] The Maryland PSC's determination was based upon several factors including the incremental cost of a charging station, and whether its functionality allows for controlled charging. Determining that the average difference in price between a smart (controllable and remotely readable) and non-smart charger is in the $300 range, the commission concluded that setting the level of the rebate to that amount would "lower ratepayer impact, ratepayer risk, and customer cross-subsidization."[77] The commission also emphasized that there is "value in collecting usage data and determining how load management profiles can be shaped by using smart chargers."[78]

Creatively securing load management benefits is also a notable aspect of several regulatory approvals of residential charging proposals. In May 2018, the Minnesota PUC approved Xcel Energy's Residential EV Subscription Pilot, which supplemented an existing off-peak rate for EVs that required customers to pay for a second meter.[79] Concern over low participation prompted a coalition of advocates[80] to argue for a modification that allowed for the use of lower-cost chargers (i.e., wireless-capable EVSE and a customer's home wireless network) instead of a second meter, as required by the existing tariff. The company agreed to the modification and the PUC approved it, which allowed customers to avoid the need for a second utility-grade meter — reportedly an outlay of over $2,000 per meter. Xcel's report on the status of the pilot indicates that 96% of the charging occurring under that pilot has been off-peak, suggesting that the pricing signals are effective.[81] The pilot has been so successful that Xcel has filed to make it a permanent offering open to all customers. The request is under PUC review in Docket 19-559.[82]

The Michigan PSC approved a similar change to an Indiana Michigan Power Co. residential charging tariff where customers had the choice of either: (1) paying for their entire household usage, including EV charging, under a time-of-day rate; or (2) paying for EV charging under a time-of-day rate and separately metering and billing all other household usage under a standard, non-time-of-day rate.[83] The PSC reached a similar conclusion as the Minnesota utilities commission in the Xcel case, allowing for the customer to be charged for its full residential load as measured by the primary meter, but then to use data from the separate submeter to reflect the application of the time-differentiated rates under the company's EV tariff for EV charging.

Multi-Unit Dwelling Charging

One of the many challenges associated with encouraging EV market development is ensuring access to charging for people in MUDs. Nationwide, most EV charging across the country occurs at home. In California, over 30% of dwelling units are condominiums and apartments. In 2015, these homes, however, represented less than 5% of home-based charging in the state.[84]

The inability to secure charging for MUD inhabitants who do not have ready access to EVSE suggests that meeting this market segment's charging needs will be difficult in the absence of policy intervention. Multifamily dwellings and condo associations often have complex bylaws and rules that have the effect of restricting EV charging. Utility involvement in this segment may level the playing field so that individual EV owners don't have to go it alone when trying to overcome these barriers.

In November 2017, the Massachusetts Department of Public Utilities approved an Eversource plan to deploy Level 2 chargers for public parking areas, workplaces, universities, governments and multi-unit dwellings; DCFCs along high-density corridors, rest stops and fueling stops; and for community charging in high density areas in the state. The department applied its test for determining the suitability of utility ownership of EVSE in these segments. It concluded that, under the circumstances, the company proposal meets the standards the commission adopted. It determined that Eversource's proposal: "(1) is in the public interest; (2) meets a need regarding the advancement of EVs in the Commonwealth that is not likely to be met by the competitive EV market; and (3) does not hinder the development of the competitive EV charging market."[85]

Massachusetts criteria for utility ownership of EVSE

1. It is part of a program determined to be in the public interest.
2. It meets a need regarding the advancement of EVs in the Commonwealth that is not likely to be met by the competitive EV market.
3. It will not hinder the development of the competitive EV charging market.

The Maryland PSC determined that multifamily and MUD market segments are underserved in part due to limited off-street parking opportunities, and that meeting those needs would help promote equity by providing the "access to EVs for the underserved and low-income communities."[86] The PSC also noted that for a number of reasons, "competitive market participants have been unsuccessful in meeting demand in the low-income and MUD segment."[87] The PSC consequently determined that "the inclusion of a MUD-focused offering serves a public interest by providing equitable access to EV charging for underserved areas" and would afford the utilities[88] "the opportunity to test whether these incentives can encourage a broader range of communities to purchase electric vehicles."[89]

Public and Fleet Charging

As with regulators' decisions on MUD charging proposals, implicit in regulators' decisions about public charging is an acknowledgment that this nascent market may not be immediately ready to provide a return for private investors and, as a result, some utility investment is justified.

In July 2019, the Minnesota PUC approved an Xcel Energy proposal for fleet charging, authorizing the company to invest in and maintain charging infrastructure for Metro Transit (the primary public transportation operator in the Minneapolis-St. Paul area), the Minnesota Department of Administration and the city of Minneapolis.[90] The program will develop EVSE under a make-ready approach and support Metro Transit in its investment in electric buses, and the Department of Administration and city of Minneapolis in electrifying their fleets.[91] Along with its approval of Xcel Energy's Metro Transit fleet charging proposal, the PUC also approved Xcel's proposal to invest in, install and maintain make-ready infrastructure for site hosts and developers of public fast-charging stations along corridors within the utility's service territory, as well as for a network of EV community mobility hubs.[92]

The commission notes that a central purpose of these pilots is to "investigate the extent to which socializing the costs of this EV-related infrastructure will encourage EV adoption, and to measure the benefit that increased EV adoption provides to ratepayers."[93] It adds that "Xcel's proposal to install, maintain, and own infrastructure is an essential and necessary part of these pilots," reasonable under the circumstances, and helpful to the commission and stakeholders in evaluating "the extent to which these investments will benefit the public."

Emphasizing market immaturity and the need to gather data on charging behavior, the Maryland PSC approved limited deployment and utility ownership of EVSE at public properties (see text box).[94] It approved a limited deployment of public charging equipment because the commission was not convinced with the analysis done regarding the number of charging stations needed. Highlighting the ability to learn from data gathered at these stations to determine the effectiveness of these types of programs, the PSC approved utility ownership and operation of the chargers, but limited the ownership opportunity to installations located at public properties.

The Maryland PSC approved pilots for MUDs and for EVSE on public property but noted a number of reasons why it was not approving other aspects of the companies' petitions. While acknowledging its support for many aspects of the petition that it reviewed, the PSC wrote that it had to balance those elements against other considerations, including:

- Coordination with the full suite of state programs and initiatives.
- The appropriate size of an EV charging program.
- The level of utility involvement.
- The ratepayer impacts.
- The cost-effectiveness of the program.
- The overall benefits to all Maryland ratepayers.
- Unnecessary duplication with other programs.
- The potential impediments to competition by market participants.[95]

The PSC found that the petition's pilots, as proposed, were "overly broad and costly to ratepayers." But it recognized that, as modified, components of the petition would be informative and have positive "potential impacts and implications for the electric distribution grid, including reliability, load management, improved system efficiency, and whether a wider expansion of a ratepayer funded EV charging network would be appropriate in the future."[96]

In June 2019, the Nevada PUC approved an electric vehicle infrastructure demonstration program for Nevada Power. With this program, the company is allowed to own DCFCs. It also agrees to, among other things, provide rebates for public charging in designated highway corridors, and to file a "demand charge transition tariff" for DCFCs.[97] Although the order is limited in its discussion, it appears that the PUC

> *Although the Commission has adopted a policy in favor of competitive markets as an integral part of the State's electricity landscape ... public charging deployment has yet to attract sufficient levels of private investment to align with the State's EV adoption and [greenhouse gas] reduction goals. Several participants acknowledged during these proceedings that there are not enough EVs in Maryland to provide a return on investment for private market participants. And where private companies have been unable or unwilling to make initial capital investments in difficult and underserved areas, utility ownership can help reach these market segments faster.*
>
> Maryland PSC Order 88997, January 2019, p. 63.

recognized that it is looking at a transition period in which EVSE deployment has to occur at a fairly rapid pace. The commission gave the utility two years to put the demonstration program in place. Furthermore, it required Nevada Power to deploy Level 2 chargers that support more than one type of vehicle make, encouraging greater vendor access.

Workplace and Commercial Charging

The ability to plug in while at work may prove to be a critical piece of the EVSE development challenge.

A 2015 analysis by Idaho National Laboratory shows that EV owners charge more than 85% of the time at home, but when they are away from home, they tend "to favor just a few public charging stations, with workplace stations being most popular."[98]

As with other charging proposals, commission approvals of those related to workplace charging balance the goals of grid management and promoting EV adoption through greater availability of EVSE with the need to protect ratepayers, by promoting an EV market that is not unnecessarily expensive but is also welcoming to non-utility players.

