Alliance for Transportation Electrification

Managed Charging for EVs: Innovative Approaches – Part 3 in a Series

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Introduction

This paper is the third in a series developed by the Alliance for Transportation Electrification and its Rate Design Task Force that discuss rate design issues for electric vehicle charging. The first paper developed "Rate Design Principles"[1] suggesting how state commissions – who have authority to regulate either the energy supply rates or distribution rates (or both) of utilities – should approach the rates at which utilities should offer to either residential (home) chargers or public charging stations. This "Principles" paper emphasized the continuing rationale for rates to be based on Cost of Service and the "Bonbright" principles which have been the basis for ratemaking by public utilities for over half a century. The second paper, "Rate Design for EV Fast Charging: Demand Charges"[2] took a deeper dive into one of the key issues related to service to third-party-owned public charging stations, i.e. the imposition of demand charges and the possible concerns raised. This second paper concluded that when demand charges are applied to chargers with low utilization during this nascent stage of market development, public charging may not be an economic proposition and may inhibit growth of needed infrastructure. We recommended both temporary and more permanent solutions to address the issue.

In this paper, the Alliance for Transportation Electrification ("ATE" or "the Alliance") provides a more focused look at one of the key objectives and necessities for optimal development of the EV charging market at the lowest possible cost to utilities and their customers – that is, managed charging. Managed charging, in all of its various forms that will be discussed in this paper, is essential to ensuring that charging – whether by residential or commercial customers – occurs during hours when the utility's costs are the lowest (typically, off-peak hours) or when large amounts of renewable energy are available to use for charging. By ensuring such charging patterns, utilities can avoid or delay the need for grid upgrades to accommodate new demands created by vehicle charging. We do a quick review of time-of-use rates developed and that have been traditionally applied either to the whole house or business, or to chargers that have their own meter and some of the customer issues that arise. But innovative

[1] (*https://evtransportationalliance.org/wp-content/uploads/2022/02/ATE-Rate-Design-Principles-Final-July-202194.pdf*

[2] *https://evtransportationalliance.org/wp-content/uploads/2022/06/Rate.Design.TF_.Demand-Charge-Paper-Final-5.25.22.pdf*

alternatives have been developed that meet the objectives of managed charging, are friendlier to customers, and don't require a second meter or significant customer expense and trouble. Managed charging includes both innovative rate designs to encourage customers to charge off-peak (such as TOU, critical peak pricing programs, and demand charges) and utility programs that offer incentives to consumers for optimal charging. Both rate designs and programs for managed charging can provide significant benefits to the grid and are discussed in the remainder of this paper, along with a sampling of case studies of various alternatives that have been implemented across the country.

Why Managed Charging?

But first, a little more on why managed charging is critical and its benefits. It has to do with utility costs and how they are incurred. There are three main categories of costs utilities incur – (1) costs of capacity (generation, transmission, and distribution) necessary to serve the highest momentary load on the system that customers impose; (2) variable costs which include fuel for power plants; and (3) non-capacity fixed costs which may include administrative types of costs. Some utilities in restructured markets do not provide the generation for their customers (except perhaps as a provider of last resort), and transmission is controlled by regional transmission organizations but still must primarily ensure that distribution system capacity is sufficient to meet peak customer loads. In vertically-integrated utility markets, utilities must ensure generation, transmission and distribution are sufficient. For both types of markets, however, costs incurred are directly related to peak loads (fuel costs also tend to be higher during peak load periods because more expensive generation must be used)[3]. Thus, when new charging loads join the system, they can create the need for increased utility investment. But there are means for mitigating this need for increased investment through managed charging.

Electric vehicles have a major advantage over many other types of loads, in that when they charge is in many cases flexible. EVs are typically used during the day, and then can be charged when system loads are lower such as overnight or weekends (off-peak periods). And there may be periods of the day when utilities have excess capacity. Consumers typically have a choice as to when they charge their vehicles and at what level to charge. They may or may not need to charge their vehicles every day and they may not always need a full charge. The key to minimizing additional utility costs due to EV charging, particularly as market penetration of EVs becomes more significant, is to encourage or incentivize customers to charge their EVs during off-peak periods or periods of excess capacity. This is typically done either through time-of-use rates (usually voluntary) which impose lower costs for off-peak charging, through managed charging where a utility or third-party may provide a monetary or other incentive in exchange for customer agreement to limit their charging to off-peak or excess capacity periods, or through EV-specific rates.

There is another important benefit to off-peak charging. When utilities see increased sales in low cost periods which do not have a commensurate impact on costs to the system, that has the potential to put downward pressure on rates for all customers. Encouraging charging during off-peak hours may also

[3] Costs are influenced both by coincident peaks on the system and non-coincident peaks on circuits, feeders, and transformers. Utilities use different methods of calculating peak capacities in their distribution systems and determining costs and benefits, coordinating with Commissions, with some preferring NCP (non-coincident peak) method with others using the system-wide approach of coincident peak (CP).

help reduce the need for upgrades to the electric system. Thus, the development of rates (or managed charging programs) to change consumer usage behavior to charge during off-peak or excess capacity periods benefits EV drivers, utility customers, utilities and society at large.

In summary, managed charging can provide all these benefits:

- Mitigate cost increases arising from new EV loads and thus reduce the cost of service to EV customers;
- Potentially provide lower rates for everyone using the grid;
- Keep EV fueling prices lower, help adoption of EVs and expand and accelerate benefits of EVs; and,
- Lower carbon emissions, make more efficient use of the grid, and reduce the curtailment of renewables

In many states, regulatory commissions do not have authority over energy supply prices for competitive suppliers and thus their ability to require EV charging rates or programs that encourage off-peak use is limited. They can, however, choose to direct the jurisdictional distribution utilities in the state to implement such managed charging programs. The discussion below applies to rates charged by electric utilities regulated by state utility commissions, whether it be for distribution only or vertically integrated utilities.

Time of Use (TOU) Rates

Time of Use Rates applied to either residential or commercial customers is the first step in encouraging off-peak charging. TOU rates have many benefits, but most importantly they help to ensure that rates paid by customers are proportional to the costs of serving them, a basic tenetof utility regulation as discussed in detail in the Alliance's previous rate design papers mentioned above. TOU rates provide proper price signals to customers thus minimizing the costs they impose on the electric system and maximizing the benefits of transportation electrification (TE).

