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It's 10 P.M. Do You Know Where Your Electric Vehicles Are?

Encouraging EV Owner Participation in Utility-Managed Charging Programs

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Introduction

In the 1970s, nearly every night a public service announcement lit up TV screens around the country saying, "It's 10 p.m. Do you know where your children are?" The announcement was clearly directed at parents and emphasized the importance of keeping track of their children.

Americans are adopting electric vehicles (EVs). Today, there are about 1.5 million on U.S. roads, but according to the National Renewable Energy Laboratory (NREL), by 2030 there may be as many as 30 to 40 million. We also know that unmanaged EV charging creates the risk of squandering electric system capacity and, instead, increasing system costs, which are borne by all ratepayers. If there was ever a time for regulators to keep track, it is now.

Given this need, a slightly modified version of the public service announcement highlights a critical regulatory issue and provides the title to this paper: It's 10 p.m. Do you know where your EVs are?

This interplay between EVs and power systems represents a significant opportunity for demand flexibility, if policymakers and planners in the power and transport sectors integrate smart charging in decision-making, e.g. charging infrastructure build-out. Results of regional case

Assessing EV managed charging programs: Five questions for regulators

Why managing load is so important If U.S. EV adoption goes from roughly 1.5 million vehicles today to 30 or 40 million by 2030, as NREL suggests, will my state be prepared for this amount of EV load?

Reflecting costs in electricity prices: rate design and time-of-use rates Is utility pricing in my state actually benefitting the grid while also meeting drivers' mobility needs?

Considering program participation: Opt in or opt out? Are utility EV charging programs in my state doing everything they can to secure the participation of EV owners?

Utility reporting and other data Do utility programs in my state report the number of EVs that are in utility service territories and whether EV owners are actually participating in charging programs?

Utility programs Do our commission orders and rules reasonably support utilities so they can provide charging programs that successfully recruit customer participation?

studies illustrate benefits from smart EV charging for both power sector planning and transport policymakers.

Why do we need to know where EVs are? Knowing where EVs are means being able to ensure that they are charging in a least-cost manner and not producing unnecessary costs for others.

Significant amounts of electric load associated with transportation electrification is flexible and controllable. Residential, light-duty vehicles especially have low-capacity utilization; they are idle more than 95% of the time.[1] This flexibility is available for utilities and is a resource that they can manage over the course of the day in response to conditions on the grid.

There's a catch, however. Capturing the benefits of managed charging actually requires customer participation in managed charging programs.

Managed charging has to be marketed to utility customers. They have to be sufficiently informed to see its value. And once enrolled and participating, customers and their charging practices need to be accounted for to ensure that programs are producing the desired results.

> *Capturing the benefits of managed charging actually requires customer participation in managed charging programs.*

This paper surveys a handful of practices from around the country that promote customer participation in charging programs. In the following pages, we look more closely at aspects of managing load, time-of-use rate design, customer program participation options, useful sources of data and reporting and characteristics of effective utility charging programs. We hope that providing this to utility regulators will help them in their work to secure the many benefits of transportation electrification.

Why Is Managing Load So Important?

Managed EV charging means being efficient with the grid resources used to charge EVs and becomes even more important as we adopt more EVs. Americans bought nearly 1.4 million EVs in 2023, bringing the EV share of the U.S. vehicle market to over 9%, up from 5.9% in 2022.[2] But historical assessments do not begin to reflect the scale of electrification that we will likely see in the next decade.

EV adoption is being further stimulated by various federal programs. The Inflation Reduction Act includes tax credits for light-duty EVs, used EVs, commercial EVs and charging infrastructure.[3] The U.S. Department of Transportation's National Electric Vehicle Infrastructure (NEVI) Formula Program provides states with over $7 billion in funding to deploy charging stations and an

"Ambitious federal clean energy goals, including efforts to see EVs represent the majority of light-duty vehicle sales by 2030, could lead to 30 million–42 million EVs on the road by 2030."

NREL. (2023, June). *2030 National Charging Network: Estimating U.S. Light-Duty Demand for Electric Vehicle Charging Infrastructure.*

interconnected network to facilitate data collection, access and reliability.[4] NREL reports that "ambitious federal clean energy goals, including efforts to see EVs represent the majority of light-duty vehicle sales by 2030, could lead to 30 million–42 million EVs on the road by 2030."[5]

Potential benefits of managing load

- Improved fairness in retail pricing (i.e., providing a better match between the costs that customers impose on the system and the amount they are billed)
- Protection for non-EV customers from subsidizing the costs imposed on the system by EV customers indifferent to these system dynamics.
- Transmission and distribution system congestion mitigation

As the term suggests, "managed charging" refers to the various ways that a utility can coordinate the charging of EVs to benefit the power grid while meeting the needs of EV owners.[a] A utility can affect charging practices by curtailing power (direct load control) and by pricing electricity (rate design) to make it more or less attractive.

