Getting From Here to There: Regulatory Considerations for Transportation Electrification

Prepared for the New Jersey Board of Public Utilities

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Executive Summary and Recommendations

The electric industry in the 21st century is evolving in different ways from the power sector and traditional regulation of the preceding century. More recently, technology advances and new customer expectations are shifting the landscape. Customers are producing their own energy; electric vehicles (EVs) are becoming a new class of end use, and utility distribution systems are becoming more active and flexible by utilizing advanced metering and data systems.

While this evolution is a broad topic, this paper focuses on the opportunities provided by increasing penetrations of EVs, and various regulatory principles that this raises. It is difficult to gauge what the pace of transportation electrification in the US is going to be in the coming years, but changes to the electric sector will pose new challenges for regulators and utility companies. Regulatory policy, like the utility landscape, will likewise have to evolve.

Currently, there are relatively low penetrations of EVs, which makes this an ideal time for decision-makers to put processes in place. This is an opportune moment for regulators to evaluate utility services in ways that promote alignment with the public interest (reflecting cost, risk, and environmental management) and to consider the application of some consumer protection guardrails to inform and safeguard newly assertive customers.

Some states have taken the lead on these matters, but there is no "one way" that they are addressing the question of how to electrify transportation. They have taken different approaches, including providing incentives and establishing mandates. What those leading states have in common is the identification of EV adoption goals. They are also coordinating between the various offices of state government and local jurisdictions that will be affected by increased EV penetration, and are developing processes that involve other potential stakeholders.

Clean transportation goals are a major force behind state efforts to develop markets for EVs because of "cross-fuel efficiency," i.e., the avoided energy use from the electrification of transportation. Cross-fuel efficiency allows for the use of fewer joules of energy to get the same results, in this case, miles traveled. As the figure on the following page illustrates, a gallon of gasoline contains 120 million joules of energy, and a gallon can fuel an average car for 25 miles. In the form of electricity, however, that energy would produce 33.3 kilowatt-hours (kWhs), which could "fuel" an EV for 114 miles—a 78 percent reduction in energy use.

Many states are motivated to transform their transportation sectors by the opportunity to avoid carbon and other air emissions. There are other benefits as well, including greater energy security, reduced energy costs for the EV owner, more efficient use of the electricity grid, and the integration of renewable energy and other grid services.

Figure ES-1: An Illustration of Relative Efficiency of EV and Gas-Fired Vehicle[1]

Policymakers can look at the electrification of transportation through different lenses, e.g., planning for grid modernization, carbon management, or market transformation. However they approach this work, utility regulators will likely find themselves revisiting many of the policies and practices upon which they have relied over the years with an eye toward managing this transformation and supporting the appropriate role of the consumer, new market participants, and utilities.[2]

The initial policy step that many states have taken is to define the legal status of EV charging service providers through legislation or administrative action. Many policy makers next consider the appropriate role of monopoly service providers in this newly-developing marketplace. Regardless of how or at what pace a state decides to develop its EV market, stakeholders will benefit from regulators explaining what they expect from third-party EV service providers and public utilities, and the manner in which regulators plan to ensure the public good as a market develops in their state.

Another important topic that regulators will likely confront will be the engineering effects that EVs will have on utility systems. There are three basic types of EV charging station, each with different requirements and capabilities, which can connect EVs at different points on the distribution grid. Left uncontrolled, EV charging risks producing longer and higher demand peaks that could create the need for upgrades to distribution infrastructure, raise electricity supply and delivery costs, and cause unnecessary air emissions. Regulators should also understand that – in addition to the Joule/MWh efficiency associated with electrifying transportation – EV charging programs, like other utility-related

[1] This illustration is borrowed from McCoy, J.J. (2016, January). *Building "Good Load" to Reduce Carbon Emissions: Getting Northwest Utilities More Involved in Widespread Transportation Electrification*. NW Energy Coalition, p. 20. Retrieved from http://www.nwenergy.org/news/nw-energy-coalition-issue-paper-weighs-benefits-and-opportunities-for-vehicle-electrification/

[2] See, e.g., endnotes 79-82 and accompanying text below.

investments, have the potential to produce a range of efficiencies in the types of charging equipment they promote and deploy.

Understanding and guiding the potential for this new category of electricity end use is also important for states. The term "smart charging" is used to describe mechanisms, other than rate design, that manage EV charging to ensure efficient use of grid resources, and that include demand response, one-way controlled charging, or at some point in the future, vehicle-to-grid (V2G). Because EVs are batteries on wheels, EV load is movable and potentially dispatchable. Recognizing the various roles that EVs can play on the grid is the first step in managing them correctly. More specifically, this means considering:

- Integration challenges, major barriers, and mitigation strategies;
- Characteristics of EVs that make them useful grid resources;
- Usage attributes and related operational and business strategies; and
- Usage cases that justify EV-owner compensation.

In addition to smart charging, the importance of good rate design cannot be underestimated. Establishing the right price signal encourages optimal asset utilization and lowers utility and consumer costs. Properly designed rates that send price signals to customers and motivate them to charge their vehicles when there is less stress on the system during off-peak periods can avoid circuit overloads and unnecessary investment. Rate designs can also protect non EV customers and EV customers who are following the price signals from subsidizing the costs that the less-careful EV customer imposes on the system during peak periods.

As utility regulators begin to analyze the next steps they plan to take regarding transportation electrification, the following principles may be useful:

1. Utility commissions—in their oversight and guidance relationship with electric utilities—are in a position to direct the pace and scale of transportation electrification in their state.

2. States, whether legislatively or administratively, should set out a clear legal framework for transportation electrification that enables utilities and third-party service providers to educate consumers and innovate in their planning for and investment in transportation electrification.

3. Because service charging has the potential to be a competitive service, Commissions may want to address where service is offered by a utility, for example by focusing on underserved areas. Moreover, appropriate codes of conduct, or other approaches that address the possibility of captive customers subsidizing competitive services, are important to protect ratepayers and also to ensure that the market for these services is fair and robust.

4. Because this nascent sector of the economy implies the involvement of a broad range of stakeholders, utility commissions considering the regulatory steps they plan to take may want to consider the establishment of a stakeholder process to benefit from the viewpoints and insights of:

    - Other branches of state government (e.g., departments of transportation, energy, and environment) and other in-state jurisdictions (municipal and county government);
    - Electric utility representatives;

- Third-party charging service providers;
- Consumer and ratepayer advocates;
- Environmental advocates;
- Environmental justice and social justice advocates;
- Transmission system operators;
- Demand aggregators;
- Vehicle manufacturers and dealers;
- Commercial building and multi-unit dwelling owners;
- Elected officials; and
- Others.

The benefit of a stakeholder process is the potential to reach a consensus position on many of the issues and to create an inclusive, transparent process in which stakeholders feel they have had a fair opportunity to participate.

5. Where utilities are allowed to engage in transportation electrification and invest in charging infrastructure, it will be beneficial to encourage them to plan for this broadly to include not only individual homes but also multi-unit dwellings, as well as workplace, industrial, and public settings, and any other hard-to-serve populations. It will also be advantageous to pay attention to issues regarding the financing of the infrastructure and whether that financing includes ratepayer funds. If the latter, then a plan that seeks to repay the ratepayer investment from the profits of the charging stations or some kind of profit-sharing proposal could be considered and evaluated.

6. Utilities can be encouraged to impose only fair charges and rates for all transportation electrification services, that should reasonably reflect utility system costs, effects on non-participating ratepayers, impose no unwarranted barriers on EV owners or service providers, and share demonstrable benefits equitably among all consumer classes.

7. Pilot programs provide an opportunity for companies and regulators to gain valuable insights, and to experiment. Where states encourage utilities to participate in transportation electrification, their pilot programs could:

   - Ensure public safety and the continued provision of reliable service;
   - Provide utility companies with the ability to develop and explore a portfolio of business models that include delivery or support of EV charging services;
   - Encourage utilities to develop both “smart charging” programs that capture all cost-effective energy efficiency opportunities, and
   - Rate designs that align the cost of charging to the cost on the system on a temporal basis so as to eliminate any subsidies from non-participating customers, enable utility load management (and other near- and longer-term grid integration benefits), and ensure the ability of customers to continue to control their own energy use;
   - Ensure that the benefits of transportation electrification are equitably shared across all classes of consumers; and
   - Monitor, collect, and report all program data that can assist in aligning state transportation electrification goals with grid management and consumer protection goals.

1. Introduction

Summary
• **Technological advances are shifting the utility landscape, and regulatory policy will likewise have to evolve to guide and redefine the utility services that it continues to regulate in ways that promote alignment with the public interest.** • **States have taken different approaches to encouraging a market for EVs, including both incentives and mandates.** • **Identify your state's EV goals to ensure their achievement.** • **Plan for coordination between various offices of state government and local jurisdictions.** • **Develop processes that involve all potential stakeholders.** • **Take advantage of the current period of relative low adoption to put processes in place.**
Suggested Resources
• **US Department of Energy Alternative Fuels Data Center, http://www.afdc.energy.gov/laws/state.** • **"Electric Vehicles: Rolling Over Barriers and Merging with Regulation," 40 Wm. & Mary Envtl. L. & Pol'y Rev. 477, Mark Detsky and Gabriella Stockmayer, 2016, http://scholarship.law.wm.edu/cgi/viewcontent.cgi?article=1646&context=wmelpr.** • **"An Action Plan to Integrate Plug-In Electric Vehicles with the U.S. Electrical Grid," Nick Nigro, Center for Climate and Energy Solutions, 2014, http://www.c2es.org/docUploads/PEV-action-plan.pdf.** • **"Electric Vehicles as Distributed Energy Resources," Chris Nelder, James Newcomb, and Garrett Fitzgerald, Rocky Mountain Institute, 2016, http://www.rmi.org/pdf_evs_as_DERs.**

The structure of the US electric industry in the 20th century has undergone little significant change. Power was produced centrally and supplied to relatively passive energy users. More recently, however, in the last few decades, technological advances have begun shifting the landscape. Customers in some states have retail choice; they are producing their own energy; electric vehicles (EVs)[1] are becoming a new class of end-use, and utility distribution systems are becoming more active and flexible with advanced metering and data systems.

While it is difficult to gauge what the pace of transportation electrification in the US is going to be in the coming years, there are indications that this is an important trend to pay attention to. For example, on April 3, for example, the New York Times reported that Tesla surpassed Ford Motor Company in market value for the first time. (See Figure 1.) According to the Times, Tesla "moved within striking distance of General Motors, starkly illustrating the growing gap in investors' optimism over its future versus the prospects for the traditional carmakers from Detroit."[2]

Additionally, between 2010-2015, the costs of a lithium-ion battery pack used in EVs fell 65 percent, and those costs could drop below $100 per kilowatt-hour over the next decade.[3] Moreover, the potential for autonomous driving, and ride-sharing and ride-hailing services like Uber and Lyft have already begun to change the way we use and own automobiles.[4] The transportation industry appears to be poised for rapid demand growth from customers, much as telecommunications, and other industries developed.

Figure 1: The Change in Tesla and Ford's Stock Prices [5]

Electric sector changes are posing new challenges for regulators and utility companies. As customers assert themselves, the question arises: will they have the tools and the motivation (that come to some extent from government policy) that promote economically efficient and socially balanced outcomes, or will it be everyone for himself or herself with many being left out?

Regulatory policy, like the utility landscape, will also have to evolve. It will be needed to guide and redefine the utility services that continue to require regulation in ways that promote alignment with the public interest (reflecting cost, risk and environmental management) and apply sufficient consumer protection guardrails to inform and safeguard all customers.

There is no "one way" that states are approaching the question of how to electrify transportation.[6] State legislatures, energy offices, and utility commissions are all engaging in various initiatives ranging from articulating their jurisdiction, to distribution system planning, to approving EV-charging tariffs.[7] Some states, for example, have developed EV-related provisions for workplace charging, preferential parking, building codes, and common interest communities.[8] Table 1 illustrates the diversity of transportation electrification-related decision-makers and regulatory topics that states are considering.[9]

Table 1: Examples of State EV-Related Actions[10]

State	Topic	Context
Minnesota	Tariff Review and Rate Design	Minnesota PUC, Docket Nos. E002/M-15-111, E017/M-15-112, E015/M-15-120, E001/M-15-200, In re Electric Vehicle Charging Tariffs, (June 22, 2015)
New York	PSC Asserts jurisdiction over public EV charging stations	New York PSC, Case 13_E_0199, In re Electric Vehicles Policies (Nov. 22, 2013)
Arizona	Pilot EV rate schedule	Arizona Corporation Commission, Docket No. E-01345A-10-0123, In re Arizona Public Service Company's Application for Approval of Proposed Electric Vehicle Readiness Demonstration Project, (Sept. 15, 2011)
Rhode Island	Issues Affecting Electric Vehicles	Rhode Island Office of Energy Resources RI H.B. Res. 7726 (2013); House Resolution Report: Addressing Regulatory Issues Affecting Electric Vehicles (June 2015
Washington	• Encouraging utility leadership in buildout of EV charging infrastructure. • Transportation Planning	• Legislation – HB 1853 - 2015-16, Encouraging utility leadership in electric vehicle charging infrastructure build-out. • Washington State Electric Vehicle Action Plan[11]
Oregon	Transportation Electrification (TE) Planning	• Oregon SB 1547 (2016) o Directs IOUs to achieve advanced TE and achieve ratepayer and environmental benefits. o Oregon PUC currently in rulemaking. o Utilities to file TE plans by 12/31/2016.

This paper looks at the manner in which a number of utility regulators around the country have been responding to EV-related issues. Some have been working on this longer than others and thus have more experience responding to the many different issues that have arisen in their states. While the purpose of this paper is to illustrate that activity, and not to endorse particular policy approaches, we do note that in undertaking these efforts in this new environment, states have reaffirmed certain regulatory principles.[12] We encourage states to keep these in mind as they consider how they want to regulate in this evolving market.