Energy supply costs vary by month, season, time of day, and day of week. Distribution costs are driven by peak demand as well, but not necessarily in synch with energy supply costs. TOU rates either for energy supply or for distribution costs can be real-time, hourly, based on distinct time periods (usually two to four time periods over the day), or by offering discounts or rebates for use during off peak periods (usually in the overnight hours, such as 11 pm to 6 am). TOU rates usually also vary by season to reflect seasonal usage variations. Whatever form of time differentiated rate is used, it should be reflective of utility supply costs and resource availability during the relevant time period. In some cases, TOU rates can also facilitate the use of what would otherwise be surplus energy from lower cost renewable or non-dispatchable resources by encouraging EV charging thereby avoiding the curtailment of renewable generation.

In most cases where residential TOU rates have been approved, they are voluntary to the customer. With respect to EV applications for TOU, and for residential customers, two options are available to utilities and their regulators. Many utilities already have, and more are developing TOU rates that apply to the whole house, as measured by a single meter at the household level. Others have developed TOU rates that apply only to the usage by the EV. Such rates require the ability to measure usage for EV

charging separately from other residential uses. Traditionally, this would mean that a separate utility meter would be required to measure electricity consumed by charging, a prospect that might make EV-only TOU rates or managed charging programs infeasible. There are pros and cons of whole house versus EV-only rates, as discussed in more detail in our previous rate design papers.

Where advanced meters have been deployed, whole-house time differentiated rates have the advantage of being fairly easy to implement. Many utilities across the country already offer voluntary whole-house TOU rates and have already installed such interval meters capable of measuring hourly or time period consumption at a residence. But on the negative side, if rates are whole house only, EV owners could be discouraged from selecting time differentiated rates if their overall non-EV use occurs during peak periods, or if they are nervous about the impacts on their overall bills. With respect to EV-only rates, participation may be higher, as homeowners could be more flexible with EV charging than with other household uses of electricity. But if an EV-only rate requires an additional meter, customer costs will be increased and lead to lower customer participation.

But technology is developing in ways that may provide for EV-only TOU rates without the necessity of an additional utility meter. For example, where utilities have interval meters (AMI infrastructure), customers have smart chargers, or where in-vehicle telematics is available to the utility, utilities can possibly use data gathered from those sources to implement a separate EV rate without the necessity for a separate utility meter. Some approaches are designed to segregate data associated with EV charging from whole house interval data using software advances. Technology is also developing that allows the utility or third-party to either offer incentives when power is used off-peak or to manage and control when charging is accomplished. In fact, there is a continuum of potential offerings to encourage or require off-peak use by chargers – whether residential or commercial, starting at voluntary TOU rates and going all the way to direct control of the charging experience. We discuss these innovative alternatives that don't require separate meters below.

Some caveats are important. The use of smart chargers, AMI disaggregation, and vehicle telematics is being tried mostly in pilot programs. The validity of the data in each case is being tested. None of the models discussed here are proven at-scale yet, although some utilities working with vendors are getting closer to scale. For residential customers, EVSE (smart charger) based solutions appear, based on experience to date, to be the most reliable, but even they have issues with data quality, connectivity, metering accuracy, low market share, and relative costs. The use of OEM telematics offers much promise but faces certain challenges in implementation of the method of accessing data, standards, and ensuring that each party acts in a collaborative way. Load disaggregation hasn't reached high accuracy yet but may over time for meters that have high sampling rates (i.e., using data that is far more granular than 15-minute intervals).

But at the same time, there are EV managed charging programs that are "robust", meaning they work even if there isn't perfect data. An EV-only TOU rate requires revenue or billing quality data meeting appropriate accuracy and reliability requirements. It has to be very accurate, on-time, at-scale, for every customer every month. But, for example, a fixed credit if you reach a certain percentage of charging off-peak is robust. The data does not have to achieve the traditional high levels of accuracy and time intervals in traditional revenue grade billing systems in order to determine whether or not the customer receives the credit. Design can matter tremendously, and some designs are far more robust than others. Utilities, regulators, and other stakeholders continue to evaluate EV submetering data

opportunities, challenges, and ongoing technological developments and these programs need to anticipate that.

It's also important to note that managed charging does not always require TOU rates. There are other ways to encourage or require off-peak use provided there is a way to measure compliance. For example, there may be simply a discount or rebate available to customers who charge off-peak, or there may be a special "subscription" rate whereby customers can charge all they want for a set fee, provided it is done off-peak. Unlike EV-only TOU rates, there is less need for revenue or billing quality data. These non-TOU alternatives are also discussed below.

Demand Charges

We discuss above the use of TOU rates to encourage off-peak use by both residential and commercial customers. There is another tool – demand charges - used mostly for commercial customers that is designed to both reflect cost of service to these customers and encourage off-peak usage. Demand charges applied to EV charging have been controversial, because when such charges are applied to low usage cases, the costs per kilowatt hour used may be extremely high. Thus, the Alliance has suggested that during these nascent years of market development, demand charges either be forgiven or mitigated as "transitional relief" until utilization becomes high enough to allow the commercial customer to bear their costs while providing an economical charging service. But as we discussed in our previous papers, it is imperative that EV rates reflect costs of service in the long run and demand charges are an important (but not the only) means of reflecting the cost of service.

But just as there are technology-based alternatives for residential customers facing TOU rates, solutions are beginning to emerge that deal with demand charges as well. Subscription rates for commercial customers – currently used by PG&E, is one such example described below. Load management/managed charging itself can help commercial charging stations avoid or mitigate demand charges. Also, battery storage for EV charging stations might be considered to help the commercial customer avoid demand charges. And several utilities have implemented specialized permanent rates dealing with low-load customers, with certain terms and conditions on peak, usage, and seasonality, which can also ameliorate the situation. While such tariffs were not originally meant for EV service providers, they can be adapted and modified to meet the needs and use cases of commercial EV customers.