The CPUC approved the San Diego Gas & Electric Co. (SDG&E) "Power Your Drive" program, which authorizes the development of charging infrastructure at MUDs and workplaces.[99] The CPUC authorized the company to own the EVSE it installs. Despite this, SDG&E relies on multiple EV service providers, and this allows customers some choice of vendor, service and equipment.[100]

The CPUC also recognized additional challenges of securing charging sites in this submarket: "property owners of prospective MUD and workplace sites will need to consent, provide an easement, and pay a participation fee."[101] It also found that getting "sufficient property owners to agree to the preconditions of siting an EV site installation and associated EVSE at a MUD or workplace may prove more difficult to obtain than in theory."[102]

In addition to noting testimony that recognizes specific barriers associated with serving MUDs and workplaces with EVSE, regulators also acknowledge that there are potentially more positive aspects worth considering. They recognized evidence suggesting that workplaces might want to provide "free or reduced fees to charge their employees' EVs," and that workplaces "may want an EV site installation as a symbol of their environmental consciousness."[103]

For purposes of this program, SDG&E developed an hourly rate design that is calculated "for each circuit based on projected demand and communicated to enrolled drivers daily for the following day."[104] Like a TOU rate that reflects on- and off-peak pricing to benefit management of the grid, this rate is also designed to encourage grid utilization but down to the circuit level. The company reports that this rate has been effective at modifying charging behavior in response to pricing incentives.[105]

The CPUC approved Southern California Edison's "Charge Ready" Program Pilot to provide charging services to non-residential, long dwell-time locations (i.e., where EVs are usually parked for at least four hours) including workplaces.[106]

Following a make-ready approach, the company was authorized to install, own and maintain all related costs for all distribution infrastructure including any necessary transformers, service lines and meters dedicated to EV charging equipment deployed under the program.[107]

In its review of this proposal, the CPUC recognized that EV charging for workplaces could help support the grid and inform load management and pricing strategies for this subsegment of the charging market (see text box).[108] The CPUC required Southern California Edison to consider its demand response pilots and how workplace and other charging segments (fleet and destination center) would inform load management strategies.[109]

Load management metrics suggested by CPUC

1. Capacity factors for renewable generators.
2. Coincidence of customers' use of preferred resource.
3. Customer load factor.
4. Curtailment of renewable energy.
5. Utilization of EVSE.
6. Strategic placement of EVSE, and as applicable the associated distributed energy resources, consistent with the system locational benefit considerations of Assembly Bill 327 and Rulemaking 14-08-013.

In each of these examples, in addition to considering specific factors affecting the submarket, utility regulators reviewing potential charging proposals balance purported benefits with proposed costs. Commissions must balance the value of learning how, in specific market contexts, to accommodate EVs on the power system and improve the delivery of electric transportation services against the desire to make sure that utility investments are neither too high nor produce barriers to opportunities for competition among potential market entrants.

Questions for PUCs to Consider

1. What is the current market penetration of EVs in your state?
2. What are the projected EV penetration rates in the next three to five years?
3. Has your state articulated an EV adoption goal?
4. Do you have data about how and where EV drivers charge, and is it broken down by market segment?
5. Has your state adopted any policy affecting utility ownership of EVSE?
6. Are any market segments receiving EVSE investment support, such as Volkswagen settlement money?

Suggested Resources

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Why Programs Are So Important: The Consumer Perspective

Summary

- Programs are what customers see; they should be accessible and helpful.
- Programs benefit from market intelligence and stakeholder input and are successful when they respond to the interests of all customers.
- Electric transportation programs can help customers gain control over their transportation energy bills and empower them to manage their energy usage.
- Regulators should be able to appreciate the role of utility programs and the effectiveness with which they deliver services to consumers.
- Utilities should be expected to report meaningful data to regulators that, in turn, demonstrate the effectiveness of EV programs.

At a meeting several years ago, ICF International's Gene Rodrigues — at that time, senior director of demand-side management strategy for Southern California Edison — offered an especially wry comment about his work to a room full of utility regulators. "Regulators think that Southern Cal Edison implements efficiency programs," he said. "We don't." He paused a second, then added, "We sell efficiency."

His remarks were not intended simply to catch the audience's attention. What he was saying was that selling anything, even energy efficiency, has little in common with program implementation. Instead, it is more about people and how they learn about and understand the product he is selling. This is a critical distinction.

Up to this point, this paper has explored electric transportation topics to help utility regulators picture and appreciate a PUC's role in — as Rodrigues put it — implementing programs. The paper has not looked at these issues from the perspective of consumers, who, after all, are the critical element of getting EV markets underway.

Appreciating this perspective requires consideration of the following:

- What does the buying of an EV look like to someone who has just become interested in one?
- Who answers all the questions that a would-be EV buyer might have?
- To get the most suitable charging arrangement, what are the different hoops that a buyer must jump though?
- Are there tax breaks or rebates available to make all of this less costly?
- What other obstacles will arise?
- At what point does a buyer risk losing interest because she lacks clarity about the various steps she needs to take?
- And at what point might she become discouraged enough to change her mind about an EV and instead simply purchase a more traditional vehicle with which she is more familiar?

These sorts of questions should be raised and answered for all of the various EV market segments that states expect utilities to develop.

Because utilities and other third parties already have expertise and access to customers, regulators should not be expected to have direct involvement in designing programs that provide services necessary for an EV market. However, regulators seeking to ensure broad participation in EV markets should be able to appreciate the role of utility programs and the effectiveness with which they deliver services to consumers. And utilities should be expected to report meaningful data to regulators that, in turn, demonstrate the effectiveness of EV programs.[110]

PG&E's EV Charge Network Program is an example of a company program designed to overcome initial barriers and meet crucial public interest goals. It focuses on two market segments in its territory: workplaces and multi-unit dwellings.[111] The program also includes the goal of deploying charging in disadvantaged communities. PG&E makes available EVSE in two ownership formats. The first is a make-ready approach where the site host owns the EV charging station. The second approach (limited to 35% of the installations) allows for a utility-owned turnkey operation applied in the context of MUDs and disadvantaged communities. The program design recognizes challenges in these market subsets — that is, the limitations on the ability of individuals to be site hosts — and seeks to meet their needs accordingly.

To help in its marketing, PG&E developed a website that provides information about its programs and content that is specifically focused to improve customer engagement and understanding.[112] The utility is also required to take feedback on its marketing, education and outreach through various approaches. One involves the use of an "interest form" that the company distributes and retrieves from customers to provide further outreach and to encourage their participation.

PG&E also uses the feedback it gets through periodic meetings with a program advisory council composed of stakeholders from industry, government and nongovernmental organizations. Regulators furthermore require PG&E to submit a marketing, education and outreach strategy which provides regulators with insight into PG&E's sense of the EV market and major issues that the company is facing.

There is certainly more to program design than this short discussion can provide. It is important to recognize that legislative support and regulatory oversight are key ingredients of effective utility programs. However, it should be clear that — in addition to reviewing the economics and engineering associated with utility proposals — utility regulators will benefit from looking at utility programs with an eye toward how they motivate potential customers. Regulators will need to determine how well the utilities know the market and submarkets for charging. And utilities should be able to explain their rationale for promoting EV-related services; for example, the reasoning behind the level of incentives they propose to provide to various types of customers. At the very least, regulators should remember Gene Rodrigues' observation: Utilities need to be able to sell these services to customers.

Questions for PUCs to Consider

1. Do your state's utilities offer, or are they planning to offer, EV-related programs? If not, why not?
2. Do utility proposals demonstrate an understanding of the needs of various market segments and the ability to provide them with EV-related services?
3. Do programs or proposed programs demonstrate how the utility will motivate customer behavior?
4. Do utility program proposals make use of third parties to meet the needs of various market segments?
5. Do the programs track data to enable policymakers, regulators and the utility to refine and improve them to achieve desired outcomes?

Suggested Resources

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Key Elements of Utility EV Pilots

Summary

- Pilot programs are transitional arrangements that allow experimentation under certain time and budget limitations and provide opportunities for learning and gaining experience that would support scaling up to more permanent programs.
- While pilots should incorporate clear and measurable goals, regulators should be willing to depart somewhat from the traditional cost/benefit standards of review they are accustomed to applying to utility investments.
- Given the short duration of pilots, regulators may need to require more extensive and frequent data reporting than they might normally require in order to monitor progress and, where necessary, take corrective action.
- Customer education will be a key to helping consumers realize that their adoption of EVs could be beneficial.
- Pilot programs should contain agreed-upon provisions for specific next steps.