After an introduction to some samples of various EV-related activities that are occurring around the country, *Section 2* (Preparing for an EV Market—Electrification Goals and Benefits) looks at transportation goals as a major force behind state efforts to develop markets for EVs. *Section 3* (Charging Infrastructure) provides a short primer on the charging equipment. *Section 4* (Rate Design) provides a run-down of different types of utility rates and their advantages and disadvantages. *Section 5* (Vehicle-Grid Integration) focuses on the opportunities and challenges for the distribution grid in accommodating EVs. *Section 6* (Defining the Role of Monopoly Service Providers) looks at the changing role of utility companies. *Section 7* (Licensing Third-Party Charging Services) focuses on the ways that states have defined the regulatory status of new EV-charging market participants. *Section 8* (Market Transformation and the Role of the Utility) considers some of the different regulatory frameworks from which states are considering the new EV market. Note also, that the end of each section contains questions on the topic that might be useful to address. Finally, an *Appendix* contains short discussions of additional issues including, EV charging for multi-unit dwellings; utility business models; and customer education.

2. Preparing for an EV Market—Electrification Goals and Benefits

Summary

- **Clean transportation goals are a major force behind state efforts to develop markets for EVs.**
- **These goals are motivated in part by "cross fuel efficiency," i.e., the avoided energy use from the electrification of transportation.**
- **In a developed EV market, recharging an EV will need to be similar in ease to refueling a gasoline-powered vehicle.**
- **Development of an EV market can be viewed through different lenses, e.g., grid modernization, carbon management, market transformation, etc.**

Suggested Resources

- **"2013 ZEV Action Plan -- A roadmap toward 1.5 million zero-emission vehicles on California roadways by 2025," https://www.opr.ca.gov/docs/Governor's_Office_ZEV_Action_Plan_(02-13).pdf.**
- **California 166 Executive Order B-16-12, https://www.gov.ca.gov/news.php?id=17463.**
- **California 167 Executive Order B-32-15, https://www.gov.ca.gov/news.php?id=19046.**
- **Results Washington – Goal 3.1.1.c, January 2017, http://results.wa.gov/what-we-do/measure-results/sustainable-energy-clean-environment/goal-map.**
- **Washington Utilities and Transportation Commission, Docket UE-160799, Draft Policy and Interpretive Statement Concerning Commission Regulations of Electric Vehicle Charging Services, https://www.utc.wa.gov/_layouts/15/CasesPublicWebsite/GetDocument.ashx?docID=94&year=2016&docketNumber=160799.**
- **"Utilities Can Get a "LEG" Up with Beneficial Electrification—But Regulators Also Have to be Ready," Rich Sedano and Ken Colburn, RA,P February 2017, http://www.raponline.org/utilities-can-get-a-leg-up-with-beneficial-electrification-but-regulators-also-have-to-be-ready/.**
- **"Building 'Good Load' to Reduce Carbon Emissions: Getting Northwest Utilities More Involved in Widespread Transportation Electrification," J.J. McCoy, NW Energy Coalition, January 2016, http://www.nwenergy.org/news/nw-energy-coalition-issue-paper-weighs-benefits-and-opportunities-for-vehicle-electrification/.**

Meeting transportation goals is a major force behind state efforts to develop markets for EVs; states have used a variety of ways to articulate clean transportation goals, which in turn drive demand, and form the underpinnings of an EV market. Understanding the role that clean transportation goals play is a good starting point for understanding the steps a state might take in developing a market for EVs. The State of Washington, for example, adopted policies to promote the development of a market for EVs, including the goal of getting 50,000 EVs on its roads by 2020.[13]

California adopted aggressive GHG goals with the expectation that the transportation sector would contribute to their achievement. In 2012, California's Governor Jerry Brown issued executive orders directing state government to participate in a Multi-State Zero-Emission Vehicle Action Plan (ZEV Plan) and establish a goal of deploying 1.5 million ZEVs in California by the year 2025.[14] The legislature passed several important laws to accelerate the ZEV market expansion, including appropriating millions of dollars to advance ZEV technologies.[15]

In 2014, New York joined with California and six other states—Connecticut, Maryland, Massachusetts, Oregon, Rhode Island, and Vermont—in the ZEV Plan, which could translate into as many as 800,000 ZEVs on New York roads by 2025.[16] As part of its strategy to achieve its goals, in 2013 New York adopted Charge NY, a coordinated effort among various New York state agencies: the New York State Energy Research Development Authority (NYSERDA), New York Power Authority (NYPA), and Department of Environmental Conservation (DEC).[17] The governor also committed to installing 500 new workplace charging stations and 69 new charging stations along the New York State Thruway.[18]

Fewer Joules and More MWhs

Figure 2 illustrates the efficiency to be gained through electrification of transportation. It assumes that a gallon of gasoline contains 120 million joules (MJ) of energy, and that can fuel a car for 25 miles. In the form of electricity, the same 120 MJ of energy would produce 33.3 kWhs which could "fuel" an EV 114 miles — a 78 percent reduction in energy use, making the efficiency gain a reduction in joules and increase in MWhs.

A central part of the rationale for clean transportation goals is "cross-fuel efficiency," i.e., the avoided energy resulting from the electrification of transportation. (See text box and Figure 2.)

Figure 2: Illustration of Relative Efficiency of an EV and a Gasoline-Fueled Vehicle[19]

While many states are motivated by the significant opportunity to avoid carbon and other emissions from the transportation sector, there are many other potential benefits associated with electrifying transportation.[20] One study in the northwest sets out the following list:

- Reduced greenhouse gas emissions;
- Improved air quality;
- Greater end-use energy efficiency;
- Low and stable operating costs;

- Greater energy security;
- State and regional economic gains;
- Greater utilization of the electricity grid; and
- Integration of renewable energy and other grid services.[21]

Questions

- Were air quality or other environmental goals considered as part of your EV market goals? If yes, how so?
- How might environmental justice or other underserved communities be encouraged to participate in an EV market?
- Has your state adopted EV or clean transportation goals?
- Are government agencies other than your engaged on these issues?

3. Charging Infrastructure

Summary

- **Charging infrastructure connects EVs at different points on the distribution grid.**
- **There are three basic types of EV charging station, each with different requirements and capabilities.**
- **Uncontrolled EV charging risks producing longer and higher demand peaks that could create the need for upgrades to distribution infrastructure, and raise electricity supply costs.**
- **In addition to the joule/MWh efficiency generally associated with electrifying transportation, charging programs can also produce greater efficiencies in the types of charging equipment they promote.**

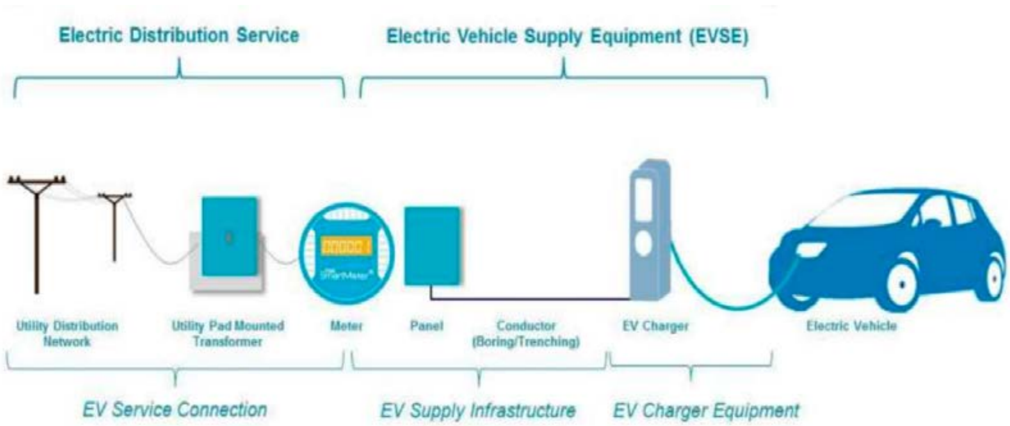
Suggested Resources

- **"What is EVSE? It's Electric Vehicle Supply Equipment, and Here's What it's all About," http://www.autoblog.com/2010/11/01/what-is-evse-its-electric-vehicle-supply-equipment-and-heres/**
- **"Electric Vehicle Charging Levels Explained," *Inside EVs*, http://insideevs.com/charging-levels-explained-bower/**
- **"An Assessment of Level 1 and Level 2 Electric Vehicle Charging Efficiency," Evan Forward, Karen Glitman, and David Roberts, Vermont Energy Investment Corporation (VEIC) Transportation Efficiency Group, March 20, 2013 (Revised), https://www.veic.org/docs/Transportation/20130320-EVT-NRA-Final-Report.pdf.**

What are we talking about when we talk about "charging infrastructure," or "electric vehicle supply equipment" (EVSE), and what is involved in connecting it to the distribution grid? The term EVSE typically refers to the apparatus like a wall charger or charging station used to deliver energy for the purpose of charging a vehicle.[22] In this paper, we use the terms, "EVSE" and "EV charging infrastructure" more broadly to also include the plant required to connect the charging apparatus to the grid.

Looking at the utility side first, connecting any electricity customer, EV user or otherwise, requires bringing the distribution system to the customer premises. In simple terms, this calls for a service drop from the street to a utility-placed transformer and then a connection to a customer's meter. See Figure 3 on the following page.

Figure 3: EV Charging Infrastructure[23]



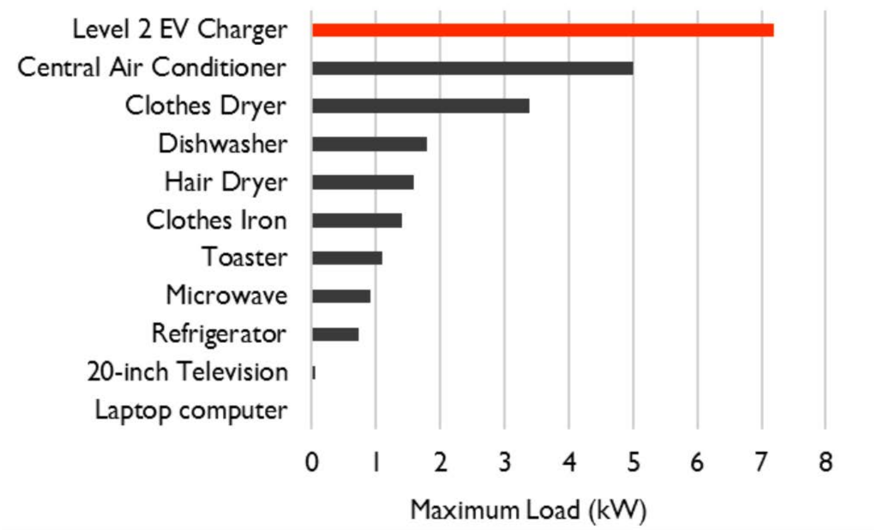
Power from the transformer gets stepped down to 110 or 220 volts (V) and passes through a service panel that, in turn, connects to the charging equipment itself. These connections can be achieved with a basic cable or, in addition, can require more effort like trenching or cutting through pavement or building structures to link with the charging station. (See discussion of multi-unit dwellings in the Appendix.)

There are three basic types of EV charging station, each with different requirements and capabilities. [24] A Level 1 charger is 110 V, and typically comes with a car. It requires no special cord, and plugs into a wall outlet just like a toaster or clothes iron. It produces about 4.5 miles of range per hour of charging. So, if roundtrip from home to work is about 30 miles, the car would need to charge for about seven hours.

A Level 2 charger is 220 V. At home, it uses the same type of plug and draws about twice the energy of an electric clothes dryer.[25] (See Figure 4.) These are available on the market and through companies like EV Go and Charge Point. It takes about 3.5 hours to charge a typical electric vehicle for about 70 miles of range. Thus, it produces about 20 miles of range per hour of charging. Home units cost roughly $600-$700 and require installation. Commercial Level 2 chargers, which can connect to a network, recognize customers, and enable services like billing, cost about $10,000.

DC Fast Chargers typically range from 208-600 V, and are well-suited for charging electric vehicles in high-traffic commercial locations and at locations along major transportation corridors. They can charge a car battery in less than an hour, approximately 40 miles of range for every 10 minutes of charging. Fast charging stations can cost $100,000 or more.

Figure 4: Level 2 Charger Load Compared With Other Household Loads[26]



It is critical that utility regulators recognize that uncontrolled EV charging could produce longer and higher peaks in demand, and drive the need to upgrade distribution infrastructure, raising utility costs and rates. (See Sections 4-5 below.) Consequently, to save consumers money and improve the functioning of the power grid, it is important to be able to analyze energy use from "the point it flows from the grid to its release in the wheels of the vehicle."[27] Regulators should encourage companies to identify opportunities for applying measures to ensure that charging occurs as efficiently as possible. For example, an EV pilot in the State of Washington allows the utility to recover program costs through its conservation rider due to the "incremental efficiency benefits associated with Level 2 chargers over Level 1 chargers, and the potential avoidance of new generation resources …"[28] Moreover, while there relative efficiencies to be gained by the use of certain charging equipment, as noted here, more active management of charging, as described further below, will be important for utility companies.

Focusing on this efficiency potential a little more closely, the Transportation Efficiency Group at Vermont Energy Investment Corporation (VEIC) has studied the relative efficiency of Level 1 and Level 2 chargers. Their work provides one illustration of this efficiency opportunity. (See Figure 5 below.)

Figure 5: Summary of Level 1 and Level 2 Charger Efficiency[29]

Charge event dataset	Average Level 2 Charge Efficiency	Average Level 1 Charge Efficiency	Efficiency gain of Level 2 charging
Total combined	86.4%	83.7%	**2.7%**
High energy only (>2 kWh charge)	86.5%	84.2%	**2.3%**
Low energy only (<2 kWh charge)	83.5%	70.7%	**12.8%**

Under circumstances that VEIC describes as "high-energy" charge events (i.e., when greater than 2 kWh is drawn from the grid) a Level 2 charger is more efficient than a Level 1 charger by 2.3 percent on average. In the case of a "low-energy" charge event (when <u>less</u> than 2 kWh is drawn from the grid[30]), they found Level 2 chargers to be 12.8 percent more efficient on average than Level 1 charging.[31] So, in addition to the joule-to-MWh efficiency associated with electrifying transportation, charging programs can also produce greater efficiencies in the types of charging equipment they promote.

Questions

- What authority does your Commission have to discourage uncontrolled EV charging?
- Have you identified steps that could be taken to encourage efficient charging?