Managed Charging – Analyzing Alternatives

Managed charging is simply a method by which the behavior of a customer wishing to charge its EV can be affected. In most cases, the objective is to affect when during the day the consumer charges and thus have maximum impact on utility costs, but it can also be used to affect other things, such as how fast the vehicle is charged (for example, charging at less than full power when the grid is congested, independent of the time of use), the type of charging (e.g., L1 vs. L2 vs. DCFC), or even where the vehicle is charged. Managed charging has multiple dimensions that define its design characteristics. First, it can be static or dynamic. Static managed charging has the customer "set it and forget it" based on utility TOU rates. The customer can set charging times at the smart charger (if they have one) or on the vehicle. Once set, it usually isn't changed by the customer unless rate schedules change. Dynamic

managed charging, which requires a communication path with the vehicle or its charger, allows the utility or a third-party to manage when the vehicle charges and how quickly by turning charging on or off or limiting the energy draw in some cases. In the following sections, we discuss both types of managed charging.

Residential Charging

The use case also affects how managed charging programs are designed. For residential charging, the choice, as mentioned earlier is primarily whole-house TOU driven or EV only, but even within those two categories there are multiple ways in which to design rates. Traditionally, the most common form of managed charging was simply defining peak and off-peak periods, which might vary by season, and applying those rates either to household use or EV-only charging. Whole house TOU rates simply require a single interval meter for the house that is able to measure usage by time period – known as automated metering infrastructure or AMI– which have already been installed by many utilities around the country to support other load management programs. And traditionally, EV-only TOU rates would typically require a separate meter in the garage at the charger to measure EV charging use. The installation of separate meters has not been very popular in the residential context because of the potentially substantial costs involved. Costs for a smart meter separate from the household's main meter can range from $500 to $5,000 or more depending on the complexity of the individual installation. In many cases, the costs of the meter can outweigh the benefits from TOU rate programs for EVs.

Because of these potential added costs, a lot of attention is being paid in the industry to alternatives – using either hardware or software, that enable control by the utility or a third-party, and that allow EV usage by time to be measured or monitored without having to have a second meter and its revenue quality data. The primary hardware solution is the use of a smart charger. A smart charger is a type of charger that has connectivity to the internet and can measure and report charging activity between the charger and the EV. Smart chargers can thus receive signals from upstream or use software programming to turn charging sessions on or off thus controlling when charging occurs. And the smart charger can also track electricity usage by time as a separate meter would. The control of charging sessions is an attractive option with broad potential applications. It can be used to limit charger output for periods when the distribution grid is congested, or even be used to limit output while the utility is waiting to be able to upgrade its system due to supply chain shortages. There are many software and network providers that offer such control capability.

There are also multiple software solutions that are being adopted which generally don't control charging sessions but are generally used to monitor when charging sessions occur. They are most often used as part of utility incentive programs that require customers to charge during off-peak periods. Software solutions can either rely on data from a household AMI meter which is disaggregated with algorithms and machine learning to segregate the charging load, or they can rely on telematics data from the vehicle itself to know when and how much charging occurred. With AMI meter analytics, customers typically sign up for a utility TOU or incentive program which provides certain benefits in exchange for agreeing to only charge during specified off-peak periods. The rate applied can be either a whole house TOU rate or an EV-only rate. The utility usually allows a certain number of exceptions per month to account for potential customer needs. The utility or a third-party assigned by the utility applies analytic

software to the customer's whole house AMI data to determine when charging occurred during each month and thus ensures that the customer is meeting the requirements of the agreement it made for a discount or rebate.

Vehicle telematics typically requires authorization of the auto manufacturer and permission of the customer to make data from the vehicle available to the utility or third-party running the managed charging program. Vehicles collect data on when charging sessions begin and end and the energy used, or software companies can impute when charging occurs. The vehicle telematics data can be used in the same way as disaggregated metering data is used in managed charging programs – that is, to ensure the customer is charging in accordance with the terms of the managed charging program in which they are enrolled.

While smart chargers, disaggregated AMI data or vehicle telematics can be used to monitor charging patterns of the customer, it is not generally used directly to bill customers. Much still needs to be learned from early pilot programs about how accurate such data is and many utilities still require revenue quality meters from which to bill customers. Thus, for EV only rates, separate metering is still required in a lot of cases. Some utilities and regulatory commissions are beginning to explore using data from these sources for billing purposes.

One of the innovative rate design forms that smart chargers, disaggregated metering data, and vehicle telematics enables is a subscription rate, sometimes coupled with the leasing of charging hardware. Such rates typically provide the customer with unlimited charging for one monthly fee, provided in most cases that the customer charges only during off-peak periods (again, allowing a limited number of exceptions per month). The utility or its third-party contractor uses data compiled from the smart charger, AMI meter, or vehicle to ensure compliance. Subscription programs can make things easy for the customer, as they can set time periods for charging and then forget it, and not have to worry about how much electricity they are using. And customers have increased certainty over their monthly bill.

In some cases, the utility will also lease the customer a charger and include the cost in the monthly subscription rate. In most of these programs, ownership of the charger is turned over to the customer after a specified period. These programs involving utility leasing of a charger can become controversial in regulatory proceedings, as there are some stakeholders who believe utility ownership of chargers, even for a limited time period is anti-competitive.[4] The Alliance strongly believes that there is an important utility role in the ownership and operation of charging stations, or EVSE, for certain use cases usually in a portfolio approach. Opposing stakeholders participate in state regulatory proceedings and are raising objections there. It remains to be seen if regulatory commissions will continue to allow such programs.

Another common emerging practice is to give customers a monthly credit or a rebate for complying with the terms and conditions of an offered rate program, which would again require off-peak charging with limited exceptions. A standard practice is a bill credit of about $10 per month. These programs have proven to be quite successful in affecting charging behavior by customers. While in most cases, utilities

[4] See the Alliance paper discussing the utility role in EV charging which discusses these issues in more detail: https://evtransportationalliance.org/wp-content/uploads/2023/06/Utility.role_.OO_.whitepaper.FINAL_.6.6.23.pdf

adopting these programs have just two time periods – peak and off-peak, some programs also offer an extra credit for charging during super off-peak periods (when utility costs are at their lowest) to further differentiate the sought-after behavior.