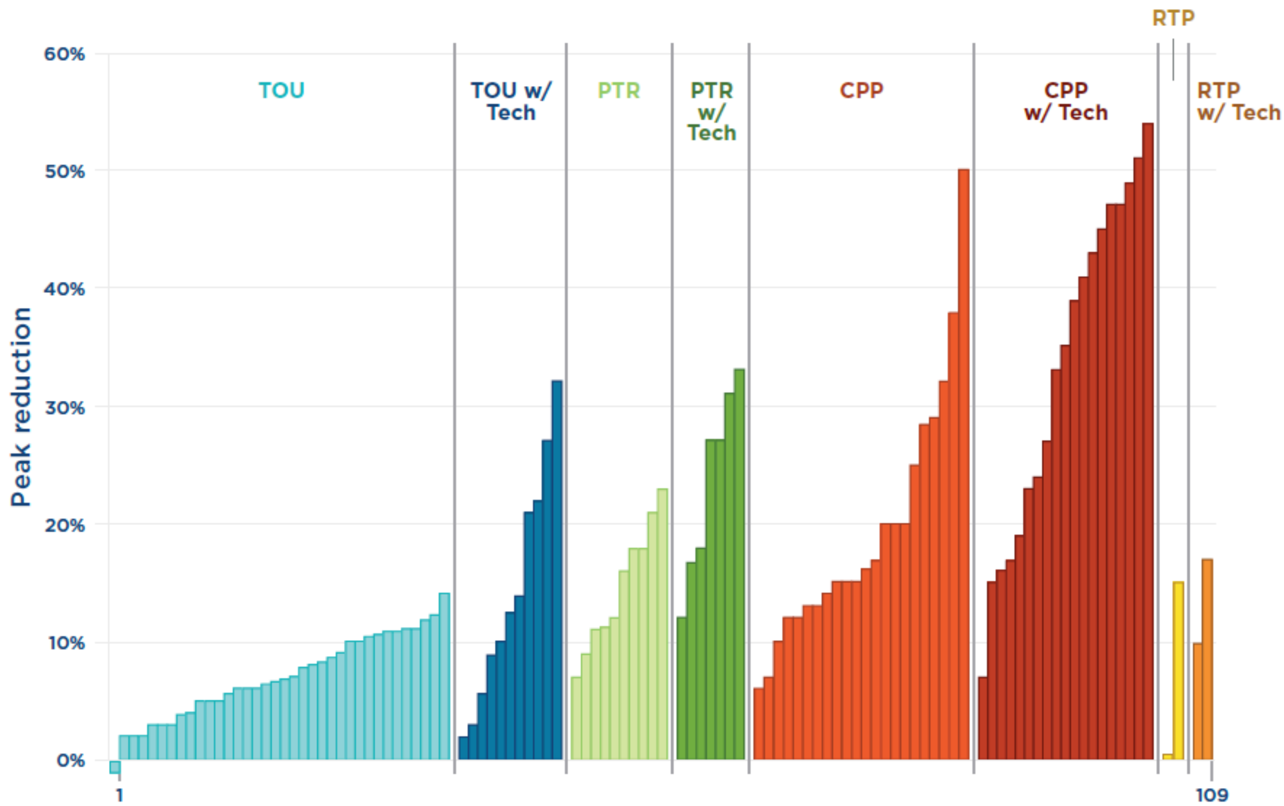
There is an upside to managed charging. Though not universally adopted, it has long been established that electric customers respond to clear price signals through rate design.[b] For example, "Time-Varying and Dynamic Rate Design," a paper jointly published by RAP and the Brattle Group, shows that peak loads of customers participating in programs with time-varying rates could decline by as much as 40% with some pricing options[6] (see Figure 1 on the next page).[c]

[a] This definition is consistent with the California Energy Commission's definition of vehicle-grid integration of VGI: "[T]echnologies, policies, and strategies for electric vehicle (EV) charging which alter the time, power level, or location of the charging (or discharging) in a manner that benefits the grid while still meeting drivers' mobility needs." See California Energy Commission. (n.d.). *Vehicle-Grid Integration Program.* https://www.energy.ca.gov/programs-and-topics/programs/vehicle-grid-integration-program

[b] Although the authors choose to focus this paper on time-of-use rate design, we recognize that EV load management can be effected through a number of approaches, generally referred to as "smart charging." These include rates designs, automation, demand response programs and direct load control approaches. All of these strategies help in using the power grid more efficiently and in "aligning charging with infrastructure capabilities and lowest cost electricity." See Morash, S. (2024, January). *Charging ahead: Grid planning for vehicle electrification; A report of the grid planning for Vehicle Electrification Task Force.* Energy Systems Integration Group. https://www.esig.energy/grid-planning-for-vehicle-electrification

[c] Figure 1 illustrates examples of peak reduction in response to time-of-use (TOU) rates, peak time rebates (PTR), critical peak pricing (CPP) and real-time pricing (RTP) with and without technology, that is, with a smart thermostat or an automatically scheduled EV charger. PTRs and CPPs encourage consumers to avoid peak

Figure 1. Average peak reduction from time-varying rate pilots



Source: Faruqui, Hledik & Palmer, 2012.