The collective thinking about how various aspects of EV markets should develop has evolved significantly around the country in recent years, but not so much that a uniform "roadmap" for all states has emerged. While such a framework, in fact, may never appear, it is still useful to get a sense of some of the approaches that states taking their first steps have adopted by reviewing, conditioning and approving utility EV pilot programs.[113, 114]

Pilot programs are transitional arrangements that allow experimentation under certain time and budget limitations and provide utilities and regulators an opportunity to test ideas, develop capabilities and gain experience before committing to typically larger-scale and more permanent programs. Pilots can be structured to promote both state and utility goals, including equitable service to all customer segments. Examples of goals include ensuring economic and environmental benefits, flexible loads for purposes of grid management, data transparency, and outreach and education. A pilot can also be designed to include provisions for course corrections if necessary, and to scale smoothly into a permanent program with minimum hurdles and lag time when it is determined that the time is right.

In this section, we consider a set of topics that could serve as the start of a checklist for states to use to review EV pilot proposals.

Incorporating Clear Goals

The first step in reviewing a pilot proposal is to determine whether it clearly articulates the state's or utility's goals and policies, and whether they are consistent with other relevant state policies. This review will ensure that affected stakeholders and investors have a good sense of what the state supports and what the regulator expects.

Promoting transportation goals, for example, is a major force behind state efforts to develop markets for EVs. Where states have them, the goals should inform how utilities propose EV pilot programs. States have used a variety of ways to articulate transportation goals, which in turn can drive demand and be explicitly adopted in utility pilots. The state of Washington, for example, adopted the goal of getting 50,000 EVs on its roads by 2020.[115] California adopted aggressive greenhouse gas reduction goals with the expectation that the transportation sector would contribute to their achievement, including participation in a multistate zero-emission vehicle (ZEV) action plan and the goal of deploying 1.5 million ZEVs in California by the year 2025.[116] California also adopted low-emission vehicle standards in 1990[117] and has been joined by 10 other states.[118]

Regulators can recognize other goals that can constitute benefits from EVs and EVSE investments. For example, in an order where it approved a more limited amount of investment than the utility had proposed, the Missouri commission still found as a general matter that:

> Financial benefits from an EV charging network accrue to both the utility and the ratepayers. Utilities and ratepayers benefit economically from the improved utilization of fixed assets when charging is done in off-peak times. EVs are considered to be a flexible load that can charge during periods when demand is low.[119]

Utilities themselves also adopt goals that can be promoted in pilot programs. And even if they are not binding on the state, regulators can use them as a benchmark. Arizona's Salt River Project, for example, recently adopted a 2035 sustainability plan in which it commits to supporting "the enablement of 500,000 electric vehicles" in its service territory and managing 90% of EV charging through pricing and demand-side management and other programs.[120] In 2018, National Grid, with programs in New York, Massachusetts and Rhode Island, released its Northeast 80×50 Pathway, a plan that calls for significant shifts in the way it does business including a "transformation of the transport sector, by reaching more than 10 million electric vehicles on Northeast roads (roughly 50% of all vehicles)."[121] The adoption of goals naturally informs the achievements of a program. Avista Corp., for example, launched a pilot program in 2016 whose goals included meeting the needs of community transportation agencies. Avista reports that:

> Since implementation, both agencies were able to substantially increase both the volume of transportation services, as well as operational savings. For example, Transitions for Women reports transportation cost savings of 54% utilizing their EV, compared to previous transportation costs.[122]

Monitoring, Reporting and Data

Because EV adoption is relatively new in many states, there are circumstances where all concerned — utilities, consumers and regulators — will have to learn as they go. Also, the limited time frame of a pilot means that regulators may also need to get comfortable with requiring more extensive reporting than they might normally consider for utility programs, particularly with respect to ensuring transparency and access to data. Making sure that there is sufficient data to inform regulatory decisions and consumer choices will be important.[123]

The need for data and its obvious connection to learning is underscored by a recent observation by the Michigan PSC:

> The experimental nature of these pilots will test technology innovations, rate design, customer response, and other factors. Pilot program data and lessons learned will help position the utilities and the MPSC to make more informed decisions over the long term.[124]

Citing a lack of information as one of the reasons, Massachusetts regulators declined to approve a $166.5 million EV infrastructure development proposal from National Grid. Regulators indicated that National Grid hadn't yet evaluated the success of an ongoing $25 million charger program, which the company had characterized as the first phase of its electrification work.[125]

Although utility pilots may be limited in size, budget and term, they should still produce useful data. Research conducted by the International Council on Clean Transportation in 2017, for example, confirms the connection between EV uptake and the availability of data. Recognizing that "public charging infrastructure is a key to growing the electric vehicle market" and finding no "universal benchmark for a number of EVs per public charge point," the organization writes that "EVSE deployment suffers from 'fragmentation, inconsistent data availability, and a lack of consistent standards in most markets.'"[126] And it would help market development, they say, if governments were to require data collection and the use of open standards for publicly funded projects.

As regulators take their first steps, they will need to decide what information will be useful in evaluating the success of utility EV charging proposals. Identifying criteria and metrics — benchmarking them against accepted goals — can help states track the progress of a utility pilot. Metrics could include:

- Program expenses.
- Charge station deployment (planned and installed).
- Load profiles, showing when drivers are charging.
- EV charging electricity rates.
- Estimates of avoided carbon dioxide emissions.[127]

Metrics can be reported in a quarterly or year-to-date format. They can also identify market segment, such as residential, workplace, MUDs and low-income and disadvantaged communities.[128]

In 2017, for example, the Washington utilities commission approved a pilot for Avista that required submission of quarterly reports on program participation levels, expenditures and revenues for each service offered.[129] Additionally, Avista is required to report the DCFC station locations, levels of utilization and amount of overall fixed and variable costs recovered through user payments. All these data help in determining the success of the program. In a subsequent order, the commission approved Avista's request to change to semi-annual reporting.[130] However, Avista agreed to provide "informal quarterly updates" to staff and other parties.[131]

Not only is it important to get performance information as pilots proceed, but unless that information is available in time for the regulator to take meaningful corrective action if necessary, it will not be as useful as it could be. Getting timely information is an important point that can be illustrated as follows.

Consider a situation in which the regulator determines the need to take corrective action with regard to, for example, a two-year pilot program, but the pilot requires only annual reporting. An annual report likely would come to the regulator in the first or second month of the second year. The earliest that staff might have a recommendation regarding any program adjustments would be March of year two. Scheduling a hearing probably could take at least another month, putting it into April. For the regulator to reach any conclusions and direct any corrective actions could take another month or two — sending the timeline into May or June. And establishing a filing, review and approval process for compliance with such an order could take an undetermined amount of time.

The point is that — in the context of a time-limited pilot — it makes little sense to rely on an annual report as a source for relevant and actionable information. It would be far more useful to have key metrics reported more frequently, and in a simple format.[132]

In San Diego Gas & Electric's EV pilot, the CPUC's reporting, monitoring and data collection requirements and rationale illustrate and provide insight into the topics that regulators should consider[133] (see text box[134]).

San Diego Gas & Electric's 2016 EV pilot reporting metrics

- The amount of interest in siting EV site installations at MUDs and workplaces.
- The number of EV site installations that were approved, or that are in the pipeline, for deployment.
- The criteria used in selecting the sites that will host the EV site installations.
- The number of EV site installations and EV charging stations that SDG&E has deployed under the approved alternate vehicle-grid integration (VGI) program terms.
- The rate option that the site hosts have chosen.
- How the VGI rate-to-host option is being implemented by the site hosts.
- The usage rates at these EV site installations and charging stations.
- The timing patterns of EV charging and the degree to which these times correlate to times of low VGI rates.
- The amount of program funds spent during the quarter, and the cumulative amount spent.
- Observable trends or correlations between the number of EV site installations deployed compared to EV charging use and growth in the number of EVs.