EV Managed Charging programs are also optimizing for several grid needs. Given the flexibility of the charging, utilities can shift charging to time windows where costs are lowest or to enable certain policy goals to be met. In some cases, utilities are prioritizing grid events and minimizing system peaks. Others are seeking to reduce curtailments of renewable resources. Still, others are exploring approaches to avoid distribution system upgrades, including downstream distribution assets, like circuits, secondary service, and transformers.

Finally, while managed charging programs are most often offered along with TOU rates, it is not a requirement that they be offered together. Most all EVs and all smart chargers have the means to automatically set times to charge based on user (and sometimes third-party) input, making it easy for the customer to correlate charging with desired time periods, independent of rate design. TOU rates do provide an incentive for off-peak or super off-peak charging, but other incentives such as bill credits or rebates can be offered with the same effect. This may be helpful to customers who do not otherwise want to be on a whole-house TOU rate when it is the only alternative offered. It also allows the utility to incentivize optimal charging behavior without the need to make major changes to rate design.

After a discussion on commercial managed charging issues, we will present a sampling of current utility programs that employ some of the innovative rate designs that are discussed above, providing some more detail on how they are used.

Commercial Charging

When we talk about commercial charging, we refer to cases where charging is deployed at non-residential locations, which could include public charging on highways and in communities, charging at workplaces, in multi-unit dwellings (MUDs), for school or transit buses, on street charging, medium and heavy-duty trucks, and fleet charging. Commercial charging differs from residential charging in a couple of dimensions. One is that different rate designs may be desired for different use cases. For example, for applications (like fleets or buses) where a user returns to a fixed depot and sits for a relatively extended period, managed charging programs can be developed that look in many ways like residential programs, targeted to encouraging off-peak charging. However, for highway charging, managed charging is more difficult, as drivers who pull up to the charger don't want to wait for prices to decline before they charge. Thus, while TOU rates generally apply to public charging, managed charging by delaying charging until an off-peak period at such sites is rare, sites may enable load sharing across EVSEs that can result in often temporary slowdowns in charging speeds.

The second dimension on which commercial charging differs from residential is the imposition of demand charges. Demand charges are based on the customer's contribution to the utility's peak load, either the coincident peak which is the highest load faced by the utility in a specified time-period, or non-coincident peak which is when the customer places its maximum demand on the system in a specified time-period. Demand charges are thus a way for utilities to allocate the fixed costs of the utility system, while at the same time providing a price signal to customers to reduce their demand during system or individual customer peak periods similar to the effect of time-differentiated pricing for energy or commodity costs.

As we stated earlier, demand charges applied to public charging use cases where the user does not have flexibility as to when they charge, can create issues for the charging operator. Especially during this nascent stage of market development when utilization of stations may be low, demand charges can result in a cost per kWh for charging service that is uneconomic. The Alliance believes that demand charges for commercial customers ought to be mitigated particularly during periods when utilization is low. Where demand charges remain in place, particularly for fixed-base use cases, however, managed charging can be significantly helpful in reducing or eliminating demand charges for customers. And battery storage or distributed generation can also be used to mitigate demand charges at all commercial stations that have the space.

Not all commercial or general service rates applicable to EV charging include demand charges. Some utilities have rates that have a maximum demand threshold before demand charges are triggered. Utilities also may have what are known as Demand Charge Rate Limiters. An example of a Demand Charge Rate Limiter is a maximum cost per kWh that will be charged based on energy and demand charges paid by the customer over a year. Other similar forms of Demand Charge Rate Limiters are in use at various utilities. And as is the case with residential EV charging, utility programs that maintain existing rate structures but provide rebates, incentives, or credits on a temporary basis could effectively provide transitional demand charge relief to commercial EV charging customers.

Irrespective of the imposition of demand charges, and as is the case for residential customers, the Alliance supports the energy or commodity charge component of the energy supply bill for EV charging applications being time differentiated. And where feasible, many of the same types of managed charging programs discussed for residential cases are applicable. One difference is that in most cases, a separate meter for charging service will be required for commercial customers, and special EV rates will be applied to the charger only. Such meters make EV-only TOU rates feasible for commercial customers and in most cases precludes the need for AMI disaggregation or vehicle telematics to determine time of use. Smart chargers, on the other hand, may still be very appropriate to allow programs that give the utility or third-party contractor some ability to control the charger's output when needed to ensure reliability of the grid.

Today, there are not many charging programs that are applied to the commercial charging sector. Pacific Gas and Electric (PG&E) does have a commercial subscription program, which we describe in detail below. And several other utilities have begun subscription rate programs available to commercial customers.

Case Studies

These case studies present an overview of a selected sample of innovative rates of the type described above that are designed to be user friendly, reflect the utility's cost of service, and encourage or require off-peak use by the charging customer. It is not meant to be all-inclusive but rather provides some diversity in geography, technologies utilized (and vendor), and program type. They all represent innovative approaches that are being adopted by many utilities across the country.

Baltimore Gas & Electric

Smart Charge Management Pilot

Baltimore Gas and Electric (BGE), a subsidiary of Exelon, has received a U.S. Department of Energy grant to run a pilot study of managed charging techniques that can be shared industry-wide. The Smart Charge Management Program is specifically designed to gain an understanding of how grid impacts can be reduced as a result of EV charging and to lessen capital investments required as EV ownership grows. The pilot also intends to identify potential cyber risks and vulnerabilities of EVSEs and vehicle telematics software. Pilots are being developed for residential, commercial fleet and public charging customers.

For the residential pilot, BGE, PEPCO and Delmarva Power & Light (also Exelon subsidiaries) have lined up 3,200 Tesla drivers in Maryland (as of August 2023) with a goal of 5000 by June of 2024. Tesla vehicles in both the utilities' service territories are eligible to participate. The BGE residential pilot is using vehicle telematics in partnership with its contractor, WeaveGrid. Customers connect to WeaveGrid's platform directly – the driver then sets their departure time so that vehicle is ready when they leave the house. BGE can control when the vehicle charges. In exchange for participation, the customer gets a $10 per month billing credit and is allowed 4 opt-outs per month. The pilot has three demonstration phases, the first using electric rate only to determine a customer's optimal charging schedule, the second will forecast PJM prices and charge when prices are the lowest, and the third will be geared towards T&D asset protection to reduce charging when the grid is stressed, or to stagger charging on a particular distribution asset, such as a transformer or feeder.