4. Rate Design

Summary

- **The importance of good rate designs should not be underestimated because the right price signal can result in better asset utilization and lower costs to the utility and consumer.**
- **Properly 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 when there is less stress on the system during off-peak periods.**
- **An EV customer that ignores price signals reflected in rates will pay for the electricity at a higher price that reflects the systems costs.**
- **Rate designs can also protect non EV customers and EV customers who are following the price signals from subsidizing the costs that an EV customer charging during peak periods imposes on the system.**

Suggested Resources

- **"A Plug for Effective EV Rates," Synapse Energy Economics, http://www.synapse-energy.com/sites/default/files/A-Plug-for-Effective-EV-Rates-S66-020.pdf.**
- **"Electricity Pricing Strategies to Reduce Grid Impacts from Plug-in Electric Vehicle Charging in New York State—Targets," New York State Energy Research and Development Authority (NYSERDA). 2015. www.mjbradley.com/sites/default/files/NYSERDA-EV-Pricing.pdf.**

With increased EV demand on the utility distribution system, it is important that the utility have the ability to manage it and avoid unnecessary circuit overloads and upgrades to equipment. According to the Washington Utilities and Transportation Commission (UTC), EV charging services are capable of providing "significant benefits to the overall utility transmission and distribution network if they are properly deployed," but, "without a price signal, drivers will generally plug in and charge immediately upon arriving home after work, exacerbating evening peak demand."[32]

A properly-designed rate can help mitigate these problems by sending price signals to customers that encourage them to charge their vehicles when there is less stress on the system during off-peak periods. If an EV customer decides to ignore the price signals, then he will pay for the electricity at a higher price that reflects the higher system costs. This result protects non EV customers and EV customers who are responding to the price signals from subsidizing the costs that the EV customer is imposing on the system during peak periods.

a. Favorable Rate Designs

i. Time of Use

Time of use (TOU) rates with critical peak pricing (CPP) are a logical design for addressing pricing for EVs due to their large contribution to load. Without a rate design that encourages off-peak charging to fill the valleys and keep the peak load from escalating, EVs would have the potential to add significant stress and cost to the system. A critical peak pricing component added to a TOU rate results in a significantly higher charge on a cents-per-kilowatt-hour basis if the customer draws power from the utility when the system is constrained. The price signal from CPP serves to limit use when doing so will have a high cost for the system. As illustrated in Figure 4 earlier, EV charging systems can draw nearly 50 percent more power than even the most energy-intensive residential appliances. If charged during a time of peak demand with a standard Level 2 charger, an EV's load is roughly equivalent to that of an entire household.[33]

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. This is because the potential savings as well as the price consequences for not aligning usage with prices are greater than if the differential between on-peak and off-peak rates were much smaller. NV Energy in Nevada illustrates this, as the utility has a TOU EV rate which includes large differentials between on- and off-peak power. Its summertime rate for northern Nevada varies from 40.7 cents/kWh for on-peak power (from 1 pm to 6 pm) to 5.53 cents/kWh for off-peak power (from 10 pm to 6 am).[34] 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 percent of customers choosing to charge during "super off-peak" periods.[35]

Under certain circumstances, however, a TOU rate would not be completely effective. In a case where many customers in a particular neighborhood charge around the same time, this could alter the standard peak period and would require further attention. As Rocky Mountain Institute (RMI) notes:

> While TOU rates are a good way to begin supporting EVs, achieving higher levels of EV penetration, or a high density of EVs on a single power circuit, will require more intelligent management of charging loads in order to prevent creating new demand peaks when the vehicles are charging, and to avoid localized impacts on neighborhood transformers, distribution line segments, or feeder transformers.[36]

In addition, using TOU rates for EVs requires that either a new meter be installed for the EV if there is a separate EV rate, or alternatively that the entire household be moved onto a TOU rate. The latter could have positive or negative impacts depending on how the customer uses electricity in the household. Studies, however, suggest that most residential households save money on a TOU rate.[37]

In Maryland, BG&E has developed whole-house (includes electric use of house and EV charger) TOU rates with on-peak and off-peak components. [38] The program was made permanent in 2016. PEPCO developed a rate design plan to encourage off-peak charging. The approach allows for either a whole house TOU rate or a rate for EVs only, requiring the installation of a discounted charging station with an embedded AMI meter for which PEPCO offers on-bill financing.

In 2011, Dominion Virginia Power began to study whether rate options affect EV charging behavior. The company was interested in encouraging load shifting, peak-shaving, or conservation during high electricity demand periods by customers, to reduce the company's future capacity needs and energy costs.[39] Like BG&E, Dominion developed a combined EV and home TOU rate, and an EV-only rate requiring a second meter.

TOU rates have been found to be effective at saving customers' money. Looking at the top five cities (Los Angeles, San Francisco, Atlanta, San Diego, and Portland, Oregon) for EV sales where the utility offers EV TOU rates, savings varied from $116 per year to $237 per year depending upon the utility.[40] Electric utilities in states such as Alaska, Hawaii, New York, and Georgia have TOU rates for residential EV customers, and "researchers have repeatedly found these rates to be effective at reducing costs and emissions. Another study estimated that EV TOU rates would save California $1.2 billion between 2015 and 2030, compared with a flat rate."[41]

ii. Hourly Rates or "Real-Time Pricing"

Hourly rates or "real-time pricing" provide more accurate price signals than TOU rates in that they reflect the actual cost of electricity in a given hour. With TOU rates, customers know what the cost of electricity will be in every time period of every day, and can choose the time period during the day that is most advantageous to charge an EV. Hourly rates on the other hand, are variable such that the price fluctuates throughout the day. This requires more active monitoring by the customer than a TOU rate would.

Commonwealth Edison in Illinois has a residential optional hourly price for charging EVs.[42] A 2013 analysis found that EV owners that charged their cars overnight on that rate reduced their average energy supply costs by 45 and 38 percent, respectively, compared with a standard rate (a price based on consumption that does not vary) and a TOU rate.[43]

SDG&E has an even more fine-grained rate that has the unique aspect of including an hourly distribution component, which covers the costs of charging during neighborhood peak demands, along with an hourly wholesale price component. The "vehicle integration rate" is comprised of the following elements:

- A base commodity amount (tied to CAISO wholesale price);
- Additional components:
    - Some differential, based on circuit and feeder level;
    - Critical peak price; and
    - Renewable energy signal (based on forecast error between CAISO day-ahead market and "day of" forecast).[44]

In regard to hourly pricing, Synapse Energy Economics has concluded that, "[t]his innovative rate design can help combine the best features of time-varying energy rates with the incentives embedded in a demand charge that help to avoid overloading the distribution system."[45]

It should be noted, however, that one of the challenges presented by an hourly rate design is its complexity for the average customer who must know the day-ahead hourly price every day in order to properly respond to a price signal. In this case, aggregators could help manage when a customer's EV should be charged (within parameters acceptable to the customer). Further, the aggregator could also manage any grid services sold back to the utility. Like TOU rates, hourly rates will require advanced metering with two-way communication.

iii. Rebates for Direct Utility Management

An alternative to rate designs that send pricing signals is a utility load-control program where the utility pays the customer to control when the vehicle charging occurs. This allows the utility to better manage its system so that it can moderate peaks and flatten its load thereby managing distribution costs within a neighborhood. Both Eversource and Pacific Gas & Electric have experimented with offering rebates in order to directly manage EV charging.[46]

b. Less Favorable Rate Designs—i.e., Those That Create Barriers

Poorly designed rates can contribute to system insecurity by increasing peak load, causing system costs to rise and threatening reliability. This can occur if the rate is designed in a manner that allows the customer to charge an EV at any time without consequence. Below is a discussion of some of the rate designs that likely should not be paired with EV charging.

i. Demand Charges

Demand charges are sometimes used to recover the nonfuel costs of generation, transmission, and distribution of large commercial and industrial customers. These demand charges have typically been applied to the individual peak demand of each consumer (often referred to as "non-coincident peaks") regardless of whether it occurs during system peak periods.[47] Because traditional demand charges are measured on the basis of the customer's peak, regardless of whether it coincides with the system's peaks, this approach results in a mismatch between the system coincident peak costs used to set prices and the actual costs incurred at the time of the customer's noncoincident peak.

Rate designs that include demand charges are common for large customers as a means of incentivizing them to levelize their load to the extent possible and to avoid dramatic fluctuations in usage. Doing so enables transformers and other distribution equipment to serve the load without the need for costly upgrades in equipment. Moreover, demand charges reflect the cost of service by assigning demand-related costs to the customers who impose those costs. However, when it comes to EVs, a demand charge may not be an appropriate complement from a rate design perspective. This is because businesses may worry about the impact on their load profile if suddenly many employees are charging cars during work hours. This could create a new peak demand for the business, raising its demand charge and monthly bill. Thus, a demand charge could create a barrier for employees to use EVs to travel to work if they cannot charge their car for their ride home after work.

ii. Flat Rates

Under a flat rate, an EV owner pays the same amount regardless of when the car is being charged. As noted above, EV customers have no incentive to charge their car during off-peak hours and may not think to do so. This could increase costs for the system and require distribution upgrades that would be borne by all customers.

iii. Straight-Fixed Variable Rates

Straight-fixed variable (SFV) rates consist of a high customer charge and a low volumetric rate that is generally not time varying. While this rate is designed to ensure utilities of revenue, it would not work well in combination with EV charging, which has the potential to result in noteworthy increases in load. A SFV rate would represent a boon to EV customers who would pay the same large fixed rate and low volumetric rate, but it could result in under-recovery of costs for the utility who might raise the high customer charge at the expense of lower-volume users. While this rate does not represent a barrier for EV customers, it would result in an inequitable distribution of revenue responsibility among customers.

SFV has been criticized as placing too high a rate burden on low-use customers for the benefit of high-use customers. An SFV for EV customers would only exacerbate this concern.

<u>Questions</u>

- What rate designs should you be considering to optimize the efficiency of the grid and to better align cost with causation?
- What steps should be taken to ensure that there is no intra-class subsidization of costs?
- In considering time varying rates for EV charging, what is the best complement to your system: evening charging to take advantage of wind resources, or daytime charging to take advantage of solar resources?

5. Vehicle-Grid Integration

Summary

- **EVs are batteries on wheels, making EV load movable and potentially dispatchable.**
- **Recognizing the various roles that EVs could play on the grid is the first step in managing them correctly.**
- **At the heart of vehicle-grid integration (VGI) is the understanding that unmanaged EV load has the potential to exacerbate system peaks and unnecessarily increase utility costs.**
- **Regulators and utilities should identify:**
    - **Integration challenges, major barriers, and mitigation strategies;**
    - **Characteristics of EVs that make them useful grid resources;**
    - **Usage attributes and related operational and business strategies; and**
    - **Usage cases that justify EV-owner compensation.**
- **The term "smart charging" is used to describe mechanisms, other than rate-design, that manage EV charging to ensure efficient use of grid resources, and include demand response, one-way controlled charging, or in the future vehicle-to-grid (V2G).**

Suggested Resources

- **"Vehicle-Grid Integration: A Vision for Zero-Emission Transportation Interconnected throughout California's Electricity System," Adam Langton and Noel Crisostomo, California Public Utilities Commission, Energy Division, October 2013, http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M081/K975/81975482.pdf.**
- **"Driving Integration: Regulatory Responses to Electric Vehicle Growth," Rachel Gold and Cara Goldenberg, Rocky Mountain Institute, 2016, http://www.rmi.org/ev_integration**
- **"Distribution System Pricing with Distributed Energy Resources," Ryan Hledik and Jim Lazar, Lawrence Berkeley National Lab, Future Electric Utility Regulation, Report No. 4, May 2016, p. 3, https://emp.lbl.gov/sites/all/files/feur-4-20160518.pdf.**
- **"Electric Vehicles as Distributed Energy Resources," Chris Nelder, James Newcomb, and Garrett Fitzgerald, Rocky Mountain Institute, 2016, http://www.rmi.org/pdf_evs_as_DERs.**

a. EV Load

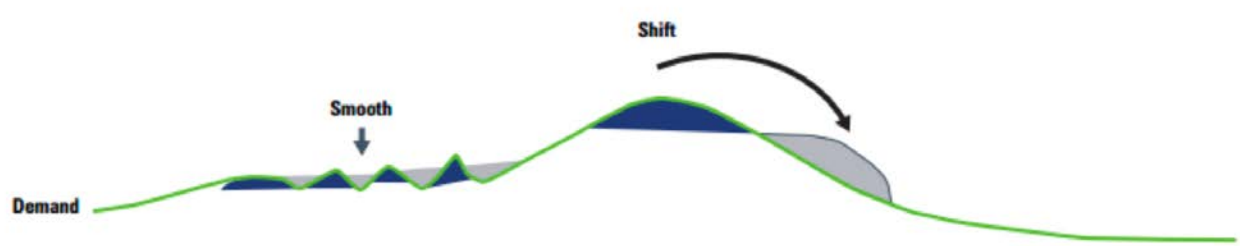
As the number of EVs requiring charging increases, so too will the load that utility companies have to manage. As noted, EV load growth has the potential to exacerbate already expensive and often dirty system peaks or, due to its flexibility, to be exploited to make the grid itself more flexible. After all, EVs are electric batteries on wheels. Managing this activity—the increased use of EVs, the associated loads, effects on the power grid, and questions related to their coordination—falls under the heading of "vehicle-grid integration" (VGI).

Although it is difficult to estimate with any certainty the amount of added load that EVs will place on US power grids, the potential is significant. Consider a simple electrification scenario[48] that assumes the following. In 2016, Americans drove over 3 trillion miles.[49] A typical EV can travel approximately 3 miles/kWh.[50] Multiply the two and add the resulting one trillion kWhs to 2016 annual utility sales of nearly four trillion kWh.[51] With those assumptions, electrifying all US vehicles could result in roughly a 20-25 percent increase in energy demand for the utility sector. [52]

In another illustration, in 2012 California adopted the goal of getting 1.5 million zero-emission vehicles (ZEVs) on the state's roads by 2025. The California Public Utilities Commission (CPUC) estimated that achieving the target could result in an additional 7,000 MWs on the grid, which is equivalent to approximately 16 percent of the state's 2013 peak load. They noted that if all the charging associated with these new vehicles were to occur on peak, it would require "major grid upgrades and construction of additional generation capacity."[53] Based on SDG&E calculations, this could add almost 10,000 MW of new peak load to the approximately 64,000 MW California grid.[54]

Given these two illustrations, it is easy to imagine that EV-related energy and peak demand could put stress on part of the power grid. However, like other battery-based technologies, EVs possess flexibility as to the times at which they are charged. As illustrated in Figure 6, the demand to which EVs might contribute (blue) could be moved off-peak (gray), avoiding new generation.