There is also a downside to consider. Unmanaged charging can unnecessarily overload transformers and other distribution and transmission system infrastructure, especially during times when the entire system load is peaking.[d] These costs don't just affect EV owners; they affect all ratepayers.[e] The Michigan Public Service Commission has observed that the effects of EV charging on the distribution system "will depend on the nature, timing, and location of charging, as well as consumer adoption rates" and that "the uncertainties in EV adoption rates require utilities to be proactive in understanding and mitigating potential impacts to the grid and related infrastructure costs."[7]

times in different ways. CPPs charge consumers more when they charge at peak times. PTRs, as the term suggests, give customers credits when they *don't* charge during peak times. RTP refers to a more fluid rate design that varies across the hours of the day and conditions on the power grid.

[d] This phenomenon is referred to as "coincident peak," in other words, when one's demand corresponds to "the time when electricity demand systemwide is the highest. See City of Fort Collins. (n.d.). *Compare facility demand and coincident peak.* https://www.fcgov.com/utilities/business/manage-your-account/rates/electric/compare-facility-demand-and-coincident-peak#:~:text=Coincident%20peak%20is%20your%20facility's,facility%20demand%20and%20coincident%20peak.

[e] A recent study analyzing potential impacts on distribution circuit and substation upgrades on the Pacific Gas & Electric system, estimated increases of "at least $1 billion and potentially over $10 billion to PG&E's rate base." See Elmallah, S., Brockway A. M., & Callaway, D. (2022, November 9). Can distribution grid infrastructure accommodate residential electrification and electric vehicle adoption in Northern California? *Environmental Research: Infrastructure and Sustainability, 4*(2): 2634-4505. https://doi.org/10.1088/2634-4505/ac949c

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

Similarly, in its recent policy statement on electric utility rate design for EV charging, the Pennsylvania Public Utility Commission recommended that utilities "at a minimum, properly reflect the cost of generation services during times of system stress. This may include, but is not limited to, use of on-peak and off-peak periods which appropriately incentivize the movement of charging consumption to off-peak periods or periods of less system stress."

> **"Without a price signal, drivers will generally plug in and charge immediately upon arriving home after work, exacerbating evening peak demand."**
>
> **Washington Utilities and Transportation Commission, Docket UE-160799, Draft Policy and Interpretive Statement, January 13, 2017.**

Questions

- Do you know how much electric transportation is expected to add to load growth in your state?
- Do utilities in your state that manage EV charging provide customer participation data to the commission or another state agency?

Reflecting Costs in Electricity Prices: Rate Design and Time-of-Use Rates

"Rate design" is the term used to describe the pricing structure in an electric customer's bill. Rate design can affect the way customers use electricity. A typical electric rate, sometimes described as a flat rate, includes a monthly fixed charge and a per-kWh rate for the electricity that a customer uses, regardless of when it is used. This type of rate design leaves an EV owner indifferent as to when to charge the EV over the course of the day because there is no difference in the cost of charging from one time to another. According to one analyst: "There is an increasing consensus that flat volumetric rates are becoming antiquated in a world where households have access to technologies that can effectively manage their load, generate, or store electricity."[8]

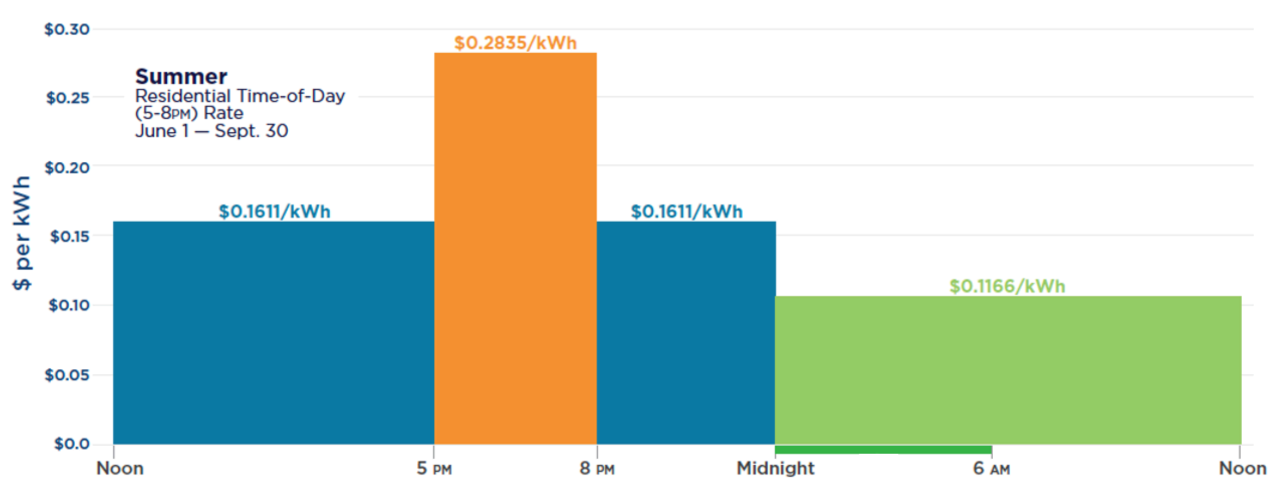
By contrast, time-of-use or TOU rates are designed to reflect the varying costs of providing electricity at different times of the day. They signal this price differential to consumers and encourage customers to shift their demand away from peak times that are more costly for utilities to serve to times that are less expensive for the utility to provide electricity. Among other things, managing this load can help utilities make more efficient use of existing grid resources, and delay or entirely avoid unnecessary grid investments (see "Potential Benefits of Managing Load" text box).