The commercial fleet pilot will offer 200 level 2 chargers to fleet operators with up to 10 per customer. The customer is responsible for installation. Program enrollment and onboarding is handled by BGE contractor Shell Recharge Solutions. Upon enrollment, the customer is required to charge its fleet vehicles on a set schedule that meets both the customer and grid needs. In exchange for participation, small commercial customers get a $25 monthly credit and large customers get a $500 monthly credit. The final pilot program, public charging, is targeted at EV drivers traveling within central Maryland. The goal is to have 850 Exelon chargers enrolled by this year. EV drivers can choose to charge at a reduced kW rate and receive a discounted price during demand response events or opt-out and charge at full power at standard costs.

The pilot launched in October 2021 and will conclude in December 2024. To date, very few unenrollments have been seen and the opt-out rate from off-peak charging has been less than 1 percent.

Con Edison of New York

SmartCharge New York!

SmartCharge New York is the country's oldest and largest managed EV charging program, initially launched in 2017 with a relaunch in January 2023. The program offers cash rewards to residential customers for; (1) off-peak charging (defined as all days, year-round, 12 am to 8 am); (2) summer peak avoidance (avoiding charging weekdays 2 – 6 pm (June – September); and, (3) an additional incentive for avoiding peak charging for the entire summer. The off-peak charging incentive is $0.10 per kWh paid as cash. The summer peak avoidance incentive is $35 per month, and the additional bonus for avoiding peak charging the entire summer is $35, making the total potential summer avoidance incentive $175.

There are three eligibility requirements. The customer must own or lease an EV and charge in the Con Edison service area, must have an internet capable smart charger or a vehicle that can provide telematics data, and cannot be enrolled in TOU rate plans. Data to ensure compliance with off-peak charging is collected either from the smart charger or from vehicle telematics. There are three chargers supported and 60 vehicle models. Participants are provided a dashboard either through a mobile app or the web. And participants are paid either through PayPal or Venmo. The cash payout feature of the program appears to be fairly unique – most utilities offer bill credits for program participation. The average enrollee gets $400 per year in incentives.

SmartCharge New York is administered by ev.energy, which offers a hardware-agnostic managed charging platform across a broad range of vehicle telematics and networked EVSEs. An estimated 90% of drivers in Con Edison's service territory have hardware that is compatible with the program, and over 10,000 private and commercial vehicles have enrolled in the program to date. Customers have a choice of enrolling via ev.energy's mobile app or web portal, and an estimated 20% of Con Edison customers with EVs are currently enrolled in the program.

Enrollment in the program is pretty straightforward. Once the customer is confirmed as eligible, they are put in touch with ev.energy to review the fleet onboarding process. Ev.energy then enrolls the customer in the program. The customer must provide either connected car login credentials (to connect to software API) or connected charger login credentials (to connect to software API). SmartCharge New York is currently authorized through December 2025.

Con Ed is currently awaiting approval from the New York PSC for a similar commercial program expected to be initiated this fall. The program will offer cash incentives to all eligible commercial stations for charging during off-peak periods (including public, workplace, light- and medium- and heavy-duty fleets, multifamily, and industrial). Like the residential program, the commercial program will offer incentives in two parts -- for off-peak charging ($0.03 per kWh, charging must occur between 12 am and 8 am, every day, all year) and a "standard" peak avoidance. The standard peak avoidance will provide $10 per kW avoided during 4-hour peak window relative to nameplate capacity (June – September) and $2 per kW avoided during 4-hour peak window relative to nameplate capacity (all other months). The incentive is based on nameplate capacity and is prorated resulting in cost relief potential to all charging stations. Enhanced incentives are offered for public DCFC and L2 charging stations and transit charging.

Consumers Energy

PowerMIDrive™ Program

The PowerMIDrive program was approved by the Michigan PSC in January 2019 with the goal of increasing participation in residential TOU rate programs and moving charging to greater than 70% off-peak. The program requires drivers to enroll in whole-house TOU rates. The program was launched offering a $500 rebate towards a networked EVSE, which is required for enrollment in the program. In August 2021, a Bring your Own Charger (BYOC) [5] was added to the program and opened to any level 2 charger. The BYOC program relies on drivers to set in-vehicle timers or smart charger timers to charge only during off-peak periods. Sagewell, Inc. was brought on as the contractor and handles enrollment in

[5] BYOC or Bring Your Own Charger is a registered trademark of Sagewell, Inc.

the program and data collection and monitoring. Any level 2 charger that is UL listed, Energy Star certified, and 9.6 kW or less is eligible. Sagewell uses whole house AMI meter data and uses analytics to assess the portion of the household load curve that is attributed to EV charging. The analytics are used to ensure that drivers are charging during super off-peak hours (11 pm to 6 am, Monday to Friday) to which they have agreed.

Under the BYOC program, 91 percent of charging has occurred in the super off-peak period and 98 percent in super off-peak and off-peak periods (6 am to 11 am and 7 pm to 11 pm, Monday to Friday). This compares to only 62 percent of customers charging in super off-peak and 92 percent charging in off-peak for customers participating only in the charger rebate portion of the program. As of the end of June 2023, the BYOC program had 3400 enrollees. One of the unique features of the program is that AMI data is used not only to monitor compliance but is also used to identify potential enrollees. Sagewell estimates that 50 percent of enrollees were identified and notified before their enrollment.

The program offers a $10 monthly rebate (or credit) to participants, but only for the first twelve months. Three exceptions are allowed per month. Consumers Energy has found that most consumers continue their off-peak charging even after the monthly rebate expires. The BYOC program was approved as a permanent program in early 2023.

CPS Energy

FLEXEV^{SM} Smart Rewards and FLEXEV^{SM} Off Peak Rewards

CPS Energy of San Antonio has two related pilot programs for up to 500 residential customers to earn rewards for off-peak charging – the FLEXEV Smart Rewards and FLEXEV Off-Peak Rewards. Smart Rewards offers a $250 credit on the customer's utility bill for allowing CPS Energy to make remote adjustments to an eligible level 2 WiFi charger. Adjustments can occur from 2:00 p.m. to 9:00 p.m. Monday-Friday up to a maximum of 15 events per month. Customers are notified of an event in advance and can opt-out of an event at any time by adjusting your charger back to its normal settings. An additional $5 credit is offered for each month the customer remains enrolled in the program.