The CPUC order requires SDG&E to meet with commission staff every three months to provide updates and relevant information related to EV charging infrastructure installations. The order also requires semi-annual reports containing the information reported in the quarterly check-in meetings, and a description of any program changes SDG&E implemented prior to the date of the report. The reports are to be submitted to the CPUC as well as to relevant service lists. The commission wrote that the data "will be useful in evaluating SDG&E's [vehicle-grid integration] program, to decide if any changes need to be made, and to help decide whether the VGI pilot program should be expanded or if other EV programs should be launched."[135] Furthermore, it indicated that the data could be useful in "comparative evaluations of the SDG&E 2016 VGI[136] Pilot Program relative to other utilities' EV infrastructure and rate programs."[137]

In addition to recognizing the value of relevant and timely data, the CPUC also emphasized that "the format of the monitoring, data reporting, and collection is crucial," and that it is important that it is reported "in a manner that ensures that the Commission can conduct an analysis of EV charging technologies that will work in a harmonious manner across the utilities' service territories."[138]

Customer Education

Reiterating the needs of consumers discussed in the earlier section on the importance of programs, EV pilots should promote customer education. Because there are many types of consumers, education must be strategic and recognize the needs of various types of customers, including communities, fleet managers and others.[139]

Consumers appear to have a lack of understanding about EVs, their availability and their suitability as a transportation option.[140] According to a recent AAA survey, "Americans may not have a solid understanding of electric vehicle performance, which may be giving consumers pause when it comes to considering electric for their next purchase."[141]

The Washington utilities commission's 2017 policy statement articulates the importance of customer education and outreach, emphasizing that it is "necessary to drive market transformation."[142] The commission also found that, as long as the information is not "promotional advertising," the cost of which cannot be included in rate base, the costs of education and outreach could be included in a company's cost of service.[143] The Citizens Utility Board in Illinois suggests that consumer education could include such things as utility-provided shadow billing to compare projected costs of charging under different rate plans, a public charge station location database, and information about available incentives.[144]

By way of analogy, when customer choice and energy efficiency programs were first initiated, multimedia advertising helped to educate customers. Likewise, EV-related efforts that take advantage of various media to the extent possible should be useful. PG&E, for example, has a webpage that explains various topics and issues that a new EV consumer in the company's territory might want to understand (see text box).[145]

PG&E checklist for buying an electric vehicle

- Consider your driving habits and budget.
- Start your research.
- Study available incentives.
- Check out your options with solar.
- Choose the charging option that suits your needs.
- Decide which rate plan is best for you.

Another example, a recently approved PG&E charging infrastructure program for low- and moderate-income communities, illustrates the need for properly targeting customer education. As described by Miles Muller of the Natural Resources Defense Council, low- and moderate-income communities face numerous barriers to EV adoption: "In addition to the upfront cost of purchasing an EV, access to charging infrastructure and lack of awareness have inhibited EV adoption in these communities."[146] The PG&E program provides 2,000 low- and moderate-income households in its territory incentives to pay the cost of residential EV chargers, and education to increase customer awareness. The company also partners with local community-based organizations — trusted partners — to help educate and inform these communities about available financial and other incentives. PG&E's community-based partners will also gather data that will support program evaluation.

Pilot Next Steps

As noted at the beginning of this section, pilot programs are transitional arrangements that allow experimentation — the obvious emphasis being on starting something new and seeing how it works. But pilots should not be a recipe for a bridge to nowhere. Pilots are a transitional arrangement because they create the conditions for utilities and regulators to develop capabilities and gain experience that can then be applied to larger-scale and more permanent programs. These observations are illustrated by the Minnesota PUC's acknowledgment of advocate recommendations and its directions to Xcel:

> Moreover, the Commission agrees with Fresh Energy, [Minnesota Center for Environmental Advocacy], and the Sierra Club that Xcel's first annual report should include

a plan to transition the pilot to a permanent program. Xcel, understandably, would like to gain experience with the pilot before moving toward a broader, permanent service offering. However, the Commission concludes that one year will give the Company and stakeholders enough experience with the pilot to inform a discussion about how to transition to a permanent offering.[147]

Thus, in reviewing a pilot proposal, it is useful for a regulator to think about the suitability of adopting lessons learned and implementing a program at full scale smoothly and without any gap in service. This was the case with Xcel's 2018 Residential EV Subscription Pilot described earlier in this paper. Due to its success, in Docket 19-559 Xcel has filed to make it a permanent offering open to all customers.

Pilot Principles

In our look at the first steps states are taking to review, condition and approve utility EV pilots, we have derived the following principles:

- **Coordinate with sister agencies in state government.** Concerted efforts across state government will improve the chances of successful program development and the achievement of state goals.
- **Ensure an open and inclusive stakeholder process.** Creating a space for useful discussion and vetting of ideas will save time, build constituencies and promote support for policies. This will also ensure the likelihood that all consumers have equitable access to electricity as a fuel and the ability to share in the benefits of this new form of transportation — regardless of consumers' specific economic and geographic circumstances.
- **Recognize EV charging load as a resource.** Given its flexibility and cost, EV load can be an economic means of securing greater grid flexibility and the capability to accommodate increased amounts of variable energy resources.
- **Promote cost-effective EV charging.** EV programs will promote confidence and have the best chance of success and providing public benefits if regulators adopt and maintain supportive policies.
- **Communicate the benefits and opportunities associated with flexible EV charging.** A well-designed charging program can benefit customers, utilities and society by reducing customer energy bills over time, promoting financially healthy utilities and contributing to other societal net benefits like carbon reductions and air quality.
- **Be willing to adapt existing policies.** Where necessary, coordinate utility rules and incentives that promote and benefit from EV adoption and cost-effective infrastructure investment including:
  - Recognition of the impact of adopting managed charging as one of the goals of retail rate design, recognizing that it must be balanced with other objectives.
  - Elimination of rate designs that discourage managed charging.
  - The adoption of rate designs that consider the unique characteristics of each customer class.
- **Ensure that pilot programs provide for next steps.** For example, adopt specific provisions that facilitate transition to a larger and more permanent program.

Questions for PUCs to Consider

1. Do utility proposals incorporate and seek to promote current state goals?
2. Will utility companies provide timely, public and relevant data so regulators and stakeholders can monitor the status of ongoing pilots?
3. Can the utility recover non-promotional, education-related costs?

Suggested Resources

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Conclusion

As states take their first steps toward electric transportation, state agencies are collaborating with each other and engaging with various stakeholders. While experience varies, many jurisdictions are encountering and working through similar early-stage topics such as managing EV charging, rate design and charging infrastructure ownership. With improved understanding of many of these basic questions, state utility commissions will be better positioned to formulate policy and support strong program proposals.

Appendix 1: Arizona Corporation Commission Stakeholder List

- City of Goodyear
- City of Phoenix
- City of Scottsdale
- City of Tempe
- City of Yuma
- Coconino County
- Town of Litchfield Park
- Greater Phoenix Economic Council
- Salt River Project
- Tucson Electric Power
- Arizona Public Service
- University of Arizona
- Arizona State University
- Rio Salado College
- Northern Arizona University
- Michigan Technological University
- Sierra Club
- Arizona PIRG
- Southwest Energy Efficiency Project
- Electric Power Research Institute
- Sonoran Institute
- Grand Canyon Sierra Club
- Keep Phoenix Beautiful
- Valley Forward
- Valley of the Sun Clean Cities
- Courtesy Chevrolet
- General Motors
- Nissan
- Ryder Transportation
- Electric Auto Association
- Alliance of Auto Manufacturers
- Arizona Automobile Dealers Association
- SmartPower
- Total Transit
- Tucson Clean Cities Coalition
- Tucson Electric Vehicle Association
- Phoenix Electric Auto Association
- Aspen Technology
- Arizona Homebuilders Association
- Capitol Consulting LLC
- Verdek EV Solutions

Appendix 2: Referenced Regulatory Commission Orders

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Endnotes

1 Argonne National Laboratory reports that plug-in vehicle sales in May 2019 were up by nearly 17% over May 2018, and that hybrid electric vehicle sales in May were over 14% higher than May 2018 sales. Argonne National Laboratory. *Light duty electric drive vehicles monthly sales updates* [Webpage]. Retrieved from https://www.anl.gov/es/light-duty-electric-drive-vehicles-monthly-sales-updates. See also Pyper, J. (2019, January 7). *U.S. electric vehicle sales increased by 81% in 2018.* GreenTech Media. Retrieved from https://www.greentechmedia.com/articles/read/us-electric-vehicle-sales-increase-by-81-in-2018. The U.S. EV sales were heavily influenced by the delivery of the Tesla Model 3.