In addition to having enough of a price differential to stimulate consumer interest, a rate design's peak time needs to be defined in a way that allows customers to actually manage their charging schedule to avoid it. If peak times are too long, then customers will be challenged to respond by adjusting their charging times. Furthermore, because power systems are evolving, utilities need to regularly assess their underlying costs so rate design elements are aligned with system load and supply changes.

> *A rate design's peak time needs to be defined in a way that allows customers to manage their charging schedule to avoid it.*

Figure 2 illustrates a summer residential TOU rate from the Sacramento Municipal Utility District (SMUD) with a significant price differential. It is designed to provide an incentive for customers to shift their usage away from the higher-cost summer hours and to take advantage of lower-cost times.

Figure 2. SMUD summer residential time-of-use rate



Source: Sacramento Municipal Utility District

The SMUD rate divides the day into three parts: off peak, midpeak and peak. Instead of 28 cents per kWh on peak, the off-peak rate is 11 cents, a differential of 17 cents/kWh, nearly a 60% discount in the volumetric portion of its rate. Even though the rate design incorporates midpeak times — noon to 5 p.m. and 8 p.m. to midnight — consumers still have a 12-hour window in which to manage their charging and take advantage of that low price.

El Paso Electric, with service territories in Texas and New Mexico, also offers EV TOU rate designs with significant price differentials.[f] The Texas electric vehicle charging (EVC) rate tariff has a summer on- and off-peak element. El Paso also offers non-summer off-peak and year-round super off-peak rate elements as illustrated in Table 1.

Table 1. El Paso Electric, Texas residential electric vehicle charging rate

Retail rate No. 01		
Customer charge per meter per month	$4.20	
Summer energy charge per kWh	On-peak period	$0.35267
	Off-peak period	$0.07001
Non-summer energy charge per kWh	Off-peak period	$0.09066
Year-round energy charge per kWh	Super off-peak period	$0.00950

El Paso Electric's EVC rate provides significant on- and off-peak differentials. Its on-peak[g] rate in the summer is roughly 35 cents per kWh, while the summer and non-summer off-peak rates are roughly 7 and 9 cents per kWh, respectively. In both cases, they provide customers with a greater than 25 cents per kWh benefit for avoiding peak times, more than a 70% discount of the volumetric portion of the rate.

The EVC rate provides an even greater differential between its 35 cents per kWh summer peak and its year-round super off-peak rate element—a difference of nearly 35 cents per kWh for

[f] In Texas, residential customers need a separate meter to take advantage of the EVC time-of-day rate design. Texas customers also pay a monthly customer charge of $4.20.

[g] Noon to 6 p.m., only Monday through Friday in the months of June through September. Any other time in the year is considered off-peak, except year-round from midnight to 8 a.m., which is considered super off-peak.

avoiding peak time. In Texas and New Mexico, El Paso Electric's year-round, super off-peak period has an eight-hour window for EV owners to take advantage of that low price.

In New Mexico, El Paso Electric offers residential and commercial customers a rate design similar to its Texas EVC rate, although more simplified.[h] As illustrated in Table 2, the rate has three time periods.[i] There is a 37 cents per kWh differential between summer on-peak (approximately 38 cents) and year-round, super off-peak (approximately 7/10 of a cent).

Table 2. El Paso Electric, New Mexico experimental electric vehicle charging rate

Retail rate No. 42		
Customer charge per meter per month	$3.55	
Energy charge per kWh	Summer	Non-summer
On-peak period	$0.38167	N/A
Off-peak period	$0.05816	$0.05816
Super off-peak period	$0.00764	$0.00764

Questions

- Do your utilities offer pricing that can affect customer energy use?
- What on- and off-peak discounts do your utilities offer their EV customers?
- Are peak times designed so customers have the flexibility to work around them?
- Do your utilities provide charging program participation information that tells you how many EV owners are actually enrolled?

[h] New Mexico customers are required to use a separate meter if they want to take advantage of Rate 42.

[i] The on-peak period is from 3 p.m. to 7 p.m., only Monday through Friday in the months of June through September. The off-peak period is comprised of the remaining hours in the day. Super off-peak hours are midnight to 8 a.m., year-round.

Participation Options: Opt In or Opt Out?

It is one thing to offer an attractive rate that could encourage EV owners to charge their vehicles at times of day that are beneficial for them and the utility. But if customers don't enroll in the utility's programs, managed charging is less likely to occur. This raises the topic of customer enrollment and what is sometimes referred to as the "opt-in/opt-out" challenge. In other words, do your utilities put EV owners in a program that they can leave if they wish, or do your utilities encourage them to join on their own? There is useful research on this topic that frames the challenges and opportunities associated with getting customers to participate.

Between 2010 and 2016, the U.S. Department of Energy supported a series of studies that they characterized as "an opportunity to advance the electric power industry's understanding of consumer behaviors in terms of customer acceptance and retention, and energy and peak demand impacts."[j] While not focused specifically on EV charging, these studies are still relevant and useful to our understanding of EV customer interest and how customers might be inclined to participate in utility demand management programs for EV charging. A number of these studies focused on the difference between programs into which customers had to enroll (opt-in programs) and those which automatically enrolled the customers and provided them with the choice to leave or opt-out of the program.