The Off-Peak Rewards program offers a $125 bill credit for charging during off-peak hours. Plus, if the customer limits charging to no more than twice monthly during peak hours, they will earn a $10 credit for the month. Again, an eligible WiFi charger is required. Peak hours for the program are Monday-Friday between 4:00 p.m. and 9:00 p.m. Customers can enroll in only one of the two programs.

EnergyHub coordinates marketing and enrollment of drivers, manages charging partners, and maintains the platform used to control charging and report data needed for evaluation and provision of incentives.

CPS Energy has begun an evaluation of these pilot programs. Under the Smart Rewards program, an average of 0.37 kW load has been shed per enrolled EVSE. In 2022, 39 events were dispatched, including all four 4CP events. Current enrollment as of May 2023 was 179 customers. Under the Off-Peak Rewards program, an incremental 16% of charging was shifted to off-peak. Enrollment in May 2023 was 109 customers.

CPS also has a pilot commercial charging program – FLEXEV Public Charging. Under its' Flat Rate Pilot Program, for an annual fee of $96, the customer gets unlimited access to CPS's charging stations at any time of day or night. There are 57 charging ports in the CPS network.

Duke Energy Florida

Off-Peak Charging Credit

Residential customers with level 2 chargers can get a $10 monthly bill credit for charging their vehicles during off-peak periods. It is not available to customers on a whole house TOU rate. The customer is required to submit a picture of the EV's charging timer set to off-peak use. Off-peak times are Monday through Friday 10 a.m. to 6 p.m. and 9 p.m. to 5 a.m., holidays and weekends.

The third-party vendor used by Duke Energy Florida is Itron and Rolling Energy Resources. These vendors collect vehicle telematics data from the EV manufacturer. Itron uses its proprietary software "DER Optimizer solution" which is a suite of modules that enables utilities to monitor residential electric vehicle (EV) charging and manage holistic residential EV charging programs at scale. In this program, Itron is integrating with an EV telematics platform provided by Rolling Energy Resources, which connects to cars through their native APIs (Application Programming Interfaces) to allow easy on-boarding for customers and their vehicles into the program without needing to install additional hardware or communicating charging stations.

Just like the other programs mentioned above, the vehicle telematics data is used to ensure compliance with the terms and conditions of the program. The utility's contractors use the vehicle telematics to determine when EVs are charging. Two opt outs per month are allowed. An opt-out charging event is defined as charging outside of off-peak periods for 15 minutes or more at 3 kW capacity or above.

When the program was approved by the Florida PSC for a four-year period, annual enrollment limits were set (1000 customers per year) and Duke Energy Florida has reached the limit for 2023. Rolling enrollments will occur as spaces become available and more spots will be added in 2024.

Duke Energy North Carolina

Residential Subscription Program

Duke Energy requested a subscription-based managed charging pilot as part of a package of proposed programs in a filing with the NC PUC February of 2022. According to Duke, the proposed pilots were the fruit of discussions in the Comprehensive Rate Review and Electric Transportation Stakeholder Collaborative. The subscription pilot program was designed to be composed of 200 EV customers, 100 each for Duke Energy Carolinas (DEC) for Duke Energy Progress (DEP). Pilot participants would agree to allow Duke to actively manage the charging of their EVs, with the Companies being allowed to schedule up to three managed charging events per month. Further, Duke stated that the pilot will consist of dynamic EV charging rates that will be managed by the Companies while providing participating customers with bill simplicity and certainty. Under Duke's proposal, DEC participants would pay $19.99 per month, and DEP participants would pay $24.99 per month (due to differences in the cost of service

in the two territories). While it is an "all you can eat" type of plan, there is a limit -- if a participant's vehicle battery charging level exceeds 800 kWh per month for three months during the year-long pilot or greater than 1,200 kWh in a single month, the participant would be subject to immediate removal from the pilot program.

Duke partnered with automotive original equipment manufacturers BMW of North America, LLC, Ford Motor Company, General Motors, LLC, and American Honda Motor Co., Inc. (collectively OEMs), to test the Open Vehicle Grid Integration Platform (OVGIP) that was developed jointly by the OEMs and the Electric Power Research Institute. The OVGIP is designed to establish communications and control between the vehicle and the utility, applying utility industry communications standards. The OVGIP allows Duke to observe charging behavior of the vehicles and to call demand response events – that is turn off the charging event. Duke in its filing also noted that it intends to use the platform to test out different pricing options without the need for a second meter. Duke requested that the Pilot run for 12 months, with a report to be made on the findings six months later.

The Duke Energy pilot does not involve leasing or a subscription for the charger itself, although Duke does have separate programs offering rebates for behind the meter make ready infrastructure, and a newly approved "charger" rental program. The monthly subscription rate is based on what Duke customers would pay if they used 225 kWh, which is what Duke expects usage to be within the subscription plan. Duke also intends to keep customers informed of their usage and give customers access to their usage data. The Duke pilot was approved by the NCPUC on June 24, 2022, opened for enrollment on September 1, 2023, and customers will begin taking service November 1, 2023.

Pacific Gas & Electric

Business Electric Vehicle Rate (Subscription Service)

Pacific Gas & Electric's (PG&E) Business Electric Vehicle Rate (BEV) was first introduced in May 2020. PG&E offers two electric vehicle (EV) rate plans for business customers with on-site EV charging, Business EV 1 (BEV-1) and Business EV 2 (BEV-2). These rates are specifically designed for customers with separately metered EV charging at locations. BEV customers self-select into five different use case categories: Direct Current Fast Chargers (DCFC), Public transit (Transit), Workplace, Medium Duty Fleets (Fleet), and Multifamily Housing (MFH). Customers on BEV rates have a choice of subscription level, based on their charging needs:

- Business Low Use EV Rate – BEV-1: For EV charging installations up to and including 100 kilowatts (kW). Best suited for smaller workplaces and multi-unit dwellings.
- Business High Use EV Rate – BEV-2: For EV charging installations of 100 kilowatts (kW) and above. Best suited for sites with fleets and fast-charging station

For customers on the BEV rate, you will pay both the subscription fee for your subscribed kW level and a volumetric kWh charge, the price of which is determined by your time-of-use period.