Figure 6: Shifting Demand[55]



Because EV charging can be scheduled, EV load can be moved to absorb production of renewable energy, making power grids more flexible. For example, in New Jersey or Arizona, EVs could charge in the middle of the day when the sun is shining and solar PV is producing. In Massachusetts or North Dakota, EVs could charge at night when wind energy is being produced and everyone is asleep.

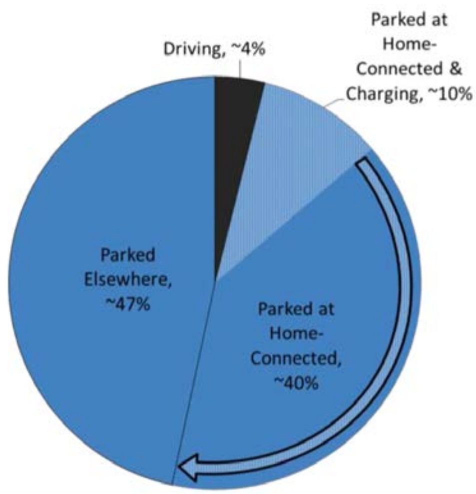
This is just the beginning of the opportunity. The CPUC emphasizes that EVs have the potential to provide "many more benefits beyond charging at night and storing electricity generated by wind that may not otherwise have been needed."[56] Rather than viewing EVs as a problem to be managed, the CPUC emphasizes that VGI opens the potential for EVs to be used as a resource to help reduce the costs of grid operations, and avoid or defer distribution maintenance and upgrades:

> Coupling the unique usage attributes of PEVs with new business and operational strategies have the potential to mitigate system impacts resulting from the growth of electrified transportation, and in turn, accelerate PEV adoption and hasten benefits to air quality, reduced GHG emissions,

and the development of the industry.[57]

The CPUC identifies three characteristics that make vehicles potential grid resources. First, they can provide operational flexibility because they possess a dual functionality of load (while charging) and generation (if discharging stored energy to the grid). Second, they have embedded communications and actuation technology because auto manufacturers have included digital control technologies into vehicles. Third, vehicles have low capacity utilization, being idle over 95 percent of the time, and needing to charge only about 10 percent of the time, as illustrated in Figure 7. This flexibility allows "drivers to shift charging to different times of the day to minimize their costs and maximize benefits to the grid."[58]

Figure 7: Charging Times Can Meet Mobility and Grid Needs[59]



The CPUC concluded that an EV's ability to provide load, and potential to provide generation, while at the same time providing the EV owner with "its primary use for mobility … demonstrates that there is an opportunity for regulators to work with customers, equipment providers, and grid operators to use electric vehicles as grid resources. "[60] Other PUCs have made similar observations.[61]

b. EV Load as a Grid Asset—A Framework

The CPUC recognizes that usage characteristics of EVs, and the technologies that they contain, allow them to function as a grid asset, "reducing operating costs for facility and vehicle owners, the utilities' distribution maintenance requirements, and energy prices in the wholesale market."[62] In order to analyze the integration challenge and the regulatory barriers to the use of EVs in this way, the CPUC developed a three-part framework that looks at:

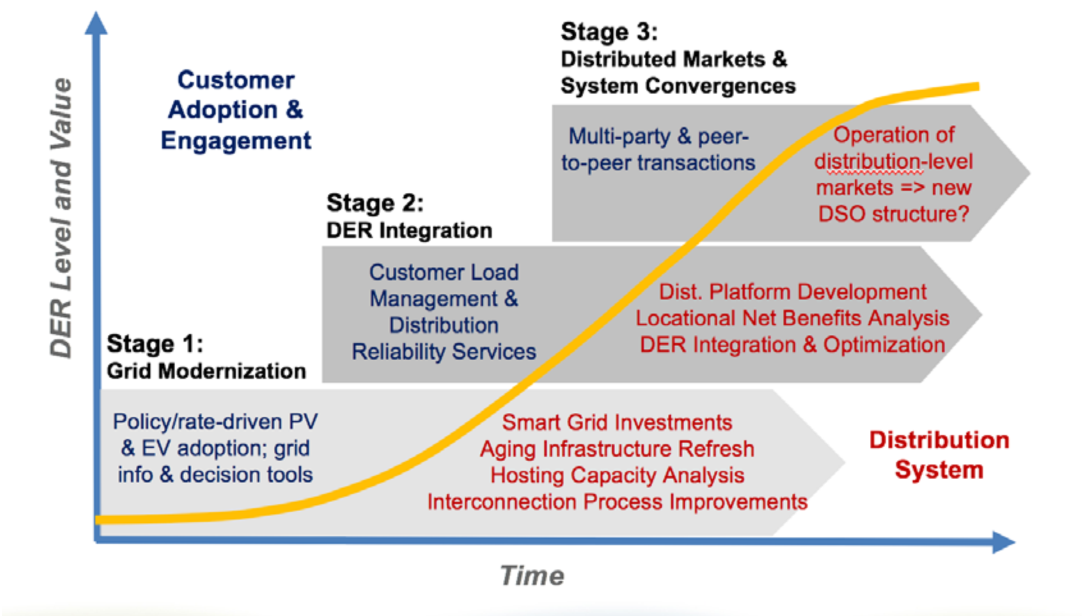
1. The capability of the resource to provide power to the grid in addition to managing its power draw;
2. The alignment of the objectives of the various actors (a vehicle owner, an electric charging station operator, and the facility at which they are located) involved with the provision of power to or from the resource; and
3. The provision of grid services from an individual or an aggregation of resources. [63]

The CPUC identifies "use cases" where an EV customer could be compensated for provision of integration benefits. It also identifies the primary regulatory issues that need to be considered to ensure the benefits of VGI.[64] The regulator needs to:

1. Define where the resource is located;
2. Determine which entities (utilities and/or third-party aggregators) are able to aggregate resources and the point at which that should occur; and
3. With the help of other agencies, define a primacy among different grid benefits.

As illustrated in Figure 8, utilities also need to develop methods to capture and return to customers the value that VGI—i.e., the distributed energy resource (DER)—provides to their distribution infrastructure.[65]

Figure 8: Distribution Systems Evolve with Growth in DER adoption and Opportunities to Realize DER Value[66]

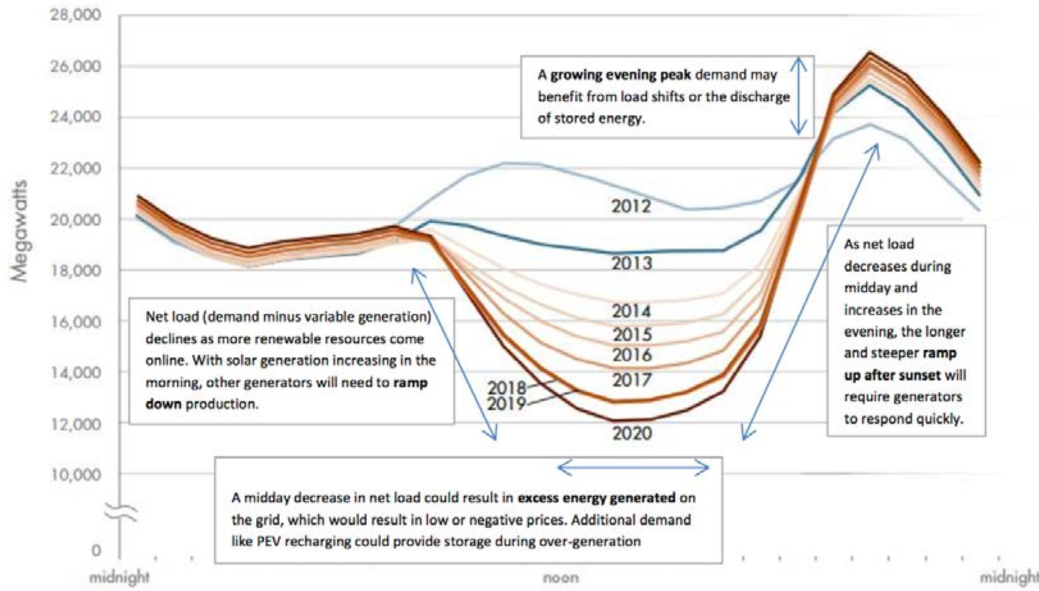


c. Grid Applications

As mentioned above, one way to think about an EV's usage characteristics is to think of them as batteries.[67] They can serve the needs of the grid, and have numerous potential applications, including:

- Frequency regulation, i.e., managing interchange power flows with other control areas to match scheduled interchange flows and momentary variations in demand within the control area.
- Spinning, non-spinning, and supplemental reserve, i.e., capacity available to be dispatched in lieu of normal supply resources.
- Load following/ramping support for renewables, i.e., smoothing the variability of a fluctuating load profile or an intermittent renewable energy system, by accommodating varying ramp rates and for a given duration. (See Figure 9 on the following page.)

Figure 9: The "Duck" Curve [68]



- Distribution upgrade deferral, i.e., an alternative to investments otherwise necessary to maintain adequate capacity to serve load.
- Voltage support, i.e., regulation of system voltage within specified tolerances for the end user.
- Power quality, i.e., protection of customer end-use loads downstream from the storage system from poor power quality.
- Power reliability, i.e., electricity service during times of a utility system outage, either planned or unplanned.
- Retail energy time-shift, i.e., lower overall customer electricity costs if they are subject to time-differentiated energy rates ($/kWh) and charging occurs during low-price times.
- Demand charge mitigation, i.e., depending on the applicable timeframes during which a demand charge would apply, the ability to reduce exposure to a demand charge based on maximum power drawn ($/kW).[69]

d. Smart Charging

Recognizing the various roles that EVs could play on the grid is the first step in managing them correctly. The term "smart charging" is applied to different programs that do this. While rate design can play a key role in managing EV charging (as noted in the prior section), utilities have developed smart charging programs to further enable vehicle integration. Examples of smart charging include demand response, one-way controlled charging, or vehicle-to-grid.

Demand response (DR) principles can be applied in the EV charging context. Utilities can simply pause charging at peak times or when supply is otherwise disrupted. A DR approach can help stabilize grid frequency and avoid the dispatch of often more-expensive and dirty peaking generation resources. In 2014, for example, PEPCO in Maryland ran a pilot designed to test DR and variable pricing programs for EV owners in PEPCO territory.[70] Southern California Edison (SCE) has applied DR to workplace charging and provided customers favorable rates for their willingness to allow their charging to be slowed or stopped when background power grid demand increased.

Another version of smart charging, referred to as “one-way, controlled charging,” adds scheduling and modulating charging to the basic DR approach.[71] This allows utilities greater flexibility to move the charging activity to times when the grid is most capable of providing the service, saving the EV owner and power company expense by avoiding the need for additional investment in infrastructure or generation capacity.

Several of the New York utilities have already begun developing charging infrastructure, including Con Edison’s Branch Circuit Energy Management Device pilot that is directed at studying managed charging.[72] The pilot is designed to test the ability of the utility to measure and control EV charging in five-minute intervals.

Vehicle-to-Grid (V2G) or two-way charging can be thought of as an advanced form of smart charging. It essentially allows for an EV’s battery to serve as a storage device that can discharge power back onto the grid when called upon. As described by Hall and Lutsey:

> With full V2G capabilities, electric vehicles could be charged when power is cheapest and most abundant and fed back to the grid when the power is most valuable, providing financial benefits to consumers. In most scenarios, a group of electric vehicles would be linked together to send power into the grid, forming a “virtual power plant.”[73]

Although V2G charging is promising, currently there are no EVs in mass production that would support the bidirectional charging required for V2G.[74] While V2G may be considered by to be hypothetical or far in the future, regulators should keep it in mind as a valuable goal. While V2G poses challenges, the Department of Defense has engaged in some V2G pilots.[75] Also, the University of Delaware in partnership with BMW and NRG Energy conducted a well-known pilot. It involved 15 vehicles that were aggregated and paid $5 per day (over $1,800 annually) to provide energy into the PJM grid for frequency regulation during peak periods.[76]

<u>Questions</u>

- Have you considered how EVs could contribute to grid management?
- What programs need to be put in place to optimize these contributions?
- What barriers exist that need to be addressed?

6. Defining the Role of Monopoly Service Providers

Summary

- **Policy makers continue to debate the appropriate role of monopoly service providers in this newly-developing marketplace.**
- **Regardless of how a state pursues the development of an EV market, stakeholders will benefit from regulators explaining what they expect from public utilities in this new market for utility services, and how regulators plan to ensure the public good as a market develops in their state.**

Suggested Resources

- **Washington Utilities and Transportation Commission, Docket UE-160799, Draft Policy and Interpretive Statement Concerning Commission Regulations of Electric Vehicle Charging Services.**
- **New York Public Service Commission, Case 14-M-0101 – Proceeding on Motion of the Commission in Regard to Reforming the Energy Vision ("REV Proceeding"), Order Adopting Regulatory Policy Framework and Implementation Plan, issued February 26, 2015.**
- **REV Proceeding, Track One Order and Order Adopting Distributed System Implementation Plan Guidance, issued April 20, 2016 ("DSIP Guidance Order"). The Commission subsequently established Case 16-M-0411, In the Matter of Distributed System Implementation Plans ("DSIP Proceeding"), to facilitate the review of both the Initial and Supplemental DSIPs.**
- **"Supplemental Distributed System Implementation Plan," Case 16-M-0411 In the Matter of Distributed System Implementation Plans, November 1, 2016 (Supplemental DSIP), http://jointutilitiesofny.org/wp-content/uploads/2016/10/3A80BFC9-CBD4-4DFD-AE62-831271013816.pdf.**
- **"The New York City Electric Vehicle Readiness Plan: Unlocking Urban Demand," Ari Kahn and Christina Ficchia, New York, 2012. https://cleancities.energy.gov/files/u/projects_and_partnerships/project_material/supporting_material/232/nyc_readiness_plan.pdf.**
- **Joint comments filed by Acadia Center, Environmental Advocates of New York, Natural Resources Defense Council, Pace Energy and Climate Center, and Sierra Club, http://documents.dps.ny.gov/public/MatterManagement/MatterFilingItem.aspx?FilingSeq=174015&MatterSeq=51282.**

While the role of third-party providers has generally been addressed with relative ease, the appropriate roles of traditional, monopoly service providers and their relationship with other market participants in this newly developing marketplace continue to be debated, as does the extent to which utility commissions should exercise their authority. The following discussion looks at three examples of how states have approached these questions.

a. Washington

In January 2017, the Washington UTC issued a Draft Policy and Interpretive Statement in order to clarify its jurisdiction and various aspects of the regulation of EV charging services to be offered by Washington utilities.[77] The UTC recognizes that the Washington Legislature provided that its utilities be "fully empowered and incentivized to be engaged in electrification of our transportation system" although it did not "require utilities to develop long-term transportation electrification plans, [or] identify a clear role for utilities or the Commission in transportation electrification," leaving that interpretive task to the UTC.