If customers don't enroll in the utility's programs, managed charging is less likely to occur.

To analyze enrollment, the studies' authors adopted a metric they called the "recruitment rate," that is, the number of recruited customers divided by the number of solicited customers.[9] Lawrence Berkeley National Laboratory (LBNL) researchers found that recruitment rates ranged from 5% to 28% for opt-in programs, but programs adopting an opt-out approach had recruitment rates ranging from 78% to 87%.[10] As one would expect, this led researchers to conclude that more customers are likely to participate in time-based rate programs with opt-out offers than in programs with opt-in offers. LBNL researchers also found, as shown in Table 3, that these disproportionate results for opt-in and opt-out enrollment remained virtually the same despite offerings of different rate designs.

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[j] In passing the 2009 American Recovery and Reinvestment Act, Congress promoted investment in the U.S. power grid. Part of the funding supported the U.S. Department of Energy's Smart Grid Investment Grant (SGIG) program, which funded studies to better understand customer engagement with utility demand management programs. These conclusions were developed based on analyses conducted by the Lawrence Berkeley National Laboratory (LBNL), a total of 11 consumer behavior studies of time-based rates. In this work, LBNL analyzed initial enrollment results from the nine projects conducting a total of 11 consumer behavior studies. This information was considered important for determining "the cost-effectiveness of demand-side programs as resource options for use in planning and operating electric power systems." See U.S. Department of Energy. (2013, July). *Analysis of customer enrollment patterns in time-based rate programs — Initial results from the SGIG Consumer Behavior Studies*, p. iii. These findings are consistent with those reported in U.S. Department of Energy. (2016, November). *Final report on customer acceptance, retention, and response to time-based rates from the Consumer Behavior Studies.* Smart Grid Investment Grant Program. https://www.energy.gov/sites/prod/files/2017/01/f34/CBS_Final_Program_Impact_Report_20161107.pdf

Table 3. Recruitment rates with various rate design offerings

	Time-of-use	Flat rate with critical peak	Time-of-use with critical peak
Opt-in	16%	17%	17%
Opt-out	81%	81%	78%

LBNL researchers emphasized the importance of education in this context. They determined that using focus groups and other approaches to determining customer preferences were vital for purposes of marketing and convincing customers to participate.

More recently, RMI reviewed existing studies to better understand "the efficacy of time-based rates for mass-market customers."[11] The authors determined that enrollment methods affect "customer acceptance, where opt-in rates attract more-engaged[k] participants, but opt-out (default) rates have enrollment rates 3 to 5 times higher than opt-in rates, as well as increased peak reduction."[12]

The terms "opt-in" and "opt-out" are somewhat misleading. Both are options and provide choices. An opt-out program should not be confused with a program requiring mandatory participation. Still, opt-in may be described as a choice while opt-out is characterized as an imposition. Customer engagement on this specific issue should clarify the aspects of either method but should also emphasize that either approach provides customers with a choice.

The terms "opt-in" and "opt-out" are somewhat misleading. Both are options and provide choices.

Questions

- Do your utilities enroll customers at the point of sale when their interest may be at its height?
- Do your utilities have an opt-out enrollment policy for EV charging?
- Do your utilities provide other reasonable ways to encourage more customer enrollment in charging programs?

[k] "Note that "more engaged" can include being attracted by utility program incentives, such as a free charger and favorable rate design. See "Utility Programs" section beginning on p. 18.

Utility Reporting

Good data is the backbone of good decision-making and critical to being able to assess the effectiveness of any utility program. More specifically, because EV adoption and the development of charging programs are relatively new or undergoing transformation in many states, having relevant program performance data is especially valuable for utilities, consumers and regulators. Here, we review several approaches that will be useful to regulators who want to better understand EV owner participation in utility-managed charging programs.

Perhaps the most common approach relied upon by utility commissions is to require utilities to report periodically and submit compliance filings to illustrate charging activity. In general, public utility commission (PUC) data requests should, at a minimum, provide the commission with necessary information to understand EV enrollment in utility programs, the impact of the managed charging on the utility system. This information will provide a basis for analysis to improve upon program design in this relatively new area of utility service.

This information can help with understanding the effectiveness of customer enrollment including the number of EVs registered in the utility service territory and the percentage of those EVs enrolled in utility EV programs. It can help in understanding the effects of managed charging on the grid and consumer behavior. This information could include:

- Estimated capacity reduction at the time of the utility's system peaks
- Average frequency, length and timing of daily charging
- Changes in overall energy consumption
- Annual customer bill savings
- Program costs per customer

Many utilities gather this information. For example, in 2017, the Utah Public Service Commission (PSC) directed PacifiCorp, doing business as Rocky Mountain Power, to report over a term of years on its progress establishing an EV TOU pilot with several charging rate designs.[l] The Utah PSC's minimum reporting requirements included metrics to enable it and Rocky Mountain Power to determine the effectiveness of the pilot rate program. These included:

- Estimated capacity reduction at the time of the company's peaks
- Differences in overall energy consumption
- Average annual bill savings
- Customer retention rate