The key components of the BEV rates are:

- Monthly subscription charge: Customers can choose one of two subscription levels based on their maximum monthly EV charging kW consumption and this can be adjusted throughout the month as often as needed – until the last day of each billing cycle – to avoid overage fees.
- Overage fees: At the end of a billing cycle, if actual consumption (kW) exceeds the subscription level, an overage fee of two times the cost of one kW for each kW over the subscription level will be charged.
- Grace period: To help customers determine the best subscription level, a grace period with no overage fees for three billing cycles is provided during initial enrollment.
- Time-of-use rate: In addition to a monthly subscription charge, customers are charged a volumetric rate (per kWh) based on energy usage and when that energy is used. Charging is the most affordable midday, when PG&E has higher levels of renewable energy generation. Time-of-use periods are consistent year-round with no seasonality. There are three time-of-use periods – peak, off-peak and super off-peak.

Unlike the residential use cases described above, business customers on the BEV rate must have a separate interval meter for their EV load so usage for charging is measured directly and billed based on the meter data. Customers on BEV rates do not incur demand charges, which are essentially subsumed in the monthly subscription fee. Thus, the rate is much simpler and more predictable for the customer.

PG&E's BEV rates are designed to reflect cost of service. As the Company had little data on charging use in the five categories at the start of the program, it used assumed load profiles and cost data from other existing rate schedules as proxies for the costs and attributes that might be expected of BEV customers. The BEV rates contain three intentional changes from standard cost-based rate making: (1) they include an artificially high peak period rate, to incentivize customers to avoid charging during that period; (2) they contain no seasonal prices differences as it was hypothesized that BEV customers will not change their usage behavior seasonally; and (3) they only collect distribution revenues equal to marginal costs estimated in an earlier proceeding. PG&E has since collected actual cost data and found that distribution costs were higher than originally estimated but generation revenues were higher than costs. There has been more peak usage at DCFC stations than originally contemplated, even as peak rates were set intentionally high. On -peak use was 23% for BEV 1 and 29 percent for BEV 2 in 2022. This is presumed due to the inelasticity of demand for the public charging use case. The differences between estimated distribution and generation costs suggests that PG&E may seek changes to the rates in its next rate case.

At the end of 2022, PG&E had 118 customers enrolled as compared to 66 the year before. The enrollees are spread over 567 sites within PG&E's service territory. Public DCFC chargers amount to 77 percent of the users, with 15 percent workplaces, and 4 percent each MUDs and Transit/Fleets. PG&E has estimated that savings from enrollment in BEV rates average about 40 percent over all use cases compared to the otherwise applicable commercial rate. Transit and workplace customers gained the greatest savings. MUD customers, who tend to have the lowest usage, have gained the least savings. PG&E has several programs and tools available to help ensure commercial customers are on their optimal rate. The Company also has a marketing education and outreach program to inform customers of the availability of the subscription rate and potential savings.

Portland General Electric

EV Smart Charging

Portland General Electric's (PGE) EV Smart Charging Program is a pilot targeted at residential customers that uses both smart chargers and vehicle telematics (for Teslas). PGE's residential EV charging pilot was first approved by the Commission in February 2018 and updated in June of 2022. It is scheduled to run through December 31, 2024 or when the pilot reaches 5,000 participants. The program includes various types of rebates for program-specified chargers that have demand response capabilities (smart chargers). PGE also offers rebates for any required electrical panel upgrades. Purchase of a qualified charger automatically enrolls the customer in the Smart Charging program, although customers can bring their own chargers if they are qualified as eligible under the program, and can receive a $50 rebate. Customers in the program get seasonal rewards - a $25 credit on their bill at the end of a Smart Charging season (October to March and April to September) for a total annual reward of $50.

Participating customers have their charging times automatically shifted away from peak times when energy use is high and sustainable energy resources are scarcer – known as smart charging events. Charging resumes when the event is declared over. And customers can opt out of charging events using their charging app. In order to qualify for the seasonal reward, customers must have their charger connected to the internet at least 50% of the time, charge their EV at least 13 times during the season, and participate in at least three charging events. Customers are divided randomly into two groups that have different charging event periods, either 5 to 8 pm Monday through Friday or 10 pm to midnight Monday through Friday. And customers are not required to be on a TOU rate.

Tesla chargers are not eligible for the regular rebate but are eligible for a separate program run by evPulse. The rationale is that Tesla owners typically do not install DR-enabled chargers and thus another path was needed. Under the evPulse (a product of WeaveGrid in collaboration with PGE) program, vehicle charging may be rescheduled to avoid charging during PGE's smart charging events and to maximize off peak charging (if the customer is on Time of Day pricing). Customers get a $50 rebate in addition to the seasonal rewards noted above. Customers choose a "Ready by" time when their vehicle will be fully charged and PGE can adjust charging times in any manner that still meets the ready-by time. Customers on TOU rates will have loads shifted to off-peak periods. When charging is to be interrupted, customers will receive a text notification. Notifications will include guidance on the battery percentage the customer's vehicle will reach and the time it will be scheduled to finish. The rescheduled charge is determined by the following factors:

- The charge limit as set in the Tesla app or vehicle console;
- The "Ready by" time selected in the evPulse application; and,
- Home charger power as determined by historical data

Charging events can be overridden in the Tesla app.

Xcel Colorado

Charging Perks Pilot

Charging Perks is a residential smart charging pilot program offered to customers of Xcel Colorado (Public Service Company of Colorado) that seeks to minimize curtailments of renewables. Under the program, customers who drive a battery electric or plug-in hybrid electric vehicle from BMW, Chevrolet, Honda, Ford, or Tesla can participate through the OEM or evPulse WeaveGrid (for Tesla) which will control charging loads.

This pilot includes multi-layered dynamic charging optimization that supports many customer rate options. The pilot features three levels of managed charging. First, Xcel Energy shifts EV charging to off-peak to provide capacity and maximize bill savings for customers participating in a time-varying rate. Second, Xcel Energy shifts EV charging into hours with the lowest electricity production costs. Third, Xcel Energy directs charging towards times when the system is forecasted to have an abundance of renewables. Each OEM and WeaveGrid uses this information in combination with driver preferences and the vehicle state of charge to schedule charging that is applied once the customer's vehicle is plugged in at home. The pilot is targeting both TOU rate and non-TOU rate customers to understand how rates in combination with active managed charging techniques can create system benefits.