The UTC indicates that its authority to apply public service requirements hinges on the question of "whether facilities are dedicated to public use," and that it is articulating EV charging policy because these activities are "subject to Commission jurisdiction, and subsidized in part by revenues from non-electric vehicle customers." [78]

The Policy Statement indicates that Washington utility companies can offer EV charging as a regulated service, subject to UTC approval and regulation. The UTC also looks at the prospects of working with utilities in this new market from the perspective of where regulation is today under current regulatory doctrine including questions related to:

- Used and useful;
- Prudence;
- Just, fair, reasonable and sufficient rates;
- Banded rates;
- Rate discrimination and preference;
- Sale, transfer, and disposal of property;
- Safe, adequate and efficient service and facilities and integrated resource planning; and
- Eligibility for the incentive rate of return.

The Policy Statement also considers specific EV charging-related policies that will "improve access to and promote fair competition."[79] These include the utility's role in "market transformation and transportation electrification."[80]

The UTC proposes that utilities "offer a portfolio of electric vehicle charging services on a regulated basis" that will "support consumer choice, and allow a competitive market for these services to continue to develop."[81] Those services must be "consistent with Commission interests and policies promoting load management and system benefits, consumer protection, service quality, direct benefits to low-income customers, interoperability, stakeholder engagement, regular reporting, and education and outreach."[82] In addition to the listed items, the UTC singles out the importance of "access to information" which it characterizes as a key to aligning "transportation electrification goals with electric system grid needs."[83]

The UTC's Policy Statement is a good illustration of the value in regulators articulating the manner in which they expect to deal with public utilities in a specific context; here, this new market for utility services. Not only does the UTC set out the issues upon which it expects to focus in its regulation of utilities in this market, it also defines the extent to which it expects public utilities to operate.

b. New York

The role of utilities in transportation electrification in New York is being shaped in the context of a statewide grid-modernization effort, the "Reforming the Energy Vision" (REV) strategy, in which the state is endeavoring to promote clean energy innovation, attract new investments, and improve consumer choice and affordability.[84] In its February 2015 "Order Adopting Regulatory Policy Framework and Implementation Plan," the New York Public Service Commission (PSC) directed utility companies—referred to in this context as "Distribution System Platform (DSIP) Providers" —to file a Distributed System Implementation Plan (DSIP).[85] In November 2016, utilities in the aggregate (the Joint Utilities) were also directed to file a "Supplemental Distributed System Implementation Plan" (Supplemental DSIP) in which they describe their plans for engaging in the EV market.[86]

The Joint Utilities indicate that they are engaged in the initial steps to "support expanded market activities and facilitate the deployment of DER, including [EVs]."[87] DSIP Providers are individually developing models to characterize EV adoption levels, and adopting forecasts to include in their system planning. According to the Supplemental DSIP, EV adoption levels in the near term are not expected to have significant effects on planning scenarios and the related investment plans. EV penetration is expected to vary by utility service territory, and each DSIP Provider is expected to develop models and estimates of the level of EV penetration that will affect utility planning.

The Joint Utilities have developed "Guiding Principles for Utility Involvement in EVSE" (Guiding Principles)[88] and support for what they call the "EV Readiness Framework" (Framework) to develop programs and means to identify thresholds relevant to system planning processes.[89] The forthcoming Framework is intended to position utility companies to support increases in EV adoption and to coordinate their responsiveness to state EV initiatives.[90] The utilities anticipate that elements of the Framework could be implemented in the near term, in order to pave the way for future market growth.

The Joint Utilities contend that implementation of specific Framework elements will depend on the "degree of market maturity and utility-specific territory considerations."[91] In the near-term, for example, infrastructure planning will include "service connection processes, building codes, and local ordinances." [92] The Framework will also be useful for judging market activity and thresholds at which distribution system benefits and impacts become material.

Responding to the DSIPs and supplemental DSIP that were filed, the PSC issued an order on March 9, 2017, providing general support for the utilities' EV planning efforts. The PSC expects the utilities to "continue investigating EV-related infrastructure effects and modifications in anticipation of a potential future when the range of needs and demands for EVs is substantial."[93] It also stated that the Guiding Principles that the utilities and stakeholders developed "are a good first step, as is the initiative to develop an EV Readiness Framework within 12 months or sooner."[94] The PSC also acknowledged that the "modeling and forecasting to assess EV-related system needs and planning should be utility-specific."[95]

The New York REV process directs utilities to plan their eventual response for when "needs and demands for EVs are substantial." This is a good illustration of a regulator ensuring that utilities will be sufficiently prepared when they need to take action to accommodate EV growth. Despite this, some REV participants have argued that the utilities should be more proactive and promote transportation electrification.[96]

c. California

The experience of the state of California and the CPUC is instructive for utility regulators trying to understand the challenges and level of difficulty associated with determining the appropriate role that investor-owned utilities (IOUs) will play in that state's developing EV market. It should be noted that SB 350, the statute that among other things required the CPUC to approve utility EV programs that accelerate transportation electrification, did not go into effect until 2015.

2011
The CPUC initiated a rulemaking to identify the role of the state's IOUs in supporting the expected statewide market growth of EVs.[97] That rulemaking (R.09-08-009) resulted in a 2011 CPUC decision (D. 11-07-029) that imposed a prohibition on utility ownership of EVSE, except for charging infrastructure

for the utilities' own fleets or workplaces. While the CPUC recognized that there could be benefits to IOU ownership of EVSE, its 2011 decision concluded that those benefits are "speculative and do not outweigh the competitive limitation that may result from utility EVSE ownership."[98]

Additionally, rather than imposing an outright ban on IOU ownership, the CPUC added that "should utilities present evidence in an appropriate proceeding of underserved markets or market failure in areas where utility involvement is prohibited, we will revisit this prohibition."[99]

2014

Less than three years later, largely reversing the earlier limitations it had placed on IOU participation in the charging market, the CPUC issued a decision expanding the ability of IOUs to own EVSE.[100] The decision set aside the requirement that utilities demonstrate a market failure or underserved market to own EV charging infrastructure. In its place, the CPUC determined that a case-specific approach would be used to evaluate whether it is appropriate for an IOU to own EV charging infrastructure.[101] And, in focusing on the more limiting participation test that it had imposed in its earlier decision, the CPUC wrote:

> Given the early stage of current PEV market development, it may well be premature to reasonably assess "market failures" or whether "underserved markets" exist when the electric vehicle market as a whole is relatively new. We conclude that these criteria are overly restrictive in evaluating the reasonableness of any particular utility proposal. [102]

The CPUC additionally acknowledged other reasons for overturning the broad prohibition on IOU ownership of EVSE. "[C]ertain market segments are harder for third parties to penetrate and the utilities may be better positioned to develop those market segments or support third party providers to do so," and that "even limited utility involvement to accelerate the PEV infrastructure market can improve the business case for third parties." [103]

The CPUC also noted that "the parties' comments represent near unanimity that the utilities should have an expanded role in EV infrastructure support and development in order to realize the potential benefits of widespread EV adoption," although there was disagreement as to the degree of that participation with some parties advocating for a limited and conditioned role.[104]

The CPUC's experience between 2011 and 2014 as illustrated by decisions D.11-07-029 and D.14-12-079 captures some of the challenges that regulators in other states will face in determining the role that public utilities can play in supporting increased EV adoption. While the CPUC's viewpoint on the appropriate role for IOUs may have changed between 2011 and the present, its goals have not. The CPUC is motivated by the interest in seeing a market for EVs develop in California. Its willingness to revisit assumptions about how that might occur were informed, in part, by the state's adoption of explicit statutory goals, the status of EV adoption in the state, and the realization that its initial view had been overly restrictive.

While originally inclined to protect an emerging market for new-comers and to allow utilities entry into only underserved segments, the CPUC significantly altered that position. It now embraces the view that, rather than constituting barriers, utilities might be able to "improve the business case for third parties" because certain "market segments are harder for third parties to penetrate," and that utilities may be better positioned "to either develop them or to assist third parties in doing so.[105]

d. Pilot Programs

Following upon regulatory investigations into the appropriate roles of traditional, monopoly service providers and their relationship with other market participants, many states have authorized utilities to submit plans for pilot programs. Many states have concluded that pilot programs offer companies and regulators the opportunity to gain valuable insights without having to first develop full-scale programs. Many states have IOUs that are piloting EV charging programs, including Washington (Puget and Avista), New York (ConEd, National Grid, NYSEG and RG&E), California (PG&E, SCE, SDG&E), and other states like Michigan (DTE Electric) and Virginia (Dominion).[106] While it is beyond the scope of this paper to go into significant detail about any specific pilot program, throughout the paper we use examples from pilot programs to illustrate various regulatory actions that have arisen in the context of state transportation electrification efforts.

Questions

- Have you engaged informally to discuss the role of the monopoly service providers in this context?
- Should they be encouraged to create public charging stations? Is there a gap that needs to be filled to create market transformation towards EVs that private entrepreneurs are not filling?
- If so, would it be as a competitive business or as a monopoly service?
- If as a monopoly service, is it ratepayer-funded? Is that permissible under the law in your state?
- If public utilities are competing with private companies, what codes of conduct and other safeguards need to be in place to ensure a robust competitive marketplace for the benefit of all citizens?

7. Licensing Third-Party Charging Services

Summary

- **States define the legal status of EV-charging service providers through legislation or administrative action.**
- **The general trend has been to exempt them from treatment as a public utility.**

Suggested Resources

- **Title 15 of Hawaii Revised Statutes (Transportation and Utilities) § 269-1, http://law.justia.com/codes/hawaii/2013/title-15/chapter-269/section-269-1/.**
- **New York PSC, Case 13_E_0199, in re Electric Vehicles Policies, November 22, 2013, http://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId=%7BCD90FD7A-5874-4DE3-AFF1-5EA4BF18903B%7D.**

Because EV charging stations, like regulated utilities, sell electricity, the question arises: should businesses engaged in charging vehicles be licensed and regulated like utilities? Or should they be treated like competitive retail service providers subject to a certification process that reviews their qualifications and conditions for service? Because utility service requirements are established and enforced under state authority, states have dealt with this issue either through legislation or administrative action.

Washington legislation clarified the Commission's jurisdiction over battery charging services by exempting those services from Commission regulation.[107] Hawaii responded to this question legislatively, as well. In its statutory definition of "public utility," Hawaii excludes from Commission jurisdiction "Any person who owns, controls, operates, or manages plants or facilities primarily used to charge or discharge a vehicle battery that provides power for vehicle propulsion."[108] Maryland law also exempts EV charging station operators from being treated as "electricity suppliers," and thus from being subject to typical public utility regulation,[109] as do other states.[110]

States have also addressed this issue under existing administrative authority. CPUC, for example, exempted charging stations in its definition of "public utility."[111] The New York Public Service Commission (PSC) issued a declaratory ruling exempting EV charging infrastructure.[112] As part of a ruling that the provision of electric vehicle charging service is not within its jurisdiction, the Massachusetts Department of Public Utilities (DPU) ruled that EVSE equipment operators that provide charging services are not distribution companies or electric companies under Massachusetts law.[113] The Oregon Public Utilities Commission (PUC) made a similar pronouncement.[114]

Irrespective of the path chosen, it will be important to have adequate consumer protections in place to ensure good customer service and reasonable practices on the part of providers. These would include such things as transparency and price disclosures. While typically a competitive supplier who is certified would not face price regulation, some oversight may be appropriate in the nascent stages of the vehicle charging industry. For example, if a customer is on a highway and needs to stop and recharge, it may not be like a gas station with multiple options; there may only be one charging station available. Until multiple charging stations are available that can compete with one another, that sole charging station on the highway is operating as a *de facto* monopoly supplier.

Questions

- Are multiple parties being offered the opportunity to provide services?
- Should businesses engaged in charging vehicles be licensed and regulated like utilities? Or should they be treated like competitive retail service providers subject to a certification process that reviews their qualifications and conditions for service?
- Does the Commission have the authority to address this issue or does it need to be addressed through legislation?