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3 For more information on auto sales, see the Auto Alliance "Advanced Technology Vehicle Sales Dashboard" that contains month-by-month and state-by-state data from equipment manufacturers. Retrieved from https://autoalliance.org/energy-environment/advanced-technology-vehicle-sales-dashboard/

4 We note that, while the focus of this paper is on PUC action, many other state agencies have also developed programs to promote clean transportation. An example is the California Electric Vehicle Infrastructure Project. See Center for Sustainable Energy. *Building EV infrastructure* [Webpage]. California Energy Commission. Retrieved from https://calevip.org

5 See, e.g., Public Utility Commission of Texas. *Project #49125: Review of issues relating to electric vehicles.* Retrieved from https://www.puc.texas.gov/industry/projects/electric/49125/49125.aspx. See also Arizona Corporation Commission Utilities Division, Docket No. RU-00000A-18-0284, memorandum on December 12, 2018 (Arizona Corporation Commission Staff Policy Statement for Electric Vehicles, Electric Vehicle Infrastructure, and the Electrification of the Transportation Sector in Arizona). Retrieved from http://docket.images.azcc.gov/0000194370.pdf

6 Vermont Public Utility Commission. (2019). *Promoting the ownership and use of electric vehicles in the state of Vermont.* Montpelier, VT: Author. Retrieved from https://puc.vermont.gov/sites/psbnew/files/doc_library/Electric%20vehicles%20report.pdf

7 For further discussion, see Farnsworth, D., Shipley, J., Lazar, J., and Seidman, N. (2018, June). *Beneficial electrification: Ensuring electrification in the public interest*, p. 12. Montpelier, VT: Regulatory Assistance Project. Retrieved from https://www.raponline.org/knowledge-center/beneficial-electrification-ensuring-electrification-public-interest/

8 See, for example, the clean vehicle-related work accomplished by Virginia Clean Cities. See the following sources, all from Virginia Clean Cities: (2019, October 16). *Mid-Atlantic biofuels infrastructure partnership.* Retrieved from http://vacleancities.org/mid-atlantic-biofuels-infrastructure-partnership/; (2016, February 8). *Virginia Clean Cities workplace charging case study 2016.* Retrieved from http://vacleancities.org/vccworkplaceevse/; and (2015, September 9). *Virginia Clean Cities' DC fast charger deployment project 2014-15.* Retrieved from http://vacleancities.org/virginia-clean-cities-dc-fast-charger-deployment-project-2014-15/

9 Virginia Department of Mines, Minerals and Energy. (2018). *The commonwealth of Virginia's 2018 energy plan.* Washington, DC: Meridian Institute. Retrieved from https://www.governor.virginia.gov/media/governorvirginiagov/secretary-of-commerce-and-trade/2018-Virginia-Energy-Plan.pdf

10 Virginia Division of Energy. *2018 Virginia energy plan* [Webpage]. Retrieved from https://www.dmme.virginia.gov/DE/VirginiaEnergyPlan.shtml

11 A number of important topics related to ensuring equitable access to the benefits of electrified transportation are beyond the scope of this paper. For a discussion of equity, environmental justice and rural transportation needs, see Farnsworth, D., Shipley, J., Sliger, J., and Lazar, J. (2019). *Beneficial electrification of transportation*, pp. 53-58. Montpelier, VT: Regulatory Assistance Project. Retrieved from https://www.raponline.org/knowledge-center/beneficial-electrification-of-transportation/

12 Working Group on Globalization and Trade. (1996, December). *Jemez principles for democratic organizing.* Retrieved from https://www.ejnet.org/ej/jemez.pdf

13 See, for example, the California Air Resources Board's Clean Vehicle Rebate Project, which promotes clean-vehicle adoption by providing rebates for the purchase or lease of zero-emission vehicles, and supports fleet modernization through financial assistance and other incentives to lower-income drivers to scrap and replace older, high-polluting cars with zero- or near-zero-emission cars and take advantage of other transportation options like vanpools and school buses. Center for Sustainable Energy. *Drive clean and save* [Webpage]. California Air Resources Board. Retrieved from https://cleanvehiclerebate.org/eng

14 Transportation and Climate Initiative. *About us* [Webpage]. Retrieved from https://www.transportationandclimate.org/content/about-us

15 Transportation and Climate Initiative. (2019, October 1). *Framework for a draft regional policy proposal*, p. 1. Retrieved from https://www.transportationandclimate.org/sites/default/files/TCI-Framework_10-01-2019.pdf

16 Arizona Corporation Commission Utilities Division, 2018.

17 The Maryland Public Service Commission initiated a proceeding "titled Public Conference 44 (PC44) to launch a targeted review of electric distribution systems in Maryland. This proceeding builds on two Commission technical conferences held recently that examined rate-related issues affecting the deployment of distributed energy resources (such as solar) and electric vehicles." Public Service Commission of Maryland. *Transforming Maryland's electric grid (PC44)* [Webpage]. Retrieved from https://www.psc.state.md.us/transforming-marylands-electric-grid-pc44/

18 Public Service Commission of Maryland, Case No. 9478, Order No. 88997 on January 14, 2019, pp. 5-6. Retrieved from https://webapp.psc.state.md.us/newIntranet/Casenum/NewIndex3_VOpenFile.cfm?FilePath=//Coldfusion/Casenum/9400-9499/9478/\109.pdf

19 To date, public charging infrastructure development in the United States has been supported by federal, state and local programs and funding. Volkswagen, under a settlement with the U.S. Environmental Protection Agency, will invest $2 billion in charging infrastructure over 10 years. Trust funds were developed in a settlement with the Environmental Protection

Agency because Volkswagen was selling cars in the U.S. with a "defeat device" (or software) in diesel engines that could detect when they were being tested, changing the performance to improve results. Hotten, R. (2015, December 10). *Volkswagen: The scandal explained*. BBC News. Retrieved from https://www.bbc.com/news/business-34324772

20 For a discussion of other types of EV chargers, see Farnsworth et al., 2019, pp. 8-9.

21 Allison, A., and Whited, M. (2017, March 2). *A plug for effective EV rates*, p. 2, Figure 1. Cambridge, MA: Synapse Energy Economics. Retrieved from http://www.synapse-energy.com/sites/default/files/A-Plug-for-Effective-EV-Rates-S66-020.pdf (citing Consumer Reports Wattage Calculator and Bosch Electrical Vehicle Solutions).

22 Public Service Commission of Maryland, 2019, p. 49.

23 Forward, E., Glitman, K., and Roberts, D. (2013, March). *An assessment of Level 1 and Level 2 electric vehicle charging efficiency: To investigate potential applications of efficiency measures to various electric vehicles and their supply equipment.* Burlington, VT: Vermont Energy Investment Corp. Retrieved from https://www.veic.org/documents/default-source/resources/reports/an-assessment-of-level-1-and-level-2-electric-vehicle-charging-efficiency.pdf

24 Public Service Commission of Maryland, 2019, p. 43.

25 This is especially the case with light duty vehicles. Different use cases, e.g., transit or school buses workplace and fleet charging, will come with their own availability and timing requirements.

26 In using the term "peak demand" in this paper, we adopt the U.S. Energy Information Administration's basic definition: "The maximum load during a specified period of time." Retrieved from www.eia.gov/tools/glossary/index.php. The authors of a recent Lawrence Berkeley National Laboratory analysis note that "there are differences in how utilities and independent system operators (ISOs)/regional transmission organizations (RTOs) define peak demand," and "report reductions in peak demand due to electricity efficiency programs ..." These authors argue that it would be useful for states, utilities and efficiency program administrators to develop more consistent methods to report peak demand to "determine the peak reduction potential from efficiency programs, and assess relative costs of achieving peak savings from efficiency compared to alternative resource options." See Frick, N.M., Hoffman, I., Goldman, C., Leventis, G., Murphy, S., and Schwartz, L. (2019). *Peak demand impacts from electricity efficiency programs.* Lawrence Berkeley National Laboratory. Retrieved from https://emp.lbl.gov/publications/peak-demand-impacts-electricity

27 Virginia Department of Mines, Minerals and Energy, 2018, p. 42.

28 Colburn, K. (2017, January 24). Beneficial electrification: A key to better grid management [Blog post]. Regulatory Assistance Project. Retrieved from https://www.raponline.org/blog/beneficial-electrification-a-key-to-bettergrid-management/. Grid operators now recognize that active efforts on the demand side can help meet today's balancing challenges. Colburn, K. (2017, February 1). Beneficial electrification: A growth opportunity [Blog post]. Regulatory Assistance Project. Retrieved from https://www.raponline.org/blog/beneficial-electrification-a-growth-opportunity/

29 Reducing peak demand is one of those values. See Frick et al., 2019, p. 34. Relying on data from utility and other efficiency programs in nine states from 2014-2017, the authors estimate program administrator cost of saving electricity to be on average $0.029/kWh and to vary by a factor of three ($0.013/kWh to $0.039/kWh). These cost reductions appear to be a relatively low-cost way for utilities to meet peak demand, compared to the capital cost of other resources.