Participants are eligible for both an up-front incentive and an ongoing reward for participation. For level 1 charging, the initial incentive is $100 and ongoing incentive is $50 issued annually. Both the Initial Incentive and Participation Reward will be issued to customers through a third-party vendor in the form of an e-gift card. To be eligible the customer must plug in their vehicle at least once a week and remain connected to their EV manufacturer's network via a cellular connection. The Smart Charging Provider – either the OEM or evPulse WeaveGrid in the case of Tesla – handles enrollment in the program.

As part of the Pilot, the Smart Charging Provider will communicate a charging schedule to the customer's EV (multiple providers are participating). The schedule is communicated from the Smart Charging Provider using the existing communications equipment installed in the EV. The schedule is customized by the Smart Charging Provider and may change every time the EV is plugged in depending on numerous factors such as your needs which you communicate to the Smart Charging Provider, the needs of the power grid based on input from Xcel Energy sent to the Smart Charging Provider, and the state of charge of the EV. The Smart Charging Provider's schedule can be overridden by the customer, and there is no limit on such overrides nor do overrides affect the Participation Reward.

The customer chooses any applicable residential rate plan, and the Company suggests that remaining on a non-TOU rate should not affect bills. Customers on a TOU rate will see their charging use shifted to off-peak periods, although in some cases usage could be shifted to higher cost on-peak periods if needed by the grid, possibly resulting in higher bills.

The pilot is scheduled to go through December 31, 2023.

Xcel Minnesota

EV Accelerate at Home (EVAH)

The Xcel Minnesota Accelerate at Home program provides the residential customer with either a rental of a smart charger or purchase of a smart charger. Only Level 2 chargers can participate in the program. The rental rate is $16.48 a month with no up-front charge. The purchase price is $6.68 a month with a $770 up front cost. Both rates include installation and maintenance and data service fees but not wiring from the panel to the charger and not permit fees. Fuel cost charges, resource adjustments, and local taxes and fees are not included in the monthly or upfront prices and will be applied upon billing. For customers with solar, they must switch to a whole house time-of-use rate to be eligible.

Customers who already participate in the Company's Time of Day program can participate in the Accelerate at Home program, but the fees are different. In these cases, charging usage is billed at the Time of Day rate, not the TOU rate available to non-Time of Day participants.

Purchase or rental of the charger gives the customer access to EV-only TOU rate plans. The charger will be programmed to charge only during off-peak hours, between midnight and 6 a.m. every day. The customer can override the charging schedule. The EV will otherwise automatically charge during the lowest cost time period. There are peak, mid-peak and off-peak time periods, and the TOU rates also vary by winter and summer. Energy consumed elsewhere in the household is billed at normally applicable rates and the EV charging fuel costs, dependent on TOU, are added.

Moving Forward

The case studies described above, only a small sample of the wide number of programs nationwide, do suggest that a lot of attention is being paid to getting EV customers to charge in lower-cost off-peak periods and innovative programs are being tested to see what works best and at what cost. Most of these programs, and others, are still either in pilot stages or the early stages of roll-out, so there is not a lot of data or analysis available on the cost-effectiveness of alternative approaches, or even a basic question of whether time-of-use rates by themselves are more cost-effective than programs which offer extra rewards or incentives for certain behaviors. For example, at least one utility, Consumers Energy which has a permanent program, decided to drop its monthly payment to participants after they're in the program for 12 months, determining that program goals could still be met. A related question is whether program participants are mostly free riders – that is they would charge off-peak even without incentives. These are questions that should be answered over the next several years as the necessary evaluations of these programs are completed.

A couple of caveats. Managed charging is not a silver bullet to meeting the needs of utilities and their customers. Both rates and programs should be seen as one pathway or tool which utilities may deploy to help ensure reliable and affordable power to EV drivers and other utility customers. But rates still need to reflect costs to ensure fairness and equity in use of the grid. And managed charging should not be considered a substitute to careful utility planning for grid needs and building in advance of need where possible. Utilities must continue to provide a grid that supports their customer needs every hour of every day.

Furthermore, the wide variety of programs that different utilities provide may cause some confusion among customers – particularly commercial customers that operate in different service areas. There are

some signs of standardization beginning to develop. Of course, most utilities are adopting time-of-use rate options for their customers with electric vehicles. And for residential customers, a fixed monthly rebate for off-peak usage seems to be common among programs as an additional incentive. Subscription-type rates are becoming more popular as well, and they have common characteristics – usually a leased-charger and an all you can charge rate in off-peak hours subject to several exceptions per month allowed. These latter two frameworks are being carried forward by many utilities across the country.

There are of course differences as well, but most pertain to the manner in which time of use for charging is monitored or enforced – either via separate meters, smart chargers, AMI disaggregation, or vehicle telematics. Which of these technology solutions ultimately wins out – if any - will depend on a lot of factors including accuracy, economics, and consumer acceptance. There is no clear or preferred solution today. But managed charging is here to stay, and will be an important part of the EV market revolution, ensuring ultimately that the grid costs of EV market penetration are minimized into the future and consumer benefits maximized.

This paper is a product of the ATE Task Force on Rate Design. The Task Force was established in the spring of 2020 to assess the broad range of rate design issues for residential and commercial customers that arise when state public utility commissions review TE rate proposals developed and filed by regulated utilities. Its primary goal was to share information on best practices in rate design across the multiple sectors within ATE, namely regulated utilities, auto OEMs, EVSPs, and other TE stakeholders. Another goal was to develop a more proactive position among ATE members on rate design as the entire EV ecosystem accelerates adoption of EVs and deployment of charging infrastructure across the country. The task force resides within the larger Policy-Regulatory Committee of ATE and reports up to the Board of Directors. The facilitators and principal authors of this consensus-based document were Philip B. Jones, Executive Director, and Bruce Edelston, Senior Advisor of ATE. They can be reached at phil@evtransportationalliance.org.

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