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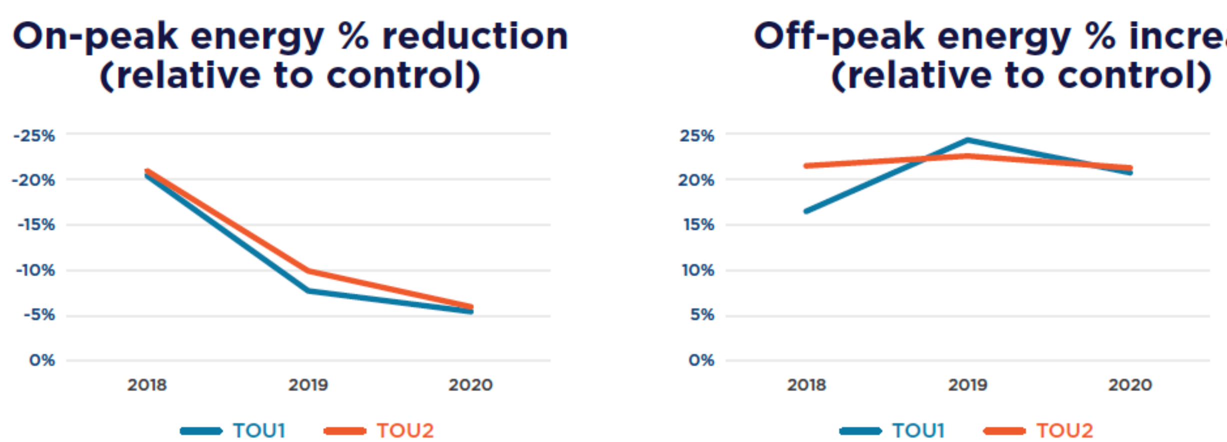
[l] Public Service Commission of Utah, Docket No. 16-035-36, in the matter of the application of Rocky Mountain Power to implement programs authorized by the Sustainable Transportation and Energy Plan Act, Phase Three Report and Order, June 28, 2017. The pilot program was approved for a roughly five-year period with the option becoming closed to new service in 2021 and terminating in 2022.

In 2021, the utility reported that its Rate 1 (with a differential of 15 cents) and Rate 2 (with a differential of 30 cents) reduced load peaks from 2018 to 2020[m] (see Figure 3 on the next page). Due to the lower cost differential, Rate 1 was found to be more cost effective. In reporting on capacity impacts, the company also observed reductions in peak use during the coincident peak hour and top 50 system hours for customers on both rates.

Rocky Mountain Power also reported that its customers were able to save money and that they were able "to adapt their energy usage to the on- and off-peak periods to minimize the cost of their EV load on the system." The company furthermore reported that its Rate 1 "performs well on the cost-of-service study, indicating that it is unlikely to shift costs to other customers." Based on the report including this and other information, in 2022, the Utah PSC approved a tariff with a TOU rate having an on-peak energy charge of 25.3532 cents per kWh and an off-peak energy charge of 5.2004 cents per kWh, a differential of over 20 cents per kWh.[13]

Figure 3. Rocky Mountain Power TOU rate pilot findings



Source: PacifiCorp, 2021

Requirements established by the Maryland Public Service Commission (PSC) provide a useful illustration of company reporting that helps in understanding customer participation in managed charging programs. In 2019, it ordered the state's utilities[n] to develop a portfolio of EV programs and to submit periodic progress reports and a final report. Reporting metrics for the utility TOU rate offerings included, for example:

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[m] PacifiCorp. (2021, December). *State of Utah electric vehicle time of use pilot: Program evaluation,* p. 3. https://pscdocs.utah.gov/electric/21docs/2103570/321640RMPCmplncFlng12-23-2021.pdf. Rate 1 Option 1 had roughly three to one differential in price (21.0339 cents per on-peak kWh and 6.4097 cents per off-peak kWh). Option 2 has a more pronounced roughly 10 to one differential in price (32.4592 cents per on-peak kWh and 3.2108cents per off-peak kWh).

[n] The Maryland PSC approved filings from Baltimore Gas and Electric Company, Delmarva Power & Light Company, Potomac Electric Power Company, the Potomac Edison Company and Southern Maryland Electric Cooperative, Inc.

- Average frequency of daily charging
- Average length of daily charging
- Timing of daily charging, including hourly breakdown
- Total number of participating customers
- Average itemized program cost per customer[14]

The Maryland utilities submitted a final evaluation report in February 2024 containing detailed information on charging practices. The report concludes that EV charging was effective in reducing energy use at peak times.[15] The report's authors also acknowledge that there are still challenges coordinating information from multiple utilities and that there is a need for:

- Working toward standardized data reporting across vendors and programs
- Enabling deeper coordination among vendors, utilities and third-party evaluators on data request requirements
- Collaborating with stakeholders to adjust reporting deadlines to account for the operational realities of program data delivery timelines

In both of these examples, Utah and Maryland regulators rely on utility data and reporting to understand the changes on their electric systems produced by EVs and the charging practices of EV owners.