8. Market Transformation and the Role of the Utility

Summary

- **Electrification of the transportation sector will call for regulators to revisit many of the policies and practices upon which they have relied over the years and develop new policies where necessary to help manage this transformation and support the appropriate roles of consumers, auto manufacturers and dealers, other new market participants, and utilities in the future.**

Suggested Resources

- **"Crossing the Chasm," Moore, Geoffrey (1991).**
- **"Driving out Pollution: How Utilities Can Accelerate the Market for Electric Vehicles," Baumhefner, Max; Roland Hwang and Pierre Bull. Natural Resources Defense Council (June 2016). https://www.nrdc.org/sites/default/files/driving-out-pollution-report.pdf.**

While many states are broadly engaged in the electrification of transportation, each appears to start on a slightly different footing. In California, the CPUC initially (in 2011) limited the role of its investor-owned utilities (IOUs), expecting greater market activity from third-party EV charging providers to occur. This was the case until the 2015 passage of SB 350, which directed IOUs to plan for transportation electrification in their integrated resource plans, and required the CPUC to approve utility EV programs that accelerate transportation electrification.[115]

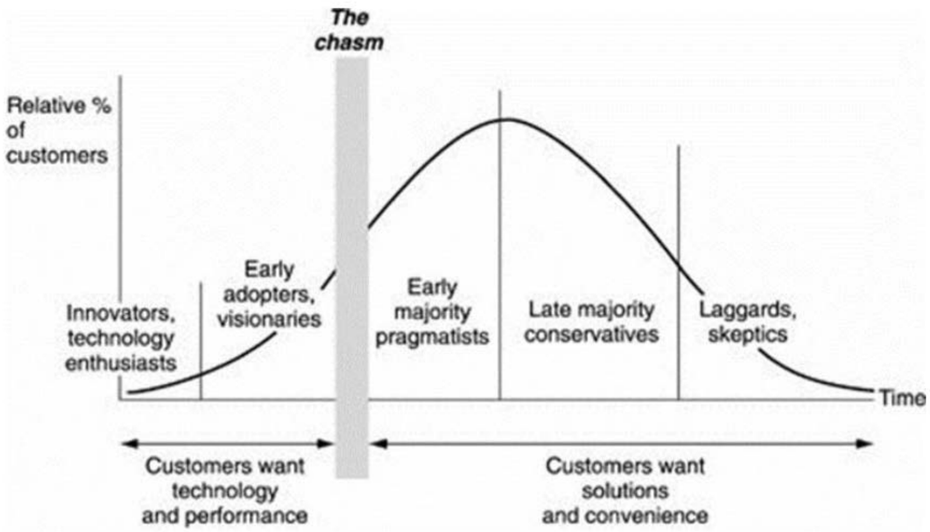
In New York and Rhode Island, transportation electrification is part of a much larger exploration of grid modernization and distribution system planning. In Vermont, it is directly connected to the development of renewable resources. The Vermont Comprehensive Energy Plan has set a goal of powering 25 percent of vehicles in the state from renewable energy sources by 2030 as a step toward the overall goal of 90 percent of the state's energy use coming from renewable sources by 2050.[116]

Washington law directs utilities to be "fully empowered and incentivized to be engaged in electrification of our transportation system."[117] Responding to this legislative directive, the UTC has approached transportation electrification in Washington as a "market transformation" effort, a term used regularly in the context of energy efficiency (EE) programs. The UTC cites the American Council for an Energy-Efficient Economy's (ACEEE) definition of market transformation and Geoffrey Moore, author of "Crossing the Chasm," who first described the concept as:

> (t)he strategic process of intervening in a market to create lasting change in market behavior by removing identified barriers or exploiting opportunities to accelerate the adoption of all cost-effective energy efficiency as a matter of standard practice.[118]

Looking at "Moore's Curve" (Figure 10 below), an illustration of the different types of participants in an emerging market, and their willingness to adopt new technologies, the UTC observes that many of the barriers associated with a growing EV market (e.g., price, range and charging availability, and low consumer awareness) are similar to those faced by EE technologies before transformation.[119]

Figure 10: Energy-Efficient Technologies' Commercialization Process[120]



According to the UTC, utilities are well-suited to address barriers of charging availability and consumer awareness, but market transformation is another matter for which utilities will need guidance from market transformation experts.[121]

It is not entirely clear how EV markets will develop from state to state, but as noted by one commentator, "to achieve widespread adoption, fueling an EV will eventually need to be similar in ease to fueling a gasoline-powered vehicle. This accomplishment will not happen in a vacuum."[122] In getting from here to there, regulators will need to both revisit many of the policies and practices upon which they have relied over the years, and develop new policies to help manage this transformation.

So, whether one views development of an EV market through the lens of grid modernization, carbon management, renewable energy development, or EE market transformation, regulators will need to consider how utilities should function in this new arena, and how to ensure the public good as a market for EVs develops in their state.

Conclusion

Whether states are actively engaged in promoting the adoption of EVs or, instead, are inclined to accommodate whatever amount of activity occurs in the market in their state, these changes to the electric sector will likely pose new challenges and opportunities for regulators and utility companies. Regulatory policy, like the changing utility landscape, will have to keep pace.

Currently, there are relatively low penetrations of EVs, which makes this an ideal time for decision-makers to consider putting processes in place. This is an opportune moment for regulators to evaluate utility services in ways that promote alignment with the public interest and to begin to analyze the next steps utilities can take regarding transportation electrification. This paper is designed to help utility regulators start that process, and to begin to ask relevant questions about transportation electrification in their states.

Appendix: Additional Issues

Multi-Unit Dwellings

Summary

- **Ensuring access to EV charging for people in multi-unit dwellings (MUDs) is a challenge.**
- **While nearly 80 percent of all EV charging occurs at home, approximately 34 percent of California's dwelling units are condominiums and apartments and they currently represent less than 5 percent of home-based charging.**
- **The high percentage of charging that is occurring in detached housing (about 95 percent) reflects who is buying or leasing EVs, as well as the ease of plugging into existing outlets or upgrading in one's own garage.**
- **There isn't a strong likelihood of a near-term change in this imbalance in access absent policy intervention that includes education and financial support for this sector.**

Suggested Resources

- **EV 101 for MUDs: http://link.novaworks.org/ev-resources**
- **City of San Jose Housing Department: http://www.sanjoseca.gov/index.aspx?NID=733**
- **City of Sunnyvale Community Development Department: http://sunnyvale.ca.gov/Departments/CommunityDevelopment.aspx**
- **First Community Housing: http://www.firsthousing.com/**
- **State of California Department of Housing and Community Services: http://www.hcd.ca.gov/hpd/housing_element2/GS_home.php**
- **City of Sunnyvale Electric Vehicle Charging Building Division Requirements: http://sunnyvale.ca.gov/Portals/0/Sunnyvale/CDD/Residential/Electrical%20Car%20Chargers.pdf**
- **LEED (Leadership in Energy and Environmental Design), U.S. Green Building Council: http://www.usgbc.org/leed**

One of the many challenges associated with encouraging EV market development is ensuring access to charging for people in multi-unit dwellings (MUDs). This is illustrated by circumstances in California. Electric Power Research Institute (EPRI) research indicates that nearly 80 percent of EV charging occurs at home. [123] However, while approximately 34 percent of California's dwelling units are condominiums and apartments, less than 5 percent of home-based charging occurs in MUDs.[124]

According to "Obstacles and Opportunities: Electric Vehicle Charging in Apartment-Based Housing," a 2015 study prepared by Nova Workforce Development under a grant from, among others, the California Energy Commission and California Workforce Investment Board:

> [T]he high percentage of charging that is occurring in detached housing (about 95 percent) is reflective of who is buying or leasing PEVs, as well as the ease of plugging into existing outlets or upgrading to higher amperage circuits in a homeowner's garage."[125]

According to the study, there isn't a strong likelihood of a change in this imbalance in access in the near-term, absent policy intervention:

> Project research indicates that many apartment residents have not yet requested charging stations and those "future residents" looking for apartments have not yet requested EV charging as an amenity that would sway their decision about where to rent their next apartment.[126]

States recognize this challenge and have made efforts to address this. For example, in Colorado, landlords cannot prohibit tenants from installing Level 1 or 2 EV charging systems at their own expense on leased premises, and common interest communities cannot prohibit residents from charging EVs.[127] Homeowner associations in Oregon are required to approve an application by a homeowner, subject to conditions, and homeowners are liable for all costs, including those related to any damage of common property.[128] California has a similar prohibition that would affect property transfers in common interest communities.[129]

The authors of "Obstacles and Opportunities" make three recommendations that would serve to encourage greater access to EV charging for MUD occupants, including: (i) education for MUD site managers; (ii) a tiered state funding program to provide relevant training; and (iii) a state capital improvements (cost-sharing) grant program to assist MUD property owners to help provide certified assessors to help plan and design EV charging projects in this sector.[130]

Monitoring, Reporting and Data Collection

Summary

- **The data that EV pilots produce help the utility and decision makers determine how effectively programs are working, and whether additional improvements need to be made.**
- **Utility regulators should consider the types of information that they will want from companies conducting pilots in order to ensure that company expenditures are in the public interest, and that there is relevant data supporting state transportation electrification plans.**

Suggested Resources

- **Application of San Diego Gas & Electric Company (U902E) for Approval of its Electric Vehicle-Grid Integration Pilot Program, Decision Regarding Underlying Vehicle Grid Integration Application and Motion to Adopt Settlement Agreement, Decision 16-01-045, January 28, 2016, http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M158/K241/158241020.PDF.**

The data that EV pilots produce help the company and decision-makers determine how effectively programs are working, and whether additional improvements need to be made. Utility regulators should consider the types of information that they will want from companies conducting pilots in order to ensure that company expenditures are in the public interest, and that there is relevant data supporting state transportation electrification plans.

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.[131] The CPUC order requires SDG&E to meet with CPUC staff every three months to provide updates on the following topics related to EV charging infrastructure installations (i.e., site installations"):

- 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 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; and
- 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 order also requires semi-annual reports containing the information reported in the quarterly check-in meetings, and a description of any program changes implemented by SDG&E prior to the date of the report. The reports are to be submitted to the CPUC as well as to relevant service lists.

The CPUC wrote that the data "will be useful in evaluating SDG&E's VGI 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."[132] Furthermore it indicated that the data could be useful in "comparative evaluations of the SDG&E 2016 VGI Pilot Program relative to other utilities' EV infrastructure and rate programs."[133]

In addition to recognizing the value of the 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."[134]

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."[135]

Elsewhere, in Washington, the UTC approved a pilot for Avista in Docket UE-160082 that allows the company to own and operate, as part of its regulated services, up to 265 Level 2 chargers and seven DC Fast Chargers throughout its territory.[136] Avista is required to submit quarterly reports on: (i) program participation levels; (ii) expenditures; and (iii) revenues for each service offered.[137] Additionally, it is required to report the DC Fast Charger station locations, levels of utilization, and amount of overall fixed and variable costs recovered through user payments.

Customer Education

Summary
• **Consumers appear to have a lack of understanding about EVs and their availability and suitability as a transportation option.** • **Consumer education is important to the development of an EV market.**
Suggested Resources
• **"High Costs, Lack of Awareness Threaten to Short Out Electric Vehicle Adoption," Cort Boulanger, December 2016, http://www.businesswire.com/news/home/20161208005809/en/High-Costs-Lack-Awareness-Threaten-Short-Electric.** • **"The ABCs of EVs: A Guide for Policy Makers and Consumer Advocates," May 2017, https://citizensutilityboard.org/wp-content/uploads/2017/04/2017_The-ABCs-of-EVs-Report.pdf.**

Many who are considering the development of EV markets in their regions have noted the importance of consumer outreach and education. Anecdotal evidence suggest that there is a need. For example, according to a December 2016 survey conducted by Altman Vilandrie & Company of over 2,500 America car buyers, "[d]espite significant advancements in electric vehicle (EV) technology, 60 percent of American drivers said they were unaware about electric cars…."[138] Stephen Edelstein of *Green Car Reports* has written that "in the six years since modern electric cars went on sale in large numbers, educating the public has been one of the greatest challenges for advocates of plug-in cars."[139]

When customer choice and energy efficiency programs were first initiated, multi-media advertising helped to educate customers and get the message out. Similar efforts, taking advantage of free media to the extent possible could be helpful. PG&E's EV pilot program, for example, has a web page that addresses various issues that a new EV consumer in the company's territory might want to understand.[140] The following topics are included on the page:

- Understand Our Rates
- Apply for the Clean Fuel Rebate
- Install an EV Charging Station
- Understand Your Options for Charging an EV
- Explore EV Fundamentals
- Prepare Yourself for Buying an EV
- Discover Incentives for Owning an EV
- Electric Vehicle Submetering Pilot
- Discover Other Helpful Tools for EVs
- Enroll in an EV Rate Plan
- Stay Informed about EV News and Events

In the "ABCs of EVs," the Citizen's 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, public charge station location database, and information about available incentives.[141]

The Washington UTC's Policy Statement also emphasizes the importance of customer education and outreach, noting that it is "necessary to drive market transformation."[142] The UTC also found that, as long as the information is not "promotional advertising," the cost of which cannot be include in rate base, the costs of education and outreach could be included in a company's cost of service.[143]

Endnotes

[1] The nomenclature for electric vehicles can be confusing. This paper uses the general term "EV" to refer to various types of electric vehicles, including battery electric vehicles "BEVs," or plug-in hybrid electric vehicles (PHEVs or PEVs). Because hybrid EVs run on gasoline and have emissions, they should not be confused with zero-emission vehicles (ZEVs).

[2] Vlasic, B. & Boudette, N.E. (2017, April 3). Tesla Passes Ford in Market Value as Investors Bet on the Future. *New York Times*. Retrieved from https://www.nytimes.com/2017/04/03/business/tesla-ford-general-motors-stock-market.html?emc=edit_nn_20170404&nl=morning-briefing&nlid=59559646&te=1&_r=0

[3] Hannon, E., McKerracher, C., Orlandi, I. & Ramkumar, S. (2016, October). *An Integrated Perspective on the Future of Mobility.* McKinsey and Co. Retrieved from http://www.mckinsey.com/business-functions/sustainability-and-resource-productivity/our-insights/an-integrated-perspective-on-the-future-of-mobility

[4] The rapid emergence of autonomous driving and both car- and ride-sharing could alter assumptions associated with the continuation of individualized transport. See, e.g., Weiss, J., Hledik, R., Hagerty, M. & Gorman, W. (January 2017). *Electrification Emerging Opportunities for Utility Growth.* Brattle Group. Retrieved from http://www.brattle.com/system/news/pdfs/000/001/174/original/Electrification_Whitepaper_Final_Single_Pages.pdf?1485532518

[5] Id.

[6] For general information and links to specific state statutes, see the US Department of Energy's Alternative Fuels Data Center: http://www.afdc.energy.gov/laws/state. For a list of the most recently updated state laws, incentives and regulations, see http://www.afdc.energy.gov/laws/recent. It should be recognized that not all states are necessarily favor the electrification of the transportation sector. There are states that have passed requirements (e.g., annual ownership fee) that some consider a barrier to EV adoption. See, e.g., Coplon-Newfield, G., & Newshan, M. (2017, February 16*). Flurry of State Bills Introduced, Likely Backed by Oil Industry, to Penalize Electric Car Drivers.* Sierra Club. Retrieved from http://www.sierraclub.org/compass/2017/02/flurry-state-bills-introduced-likely-backed-oil-industry-penalize-electric-car.