30 Washington Utilities and Transportation Commission, Docket UE-160082, Order on April 28, 2016. Retrieved from https://www.utc.wa.gov/_layouts/15/CasesPublicWebsite/GetDocument.ashx?docID=65&year=2016&docketNumber=160082

31 Based on Langton and Crisostomo, 2013, p. 9, Figure 6 (citing California Independent System Operator 2014-2016 Strategic Plan); see also Lazar, J. (2016). *Teaching the "duck" to fly,* Second Edition. Montpelier, VT: Regulatory Assistance Project. Retrieved from https://www.raponline.org/knowledge-center/teaching-the-duck-to-fly-second-edition/

32 See, e.g., the discussion of San Diego Gas & Electric Company's "Power Your Drive" program beginning on p. 24.

33 Stern, F. (2013). Peak demand and time-differentiated energy savings cross-cutting protocols. In National Renewable Energy Laboratory. *The Uniform Methods Project: Methods for determining energy efficiency savings for specific measures* (NREL/SR- 7A30-53827). Golden, CO: National Renewable Energy Laboratory. Retrieved from https://www.energy.gov/sites/prod/files/2013/05/f0/53827-10.pdf

34 Michigan Public Service Commission. (2019, May 2). *Utility electric vehicle pilot programs* [Issue brief]. Retrieved from https://www.michigan.gov/documents/mpsc/EV_Pilot_Issue_Brief_05-02-2019_653974_7.pdf

35 Lowell, D., et al. (2017, February 14). *MJB&A analyzes state-wide costs and benefits of plug-in vehicles in five Northeast and Mid-Atlantic states.* M.J. Bradley & Associates. Retrieved from https://www.mjbradley.com/reports/mjba-analyzes-state-wide-costs-and-benefits-plug-vehicles-five-northeast-and-mid-atlantic. See also Frost, J., Whited, M., and Allison, A. (2019, February). *Electric vehicles are driving electric rates down*. Cambridge, MA: Synapse Energy Economics. Retrieved from https://www.synapse-energy.com/sites/default/files/EVs-Driving-Rates-Down-8-122.pdf

36 Washington Utilities and Transportation Commission, Docket UE-160799, Draft Policy and Interpretive Statement, January 13, 2017, paragraph 70. Retrieved from https://www.utc.wa.gov/_layouts/15/CasesPublicWebsite/GetDocument.ashx?docID=94&year=2016&docketNumber=160799

37 The vast majority of residential rate structures do not include a demand charge. However, some utilities are beginning to propose such charges for residential customers, and the issues we will identify for commercial, industrial and public charging rate design could become real issues for residential EV rate design as well. In January 2018, Massachusetts became the first state to approve such a rate structure, for customers of the Eversource utility.

38 Minnesota Public Utilities Commission, Docket No. E002/M-15-111 and E0002/M-17-817, Xcel Energy compliance filing on May 31, 2019. Retrieved from https://www.edockets.state.mn.us/EFiling/edockets/searchDocuments.do?method=showPoup&documentId=%7bA0BF0F6B-0000-C016-839D-F8267E380A28%7d&documentTitle=20195-153306-01

39 Minnesota Public Utilities Commission, May 2019.

40 See discussion of "Time-Varying Rate Design Criteria" in Faruqui, A., Hledik, R., and Palmer, J. (2012). *Time-varying and dynamic rate design*, pp. 18-19. Montpelier, VT: Regulatory Assistance Project. Retrieved from https://www.raponline.org/knowledge-center/time-varying-and-dynamic-rate-design/

41 Fitzgerald, G., Nelder, C., and Newcomb, J. (2016, June). *Electric vehicles as distributed energy resources*, p. 63. Boulder, CO: Rocky Mountain Institute. Retrieved from https://www.rmi.org/wp-content/uploads/2017/04/RMI_Electric_Vehicles_as_DERs_Final_V2.pdf. The authors argue that getting the most out of using EV charging as a distributed energy resource will require coordination with an even broader range of stakeholders, including:

regulators, transmission system operators, distribution system operators, utilities, customers, aggregators, vehicle manufacturers, commercial building owners, elected officials and others.

42 Fitzgerald, G., and Nelder, C. (2017, March). *EVgo fleet and tariff analysis — Phase 1: California*, p. 3. Boulder, CO: Rocky Mountain Institute. Retrieved from https://d231jw5ce53gcq.cloudfront.net/wp-content/uploads/2017/04/eLab_EVgo_Fleet_and_Tariff_Analysis_2017.pdf

43 Whited, M., Allison, A., and Wilson, R. (2018, June 25). *Driving transportation electrification forward in New York: Considerations for effective transportation electrification rate design*. Cambridge, MA: Synapse Energy Economics. Retrieved from https://www.synapse-energy.com/sites/default/files/NY-EV-Rate-%20Report-18-021.pdf

44 Murach, J. (2017). *BGE electric vehicle off peak charging pilot* [Presentation]. Baltimore Gas and Electric Co. Retrieved from http://www.madrionline.org/wp-content/uploads/2017/06/BGE-EV-rate-design-pilot.pdf

45 Whited et al., 2018.

46 For example, in places with growing quantities of solar on the grid, workplace charging in the middle of the day can take advantage of cheaper and cleaner power and help smooth out a utility's load curve.

47 For more detail and an illustration of how standard commercial rate design negatively impacts the economics of EV charging, see Farnsworth et al., 2019, p. 69.

48 California Public Utilities Commission, Application 18-11-003, Decision 10-10-005 on October 24, 2019. Retrieved from http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M318/K552/318552527.PDF

49 Pacific Gas & Electric. (2018, November 20). *PG&E commercial EV rate proposal* [Presentation]. Retrieved from https://caltransit.org/cta/assets/File/Webinar%20Elements/WEBINAR-PGE%20Rate%20Design%2011-20-18.pdf. C&I rates depicted are from 2017 General Rate Case Phase 2.

50 California Public Utilities Commission, Application 17-01-021, Decision 18-05-040 on June 6, 2018, p. 112. Retrieved from http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M215/K783/215783846.PDF

51 See, e.g., Muller, M. (2019, May 15). Guest post: As Xcel gouges RTD to charge electric buses, California model could help [Blog post]. *StreetsBlog Denver*. Retrieved from https://denver.streetsblog.org/2019/05/15/guest-post-as-xcel-gouges-rtd-to-charge-electric-buses-california-model-could-help/.

52 Fitzgerald and Nelder, 2017.

53 Research conducted in 2017 confirms the connection between EV uptake and the availability of both Level 2 and DC fast charging infrastructure. The researchers conclude that "public charging infrastructure is a key to growing the electric vehicle market." Hall, D., and Lutsey, N. (2017, October). *Emerging best practices for electric vehicle charging infrastructure.* Washington, DC: The International Council on Clean Transportation. Retrieved from https://theicct.org/sites/default/files/publications/EV-charging-best-practices_ICCT-white-paper_04102017_vF.pdf

54 National Renewable Energy Laboratory. (2018, May). *NREL's EVI-Pro Lite Tool paves the way for future electric vehicle infrastructure planning*. Retrieved from https://www.nrel.gov/news/program/2018/nrels-evi-pro-lite-tool-paves-the-way-for-future-electric-vehicle-infrastructure-planning.html. See also U.S. Department of Energy. *Electric Vehicle Infrastructure Projection Tool (EVI-Pro) Lite* [Webpage]. Retrieved from https://afdc.energy.gov/evi-pro-lite

55 National Center for Sustainable Transportation. *Expanding the UC Davis GIS Electric Vehicle Planning Toolbox beyond California* [Webpage]. University of California, Davis. Retrieved from https://ncst.ucdavis.edu/project/expanding-uc-davis-gis-electric-vehicle-planning-toolbox-beyond-california

56 M.J. Bradley & Associates. *Electric vehicle infrastructure planning tools* [Webpage]. Retrieved from https://www.mjbradley.com/content/electric-vehicle-infrastructure-planning-tools-0

57 Francfort, J., Bennett, B., Carlson, R.B., Garretson, T., Gourley, L.L., Karner, D., et al. (2015, September). *Plug-in electric vehicle and infrastructure analysis* (Report INL/EXT-15-35708), p. 3-1. Idaho Falls, ID: Idaho National Laboratory. Retrieved from https://avt.inl.gov/sites/default/files/pdf/arra/ARRAPEVnInfrastructureFinalReportHqltySept2015.pdf

58 See Pennsylvania Public Utilities Commission, Docket No. M-2017-2604382, comments filed by Pennsylvania Office of Consumer Advocate on August 22, 2017. Retrieved from http://www.puc.state.pa.us/pcdocs/1532788.pdf (exploring various state approaches to this question).

59 See, e.g., Massachusetts Department of Public Utilities, D.P.U. 17-05, Order on November 30, 2017, p. 475. Retrieved from https://fileservice.eea.comacloud.net/FileService.Api/file/FileRoom/9171660 ("The Department has determined that EVSE is not a distribution facility within the meaning of G.L. c. 164. D.P.U. 13-182-A at 6. Therefore, the ownership or operation of EVSE does not transform an entity that otherwise is not a distribution company into a distribution company. D.P.U. 13-182-A at 6. The Department also determined that an EVSE owner/operator is selling a service and not electricity within the meaning of G.L. c. 164, and that the provision of EV charging service is not within the Department's jurisdiction under G.L. c. 164. D.P.U. 13-182-A at 9.").