Other Data

Understanding the charging behavior of a predetermined number of participants in a pilot program or the number of overall participants in a charging program is helpful for understanding how EV adoption and load management is progressing. The adoption of standardized and publicly available data can also help in understanding the participation of EV owners in utility-managed charging programs. This is particularly critical as EV adoption increases, to ensure that EVs are optimized for consumers and the grid.

At the outset of this project, the authors asked themselves: How many EV owners in utility service territories that offer TOU rates are actually participating in those programs? We mistakenly assumed that we would be able to find charging program participant data. But getting that information proved to be very difficult for a number of reasons. Consequently, we relied largely on published literature but found that even that data is sparse. Certainly, many U.S. utilities have adopted TOU rates, but what still is not clear is just how many utility customers, especially EV owners, are taking advantage of those rates.

In 2019, Brattle reported that 14% of all U.S. utilities offered a residential TOU rate and that half of the investor-owned utilities (IOUs) offer at least one.[16] They also indicated that, where TOU rates are available, roughly 3.4% of customers are enrolled. With regard to IOUs alone (i.e., the utilities that serve over 70% of U.S. electricity users), fewer than 1% of customers are enrolled.[17]

Furthermore, this data doesn't distinguish between "whole house" TOU rates[o] and rates for EVs only. Thus, securing information on EV owner participation in managed charging programs is difficult.

Despite the lack of published information, while we were researching the question we also found some really good news in Minnesota. In that state, the utility commission has developed a simple approach to determining (1) how many EVs are in a utility service territory, and (2) how many EVs actually participate in a given utility's managed charging programs. So, while getting this information was difficult for an NGO like RAP, utility regulators anywhere in the country could adopt the approach developed at the Minnesota PUC and readily secure this information.

On its *Electric Vehicles* webpage, the PUC publishes the number of EV registrations by electric utility service territory, along with more granular data by city, zip code and vehicle make and model.[18] The PUC developed this information by coordinating with the Minnesota Department of Vehicle Services (DVS). Both agencies protect EV owner confidentiality as no owner addresses are published when mapping locations that eventually get superimposed on maps of utility service territories.

> *In consultation with their state transportation agencies, utility regulators can determine the number of EVs in a utility service territory and the percentage of those vehicles whose charging is actually being managed.*

To identify vehicle types, the DVS uses National Highway Traffic Safety Administration "VIN-Decoder" shareware that unbundles information from vehicle identification numbers (VINs) provided with vehicle registrations.[p] This means that the PUC and utilities can access information with significant load-management implications. For example, VIN-decoded information can indicate that a vehicle is a 2017 Chevrolet Volt (with a 16-kWh battery system) or a 2017 Tesla Model 3 (with a 50-kWh battery system). The PUC also revisits and updates this information annually.

Because this information is standardized and available to the public, it provides a common basis for understanding EV adoption trends. This data is also used for regulatory purposes. Otter Tail Power Company's (OTP) most recent Transportation Electrification Plan (TEP) utilizes this publicly available data.[19]

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[o] A rate design that applies to all the electricity use in a home and not just to EV charging.

[p] See National Highway Traffic Safety Administration. (n.d.). *VIN decoder*. https://www.nhtsa.gov/vin-decoder

The same data served as the basis for recent comments on OTP's TEP from the state's public advocate, the Minnesota Department of Commerce. Regarding, the participation of the utility's EV customers in OTP's managed charging program, the Department of Commerce wrote:

OTP's TEP directly addresses improved operation of the electric grid through its current and future residential charging programs. OTP's total number of customers enrolled in off-peak EV rates is limited to just 19 customers, however this compares relatively favorably to the total number of EVs in its territory of 144, including just 84 BEVs which would likely comprise the majority of total EV charging.[20]

This data provides a useful degree of precision for characterizing the progress that a utility like OTP is making in supporting EV adoption and integration. In this case, the department is able to set out the ratio of controlled EVs in the OTP's service territory to the overall number of EVs in the territory.

More broadly, information like this could provide the basis for an "EV customer participation score" that would reflect the relation between EVs in a utility's service territory and EVs that the utility is managing. A participation score would also allow for a comparative look between utilities. For example, OTP would have "scored" 13%, when focusing on all 144 EVs in its service territory, and 23%, if the ratio were between the 84 all-electric vehicles in its territory and those whose charging is managed. As illustrated above in the "Managed Charging at Minnesota Co-ops" text box and based on the EVs in their territory compared to EVs that they manage, Great River Energy and Runestone Electric Association would have participation scores somewhere between 40% and 50%.

Managed charging at Minnesota co-ops

Several Minnesota co-ops report their reliance on the PUC's *Electric Vehicles* webpage to account for the EVs in their territory and to manage that load.

Great River Energy, a generation and transmission cooperative that supplies energy and capacity to retail co-ops like Runestone Electric Association, has been managing electric water heating loads for decades. It is doing the same with EVs.

Runestone reports that 23 of the roughly 40 vehicles in its territory participate in its opt-in managed charging program—a participation rate, like Great River's, of roughly 50%.

Questions

- Do your utilities know and report the number of EVs in their service territory and how much load they represent?
- Do your utilities gather and report essential program information including, at minimum, the enrollment rate and peak coincidence?