[7] See Nelder, C., Newcomb, J., & Fitzgerald, G. (2016). *Electric Vehicles as Distributed Energy Resources*. Rocky Mountain Institute, p. 63. Retrieved from http://www.rmi.org/pdf_evs_as_DERs. 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.

[8] Examples include: Colorado landlord/tenant EV charging requirements, CO. Rev. Stat. §§ 38-12-601 and 38-33.3-106.8; Oregon homeowner associations provisions, OR. Rev. Stat. § 94.550, or limits in California on unreasonable property-transfer restrictions related to EV charging infrastructure, Cal Civ. Code § 1353.9.

[9] Pennsylvania PUC. (2012, April 9). Docket No. M-2012-2287224: Alternative Fuel Vehicles Forum on PUC Jurisdictional Issues. See also Maryland (http://www.psc.state.md.us/wp-content/uploads/EV-Public-Conference-Notice.pdf); and Illinois (https://www.icc.illinois.gov/Electricity/programs/pev.aspx).

[10] Detsky, M. & Stockmayer, G. (2016). Electric Vehicles: Rolling Over Barriers and Merging with Regulation. *40 William and Mary Environmental Law and Policy Review*, p. 485. Retrieved from http://scholarship.law.wm.edu/cgi/viewcontent.cgi?article=1646&context=wmelpr

[11] Washington State Electric Vehicle Action Plan. Retrieved from http://www.wsdot.wa.gov/NR/rdonlyres/28559EF4-CD9D-4CFA-9886-105A30FD58C4/0/WAEVActionPlan2014.pdf

[12] See, e.g., endnotes 78-80 and accompanying text below.

[13] Results Washington. (2017, January). Goal 3.1.1.c. Retrieved from http://results.wa.gov/what-we-do/measure-results/sustainable-energy-clean-environment/goal-map

[14] See California documents: 166 Executive Order B-16-12, https://www.gov.ca.gov/news.php?id=17463; 167 Executive Order B-32-15, https://www.gov.ca.gov/news.php?id=19046, and *2013 ZEV Action Plan -- A roadmap*

toward 1.5 million zero-emission vehicles on California roadways by 2025, https://www.opr.ca.gov/docs/Governor's_Office_ZEV_Action_Plan_(02-13).pdf.

[15] California SB 350: Clean Energy & Pollution Reduction Act—Overview. Retrieved from http://www.energy.ca.gov/sb350/.

[16] 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. Also see: International Alliance Aims for All New Cars to be Zero Emission by 2050. Retrieved from http://zevalliance.org/content/cop21-pr-zero-emission-2050

[17] Office of Governor Andrew M. Cuomo. (2017, March 6). Governor Cuomo Announces New Campaign to Install Charging Stations and Promote Electric Vehicle Use Across New York State [Press release]. Retrieved from https://www.governor.ny.gov/news/governor-cuomo-announces-new-campaign-install-charging-stations-and-promote-electric-vehicle

[18] Office of Governor Andrew M. Cuomo. (2017, January 8). Governor Cuomo Announces 8th Proposal of the 2017 State of the State: Install Over 500 New Charging Stations to Promote Electric Vehicle Use [Press release]. Retrieved from https://www.governor.ny.gov/news/governor-cuomo-announces-8th-proposal-2017-state-state-install-over-500- new-charging-stations

[19] This illustration is borrowed from McCoy, J.J. (2016, January). *Building "Good Load" to Reduce Carbon Emissions: Getting Northwest Utilities More Involved in Widespread Transportation Electrification*. NW Energy Coalition, p. 20. Retrieved from http://www.nwenergy.org/news/nw-energy-coalition-issue-paper-weighs-benefits-and-opportunities-for-vehicle-electrification/

[20] See, for example, Sedano, R. & Colburn, K. (2017, February). Utilities Can Get a "LEG" Up with Beneficial Electrification—But Regulators Also Have to be Ready [Blog post series]. Regulatory Assistance Project. Retrieved from http://www.raponline.org/utilities-can-get-a-leg-up-with-beneficial-electrification-but-regulators-also-have-to-be-ready/

[21] McCoy, 2016.

[22] EVSE typically includes features to ensure that power delivered to a vehicle does not exceed the limits of what the car can receive, and is also designed so power does not flow from the attachment plug until it is attached to the car. See: Auto Blog. (2010, November 1). What is EVSE? It's Electric Vehicle Supply Equipment, and Here's What it's all About. Retrieved from http://www.autoblog.com/2010/11/01/what-is-evse-its-electric-vehicle-supply-equipment-and-heres/; and Inside EVs. Electric Vehicle Charging Levels Explained. Retrieved from http://insideevs.com/charging-levels-explained-bower/

[23] California Public Utilities Commission (CPUC). Proposed Decision of ALJ Farrar (Mailed 11/14/2016) Before the Public Utilities commission of the State of California, In the Matter of the Application of Pacific Gas and Electric Company for Approval of its Electric Vehicle Infrastructure and Education Program (U39E). Application 15-02-009 (Filed February 9, 2015) Decision Directing PG&E to Establish an Electric Vehicle Infrastructure Education Program, p. 8 Retrieved from http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M171/K213/171213824.PDF

[24] Plug In America. Understanding Electric Vehicle Charging. Retrieved from https://pluginamerica.org/understanding-electric-vehicle-charging/; Berman, B. (2017, March 7). Buying Your First Home EV Charger. *PlugInCars.com.* Retrieved from http://www.plugincars.com/quick-guide-buying-your-first-home-ev-charger-126875.html

[25] Level 2 chargers allow for a wide range of charging speeds, all the way up to 19.2 kilowatts (kW), or about 70 miles of range per hour of charging.

[26] Allison, A. & Whited, M. (2017, March 2). A Plug for Effective EV Rates. Synapse Energy Economics, p. 2 (citing Consumer Reports Wattage Calculator and Bosch Electrical Vehicle Solutions). Retrieved from http://www.synapse-energy.com/sites/default/files/A-Plug-for-Effective-EV-Rates-S66-020.pdf

[27] Forward, E., Glitman, K., & Roberts, D. (2013, March 20). *An Assessment of Level 1 and Level 2 Electric Vehicle Charging Efficiency.* Vermont Energy Investment Corporation (VEIC) Transportation Efficiency Group. Retrieved from https://www.veic.org/docs/Transportation/20130320-EVT-NRA-Final-Report.pdf

[28] Washington Utilities and Transportation Commission (WUTC). (2017, January 13). Docket UE-160799: Draft Policy and Interpretive Statement Concerning Commission Regulations of Electric Vehicle Charging Services, ¶ 70. Retrieved from https://www.utc.wa.gov/_layouts/15/CasesPublicWebsite/GetDocument.ashx?docID=94&year=2016&docketNumber=160799

[29] Forward, Glitman & Roberts, 2013, Table 1, p. 9.

[30] Not an unlikely occurrence. If one were using a 6.6 kW charging station for 15 minutes while parked and running an errand, this would be a "low-energy" charge event.

[31] Forward, Glitman & Roberts, 2013, note 9, citing analysis provided by FleetCarma (unpublished manuscript, December 2012).

[32] WUTC, Docket UE-160799.

[33] Allison and Whited, 2017 (citing Nexant, 2014).

[34] RMI_Electric_Vehicles_as_DERs_Final_V2.pdf, p.61; 95 NV Energy Electric Vehicle Rates. https://www.nvenergy.com/renewablesenvironment/EV/ electricVehicle.cfm

[35] RMI, 2017, p.3.

[36] RMI, 2017, p. 62.

[37] Tweed, K. (2013, July 15). Dynamic Pricing Saves Energy and Costs at SMUD. Retrieved from https://www.greentechmedia.com/articles/read/Dynamic-Pricing-Saves-Energy-and-Costs-at-SMUD; and Tweed, K. (2011, February 14). OG&E Finds Time of Use Pricing Sweet Spot. Retrieved from https://www.greentechmedia.com/articles/read/oge-finds-tou-pilot-sweet-spot

[38] Mills, J. (2016, November). Charging Ahead: Rate Design & Electric Vehicles [Presentation to NARUC Annual Meeting]. Maryland Public Service Commission. Retrieved from http://pubs.naruc.org/pub/35BA126B-D9AC-A9FE-7CF6-4D30F0577FCA

[39] New York State Energy Research and Development Authority (NYSERDA). (2015). *Electricity Pricing Strategies to Reduce Grid Impacts from Plug-in Electric Vehicle Charging in New York State*, Section 3.1.2. Retrieved from https://www.nyserda.ny.gov/-/media/Files/Publications/Research/Transportation/EV-Pricing.pdf

[40] FleetCarma. How Much Can You Save With Off-Peak Charging? Retrieved from http://www.fleetcarma.com/electric-vehicle-off-peak-charging-cost/

[41] NYSERDA, 2015, p.3.

[42] NYSERDA, 2015, p. 4; also see ComEd's Hourly Pricing Program: https://hourlypricing.comed.com/.

[43] NYSERDA, 2015, p.5; also see Elevate Energy. Hourly Pricing and Electric Vehicles. Retrieved from http://www.elevateenergy.org/wp/wp-content/uploads/Hourly-Pricing-and-EVs-050714.pdf

[44] See San Diego Gas & Electric's notice of a rate increase request in conjunction with its electric vehicle pilot program: https://www.sdge.com/sites/default/files/documents/69342274/VehicleGridIntegration.pdf. This rate design is described by Noel Crisostomo, air pollution specialist at the California Energy Commission, in *Driving Integration: Regulatory Responses to the EV Opportunity*, an RMI webinar presented on November 17, 2016. Retrieved from https://www.youtube.com/watch?v=OTZlIR6z43o

[45] Allison and Whited, 2017, p. 5.

[46] Allison and Whited, 2017, p. 5; NYSERDA, 2015.

[47] Because traditional demand charges are measured on the basis of the individual customer's peak, regardless of whether it coincides with the peaks on any portion of the system, this approach results in a mismatch between the system coincident peak costs used to set prices and the actual costs incurred at the time of the customer's noncoincident peak. While the revenue to be collected is represented by the system coincident peak costs, the billing units used to set the prices are the sum of all customers' individual non-coincident peaks. This results in a lower demand charge for everyone, but has the effect of requiring customers who are not contributing

proportionately to the system peak to bear a greater share. Lazar, J. & Gonzalez, W. (2015). *Smart Rate Design for a Smart Future.* Regulatory Assistance Project, p 37. Retrieved from http://www.raponline.org/document/download/id/7680

48 This illustration was proposed by Ranjit Bharvirka, RAP senior associate and India program officer.

49 3.148 trillion miles. See Federal Highway Administration. U.S. Driving Tops 3.1 Trillion Miles In 2015 [Press release]. Retrieved from https://www.fhwa.dot.gov/pressroom/fhwa1607.cfm

50 A 2012 Nissan Leaf has an average rated efficiency of 99 MPGe, which translates to 34 kilowatt-hours per 100 miles. Voelcker, J. (2013, March 6). Electric-Car Efficiency: Forget MPGe, It Should Be Miles/kWh. *Green Car Reports*. Retrieved from http://www.greencarreports.com/news/1082737_electric-car-efficiency-forget-mpge-it-should-be-miles-kwh

51 In 2016, there were 3,710,779,000 MWh total sales of electricity. See Energy Information Administration (EIA). Sales of Electricity to Ultimate Customers. Retrieved from https://www.eia.gov/electricity/monthly/epm_table_grapher.cfm?t=epmt_5_01

52 3,758,992,390. See EIA State Electricity Profiles (2015).

53 Langton, A., & Crisostomo, N. (2013, October). *Vehicle-Grid Integration: A Vision for Zero-Emission Transportation Interconnected throughout California's Electricity System*. California Public Utilities Commission, Energy Division, Retrieved from http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M081/K975/81975482.pdf

54 Nelder, Newcomb & Fitzgerald, 2016, p. 54. Citing California ISO, 2015 Summer Loads & Resources Assessment, https://www.caiso.com/ Documents/2015SummerAssessment.pdf. In CAISO's summer 2015 resource adequacy planning convention, the ISO had a 63,822 MW total net supply

55 Figure adapted from Podorson, D. (2014, September 9). Battery Killers: How Water Heaters Have Evolved into Grid-Scale Energy-Storage Devices—An E Source White Paper. Retrieved from https://www.esource.com/ES-WP-18/GIWHs

56 Cook, J., Churchwell, C., & George, S. (2014). Final Evaluation for San Diego Gas & Electric's Plug-in Electric Vehicle TOU Pricing and Technology Study. Nexant, Inc. & San Diego Gas & Electric, p. 3. Retrieved from https://www.sdge.com/sites/default/files/ documents/1681437983/SDGE EV Pricing %26 Tech Study.pdf. See also McCoy, 2016.

57 Langton & Crisostomo, p. 3.

58 Langton & Crisostomo, p. 4.

59 Adapted from Langton & Crisostomo, Figure 2, p. 5.

60 Langton & Crisostomo, p. 5.

61 See, e.g., WUTC, 2017, p. 19.

62 Langton & Crisostomo, p. 2.

63 Langton & Crisostomo, p. 2.

64 These questions are not meant to supplant regulatory goals such the importance of ensuring the safe operation of grid-connected PEVs.

65 The CPUC also recommends that the categories of VGI use cases be implemented sequentially, starting with the relatively simple and building in complexity. Langton & Crisostomo, p. 7.

66 CA Distributed Energy Resource Models, Mark Rothleder, VP Market Quality and Renewable Integration, CA ISO, NPCC DR Advisory Committee, March 8, 2017.

67 The descriptions of grid storage applications are based on categories of "Energy Storage Services" developed by DOE and EPRI in the 2013 Electricity Storage Handbook. See Akhil et al. (2013). *DOE/EPRI 2013 Electricity Storage Handbook in Collaboration with NRECA.* Retrieved from http://www.sandia.gov/ess/publications/SAND2013-5131.pdf.