60 Kentucky Public Service Commission, Case No. 2018-00372, Order on June 14, 2019, p. 17. Retrieved from https://psc.ky.gov/order_vault/Orders_2019/201800372_06142019.pdf

61 California Public Utilities Code Section 216(i).

62 Hawaii Revised Statutes, § 269-1. Retrieved from https://www.capitol.hawaii.gov/hrscurrent/Vol05_Ch0261-0319/HRS0269/HRS_0269-0001.htm. See also Section 10 of New Jersey Senate Bill No. 2252, "The charging of a plug-in electric vehicle shall be deemed a service and not a sale of electricity by an electric power supplier or basic generation service provider ..." Retrieved from https://www.njleg.state.nj.us/2018/Bills/S2500/2252_U2.HTM

63 New York Public Service Commission, Case 13-E-0199, Declaratory Ruling on November 22, 2013. Retrieved from http://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId={0A1AB82A-ABD4-43FA-B3E6-A4C54EC02220}

64 Allen, P., Bradbury, J., Goetz, M., Van Horn, G., and Zyla, K. (2017, November). *Utility investment in electric vehicle charging infrastructure: Key regulatory considerations*. M.J. Bradley & Associates and Georgetown Climate Center. Retrieved from https://www.mjbradley.com/sites/default/files/GCC-MJBA_Utility%20Investment%20in%20EV%20Charging%20Infrastructure_FINAL.PDF

65 EVSE installations do not necessarily require investment in a separate transformer and pad.

66 The Massachusetts Department of Public Utilities describes the elements of Eversource's make-ready proposal as follows: "(1) distribution primary lateral service feed; (2) necessary transformer and transformer pad; (3) new service meter; (4) new service panel; and (5) associated conduit and conductor necessary to connect each piece of equipment." Massachusetts Department of Public Utilities, 2017, pp. 472-473.

67 Massachusetts Department of Public Utilities, 2017, pp. 22-23.

68 Public Service Commission of the District of Columbia, Formal Case No. 1130 and Formal Case No. 1155, Order No. 19898, April 12, 2019, p. 4. Retrieved from https://edocket.dcpsc.org/apis/api/filing/download?attachId=84361&guidFileName=c302b307-c4b3-40e3-bf2e-3c8d9e064e64.pdf

69 Vermont Public Utility Commission, 2019.

70 Vermont Public Utility Commission, 2019.

71 Washington Utilities and Transportation Commission, 2016.

72 Massachusetts Department of Public Utilities, D.P.U. 13-182-A, Order on August 4, 2014. Retrieved from https://fileservice.eea.comacloud.net/FileService.Api/file/FileRoom/9233599

73 See Minnesota Public Utilities Commission, May 2019, p. 4.

74 Casale, M., and Mahoney, B. (2019, May). *Volkswagen settlement state scorecard: Ranking the states on their plans for the VW mitigation trust funds*. Denver, CO: U.S. PIRG Education Fund and Environment America Research & Policy Center. Retrieved from https://uspirg.org/sites/pirg/files/reports/USP%20VW%20Scorecard%20May19.pdf

75 See, for example, the Maryland PSC's list of factors in favor of EV adoption balanced against other state goals. Public Service Commission of Maryland, 2019, pp. 36-37.

76 Public Service Commission of Maryland, 2019, pp. 47-48.

77 Public Service Commission of Maryland, 2019, p. 46.

78 Public Service Commission of Maryland, 2019, p. 46.

79 Minnesota Public Utilities Commission, Docket No. E-002/M-17-817, Order on May 9, 2018. Retrieved from https://www.edockets.state.mn.us/EFiling/edockets/searchDocuments.do?method=showPoup&documentId=%7b40004663-0000-C51C-AF02-34594A5E471C%7d&documentTitle=20185-142865-01

80 Including Fresh Energy, Sierra Club and Minnesota Center for Environmental Advocacy.

81 See Minnesota Public Utilities Commission, May 2019, p. 5.

82 Xcel's petition can be found at https://www.edockets.state.mn.us/EFiling/edockets/searchDocuments.do?method=showPoup&documentId={E067E46C-0000-C51B-9F3A-CE1803EC2609}&documentTitle=20198-155611-01.

83 Michigan Public Service Commission, Case No. U-20282, Order on November 8, 2018. Retrieved from https://mi-psc.force.com/sfc/servlet.shepherd/version/download/068t00000032DjfAAE

84 EV Charging Pros and LightMoves. (2015, April). *Electric vehicle charging in apartment-based housing: Obstacles & opportunities*. San Mateo, CA: NOVA Workforce Development. Retrieved from http://files.novaworks.org/Reports/EV-MUD.pdf

85 Massachusetts Department of Public Utilities, 2017, p. 501.

86 Public Service Commission of Maryland, 2019, pp. 57-58.

87 Public Service Commission of Maryland, 2019, pp. 57-58.

88 Baltimore Gas and Electric Company, Delmarva Power & Light Company, Potomac Electric Power Company, and the Potomac Edison Company.

89 Public Service Commission of Maryland, 2019, pp. 57-58.

90 Minnesota Public Utilities Commission, Docket No. E-002/M-18-643, Order on July 17, 2019. Retrieved from https://www.edockets.state.mn.us/EFiling/edockets/searchDocuments.do?method=showPoup&documentId={D017016C-0000-CD10-8791-F2FF6B5C1546}&documentTitle=20197-154444-01

91 Xcel will partner with St. Paul and Minneapolis to build a network of community mobility hubs that will help expand a nonprofit car sharing service that is intended to increase access to EVs and mobility services for low-income customers.

92 Community mobility hubs are intended to support car sharing service at charging locations for the public and for transportation network companies like Lyft and Uber. The program is also supposed to support the work being done by Volkswagen Environmental Mitigation Settlement fund recipients in their efforts to develop fast charging stations with the "goal of expanding the EV market by broadening access to charging stations, which would in turn alleviate impediments to long-range driving." See Minnesota Public Utilities Commission, July 2019.

93 Minnesota Public Utilities Commission, July 2019, p. 13.

94 Public Service Commission of Maryland, 2019, pp. 63-67.

95 Public Service Commission of Maryland, 2019, pp. 5, 36.

96 Public Service Commission of Maryland, 2019, pp. 5, 36.

97 Nevada Public Utility Commission, Docket No. 18-02002, Order on June 29, 2019. Retrieved from http://pucweb1.state.nv.us/PDF/AxImages/DOCKETS_2015_THRU_PRESENT/2018-2/31126.pdf

98 Idaho National Laboratory. (2015, September 30). *INL reports analysis result from the largest collection of light-duty plug-in electric vehicle and charging infrastructure demonstrations in the world* [Press release]. Retrieved from https://inl.gov/article/electric-vehicle-charging-habits-revealed/

99 California Public Utilities Commission, Application 14-04-014, Decision 16-01-045 on January 28, 2016. Retrieved from http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M158/K241/158241020.PDF

100 California Public Utilities Commission, Rulemaking 13-11-007, San Diego Gas & Electric Company compliance filing on February 12, 2019 (Electric vehicle-grid integration pilot program ("Power Your Drive") fifth semi-annual report [corrected]). Retrieved from https://www.sdge.com/sites/default/files/regulatory/FINAL%20September%202018%20Power%20Your%20Drive%20Semi-Annual%20Rpt_0.pdf

101 California Public Utilities Commission, January 28, 2016, p. 168.

102 California Public Utilities Commission, January 28, 2016, p. 168.

103 California Public Utilities Commission, January 28, 2016, p. 133.

104 California Public Utilities Commission, 2019, p. 14.

105 California Public Utilities Commission, 2019, p. 14.

106 California Public Utilities Commission, Application 14-10-014, Decision 16-01-023 on January 14, 2016. Retrieved from http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M157/K835/157835660.PDF

107 California Public Utilities Commission, January 14, 2016, pp. 19-20.

108 California Public Utilities Commission, January 14, 2016, p. 36.

109 It also directed the company to help in determining appropriate metrics for evaluating the effectiveness of load management strategies and suggested a set to use. California Public Utilities Commission, January 14, 2016, p. 62.