- Is there capacity in your commission to coordinate with your state's department of motor vehicles to share data that would enable you to develop a utility program EV customer participation score?

Utility Programs

Up to this point, this paper has taken a regulatory perspective and been about the importance of specific program elements that help encourage customer participation in utility programs to manage EV load. In this section, however, we want to emphasize the relationship between the utility and its customer. We focus on how a utility program can capture and maintain customer interest. For example, enrolling EV customers at the point of sale gets their attention when their motivation is at its height. It is at this point that customers can be introduced to program offerings including managed charging options that can further lower their fueling costs.

EV programs are all about the relationship between the utility and the customer; they're about "selling" the benefits of participation to EV owners. This is about educating customers so they take advantage of useful elements of a utility program, and so they will take part in utility-managed charging.[21] Programs that support customers are also likely to increase the odds of those customers being willing to invest some of their own money, for example, paying for an electrician to install a Level 2 charger that is offered, for free, by their utility.

EV programs are all about the relationship between the utility and the customer; they're about "selling" the benefits of participation to EV owners.

The EV program provided by Green Mountain Power (GMP) in Vermont provides a useful illustration of elements of a customer-focused model. It comprises three complimentary parts:

1. A **rebate** program on the purchase of an electric vehicle
2. A **home-charging program**
3. **EV-specific electric rates**

Rebates

GMP's rebate program is typically the starting point for most customers, and they are primarily offered in partnership with car dealerships who apply them against the upfront cost of a new or used EV.[22] This point-of-sale approach is designed to both maximize customer participation and minimize customer acquisition costs. Even customers who acquire a qualifying vehicle outside of a partner dealer are able to apply for the rebate online through their GMP customer account.

This utility's rebates are highest for all-electric vehicles because they consume the most electricity, but smaller rebates are also available for plug-in hybrid vehicles. An extra $1,000 is offered for income-qualified customers, and these rebates are in addition to any federal, state and local incentives.

Home Charging

Customers who participated in the rebate program and have reliable internet access are encouraged to also enroll in GMP's home charging program.[23] This program offers customers a choice between three different Level 2 charger manufacturers at no cost. The charger is mailed to the customer directly from the retailer and is capable of both metering and controlling the charging load.

Customers are responsible for arranging and paying for meter installation costs. This insulates the utility from the cost variability and management complexity of the installation process. Because customers need to spend their own money on installation, it also imparts a sense of ownership of the equipment and of the outcome.

EV-Specific Electric Rates

After the EV charger is installed, customers use the manufacturer's app to enroll in one of two EV-specific rates that the utility markets as an opportunity to "pay about $1.20/gallon to fill up with gas."[24] The first is a TOU rate where the off-peak hours are priced at a discount.[25] The off-peak volumetric customer usage rate is 14.5 cents per kWh compared to roughly 19 cents per kWh on-peak, a roughly 24% differential. Peak times are from 1 p.m. to 9 p.m. leaving a 16-hour window for off-peak charging. It is the customer's responsibility to manage their own charging habits and costs under this rate.

The second is a flat "interruptible rate" whose cost is comparable to the off-peak TOU rate.[26] This rate design combines pricing with direct load control and gives the utility the ability to delay charging during late afternoon and early evening hours five to 10 times per month, for average periods of between two and six hours. The rate includes an opt-out feature. If the customer wishes to charge during a peak time, a higher rate applies.

Because the charger acts as a meter, the utility is able to show these rates as a separate line item on the customer's bill. This gives customers two ways to monitor and manage their charging, first through the manufacturer's app and second through the monthly bill. Finally, enrolling customers on a rate through the manufacturer's app simplifies the process. They are able to enroll either through the manufacturer's app or through their online utility account to elect the rate.

This program model illustrates an approach that is encouraging and relatively seamless. The customer is assisted from the beginning when she purchases an EV. The dealership manages the rebate application; the manufacturer ships the L2 charger to the customer's address, and the utility allows for rate enrollment through the manufacturer's app at the time of installation.

Questions

- Does the program lower costs for customers and is it easy to enroll?
- Does the program collect customer satisfaction and other participation data?
- Does the utility regulator support utility marketing of its EV-charging programs?

Conclusion

Being able to manage electricity demand is critical — especially as transportation electrification in this country builds momentum. The charging flexibility associated with light-duty residential vehicles that are idle for most of the day is a resource available to utilities. But if utilities are not securing the participation of EV owners, this resource is wasted, as is the available space on the country's power grids and the many other opportunities for the use of charging flexibility that are available to our country's electric power systems.[27]

A passive approach that simply offers TOU rates with minimal attention to actual successful enrollment is not sufficient to meet the coming electrification challenge as it wastes valuable, untapped grid resources. "You can lead a horse to water but you can't make them drink" is not helpful here. Utilities can use many of the tools illustrated in this paper to successfully incorporate customers into programs, and commissions can ensure that utilities employ relatively available data to demonstrate this participation.

"It's 10 p.m. Do You Know Where Your EVs Are?" is intended to illustrate some of these basic strategies that utilities, with the support of regulators, can adopt to engage EV owners and ensure that electrification is beneficial and not just added load and added costs. With the scale of electrification that the United States is likely to see in the next few years, developing EV load management programs is more important than ever.

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