68 Based on Langton & Crisostomo, p. 9, Figure 6, adapted from CAISO 2014-2016 Strategic Plan.

69 Langton & Crisostomo, pp. 7-8.

[70] St. John, J. (2014). Itron and ClipperCreek Launch the EV Charger as Virtual Smart Meter. *Greentech Media*. Retrieved from http://www.greentechmedia.com/articles/read/itronand-clippercreek-launch-the-ev-charger-as-virtual-smart-meter

[71] Hall, D., & Lutsey, N. (2017, February). *Literature Review on Power Utility Best Practices Regarding Electric Vehicles*. International Council on Clean Transportation, p. 20. Retrieved from http://www.theicct.org/sites/default/files/publications/Power-utility-best-practices-EVs_white-paper_14022017_vF.pdf. Citing to Berkheimer, J., Tang, J., Boyce, B., & Aswani, D. (2014). Electric Grid Integration Costs for Plug-In Electric Vehicles. SAE Int. J. Alt. Power 3, No. 1.

[72] See Landis+Gyr. (2014, October 28). ConEdison Deploys Landis+Gyr's Intelligent switches for EV Charging Stations [Press release]. Retrieved from http://www.landisgyr.com/con-edison-deploys-landisgyrs-intelligent-switches-ev-charging-stations/; and Electric Power Research Institute. (2016, July 8). Open Vehicle-Grid Integration Platform. Retrieved from http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=000000003002008705. According to MJ Bradley, there are four voluntary EV charging pilot programs are currently underway, including Con Edison's Branch Circuit Energy Management Device, with others being conducted by Eversource, Potomac Electric Power Company (Pepco), and Pacific Gas & Electric (PG&E). The Con Edison pilot is testing the ability to measure and control, EV charging in five-minute intervals, using the same technology that the company is using measure solar energy consumption, and evaluate customer responsiveness to pricing.

[73] Hall and Lutsey, 2017, p. 20.

[74] There is also concern that batteries may not be warrantied to serve bidirectional charging purposes.

[75] The Fort Carson Colorado V2G demonstration project, a similar pilot at the Los Angeles Air Force Base. See Markel, T., Meintz, A., Hardy, K., Chen, B., Bohn, T., Smart, J., … & Pratt, R. (2015). MultiLab EV Smart Grid Integration Requirements Study. National Renewable Energy Laboratory (NREL), pp. 27-32. Retrieved from http://www.nrel.gov/docs/fy15osti/63963.pdf

[76] Markel et al., 2015.

[77] WUTC, 2017.

[78] WUTC, 2017, p. 9, paragraphs 18-19.

[79] WUTC, 2017, p. 3 and p. 24.

[80] WUTC, 2017, p. 24.

[81] WUTC, 2017, p. 3.

[82] WUTC, 2017, p. 3.

[83] WUTC, 2017, p. 3. The UTC also noted its readiness to work with "regional planning organizations to facilitate efficient electrification of the transportation system to meet state policy goals."

[84] New York State. DPS – Reforming the Energy Vision: About the Initiative. Retrieved from http://www3.dps.ny.gov/W/PSCWeb.nsf/All/CC4F2EFA3A23551585257DEA007DCFE2?OpenDocument

[85] New York Department of Public Service. Case 14-M-0101 - Proceeding on Motion of the Commission in Regard to Reforming the Energy Vision. Staff Proposal Distributed System Implementation Plan Guidance, October 15, 2015, citing to Case 14-M-0101, Proceeding on Motion of the Commission in Regard to Reforming the Energy Vision, Order Adopting Regulatory Policy Framework and Implementation Plan, (issued February 26, 2015) (Track I Order), p. 32. Retrieved from http://documents.dps.ny.gov/public/MatterManagement/MatterFilingItem.aspx?FilingSeq=163160&MatterSeq=44991

[86] Joint Utilities of New York. (2016, November 1). Supplemental Distributed System Implementation Plan. Case 16-M-0411 In the Matter of Distributed System Implementation Plans. Retrieved from http://jointutilitiesofny.org/wp-content/uploads/2016/10/3A80BFC9-CBD4-4DFD-AE62-831271013816.pdf. This was filed by the "Joint Utilities" that includes Central Hudson Gas & Electric Corporation ("Central Hudson"), Consolidated Edison Company of New York, Inc. ("Con Edison"), New York State Electric & Gas Corporation ("NYSEG"), Niagara Mohawk Power Corporation d/b/a National Grid ("National Grid"), Orange and Rockland Utilities, Inc. ("O&R"), and Rochester Gas and Electric Corporation ("RG&E"). "Joint Utilities" refers to activities or

proposals the Joint Utilities are undertaking as a collective, single group. Filed in the NY REV proceeding, REV Proceeding, Track One Order and Order Adopting Distributed System Implementation Plan Guidance (issued April 20, 2016) ("DSIP Guidance Order"). The Commission subsequently established Case 16-M- 0411 – In the Matter of Distributed System Implementation Plans ("DSIP Proceeding") to facilitate the review of both the Initial and Supplemental DSIPs.

[87] Joint Utilities of New York, p. 8.

[88] Joint Utilities of New York, p. 115. The Joint Utilities will facilitate EVSE growth and encourage EV adoption in New York by increasing their collective readiness for future market development;

- The resulting EV Readiness Framework will be aligned with and responsive to New York initiatives for advancing the adoption of EVs;
- The development of the EV Readiness Framework will be directed by federal, state, and Commission policies for advancing the adoption of EVs;
- The Joint Utilities and each utility are stakeholders that must collaborate to support the achievement of state and regional EV market objectives;
- The utilities will seek to maximize long-term net benefits to utility customers by enabling the improved asset utilization that EVs offer, while mitigating incremental peak load impacts and supporting local, state, regional, and federal energy policy goals; and
- For the near-term, demonstration and pilot projects will be the primary means for the utilities, in concert with stakeholders, to develop and test different EVSE deployment approaches.

[89] See Joint Utilities of New York, footnote 105 and accompanying text. According to the Supplemental DSIP, the concept of "EV Readiness" has been successfully applied in California and Texas, and by cities like New York City. *See, e.g*., Kahn, A. and Christina Ficchia, C. (2012). *The New York City Electric Vehicle Readiness Plan: Unlocking Urban Demand*. Empire Clean Cities and the Mayor's Office of Long-Term Planning and Sustainability.

[90] Joint Utilities of New York, p. 115.

[91] Joint Utilities of New York, p. 116.

[92] Joint Utilities of New York, p. 115.

[93] First full citation page 9.

[94] Id.

[95] Pages 9-10.

[96] New York Department of Public Service. Joint comments filed by Acadia Center, Environmental Advocates of New York, Natural Resources Defense Council, Pace Energy and Climate Center, Sierra Club. Retrieved from http://documents.dps.ny.gov/public/MatterManagement/MatterFilingItem.aspx?FilingSeq=174015&MatterSeq=51282

[97] To also continue the work from a prior Rulemaking, R.09-08-009.

[98] CPUC, D.11-07-029, p. 79.

[99] CPUC, D.11-07-029, p. 50.

[100] CPUC. Decision 14-12-079 December 18, 2014, Application of San Diego Gas & Electric Company (U902E) for Approval of its Electric Vehicle-Grid Integration Pilot Program (D.14-12-079). Retrieved from https://perma.cc/6PA8-CXJY. This decision in Phase 1 of Rulemaking 13-11-007 is a first step in adopting rules to encourage the expansion of EV infrastructure and their widespread deployment and use.

[101] The decision, wrote the CPUC, "reaffirms the balancing test applied in D.11-07-029, that the benefits of utility ownership of PEV charging infrastructure must be balanced against the competitive limitation that may result from that ownership." D.14-12-079, p. 5. It observed, "we eliminate the necessity of a showing that, but for the utility program, a market failure or underserved market would result, or if already in existence, would continue." Id.

[102] CPUC, D.14-12-079, p. 6.

[103] CPUC, D.14-12-079, p. 7.

[104] CPUC, D.14-12-079, p. 5.

[105] CPUC, D.14-12-079, p. 7.

[106] For a detailed look at some of the pilots, see NYSERDA, 2015.

[107] RCW 80.28.320, 2011.

[108] HI Rev. Stat. § 269-1.

[109] Md. Code Ann., § 2-113, §1–101,(j) 3. iii. Retrieved from http://mgaleg.maryland.gov/2016RS/Statute_Web/gpu/gpu.pdf

[110] See, e.g., CO Rev. Stat. 40-1-101-104; FL. Stat. § 366.94; 220 IL. Comp. Stat. 5/3-105; 20

IL. Comp. Stat. 627/10 (applied to alternative fueled vehicles including sellers of compressed natural gas); MN. Stat. § 216B.02 (also applies to natural gas); MD. Code Ann. § 10-101(a)) & MD Code Ann., Pub. Util. Cos.§1-101(j); H.B. 19, 2014, and UT Code Ann. 54-2-1; VA Code Ann. 56-1.2, 56-232.2:1.

[111] CA Pub. Utils. Code § 216.

[112] *In re Electric Vehicles Policies*, Case 13_E_0199, NYPSC, November 22, 2013.

[113] Docket 13-182A, August 2014.

[114] Oregon PUC. (2012, January 19). Order 12-13, Docket No. UM 1461.

[115] As discussed further below, legislative direction appears to have been a big factor in each of these examples.

[116] According to Vermont Energy Investment Corporation's Transportation Efficiency Group, projections of the number of EVs that will be registered in Vermont by 2030 have been modeled from a conservative 10,000, by the Vermont Agency of Natural Resources, to 100,000 in *Plug in Hybrid Electric Vehicle Research Project: Phase II Report* (2010) from UVM's Transportation Research Center.

[117] Finding – 2015 c 220 § 1, paragraph 63: "The legislature finds that utilities, who [that] are traditionally responsible for understanding and engineering the electrical grid for safety and reliability, must be fully empowered and incentivized to be engaged in electrification of our transportation system."

[118] See ACEEE's Market Transformation portal at http://aceee.org/portal/market-transformation; as well as Moore, G. (1991). *Crossing the Chasm.* Harper Business Essentials*.*

[119] In acknowledging these arguments, the UTC cites Baumhefner, M, Hwang, R., & Bull, P. (2016, June). *Driving Out Pollution: How Utilities Can Accelerate the Market for Electric Vehicles*. Natural Resources Defense Council.

[120] WUTC. (2017b). Notice of Opportunity to Comment on Draft Policy and Interpretive Statement Describing Commission Policy Related to Utility Investment in Electric Vehicle Supply Equipment pursuant to RCW 80.28.360 and Commission Regulation of Electric Vehicle Charging Services. Retrieved from https://www.utc.wa.gov/_layouts/15/CasesPublicWebsite/GetDocument.ashx?docID=97&year=2016&docketNumber=160799

[121] Paragraph 65, citing to a November 17, 2016, memorandum from Jeff Harris, Chief Transformation Officer to Northwest Energy Efficiency Alliance (NEEA) Executive Committee, about market transformation opportunities to improve efficiencies of EV charging infrastructure.

[122] Detsky & Stockmayer, 2016, p. 483.

[123] US Department of Energy. *EV Everywhere Workplace Charging Challenge: Progress Report*. Retrieved from http://energy.gov/sites/prod/files/2014/11/f19/progress_report_final.pdf

[124] Tal, G., Turrentine, T., & Nicholas, M. Coast-to-Coast Workshop on E-Mobility. UC Davis Plug-In Hybrid & Electric Vehicle Research Center. Retrieved from http://www.pevcollaborative.org/sites/all/themes/pev/files/Coast-to-Coast%20Workshop%20on%20E-Mobility%20_Gil%20_Tal.pdf

[125] Nova Workforce Development. (2015). Obstacles and Opportunities – Electric Vehicle Charging in Apartment-Based Housing. Retrieved from http://files.novaworks.org/Reports/EV-MUD.pdf

[126] Nova Workforce Development, 2015.

[127] CO. Rev. Stat. §§ 38-12-601; 38-33.3-106.8.

[128] OR. Rev. Stat. § 94.550.

[129] In California, for example, it is unreasonable restrictions on the installation or use of EV charging infrastructure cannot be included in any instruments that would affect the sale or transfer of property in a common interest development. Cal Civ. Code § 1353.9.

[130] Nova Workforce Development, 2015.

[131] CPUC. (2016, January 28). Decision 16-01-045. Application of SAN DIEGO GAS & ELECTRIC COMPANY (U902E) for Approval of its Electric Vehicle-Grid Integration Pilot Program, DECISION REGARDING UNDERLYING VEHICLE GRID INTEGRATION APPLICATION AND MOTION TO ADOPT SETTLEMENT AGREEMENT, pp. 140-141. Retrieved from http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M158/K241/158241020.PDF.

[132] Id., p. 140.

[133] Id.

[134] Id.

[135] Id., p. 141.

[136] WUTC, 2017.

[137] WUTC, 2017.

[138] Altman Vilandrie & Company (2016, December 8). High Costs, Lack of Awareness Threaten to Short Out Electric Vehicle Adoption [Press release]. *BusinessWire.* Retrieved from http://www.businesswire.com/news/home/20161208005809/en/High-Costs-Lack-Awareness-Threaten-Short-Electric

[139] Edelstein, S. (2017, January 26). More than half of car buyers know little about electric cars, if anything. Green Car Reports. Retrieved from http://www.greencarreports.com/news/1108540_more-than-half-of-car-buyers-know-little-about-electric-cars-if-anything; and Edelstein, S. (2016, December 22). Electric cars are on the market, so where are all the ads? *Green Car Reports.* Retrieved from http://www.greencarreports.com/news/1107941_electric-cars-are-on-the-market-so-where-are-all-the-ads

[140] See PG&E. *Learn about plug-in electric vehicles and PG&E*. Retrieved from: https://www.pge.com/en_US/residential/solar-and-vehicles/options/clean-vehicles/electric/electric.page?WT.mc_id=Vanity_ev; SCE has a similar educational page.

[141] Citizens Utility Board. (2017, May). *The ABCs of EVs: A Guide for Policy Makers and Consumer Advocates*, p. 23. Retrieved from https://citizensutilityboard.org/wp-content/uploads/2017/04/2017_The-ABCs-of-EVs-Report.pdf

[142] WUTC, 2017, paragraph 90.

[143] Id.