110 See, e.g., Johnson, C., Williams, B., Anderson, J., and Appenzeller, N. (2017). *Evaluating the Connecticut dealer incentive for electric vehicle sales*. Center for Sustainable Energy. Retrieved from https://energycenter.org/sites/default/files/docs/nav/research/CT-Dealer-IncentiveEvaluation-CSE-2017.pdf

111 California Public Utilities Commission, Application 15-02-009, Pacific Gas & Electric compliance filing in August 2017 (Electric vehicle charge network quarterly report, second quarter, 2017). Retrieved from http://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M196/K991/196991538.PDF

112 Pacific Gas & Electric. *Electric vehicles* [Webpage]. Retrieved from https://www.pge.com/en_US/residential/solar-and-vehicles/options/clean-vehicles/electric/electric.page?ctx=business

113 Often following upon legislative or regulatory authorization or investigations, many states have authorized utilities to submit plans for pilot programs. They include Washington (Puget Sound Energy and Avista), New York (Consolidated Edison, National Grid, New York State Electric and Gas and Rochester Gas and Electric), California (PG&E, Southern California Edison, San Diego Gas & Electric), Michigan (DTE Electric), Minnesota (Xcel) and Virginia (Dominion Energy). See, e.g., Merchant, E.F. (2018, January 17). *PG&E launches country's largest utility-sponsored EV charging program*. Greentech Media. Retrieved from https://www.greentechmedia.com/articles/read/pge-launches-countrys-largest-utility-sponsored-ev-charging-program

114 For example, in December 2018, the Arizona Corporation Commission adopted an EV policy encouraging investor-owned utilities in Arizona to propose pilot programs supporting EV growth. See Arizona Corporation Commission Utilities Division, 2018. Similarly, in January 2019, the Michigan Public Service Commission approved Consumers Energy's "PowerMiDrive" proposal to promote the development of EV charging infrastructure around the state. Michigan Public Service Commission. (2019, January 19). *MPSC approves Consumers Energy electric rate increase, EV pilot* [Press release]. Retrieved from https://www.michigan.gov/mpsc/0,9535,7-395-93307_93313_17280-487034--,00.html. See also North Carolina Utilities Commission, Docket No. E-2, Sub 1197, and E-7, Sub 1195, Duke Energy Carolinas and Duke Energy Progress application filed on March 29, 2019. Retrieved from https://starw1.ncuc.net/NCUC/ViewFile.aspx?Id=991a74b5-15ed-46ca-9706-aac6d45897a7

115 Results Washington. *Goal 3: Sustainable energy & a clean environment — Goal map.* Retrieved from https://results.wa.gov/measuring-progress/archived-outcome-measures/goal-3-sustainable-energy-clean-environment-goal-map (see Goal 3.1.1.c).

116 See California Office of the Governor Edmund G. Brown Jr. (2012, March 12). Executive Order B-16-2012. Retrieved from https://www.ca.gov/archive/gov39/2012/03/23/news17472/index.html; California Office of the Governor Edmund G. Brown Jr. (2015, July 17). Executive Order B-32-2015. Retrieved from https://www.ca.gov/archive/gov39/2015/07/17/news19046/index.html; California Governor's Interagency Working Group on Zero-emission Vehicles. (2013, February). *2013 ZEV action plan — A roadmap toward 1.5 million zero-emission vehicles on California roadways by 2025*. Retrieved from http://opr.ca.gov/docs/Governors_Office_ZEV_Action_Plan_(02-13).pdf. New York and six other states — Connecticut, Maryland, Massachusetts, Oregon, Rhode Island and Vermont — joined the ZEV Plan. See Office of Governor Andrew M. Cuomo. (2014, May 29). *Governor Cuomo announces multi-state plan to increase the number of zero-emission vehicles in the U.S.* [Press release]. Retrieved from https://www.governor.ny.gov/news/governor-cuomo-announces-multi-state-plan-increase-number-zero-emission-vehicles-us. In December 2015, New York increased its ZEV goals, agreeing to make all passenger vehicle sales zero emission vehicles as soon as possible, and no later than 2050. This was part of the International ZEV Alliance. See also ZEV Alliance. (2015, December 3). *International alliance aims for all new cars to be zero emission by 2050* [Press release]. Retrieved from http://zevalliance.org/content/cop21-pr-zero-emission-2050. This could translate into as many as 800,000 ZEVs on New York roads by 2025. See also Colorado Office of the Governor. (2019, January 17). Executive Order B-2019-002. Retrieved from https://assets.documentcloud.org/documents/5688666/B-2019-002-Zev.pdf

117 Low-emission vehicle standards impose fleet-wide criteria pollutant and greenhouse gas emissions standards for light-duty vehicles. TransportPolicy.net. *California: Light-duty emissions* [Webpage]. Retrieved from https://www.transportpolicy.net/standard/california-light-duty-emissions/

118 Neustifter, J. (2018, November 16). *Air Quality Control Commission approves low emission vehicle standards* [Press release]. Colorado Department of Public Health & Environment. Retrieved from https://www.colorado.gov/pacific/cdphe/LEV-standards. Colorado joins Connecticut, Maine, Maryland, Massachusetts, New Jersey, New York, Oregon, Rhode Island and Vermont.

119 Public Service Commission of Missouri, File No. ET-2018-0132, Report and Order on February 6, 2019, pp. 16-17. Retrieved from https://www.efis.psc.mo.gov/mpsc/commoncomponents/view_itemno_details.asp?caseno=ET-2018-0132&attach_id=2019011427

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121 National Grid. (2018). *Northeast 80x50 Pathway.* Retrieved from http://bit.ly/80x2050. The document says: "In National Grid service territory, the legal basis for the 80×50 targets includes the Massachusetts Global Warming Solutions Act (GWSA) (2008), New York Executive Order No. 24 (2009), and the Resilient Rhode Island Act (2014)."

122 Washington Utilities and Transportation Commission, Docket No. UE-160082, Avista compliance filing in April 2019 (Avista utilities semi-annual report on electric vehicle supply equipment pilot program), p. 31. Retrieved from https://www.utc.wa.gov/_layouts/15/CasesPublicWebsite/GetDocument.ashx?docID=151&year=2016&docketNumber=160082

123 See, for example, the California Air Resources Board's EV Consumer Survey Dashboard at http://energycenter.org/clean-vehicle-rebate-project/survey-dashboard.

124 Michigan Public Service Commission, 2019, paragraph 8.

125 Iaconangelo, D. (2019, October 7). *Mass. kills one of nation's biggest EV charger plans*. E&E News. Retrieved from https://www.eenews.net/energywire/2019/10/07/stories/1061210459

126 Hall and Lutsey, 2017.

127 Not only can states use metrics for tracking progress in EV pilots, as states reconsider established regulatory practices, they can use these same metrics to develop performance incentives for utilities. See Littell, D., Kadoch, C., Baker, P., Bharvirkar, R., Dupuy, M., Hausauer, B., et al. (2017). *Next-generation performance-based regulation* (NREL/TP-6A50-68512). Golden, CO: National Renewable Energy Laboratory. Retrieved from https://www.nrel.gov/docs/fy17osti/68512.pdf

128 Other commissions have imposed similar reporting requirements. See, e.g., Public Service Commission of the District of Columbia, 2019, p. 27. See also Public Service Commission of Missouri, 2019, pp. 30, 35, 36.

129 Washington Utilities and Transportation Commission, Docket UE-160799, Draft Policy and Interpretive Statement, January 13, 2017, paragraph 6 (citing Washington Utilities and Transportation Commission, Docket UE-160082, Order on April 28, 2016).

130 Washington Utilities and Transportation Commission, Docket UE-160082, Order on February 8, 2018, p. 7. Retrieved from https://www.utc.wa.gov/_layouts/15/CasesPublicWebsite/GetDocument.ashx?docID=126&year=2016&docketNumber=160082

131 Washington Utilities and Transportation Commission, 2018, p. 5.

132 The CPUC reporting requirements for a 2014 PG&E pilot program provide a useful example. See, e.g., California Public Utilities Commission, August 2017.

133 California Public Utilities Commission, January 28, 2016, pp. 140-141.

134 California Public Utilities Commission, January 28, 2016, pp. 140-141.

135 California Public Utilities Commission, January 28, 2016, p. 140.

136 See California Independent System Operator. (2014, February). *California vehicle-grid integration (VGI) roadmap: Enabling vehicle-based grid services*. Folsom, CA: Author. Retrieved from https://www.caiso.com/Documents/Vehicle-GridIntegrationRoadmap.pdf

137 California Public Utilities Commission, January 28, 2016, p.140.

138 The order notes that, due to the "common geospatial nature" of the state's various pilot programs, the companies should "work with commission staff to select a geographic information system (GIS) based tool and interface that the public and other utilities can use to track the progress and attributes of the deployment." This, the CPUC notes, will help inform efforts to identify "the VGI rate design as a means of optimizing the use of grid assets on the local distribution system." California Public Utilities Commission, January 28, 2016, p. 141.

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142 Washington Utilities and Transportation Commission, Docket UE-160799, Draft Policy and Interpretive Statement, January 13, 2017, paragraph 90.

143 Washington Utilities and Transportation Commission, January 13, 2017, paragraph 90.

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145 Pacific Gas & Electric, *Electric vehicles.*

146 Muller, M. (2019, September 12). *California approves novel low-income EV charger program* [Blog post]. Natural Resources Defense Council. Retrieved from https://www.nrdc.org/experts/miles-muller/california-approves-novel-low-income-ev-charger-program

147 Minnesota Public Utilities Commission, May 2018, p. 8.

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